

# **THESIS**

**THE DEVELOPMENT OF A COURSE TO ENHANCE  
PRE-SERVICE SCIENCE TEACHERS'  
PROFESSIONAL KNOWLEDGE**

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THESIS

THE DEVELOPMENT OF A COURSE TO ENHANCE PRE-SERVICE SCIENCE  
TEACHERS' PROFESSIONAL KNOWLEDGE

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Professional knowledge has been explained as the knowledge that is held in active relation with practice, and also is used to shape professional practice or action. The purpose of this study was to design, implement, and determine the effectiveness of a course to enhance pre-service science teachers' professional knowledge during the course and student teaching. The course was designed with guiding principles, current situation of professional experience training, previous methods courses, and expected levels of professional knowledge derived from analysis of documents and needs of participants. The results from the Designing Phase revealed the course characteristics which included: providing opportunities for pre-service science teachers to see examples of how to teach; enhancing scientific, technological, and research on best practice knowledge; enhancing inquiry, planning, and teaching skills, and reflective thinking; encouraging the happiness, attitude toward the teaching profession; enhancing knowledge of topic-specific instructional strategies, subject matter knowledge, lesson plans, science process skills, classroom management, producing instructional media, utilizing technology, assessment and teaching based-on the student centered approach; providing opportunities for pre-service science teachers to revise and implement domains of professional knowledge into planning and teaching practice through the process of seminar discussion; integrating reflection and role models were used as activities in the course. The course aimed to enhance pre-service science teachers' professional knowledge in lesson planning and transforming science content into effective teaching with respect to the National Education Acts 1999.

The findings from the implementation of a course through fifteen weeks of activities indicated that the course influenced pre-service science teachers' underlying professional knowledge by enhancing them to be more consistent in constructivist-based views of teaching and learning science. Moreover, the course also affected the ability to implement professional knowledge during the school based portion of a companion course by having some influencing factors emerge from the study. In the follow up phase, the course continued to enhance pre-service science teachers' underlying professional knowledge and their abilities to implement professional knowledge during their student teaching. There were factors that affected the development of the professional knowledge that emerged during the study. The key factors included the cooperating teachers, practicum school context, the university advisor, and the course. The main influence pre-service science teachers received from the course was on lesson plan writing. The characteristics of pre-service science teachers' students tended to be enhanced in a positive manner which included knowledge, process, and attitude toward science.

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# CHAPTER I

## INTRODUCTION

### Reform Education in Thailand

Thailand has encountered challenges with the improvement of its economic system. Pillay (2002) and Roadrangka (2004) reported on the rapidly transforming economic system that Thailand has experienced in changing from a government-supported economy emphasizing agriculture to a market-oriented economy based upon industry. They also pointed out the need to improve human resources with educated and skillful people, in which to support the transforming economy (Pillay, 2002: 2; Roadrangka, 2004: 14).

The need for improving education in Thailand is identified in the National Education Act of B.E. 2542 (1999). Specifically, the Act states that:

... the economic, political, cultural and social crisis has caused all concerned to realize the expediency for the reform of Thai education. The needed reform is expected to redeem the country from its downward spiral, so that Thailand will arise in the immediate future as a nation of wealth, stability and dignity, capable of competing with others in this age of globalization (Office of the National Education Commission [ONEC], 1999: (i))...

It is apparent that high quality education is required to produce and develop competent and capable Thai citizens to support the transformation of the Thai economic system (Pillay, 2002: 2; Roadrangka, 2004: 14) and to develop competent citizens. Teachers play an important role in this process (Pongsopon, 2003: 134; Pitiyanuwat, 2004: 1; Roadrangka, 2004: 1), because teachers are the people who transform current national education policy into student knowledge. In addition, science teachers have an even more important function, since science education is at

the core of economic improvement. The content and professional knowledge of science teachers together with high quality teaching practices must be used to enhance students' knowledge construction for the future.

With the support of the Thai government, The Institute for the Promotion of Teaching Science and Technology (IPST) was established in 1972. The IPST developed new science curriculum which emphasized a learner-centered orientation for school systems. This curriculum attempts to develop three main characteristics of science including scientific knowledge, practice of scientific inquiry, and development of scientific attitudes. It is clear that effective science teachers who are well trained in science content and professional knowledge are needed if Thai education is to be improved.

### **Teachers and Teaching**

Teaching involves complex activities that require knowledge, skills, dedication and also personal experience. Lapp *et al.* (1975) stated that “a teaching career is not a nine-to-five job”. In other words, teaching requires critical thinking to improve students' performance. Moreover, “it is a stitched-together affair that contains more pain and conflict, more joy and intelligence, more uncertainty and ambiguity” (Ayer, 2001). It can be concluded that to produce effective teachers is a complex task that requires an elaborate process to prepare persons access into the career of teaching. Teachers need to be well trained in using the very best teaching methods to help students learn in different situations (Arends, 2004)

Batten, Marland, and Khamis (1993) defined qualities of teachers in terms of teaching and learning, their attitudes toward students and classroom management. A good teacher is one who: helps students with their work; explains well so students can understand; is friendly; makes lessons interesting and enjoyable; cares about students and always is ready to listen to students; has a sense of humor and can control the class. In addition, Borich (2004) suggested a new direction that occurred by changing

the definition of good teaching to effective teaching, aiming to assess the effectiveness of teachers by linking effectiveness to the accomplishment of students.

New notions of effective teachers are “those who understand their own strengths and capabilities and adapt suitable teaching strategies” (Eggen and Kauchak, 1994). In other words, “those who have command of the subject they teach, those who care about the well-being of children, and those who have the knowledge base to guide the art of practice” (Arends, 2004).

“Pre-service teacher” is a term used to describe the transformational status between the times that aspiring teachers are students to the time that they become full fledged teachers. Becoming an accomplished teacher takes a long time and requires an attitude of striving for improvement. Therefore, learning how to teach, a process that begins in teacher preparation is an important life long process for the career of teaching (Arends, 2004).

### **Thai Science Teacher Preparation**

The development of the Thai teacher preparation system began in B.E. 2435 (1892), when the first Thai teacher preparation school was established, and has continued through the period of education reform in B.E. 2542 (1999). In science education, teacher preparation has evolved since the 3<sup>rd</sup> national education plan in B.E. 2515-2519 (1972-1976). The Bachelor’s Degree in science teacher preparation was first awarded as a result of the 3<sup>rd</sup> National Education Plan, but the goal of producing teachers in science and technology intensified during the 8<sup>th</sup> National Education Plan B.E. 2540-2544 (1997-2001) (Silapabanlaeng, 2006). Teacher preparation in the 8<sup>th</sup> National Education Plan emphasizes quality teacher education reform according to National Education Acts B.E. 2542 (1999).

## **1. National Requirements for Teacher Production**

To produce quality teachers according to national requirements, the process of pre-service teacher preparation is enormously important (Pongsopon, 2003: 134; Pitinyanuwat, 2004: 1; Roadrangka, 2004: 1).

According to the National Education Act of B.E. 2542 (1999):

The Ministry shall promote development of a system for teachers and educational personnel, including production and further refinement of this category of personnel, so that teaching will be further enhanced and become a highly respected profession. The Ministry shall, in this regard, take a supervisory and co-coordinating role so that the institutions are responsible for production and development of teachers, faculty, staff, and educational personnel and shall be ready and capable of preparing new staff and continuously developing in-service personnel (ONEC, 1999: 52)

There is also a national requirement for developing a system of teacher production and refinement, and the aim of the system is to encourage teachers to organize the learning process according to the National Education Act of B.E. 2542 (1999). Chapter 4 Section 24 of the Act mentions learning process organization. It can be concluded that educational institutions and agencies concerned shall arrange learning activities for learners to draw from authentic experience and provide all substances to be in line with learners' interests, aptitudes, and individual differences. The learning process organization should aim to enhance students' critical thinking for problem solving skills in daily life. Also, instructors should be enabled to create a learning environment, instructional media and facilities for learners, and should be enhanced using research based knowledge, and a variety of teaching and learning medias and sources for improving individuals to learn in all times and all places. In other words, teacher education should provide teachers who can achieve the level of the national requirement.

To achieve the national requirement for organizing the learning process, Pillay (2002) suggested that “teachers must become professional practitioners”. In other words, teachers should have the ability to select appropriate teaching strategies for specific learning situations for individual differences, and for a variety of content areas. Further, they should be enhanced to extend their teaching skills, develop an understanding of a variety of types of teacher professional knowledge, and refine the underlying philosophies of the new approach to teaching and learning (Pillay, 2002: 11)

## **2. Thai Science Teacher Preparation Curriculum**

### **2.1 Current Curriculum**

In Thailand, two types of institutions of higher education prepare science teachers. They are the University Faculty of Education and the Rajabhat Institutes (Rochanasmita, 2006). The four-year science teacher preparation curricula provided by University Faculties of Education and Rajabhat Institutes (Teacher Training College) enhance pre-service science teacher’s professional knowledge with courses and activities. The aims of these courses and activities are for pre-service teachers to acquire and apply professional content or subject matter knowledge, to develop a thorough understanding of the nature of learning and the nature of teaching, and to base their decisions upon appropriate values and attitudes (Roadrangka, 2004). Science teacher education curriculum provided by both University Faculties of Education and Rajabhat Institutes requires from 120 to 150 credit hours. The curriculum consists of three main types of core courses and experiences. These core courses are the General education courses, the specialized courses, and the Elective courses. The General education courses are in the areas of Social Science, Humanities, Languages, Mathematics and Science. Total credit hours in General education for university Faculties of Education is not less than 30 hours, but for Rajabhat Institutes, it is 33 hours. The specialized courses are in areas of science content and professional education courses. In this category the total credit hours for university Faculties of Education is not less than 84 hours, but for Rajabhat Institutes

it is 105 hours. The required credit hours for compulsory science content courses are at least 44-46 hours and for selective science content courses at least 10 hours. Of the amount of compulsory science content course, pre-service science teachers must take 10 hours in every major field and 34-36 credit hours in each major field. The required credit hour for education area is at least 41 credit hours. The elective courses are chosen by students based on their own interests. The total credit hour for students in the University Faculties of Education is 6 hours, but for Rajabhat Institutes it is 10 hours (Roadrangka, 2004).

## **2.2 Field Experiences**

After finishing methods courses, pre-service science teachers have a very important requirement to participate in a student teaching practicum. One semester of a teaching practicum is necessary during the process of teacher preparation (Northfield, 1998; Jaiswang and Chantawan 2003; Roadrangka, 2004). It is designed to allow pre-service science teachers to integrate and apply their knowledge of science content and education into teaching practice. In other words, it is an opportunity for pre-service science teachers to practice blending their knowledge of content, curriculum, pedagogy, student psychology, instructional media, and assessment to help students understand science.

The field experience or teaching practicum is the culmination of a series of coordinated activities which advance the pre-service teacher from classroom observation through the fulltime teaching practicum or teaching practice (Schoon and Sandoval, 1997). Teaching practicum is an important aspect of pre-service preparation (Richardson-Koebler, 1988; Cochran-Smith, 1991; Schoon and Sandoval, 1997; Collier, 1999). Each of the institutions of higher education prepares science teachers with different types of student teaching practicum.

University Faculties of Education offer two levels of field experiences. First, Level 1 Field Experiences (Observation and Participation) are provided for the third year student teachers to connect university coursework to classroom practice. In

Level 2 Field Experiences (Student teaching), students spend an entire semester of the fourth year as a student teacher for 18 weeks in a practicum school. They are expected to teach science 8-12 hours per week.

There are three forms of field experiences provided by Rajabhat Institutes. Students are provided field experience activities in the second year to the fourth year of their programs. The first is a full-time field experience opportunity, which is composed of 1 credit for observation and participation, another 1 credit for microteaching, and 5 credits for student teaching. Student time spent varies from 2 weeks, to half of a semester, to a full semester. This type of field experience aims to enhance student teacher knowledge, skills, and personal competency. The second kind of experience is an occasional field experience. This type aims to connect university course work with classroom practice. Student time spent varies from a few hours, to half or a whole day. The last is a supplementary professional experience. This type aims to increase student teacher expertise in knowledge, teaching skills, and teacher characteristics. This form provides additional activities from the basic curriculum to enhance student expertise (Roadrangka, 2004).

During field experiences, pre-service teachers can acquire knowledge over time and through experience. The knowledge that pre-service teachers articulated by practice teaching, discussing with experienced teachers, and exchanging with peers is called professional knowledge or teacher craft knowledge (Batten *et al.*, 1993).

### **Teacher Professional Knowledge**

Hoyle and John (1995) explained teacher professional knowledge by comparing it with professional knowledge in other professional careers. They described professional knowledge as “the notion that a profession bases its practice on a body of technical or specialist knowledge” (Hoyle and John, 1995: 45). In addition, Elbaz (1981) defined professional knowledge as the knowledge that is held in active relation with practice, and also is used to shape professional practice or action (Elbaz, 1981: 47). Medicine and law are examples of professional occupations, because they

base practice on a body of technical or specialist knowledge. In medicine, the practitioner is taught to understand the universal laws of scientific procedure, particularly as they apply to Chemistry, Biology, Physiology, etc. When doctors diagnose patients, they must draw upon knowledge that has been taught to guide their actions. In law, the body of knowledge is comprised of statutes and legal precedents. Lawyers have to use that legal knowledge to diagnose legal situations. (Hoyle and John, 1995)

To apply this conception of professional knowledge to education, teachers are categorized as professionals, because they utilize general laws of education based on research and study of the four disciplines of human science; namely, psychology, sociology, philosophy, and history. It can be considered that in Education using knowledge of Social Sciences reflects using scientific knowledge of doctors to be a basis of knowledge production (Hoyle and John, 1995: 49).

Numerous researchers using an interpretive view emphasize the nature of teacher's professional knowledge, and they use many words to describe the professional knowledge of teachers. 'Teacher's practical knowledge' or 'teacher's tactic knowledge' (Elbaz, 1981); personal, practical knowledge (Connelly and Cladinin, 1988); and pedagogical content knowledge (Shulman, 1987; Goodnough, 2001) have all been terms used to describe teachers' professional knowledge.

Many researchers have tried to identify components of teachers' professional knowledge, including individual researchers like Elbaz (1981), Nazri and Barrick (1990), Vonk (1995) and Collinson (1996) and professional organizations like the Education Review Office [ERO] (1998) and the National Science Teachers Association [NSTA] (2003). The components identified by these researchers and associations can be summarized into seven core domains of teacher knowledge including:

- Educational context: this includes national requirements as well as school and classroom context (Elbaz, 1981; Nazri and Barrick, 1990; ERO, 1998; NSTA, 2003);
- General pedagogical knowledge: this includes knowledge of the learner and the learning process, classroom management, curriculum, instruction, and lesson planning (Elbaz, 1981; Nazri and Barrick, 1990; Vonk, 1995; ERO, 1998; NSTA, 2003);
- Subject matter knowledge: this includes syntactic structure, substantive structure and nature of science (Elbaz, 1981; Nazri and Barrick, 1990; Vonk, 1995 ; ERO, 1998; NSTA, 2003);
- Pedagogical content knowledge (PCK): this includes knowledge of student misconceptions, specific science curricula and, topic-specific instructional strategies (Elbaz, 1981; Nazri and Barrick, 1990; Vonk, 1995; ERO, 1998; NSTA, 2003);
- Knowledge of instructional media and technology: this includes using appropriate instructional media and technology to contribute to learning (Nazri and Barrick, 1990; ERO, 1998; NSTA, 2003);
- Knowledge of educational philosophy (Nazri and Barrick, 1990): this includes knowledge and philosophy of the purposes for teaching science; and
- Knowledge of research on best practices: this includes teaching practices that take into account the results and suggestions of research (ERO, 1998; NSTA, 2003).

Teachers must be educated in all of this knowledge in teacher preparation programs. Nevertheless, there are many teachers who have minimal qualifications or who have not experienced high quality professional development courses since they finished their teacher training program (Pillay, 2002). Therefore, this study aims to enhance teachers' professional knowledge in pre-service science teacher preparation

by providing experiences for them to implement their professional knowledge into planning and teaching science lessons in the last educational course.

### **Statement of Problem**

In the current four year program, pre-service teachers in Thailand take methods courses which aim to enhance many aspects of teacher professional knowledge. But a study of pre-service science teachers' problems during student teaching practice revealed that pre-service science teachers encountered problems in nine areas: teaching preparation, instructional media, teaching, student teachers, cooperating teachers, university supervisors, students, schools, and professional experience training preparation programs. In the teaching preparation section, all of the pre-service science teachers encountered difficulties in writing lesson plans and preparing activities and also using assessment to account for content and individual differences (Roadrangka and Srisukvattananan, 2002).

In addition, the research revealed that Physics, Biology, and Chemistry pre-service teachers encountered problems with content knowledge, writing lesson plans, and teaching by emphasizing scientific processes (Rochanasmita and Roadrangka, 2005). Moreover, when investigating whether pre-service science teachers used teaching methods based on a learner-centered approach in the 2004 academic year, the crucial evidence suggested that some pre-service science teachers could not teach according to this approach. For example, they rarely used students' prior knowledge to make connections with new scientific ideas, they could not set learning activities for enhancing student thinking processes, and they asked many knowledge level questions. They also still lacked skills to use a variety of resources and lacked the appropriate skills to apply in teaching. It seems that, although pre-service science teachers have already been presented with content and teaching methods, they still have problems, so how can a teacher education program provide better support for pre-service science teacher entering their practicum and first year of teaching?

### **Rationale for the Study**

When pre-service science teachers graduate with teaching deficiencies and cannot appropriately plan lessons or assess student learning to deal with individual differences, it will result in recurring problems throughout their teaching careers. To resolve these problems, teacher education institutions and agencies must help instructors emphasize the student's habit of inquiry to prepare them to confront science content problems, and support them with a variety of learning resources, prepare them for lesson plan writing, and help them become the kind of science teacher they should be not just tell them what they should be (Roadrangka and Srisukvattananan, 2002).

In addition, most pre-service science teachers who had already finished teaching practice asked that certain preparation courses that dealt with the topics discussed above be provided before the practicum. If a preparation program is to be successful, it must help pre-service teachers with teaching problems and increase their confidence for teaching.

This study has significant implications because the study will develop preparation courses to provide opportunities for pre-service science teachers who encounter many problems in their teaching careers. Also, they can practice their abilities in writing and implementing science lessons before the teaching practicum. All activities in this course will be designed to be in line with pre-service teacher's interests. All pre-service teachers will be familiar with problems in teaching which makes them more confident in their teaching careers.

### **Statement of Research Purposes**

The main purpose of this research is to develop and evaluate a capstone course to enhance pre-service science teachers' professional knowledge. The capstone course will focus on the following topics: lesson planning, national science curriculum framework and the nature of science, instructional methods and strategies, learner and

learning, formative assessment, instructional media and technology, classroom management strategies, and teaching and assessing science process skills. Data will be collected to determine whether the capstone course affects pre-service teachers' conceptions about science teaching and learning, lesson planning, and teaching, both during the course and in the subsequent student teaching experience.

In particular, this research aims to design and implement a capstone course to enhance pre-service science teachers' professional knowledge. Moreover, this research aims to determine whether the capstone course enhances pre-service science teachers' professional knowledge in lesson planning and teaching during the course and also continue to enhance pre-service science teachers' professional knowledge during student teaching.

### **Research Questions**

The main research question posed by this study is as follows:

How does a course designed to enhance Thai pre-service science teachers' professional knowledge affect the pre-service teachers' conceptions about science teaching and learning, lesson planning and teaching?

Four specific sub-research questions were set to guide an investigation of the study which includes:

1. What are the characteristics of a course designed to facilitate Thai pre-service science teacher professional knowledge?

2. In what way does the course enhance pre-service science teachers' professional knowledge during the course?

- 2.1 In what way does the course influence Thai pre-service science teachers' underlying professional knowledge?

2.2 In what way does the course influence Thai pre-service science teachers' ability to implement the professional knowledge during the school based portion of a companion course?

3. In what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching?

4. What learner characteristics results from being taught by the Thai pre-service who have received the special teacher education?

### **Operational Definitions**

#### **1. Professional Knowledge**

Professional knowledge is a broad range of knowledge that is held in active relation to practice and is used to give shape to practice of the teacher (Elbaz, 1981). The teacher professional knowledge is made up of seven domains of educational context, general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, knowledge of instructional media and technology, educational philosophy, and knowledge of research on best practices.

#### **2. Underlying Professional Knowledge**

An underlying professional knowledge is conception about teaching and learning or the epistemological beliefs about teaching and learning of pre-service science teachers.

#### **3. Pre-service Science Teachers**

Pre-service science teachers are students in the four year Thai science teacher preparation program provided by University Faculties of Education. They are

majoring in teaching science and minor in Physics, Chemistry, or Biology. These students take about 30 hours of General education, 84 hours of the specialized courses, and 6 hours of the elective courses. In the specialized courses the required credit hours for compulsory science content courses are at least 44-46 hours, and for selective science content courses at least 10 hours.

#### **4. A Course**

A course is the capstone course implementing in the seminar course (159497). This course is a 1-credit course for pre-service or student teachers majoring in science teaching register in the first semester, before student teaching.

#### **5. Student Teaching**

Student teaching or field experience (151429) is a 5-credit compulsory course. This course provided the fulltime teaching experience pre-service science teachers to practice their teaching in the middle schools. The pre-service science teachers have to work as a full time teacher in school. They have to teach science at least eight to nine hour a week. During the student teaching period, there were three conferences organized in the university. All pre-service science teachers came back from the school setting to participate in a university conference. The conference aimed to enhance pre-service science teachers to discuss about problem during their student teaching with peer and instructor.

### **Overview of the Study**

To provide a reader an overview of coming chapters, the following paragraphs provide the conclusions of each coming chapters that explains important components to guide this research study. These components include the context of the study, important qualitative research components. Those components are theoretical perspectives, epistemology, methodology and methods, and finding and discussion.

Chapter 2, a literature review, provides the reader with an understanding of a Thai teacher education context which includes the details of the National Education Acts B.E. 2542 (1999), and details of teacher preparation curricula. The theoretical perspective and epistemology part provides a description of constructivism which is a theory that describes how people construct their knowledge by interacting with the physical and social world (Fosnot, 1996). This theory is implemented to guide this study to determine what and how pre-service science teachers construct their teachers' professional knowledge in and after capstone course. Teachers' professional knowledge and reflections are also described in this chapter to provide an understanding of theoretical perspectives of this study.

Chapter 3, methodology describes grounded theory that is used to guide the research processes. A variety of research methods such as interviews, observation, questionnaires and documents are explained in this chapter. Data collection and analysis are described to present how data is collected and analyzed in each phase of the study.

Chapter 4, findings of the study in phase I, described a research intervention which referred to a capstone course. This chapter provides the answer for the first sub-research question, which is what are the characteristics of a course designed to facilitate Thai pre-service science teachers' professional knowledge? To answer the research question, the guiding principals, process of developing a capstone course, and outline and scope of the intervention are explained.

Chapter 5 contains findings of the study in phase II. This chapter provides the first episode for answering the research question. This chapter aims to answer the second sub-research question which is in what way does the course enhance pre-service science teachers' professional knowledge during the course? To answer the research question, the researcher presents four cases of pre-service science teachers during the capstone course. In each case, an underlying professional knowledge and ability to implement their professional knowledge of pre-service science teachers during the course are explained.

Chapter 6 contains findings of the study in phase III. This chapter presents the second episode for answering the research question. This chapter provides a continuous description of the cases which aims to answer the third and fourth sub-research questions. These include in what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching? And what learner characteristics results from being taught by the Thai pre-service who have received the special teacher education?

Chapter 7, conclusions, discussion, and recommendations, presents a discussion of the results, conclusions for answering the research question and provides recommendations to imply for the science teacher education program

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **Introduction**

The main purpose of the study is to develop a capstone course to enhance Thai pre-service science teachers' professional knowledge. While enhancing pre-service science teachers' professional knowledge, the researcher utilized an understanding of constructivism, reflection, teacher knowledge and beliefs, information and communication technology (ICT), professional development including an understanding of Thai teacher education to design the course. This chapter aims to provide an understanding of the theoretical perspective guided in this research, and also to connect these epistemologies to this research study.

This study is drawn on the Constructivism theory about knowledge and learning. Learning from the constructivist perspective is a process of struggle between existing personal knowledge and the new knowledge developed by experience and social activity (Fosnot, 1996). Teacher professional knowledge or craft knowledge can be constructed from the conflict between teachers' experiences in learning and their reflective practice that provides opportunities for teachers to elaborate their knowledge within their teaching careers (Batten *et al.*, 1993). Therefore, reflection is an essential process that helps teachers go beyond their personal minds and knowledge to re-elaborate their own thinking (Lang, Mcbeath, and Hebert., 1995: 7). Teacher professional knowledge is not only related to knowledge and teaching practice, but also other professional roles in and outside the classroom, which in this century, those roles are related to utilizing ICT supporting their professional lives (Pedro da Ponte, Oliveira, and Varandas, 2002).

This part of the research provides the dimension of theoretical perspectives and epistemology of the study. Constructivism is viewed as a theory of studying

teacher knowledge construction. Reflection, teacher knowledge and beliefs, teacher professional knowledge, information and communication technology (ICT), and professional development are described in the following topics. The researcher will also provide an understanding of Thai context about teacher preparations and National Education Acts that relate with teacher production. Part of the context of the study will be described below.

### **Theoretical Perspective and Epistemology: Constructivism**

Constructivism is a view about the nature of human knowledge; a view about the origin, transmission mechanisms, and validation procedures of scientific knowledge (Mathews, 1994). In transmission mechanisms, even if a giver intends to transfer knowledge from the mind of the giver to the mind of the receiver, the concepts or ideas will be interpreted and transformed by the receivers related to their existing experiences (Bettencourt, 1993). So, Bettencourt assumed that to know is not to transmit knowledge but is “to transform the object knowledge, the purposes, processes, and results of that transformation are the subject matter of constructivism” (Bettencourt, 1993). There are basically two major traditions of constructivism which were described by Mathews (1994) and Fosnot (1996). psychological constructivism and sociological constructivism.

First, cognitive psychological constructivism or Piagetian constructivism (Marin, 2000), originated with Jean Piaget’s account of the child learning as a process of personal, individual, intellectual construction arising from his/her activity in the world. Sociological constructivism (Mathews, 1994; Marin, 2000) or Sociocultural constructivism (Cobb, 1996) originated with Vygotsky who stressed the importance of language communities for the cognitive constructions of individuals (Mathews, 1994).

## **1. The Constructivism of Jean Piaget**

The more subjective tradition of Piaget's work can be seen in von Glasersfeld's proposals. von Glasersfeld described constructivism in terms of study meaning representation and its controlling process within people. He explained that Jean Piaget is the one who takes the ideas of adaptation that set constructivism apart from other cognitive theory. In his view, knowledge has adaptive function in which knowledge is not a copy of reality, but knowledge is "a mapping of actions and conceptual operations that had proven viable in the knowing subject's experience" (von Glaserfeld, 1996: 4).

Moreover, Fosnot (1996) added that Piaget proposed the concept of cognitive equilibration as the mechanism to explain learning. He believed that "the mechanism promoting change in cognition is balancing between assimilation and accommodation" (Fosnot, 1996: 13). Assimilation is a process where an individual person organizes a new experience into his/her own understanding. Sometimes new experiences contrast with present understanding that causes insufficiencies and disequilibrium. A person is forced to accommodate that understanding (Fosnot, 1996).

According to Piaget's view, von Glaserfeld (1996) concluded that knowledge arises when a person, who previously constructed conceptual structures by experiences, has interaction with his/her environment. The prior conceptual structures are adapted and have effects on a new knowledge that is constructed inside a person's mind (von Glaserfeld, 1996).

## **2. The Constructivism of Lev Vygotsky**

Fosnot (1996) explained Vygotsky's view as one in which learning occurs through individual and social views. In the individual view, Vygotsky, like Piaget, viewed learning as an individual construction of knowledge which reflects on everyday experience. He named this knowledge 'spontaneous concepts' (Fosnot, 1996). This concept is developed in an actual development level in which a child's

concepts originated from a child's capability in solving problem independently (Vygotski, 1978; Ricardo, 2004). Moreover Vygotsky added the idea of the zone of proximal development (potential development) level that includes concepts that a child constructed under the guidance of a teacher or collaborating with peers (Vygotski, 1978; Ricardo, 2004). This knowledge is called 'scientific concepts' (Fosnot, 1996).

Vygotsky states that the knowledge of the learner is actively constructed in response to interaction with his/her environment and that language and culture play an important role in this interaction (Vygotski, 1978; Boudourides, 2003; Ricardo, 2004). Learning is "an interpretive, recursive, building process by active learners interacting with the physical and social world" (Fosnot, 1996), therefore, to motivate learning, the internal drive of a child can be stimulated by external activities where a child interacts with people in his/her environment and cooperates with peers by using languages and communication (Vygotski, 1978; Boudourides, 2003; Ricardo, 2004).

When discussing Piagetian and Vygotsky constructivism, some authors argued that both of them believe in common ideas. They believe in the same theory about the concept formation of the student (Cobb, 1996; Marin, 2000; Boudourides, 2003). Both theories suggest that students' concepts originate from the process of internalization (Boudourides, 2003) and that individual students have different interpretations of knowledge from the environment or an activity (Cobb, 1996; Marin, 2000). However, an important aspect that differentiates the social constructivism of Vygotsky from Piaget's constructivism is the activity of learning (Cobb, 1996). Social constructivism emphasizes learning activity that enhances students' participation in culturally organized practice to improve individual construction of knowledge (Cobb, 1996) or change their conceptions through speech and communication (Boudourides, 2003) more than activity that emphasizes individual sensory-motor practices of Piaget (Cobb, 1996). Especially in science, technology, and society education, social constructivism gives more advantages in providing flexibility in the process of education development (Boudourides, 2003).

In this study both Piaget's and Vygotsky views on constructivism will be applied. In particular, the notions of Vygotsky that knowledge is socially constructed will be utilized in the activities of the capstone course.

### **3. Constructivism in Teaching and Learning**

There have been developments using constructivism to describe teaching and learning. Tobin and Tippins (1993) stated that constructivist perspectives frame learning as a process where learners actively construct their own knowledge. They concluded about knowledge in constructivist perspectives that "knowledge is personally constructed but socially mediated". That means when a learner constructs knowledge, he will think in terms of language. The language is a tool for communication between individuals. Thinking is a social process that happens in the individual's mind; the thinker will construct his own environment by assigning the roles of speaker and listener to those with whom he interacts with. So, when thinking about knowledge, one should think in terms of both the individual and social components (Tobin and Tippins, 1993: 6).

In their view about student learning in constructivism, they suggested that "learning is a social process of making sense of experience in terms of what is already known". That means in the process of learning, the learner will create knowledge that comes from giving meaning to specific experience by relating with their existing knowledge (Tobin and Tippins, 1993). Moreover, Henderson (1996) described constructivism as an educational activity that emphasizes the learners individually constructing meaning through experiencing and then reflecting on those experiences.

So, to approach teaching from the constructivist view, the teacher's role is not transferring knowledge to the student, but it is to assign a specific activity that facilitates students to construct their own experience. Teachers can not infer from their own experiences to design a ready-made knowledge for student to pick up, rather each student has to build up for him or herself (von Glaserfeld, 1996)

Moreover, teachers should allow students to present their existing knowledge through a variety of strategies such as writing, drawing, using symbols and language to show what they already know. Providing time for students to think is another role of the teacher, because students need time to clarify and elaborate their knowledge (Tobin and Tippins, 1993).

Fosnot (1996) concluded that constructivism is a theory about learning that no ideal teaching techniques can be abstracted from the theory; however general ideas about teaching and learning include:

- learning requires the invention and the self-organization of the learner. So, the teacher should let learners create their own questions, hypothesis, models and possibilities.

- ‘disequilibrium facilitates learning’. So, teachers should not eliminate errors in learners’ conceptions. Challenging learners’ alternative conceptions by open-ended investigations.

- reflection is the driving force of learning. Allowing reflection time for learners to organize and generalize knowledge across experiences is important.

- dialogue within the community of learners facilitates thinking. The learners should defend, prove, justify and communicate their ideas to the classroom community.

In terms of the constructivist view on teaching and learning from a variety of sources, it can be concluded that the aims of constructivism are emphasizing an individual’s construction of knowledge by him/her selves. The knowledge construction is an active and lifelong process. In addition, learning is encouraged by sharing with others and by rethinking errors and reflection.

#### **4. Constructivism in the Teacher Preparation Program**

Using constructivism in staff development or in a teacher preparation program addresses the issue of the teacher as a learner who learns from doing, discussing, and reflecting. So, when designing a teacher preparation program, Peterman (1993) argues that one should keep in mind how pre-service teachers construct knowledge in the program as students do when learning in the classroom (Peterman, 1993: 241).

In the constructivist view of learning on a teacher preparation program, all pre-service students enter the program with their own unique background, personality, motivation levels, and skills. These factors influence a student's individual way of learning how to teach (Richardson, 1996; Bain, 2004). Thus, a constructivist view for learning to teach implies that very careful attention needs to be given to the various contexts in which teaching are to be developed, and that learning should be situated in a context as much as possible (Howey, 1996). Cochran, DeRuiter, and King (1993) concluded that learning to teach often demands teaching specific content to specific students in specific situations. Thus, every method in a preparation program provided for pre-service teachers should involve them in realistic contexts in which active learning can occur and in which the social construction of knowledge can be best fostered.

To promote professional development by using constructivist teaching, Marx (1998: 668) suggested successful professional development should be connected to the prior knowledge of teachers and also should provide and support a long-term environment for change to help teachers to go beyond their profession based on their previous knowledge. In addition, Radford (1998), who implemented the philosophy of constructivism into constructing a professional development program, suggested that to design constructivist professional development, three aspects of the program should be concerned in translating this philosophy into practice. The program should provide opportunities for participants including: learning from active engagement; learning based on personal experience, and learning by confronting previous understanding.

In conclusion, to design professional development or initiate teacher preparation based on constructivism, the researcher should incorporate aspects of constructivism including: concern and challenge participants' existing knowledge, enhance active engagement of participants, enhance social interaction for participants to construct knowledge, and provide long term supporting knowledge construction.

In professional development, which relies on a constructivist view of learning, reflection is an effective process that can promote long term teacher professional knowledge by encouraging participants to think about their own teaching circumstances and further think about how to deal with those circumstances. There are some suggestions from Tom Russell (1993) in "Learning to Teach Science: Constructivism, Reflection, and Learning from Experience" about developing teacher preparation where "the process of learning to teach science is a significant meeting ground for the perspectives of constructivism and reflection" (Russell, 1993: 247). The aim of both constructivism and reflection is to develop frames for experience that lead to new possibilities for actions (Russell, 1993). In other words, using constructivism and reflection in teacher development activity involves teachers constructing new frames of teaching or understanding existing theory by coming to view teaching and the goals of teaching through their own experience and reflecting on that experience (Russell, 1993).

In teacher education research literatures, both terms, *constructivism* and *reflection*, have joined to have a similarity of meaning. Constructivism relates to the study of how children learn and is driven by perspectives on nature of learning, but reflection is related to how the teachers acquire their professional knowledge which is driven by perspectives on the relationship between thought and actions. The important part is the similarity between how students learn science and student teachers learn professional knowledge (Russell, 1993).

## Reflection

In the 1990s, the research on teaching examined the multifaceted nature and context of teaching. One of the most emphasized was exploring teacher thinking from the perspective of teachers themselves which was called *teacher reflection* (Ornstein, 1995: 73). In recent years, teacher education has been characterized by reflective practice that relates to the issue of bringing theory into practice or using theory to improve practice (Russell, 1993; Hatton and Smith, 1995).

The general meaning of reflection is ‘to think about one’s teaching’ (Russell, 1993), which is an active cognitive process that involves carefully thinking and ordering ideas to address practical problems (Dewey, 1993). This process gives meaning to a teacher’s experiences which involves the construction of images, reconstruction of past thoughts and practice, and the assignment of language to images of those experiences (Tobin and Tippins, 1993). So, reflection is an exercise that allows a teacher to go beyond his/her personal thinking by writing about and discussing teaching experiences. This process can be done both by individuals and/or in a group setting (Lang *et al.*, 1995: 7).

### 1. Reflection in Professional Development

Reflective practice is emphasized in many teacher training courses (Peterman, 1993; Tobin and Tippins, 1993; Lang *et al.*, 1995; Wise *et al.* 1999). Nichols, Tippins, and Wieseman (1997) proposed that crucial opportunities for pre-service teachers are to reflect on their prior educational experiences and innovatively explore how these reflective tools might inform us of their past, present, and future science teaching and learning practices (Nichols *et al.*, 1997: 82). Reflection helps pre-service teachers to be successful by preparing them to be more aware of problematic situations and provides opportunities for them to revise their teaching by applying research and theory based knowledge to their teaching practice (Hatton and Smith, 1995).

To use the Reflective Model in professional development and teacher preparation requires an approach that is social and collaborative rather than individually introspective (Wise, Spiegel, and Bruning 1999; Andy, 2001: 140) and should be conducted as a continuous process (Hatton and Smith, 1995). In a collaborative professional development model, pre-service teachers, cooperating teachers, university supervisors, and researchers should work together. Teachers provide knowledge of the classroom, students, and school, but university supervisors and researchers can bring useful information or new skills into the cooperating community. Thus, collaboration is crucial in helping the new teacher to develop habit of reflective practice that can be supported by others who the teacher sufficiently respects (Andy: 2001: 138). Hatton and Smith (1995) suggested that a continuous process of reflection should be paid attention to in teacher preparation programs. After finishing the program, they proposed a follow up study in the first year of teaching to assess the development or lack of development in the reflective actions of pre-service teachers (Hatton and Smith, 1995).

In teacher education, it is important for teachers to reflect on their images of teaching and learning (Tobin and Tippins, 1993). Peterman (1993) suggested for projects or staff development activities to include reflection activity by providing rich evidential arguments that challenge participants' beliefs and provide a variety of practices for participants to analyze (Peterman, 1993). Because of the interrelation of reflection and action (Schon, 1983), teachers can identify potential changes in their teaching by reflecting on what they perceive to be happening in the classroom (Tobin and Tippins, 1993). So, reflective practice in teacher education can enable the prospective science teacher to recognize and build upon his/her prior knowledge and experience (Arellano *et al.* 2001: 503). Professional knowledge can be generated from existing knowledge when prospective teachers learn to frame and reframe problems and use various interpretations in making a judgment to select a way in solving problems (Schon, 1983).

Reflective teaching is a social activity which looks back at social interactions and tries to make sense of them in order to plan for future teaching, or looks forward

to social interactions of teaching and learning that have not yet taken place and attempts to shape these (Handcock, 2001: 83). To enhance pre-service science teachers' professional knowledge in planning and teaching, the course being planned in this study needs to enhance students' reflective ability and provide opportunities for them to think about the past and the future of teaching in the classroom.

## **2. Reflective Tools for Enhancing Teachers' Professional Knowledge**

Many Professional development models that enhance reflective thinking have been proposed. There are a variety of strategies that have been used to develop reflective thinking in science teachers and these include:

- reflective journals (Hatton and Smith 1995, Nichols *et al.*, 1997; Collier, 1999, Wise *et al.* 1999; van Zee and Roberts, 2001; Amobi, 2005)
- curriculum analysis and development (Bayer, 1984; Zeichner, 1987; Ross, 1990; Wise *et al.* 1999)
- collaborative journals (Alterio 2004)
- case-based pedagogy (Nichols *et al.*, 1997; Arellano *et al.*, 2001)
- reflective teaching (Zeichner, 1987; Ross, 1990; Wise *et al.* 1999)
- action research (Zeichner, 1987; Ross, 1990)
- microteaching (Zeichner, 1987; Ross, 1990; Hatton and Smith, 1995; Amobi, 2005; Wilson and I'Anson, 2006; Bell, 2007)
- reflective interviews (Collier, 1999)
- peer observation conferences, (Collier, 1999)
- group seminars (Collier, 1999; Collins, 2002)
- portfolios (Nichols *et al.*, 1997)
- learning maps (Nichols *et al.*, 1997)
- stories re-told, (Nichols *et al.*, 1997)
- metaphors (Ornstein, 1995 and Nichols *et al.*, 1997)
- proverbs (Nichols *et al.*, 1997)
- drawing (van Zee and Roberts, 2001) and

- reflective dialogue online forum (Ebenezer *et al.*, 2003; Makinster *et al.*, 2006; Ikpeze, 2007)

Among this variety of strategies using *reflective journals* is a common writing tool that promotes reflective thinking (Zeichner, 1987; Ross, 1990). Reflective journals were identified as an effective tool to promote critical analysis and reasoning among pre-service teachers and also presents a way for education faculty to support long-term reflective thinking among students (Ross, 1990). Effectiveness in using reflective journals was presented in Wise, Spiegel and Bruning (1999)'s work. They reported an achievement of PEERS (Promoting Educational Excellence Regionally and Statewide) workshop of the Nebraska Math and Science Initiative (NMSI) in promoting teacher understanding of mathematic and scientific process, improving teaching methods by incorporating more constructivist methods, and providing supportive network for systematic change in the state by using reflective journals (Wise *et al.*, 1990).

Effectiveness in using reflective journals was facilitated by constructing guiding questions (Hatton and Smith, 1995, Wise *et al.* 1999) and providing teachers opportunities to develop individual reflective practices (Hatton and Smith, 1995). PEER workshops constructed reflective questions to guide teachers' journal writings and facilitated teachers' reflective thinking (Wise *et al.*, 1999). These guiding questions include the following topics: details of the lesson and teaching strategy, the relationships between lesson and standard, goals of the lesson, student response to the lesson, the evidence to present student learning or changing attitudes, re-using that lesson again and modification of the lesson. The scope of questions asked teachers to reflect on how the lesson fit with the standard, how well it worked for students, and how they assess student understanding (Wise *et al.*, 1990).

Curriculum analysis and development was implemented in PEER workshops (Wise *et al.* 1999). The program helped teachers to design and implement lessons and reflective journal writing. Providing teachers opportunities to analyze, and develop their own curriculum in the workshop, resulted in the majority of teachers articulating

the specific standard to which their lesson or teaching strategy applied. Teachers can use a variety of teaching strategies to create the active participation of students, and use activities that keep student motivation in the lesson (Wise *et al.* 1999).

Microteaching was suggested as an effective strategy used for enhancing pre-service teachers' teaching and reflects upon the teaching practice before engaging with the greater complexity in school experience (Wilson and I' Anson, 2006; Bell, 2007). Wilson and I'Anson (2006) engaged Schon's idea of reflective practice and practicum in designing core aspects of his program including a simplified environment for the development of practice, a context which promotes the development of professional identity, and the conditions necessary for a critical reflection. The results showed that it was beneficial for students in developing confidence and preparing them to teach. However, the microteaching was recognized that it was different from the real classroom (Wilson and I'Anson, 2006). Bell (2007) supported the idea that microteaching is effective but not real. However, she argued that the educator can use microteaching as a form of practice to show evidence of teaching and learning; it can encourage creativity and risk-taking in class (Bell, 2007).

Lesson planning and the formative-evaluation of lesson plans were implemented in the study of Sanchez and Victoria Valcarcel (1999) and Ozogul, Olina, and Sullivan (2006) receptively. Sanchez and Victoria Valcarcel (1999) studied the views and practices of a group of in-service science teachers in planning teaching units. They concluded that during planning, the teachers thought about the content to be taught, selected activities, and drew up documents. This helped the teachers prepare themselves both physically and mentally. For evaluating the lesson plans, Ozogul *et al.* (2006) found that self and peer evaluation provide different perspectives for pre-service teachers. The teachers can provide knowledgeable feedback for improving the lesson plan, but in the limitation of time, students should be engaged in self and/or peer evaluation for checking the agreements among that feedback (Ozogul *et al.*, 2006).

Case-based pedagogy is another reflective tool in the research literatures (Nichols *et al.*, 1997; Arellano *et al.*, 2001). Arellano *et al.* studied case-based pedagogy which was utilized in pre-service science programs in the Philippines by use of collaboration between groups of elementary student teachers, their cooperating teacher, and a research team to encourage learning as a culturally constituted activity. All members of the collaboration received benefits from the program. Both in-service and pre-service teachers developed awareness of how they made sense of dilemmas they faced in their professional lives. Moreover, experienced teachers were available to share their insights with prospective teachers as the cases were discussed. The research team was also acutely aware of the strong sense of moral consciousness expressed throughout the classrooms. Case-based pedagogy can serve as an opportunity to teach critical inquiry practices by highlighting and critiquing deeply held assumptions (Arellano *et al.*, 2001).

Reflective interviews (Collier, 1999) were used to promote pre-service teacher reflective practices (Bryan and Abell, 1999; Collier, 1999). Bryan and Abell studied one pre-service science teacher's beliefs about science teaching and learning and how her experiences influenced her thinking. Continuous reflective interviews were organized as one of the reflective tools throughout the semester. Topics in interview questions stimulated pre-service science teachers to refine their ideas by providing opportunities for them to reflect on their own and peer teaching, theories presented in current educational research, and their own science learning. Through the process of reflection, the pre-service teacher started to understand the complex nature of science teaching and learning. Moreover, she learned to frame and re-frame her beliefs helped her to make some changes in practices (Bryan and Abell, 1999).

Using portfolios is an evaluative tool for assessment of knowledge based on personal experience. Nichols *et al.* (1997) suggested components of a portfolio should include artifacts, attestations and productions. Artifacts are products of teaching including lesson plans, tests, philosophy of teaching written on paper, or videotapes of teaching. Attestations are documents that are produced by other people to inform about aspects of individual science teaching and learning, which include letters or

progress reports. Productions are specific items created for portfolios including goal or expectation of learning and teaching, pieces of evidence that represent personal learning, and table of contents or road maps that represent learning progression. Using portfolios not only supported a reflection on conception about teaching and learning of teachers, moreover, they provide opportunities to support life long learning (Nichols *et al.*, 1997).

In conclusion, designing a capstone course to enhance pre-service science teachers' professional knowledge, the researcher will incorporate effective reflective tools suggested from the research literature. The main strategy used in the course will be reflective journals. Moreover, conferences and group seminars will provide opportunities for pre-service science teachers to develop and implement their own curriculum, talking and discussing to reflect cases in the classroom. Individual and group reflective interviews will be organized during the course and in the follow up study to provide opportunities for pre-service teachers in reflective talking. Portfolios will be used as a tool to assess development of teacher professional knowledge and effects on student learning among pre-service science teachers.

When teachers engage in learning by reflecting, discussing, practicing and analyzing practice, they tend to change both in beliefs and practice (Peterman, 1993). Beliefs are consistent with actions and thoughts. To study about teachers' changes in actions, one has to study both teachers' knowledge and beliefs through reflection activity (Tobin and Tippins, 1993)

### **Teacher Knowledge and Beliefs**

Teacher knowledge and beliefs are crucial factors that should be considered in any constructivist professional development. Shulman's view of teacher knowledge is what teachers should know or do know (Carksen, 1999). To understand teacher knowledge, Carksen studied a model of Lee Shulman's original formulation of teacher knowledge and argued that the model is more general. He reviewed and concluded a new model of teacher knowledge that included five domains. These five

domains are: 1.) knowledge about the general educational context 2.) knowledge about the specific educational context 3.) general pedagogical knowledge including learners and learning, classroom management, and general curriculum and instruction knowledge 4.) subject matter knowledge including syntactic structures of science, substantive structure of science and the nature of science (NOS) and 5.) pedagogical content knowledge including common student misconceptions, specific science curricula, topics-specific instructional strategies, and the purpose for teaching science. This knowledge should be provided for all science teachers. To understand and promote teacher knowledge, we should be reminded of teacher beliefs because knowledge and beliefs are interwoven inside the teacher and they have an influence on the teacher's teaching (Kagan, 1992; Richardson, 1996)

Beliefs are defined by agreements of anthropologists, social psychologists, and philosophers that are thought of as psychologically held understandings, premises, or propositions about the world that are felt to be true (Richardson, 1996), and on individual's mental constructions of experience (Peterman, 1993). Kagan defined beliefs as teachers' implicit assumptions about students, learning, classrooms and the subject matter to be taught (Kagan, 1992), and it is often integrated into concepts about the truth (Peterman, 1993). The epistemological beliefs or what we believe about teaching and learning influences the conceptions about teaching and learning that we hold (Chan and Elliott, 2004; Porlan and del Pozo, 2004). Recently, research on the development of teachers' professional knowledge has been considered in two aspects including past experiences and the influences on teaching and learning conceptions (Bryan and Abell, 1999) because life experiences influences the development of teacher beliefs about teaching and learning (Kagan, 1992; Bryan and Abell, 1999). Moreover teacher's beliefs or concepts about teaching may guide personal action (Peterman, 1993)

There were three categories of experiences that influenced the development of knowledge and beliefs about teaching as suggested by Richardson (1996: 105). These categories are personal experience, experience with schooling and instruction, and experience with formal knowledge. Within a constructivist learning and teaching

framework, a pre-service teacher should be encouraged to think about their own learning during a teacher education program if the aims of the program want to make a difference in the deep structure of knowledge and beliefs held by the students.

## **Teacher Professional Knowledge**

### **1. The Domains of Teacher Professional Knowledge**

Teacher professional knowledge is described as a broad range of knowledge that is possessed by teachers. The professional knowledge is dynamic and is held in active relation to practice and is used to give shape to practice (Elbaz, 1987: 47). He used the word ‘teacher’s practical knowledge’ and ‘teacher’s tacit knowledge’ to describe teacher professional knowledge that teachers develop within their experiences. His components of teacher professional knowledge consist of knowledge of the structuring of learning experiences and curriculum content, knowledge of subject matter, knowledge of students’ needs, abilities, and interests, knowledge of classroom organizational and instructional techniques, knowledge of the social framework of school and community, and knowledge of their own strengths and shortcomings as teachers.

In addition, The Education Review Office: ERO (1998) described how teachers improve their professional knowledge including: knowledge of curricula, knowledge of learning, knowledge of content, knowledge of teaching practice presented by current research, knowledge of students, knowledge of assessment, knowledge of instructional media, and knowledge of learning organization. Teacher professional knowledge is used in the planning and preparation for teaching and learning and with the willingness of the teacher to extend knowledge of content and theory throughout a career can provide quality learning for many years (The Education Review Office: ERO, 1998). This knowledge has been needed to help students think critically and solve complex problems (Arizona Board of Regents, 2000-2005). In addition, Goodnough (2001) described teacher professional knowledge as pedagogical content knowledge and knowledge of the self. She added

that professional knowledge of science teaching could be developed through a variety of means (workshops, action-research groups, study groups, school-university partnerships). These professional development activities require teachers to explore their beliefs about subject matter, students, pedagogy, and themselves as teachers.

A clarification of the meaning of teacher professional knowledge from various pieces of literature and comparison with the domains of teacher knowledge as defined by Carlsen (1999) is noted in Table 2.1 below:

**Table 2.1** Conclusion of teacher professional knowledge

Teacher professional knowledge		Defined by							
Domains of teacher professional knowledge	Sub-domains of teacher professional knowledge	Elbaz (1981)	Nazri and Barrick (1990)	Vonk (1995)	Collinson (1996)	ERO (1998)	NSTA (2003)	Leou and Liu (2004)	
Domains of Teacher knowledge (Carlsen, 1999)	Context	general educational	-	/	-	-	/	/	/
		specific educational	/	/	-	-	/	/	/
	General pedagogical knowledge (PK)	learners and learning	/	/	/	/	/	/	/
		classroom management	/	/			/		
		curriculum	-	-			/		
		instruction	-	/			/		
		assessment	-	-			-		
	Subject matter knowledge	syntactic structures	/	/	/	/	/	/	/
		substantive structure							
		NOS							
	Pedagogical Content Knowledge (PCK)	student misconceptions	-	-	-	-	/	/	/
		specific science curricula	/	-	-	/	/		
		topics-specific instructional strategies	-	-	-	-	/		
		purpose for teaching science	-	-	/	-	/		

**Table 2.1** (Continued)

Teacher professional knowledge		Defined by						
Domains of teacher professional knowledge	Sub-domains of teacher professional knowledge	Elbaz (1981)	Nazri and Barrick (1990)	Vonk (1995)	Collinson (1996)	ERO (1998)	NSTA (2003)	Leou and Liu (2004)
Addition	Knowledge of Instructional media and technology	-	/	-	-	/	/	/
	Knowledge of Educational Philosophy	-	/	-	-	-	-	-
	Knowledge of research on best practice	-	-	-	-	/	/	-

Note: / means that it was defined                      - means that it was not defined

The table concludes that teacher professional knowledge is made up of four domains of teacher knowledge in Carlsen (1999)'s model including educational context, general pedagogical knowledge, subject matter knowledge, and pedagogical content knowledge (Elbaz, 1981; Nazri and Barrick, 1990; Vonk, 1995; Collinson, 1996; ERO, 1998; NSTA, 2003; Leou and Liu, 2004). Three additional domains of knowledge were added by other researchers, and these are knowledge of instructional media and technology, educational philosophy, and knowledge of research on best practices (Nazri and Barrick, 1990; ERO, 1998; NSTA, 2003; Leou and Liu, 2004).

Teacher professional knowledge is complicated, so there are many research projects that emphasize the development of teacher professional knowledge (Vonk, 1995; Collinson, 1996; Bell, 1998; Bryan and Abell, 1999; Goodnough, 2001; Goodnough, 2002; Turnbull, 2003; Leou and Liu, 2004).

## **2. The Development of Teacher Professional Knowledge**

One important factor of developing teacher professional knowledge is using teacher's reflective experiences. In the preparation program, professional knowledge can be developed by pre-service science teachers that participate in framing and reframing activities of their beliefs about teaching and learning, which provide them

an understanding of the nature of teaching and learning (Bryan and Abell, 1999: 136). This learning process provides more productive frames for them to make changes to their practice (Bryan and Abell, 1999: 135)

Vonk (1995) viewed the development of professional knowledge as concerning the development of pedagogical content knowledge including academic content knowledge, pedagogical content knowledge, knowledge of aims and purpose, knowledge of learners, knowledge of educational contexts, and setting and governance. So, it is impossible to prepare pre-service teachers professional knowledge by learning only from coursework (Vonk, 1995). Moreover, Bryan and Abell (1999) suggested that this development required pre-service teachers to extend their professional knowledge through earlier school experiences. Turnbull (2003) added that teacher preparation should not only provide in depth teacher professional knowledge, but also provide appropriate opportunities for each one to develop and practice their professional knowledge in a final practicum.

From the research literature, aspects of teacher's professional knowledge suggested to be enhanced includes knowledge of specific science curricula (Goodnough , 2002, 2008), topic-specific instructional strategies (Coble and Koballa, Jr, 1996; Halim and Meerah, 2002; Goodnough , 2002, 2008; Zembal-Saul, Krajcik, and Blumenfeld, 2002), knowledge of research on best practices (Goodnough , 2002), assessment (Goodnough, 2002, 2008), the learner and learning (Penso, 2002), student misconceptions (Halim and Meerah, 2002; Goodnough , 2008), and knowledge of instructional media and technology (Coble and Koballa, Jr, 1996)

Goodnough (2002) designed research aimed to foster the development of teacher professional knowledge in the context of primary science education that occurs in a collaborative community of learners. She used a variety of data collection methods including videotaping during collaborative meetings, semi-structured and informal interviews, classroom observation, and teacher lesson planning. The results of the study revealed that teacher professional knowledge was enhanced throughout this collaboration. She suggested that preparation programs should enhance the role of

the teachers in curriculum development and implementation, selecting effective instruction and assessment strategies, and utilizing knowledge in using educational research. Moreover, in 2007, she proposed using an action research community of practice to enhance elementary teachers' professional knowledge. Several aspects of teachers' professional knowledge were examined from a variety of data sources including audiotape planning meeting, documents, journals, and semi-structured and informal interviews. The results of this study supported an idea proposed in 2002 that the collaborative community of learners enhanced teacher professional knowledge (Goodnough, 2008).

Halim and Meerah (2002) used reflective interviews to study pre-service teachers' awareness of pupils' misconceptions of topics and their ability to formulate analogies, explanations, examples and demonstrations to teach the topics. They suggested that developing science trainee teachers' awareness of pupils' misconceptions and topics specific instructional strategies at pre-service level would be beneficial for teacher preparation.

Penso (2002) described and analyzed one of the components of teacher professional knowledge, which relates to knowledge about learners and learning processes. She focused on the ability of teachers to identify the learners' difficulties in aspects of frequency, characterization of the sources and relating factors by utilizing classroom observation and journal writing methods. The study points to the need to include a component focusing on didactic processes, aiming at exposing student teachers to pupils' learning difficulties, and ways of dealing with them in the teacher education program.

Zemal-Saul *et al.* (2002) examined whether and how a group of prospective teachers who had early opportunities to teach science would approach science content representation within the context of their student teaching experience. They analyzed data from teachers' science lesson plans and reflective journals. Moreover teachers were interviewed and observed during practice teaching. The results revealed that the teachers became learners through the act of teaching and reflecting on teaching. This

study provided suggestions for teacher preparation programs to understand the role of experience in learning to teach, and the role of supporting new teachers' continuing development in the domain of science content representations.

Coble and Koballa, Jr. (1996) suggested utilizing a constructivist framework applied to develop pre-service teachers' professional knowledge in elementary teacher. A variety of strategies was introduced including integrated coursework in science and pedagogy, use of technology to enhance students' interests, and the development and implementation of practical lessons (Coble and Koballa, Jr., 1996: 475).

The research literature suggests that teacher professional knowledge development can be accomplished by using many strategies including: using an individual way of thinking by reflection (Collinson, 1996; Bryan and Abell, 1999; Wise *et al.*, 1999; van Zee and Roberts, 2001; Penso, 2002; Halim, and Meerah, 2002; Zembal-Saul *et al.*, 2002; Eick and Dias, 2005) through specific strategies such as reflective journals (Penso, 2002; Zembal-Saul *et al.*, 2002), reflective interviews (Goodnough, 2002; Halim, and Meerah, 2002; Zembal-Saul *et al.*, 2002) seminar discussions (Goodnough, 2002) and action research (Goodnough, 2008); elaborating on many aspects including knowledge of instruction and assessment, how to plan standards-based science curriculums, and how to integrate content and pedagogy in collaboration conditions (Goodnough, 2002, 2008; Zembal-Saul *et al.*, 2002,); continuing a professionally knowledgeable way of teaching, and learning through interactions with many children and adults (Collinson, 1996; Wise *et al.*, 1999); the adoption of the multiple intelligence theory in forum discussions as an instructional organizer (Goodnough, 2002); and integrating technology into teacher preparation program (Coble and Koballa, Jr., 1996)

### **Information and Communication Technology**

Over several decades, many learning resources such as educational documents and instructional media have been produced in electronic formats. This is causing the

learning process to change from paper resources to electronic resources. An essential tool used by humans to acquire knowledge in the 21<sup>st</sup> century is Information and Communication Technology or ICT literacy (Partnership for 21<sup>st</sup> century skills, 2007). ICT literacy was broadly defined as a combination of computer skills and knowledge of how to use information in new formats made possible by computers (Sellen, 2002).

When workplaces, communities, and everyday lives require skills for the 21<sup>st</sup> century, students need to be trained for it. 21<sup>st</sup> century skills include reading, writing, computing, and how to use essential tools such as computer hardware/software, networking, and other technologies such as audio, video, and multimedia tools (Partnership for 21<sup>st</sup> century skills, 2007). Teachers cannot prepare students for 21<sup>st</sup> century context unless they understand, possess, and use those skills themselves (Laferriere, Lamon, and Chan, 2006).

Knowledge of instructional media and technology is an essential category of teacher's professional knowledge, which refers to a combination of knowledge and skills in using information technology. Working as a teacher in this decade is related to utilizing knowledge in teaching practice, and also related to other professional roles in and outside the classroom including tutoring students, participating in school activities and projects, interacting with members of the community, and working in professional groups. As ICT changes the environment in which teachers work and the way they relate to other teachers, it has an important impact on the nature of the teachers' profession (Pedro da Ponte *et al.*, 2002). In the workplace, teachers have been encouraged to use technology in their subject teaching, both at in service and pre-service levels (Kay 2006; Mishra and Koehler, 2006) including teaching-with-technology, designing software and creating of technologically based tools to support their professional work (Kerr, 1989).

So, now in teacher education, to prepare professional teachers, a web-based system was suggested to be a tool for revitalizing and reforming teacher education courses (Coble and Koballa, Jr., 1996; Pedro da Ponte *et al.*, 2002; Rodrigues *et.al.*, 2003; Shi *et al.*, 2004; Barnett, 2006; Kay, 2006; Laferriere *et al.*, 2006; Ikpeze,

2007). Multiple strategies have been used such as web page design (Pedro da Ponte *et al.*, 2002; Shi *et al.*, 2004), digital photography, and PowerPoint presentations (Wursta, Brown-DuPaul, and Segatti, 2004), technology-based search activities (Schrader *et al.*, 2003; Bahr, *et al.*, 2004; Spector, Burkett, and Leard, 2007), online discussion, (Kay, 2006; Laferriere *et al.*, 2006; Makinster *et al.*, 2006; Ikpeze, 2007; Spector *et al.*, 2007) and movie production (Mishra and Koehler, 2006).

Among these, technology-based search activities, in which teachers in school and university instructors use the web to support their teaching, and helped teachers use technology as a tool in the classroom to support their instruction (Bahr *et al.*, 2004, Schrader *et al.*, 2003; Spector *et al.*, 2007). In addition, an online discussion provides opportunities for teachers to reflect, collaborate, and share ideas with other members in the group (Makinster *et al.*, 2006; Ikpeze, 2007; Spector *et al.*, 2007). This activity can be used effectively to enhance development of teachers' professional knowledge (Ikpeze, 2007).

There was a variety of research scholar integrated technologies in the form of an online discussion into teacher education. In 2003, Ebenezer and colleagues integrated WebCT Bulletin Board in a Chemistry Curriculum and Instruction methods course. His results presented that the pre-service teachers' reflective practice were enhanced through the WebCT Bulletin Board. The board helped in building a reflective community among pre-service chemistry teachers (Ebenezer *et al.*, 2003). In 2006, Makinster *et al.* examined the use of electronic networking in a secondary science methods course to enhance pre-service teachers' reflection. The results from his qualitative study revealed positive results. The network supported meaningful reflection and collaboration among the participants. His works suggested the use of web-based discussion to enhance students' reflection (Makinster *et al.*, 2006). Moreover, in the 2007, Ikpeze integrated a Peer-Led Electronic discourse in teacher education. He found that a small group discussion facilitated effective learning of pre-service teachers. This interaction promoted pre-service teachers' empowerment and active learning (Ikpeze, 2007).

Another idea of using technology to support teaching was producing a movie. Mishra and Koehler (2006) integrated a movie production activity in a master level course of technology education. He used concepts of learning-technology-by-designing to offer learners authentic situations. The results presented that participants were provided opportunities in communicating the content area through the processes of storyboarding, filming, digitizing, editing, revising, and providing feedback. From these chances, TPCCK or technological pedagogical content knowledge was promoted. So, in the 21<sup>st</sup> century context, preparing the new teachers was suggested to integrate technology in a process of teacher production to promote the professional knowledge.

Teacher professional knowledge can be enhanced during professional development. So, the course that will be set can apply concepts of professional development to enhance pre-service science teachers' professional knowledge. The model for professional development involves changing concepts and beliefs about science teaching, conceptions underlying teaching activities, subject matter knowledge and skill, and moreover, involves changing of classroom practices or the development of ways of working with and relating to other teachers and students. In addition, it helps each individual teacher to construct, evaluate, and accept or reject what it means to be a science teacher (Bell, 1998).

### **Professional Development**

The professional development process is a complex set of procedures that involves deciding on lesson content (what you will teach) and format (how you will teach it). (Lang *et al.*, 1995: 13), moreover, teacher professional development is an opportunity for the teacher to work with master educators and reflect upon teaching practice (National Research Council [NRC], 1996: 5).

The professional development process is a continuous process that is strengthened from pre-service experience to the end of a professional career (NRC, 1996). Professional development plays an essential role in bridging the gap between prospective and experienced educators to meet the new challenges of guiding all

students in achieving learning standards (Eisenhower National Clearinghouse for Mathematics and Science Education [ENC], 1998).

## **1. Principles for Effective Professional Development**

Eisenhower National Clearinghouse for Mathematics and Science Education (1998), Rhoton and Bowers (2001), and the Education Research and Development Center of University of Delaware (2004) identified effective professional development for teachers of science with the following main factors:

**1.1 Content-Focused** Excellent science teachers have a very unique kind of knowledge, which is identified as pedagogical Content Knowledge that must be developed through their professional learning experiences.

**1.2 Extended** Professional development experiences should extend beyond more than one session.

**1.3 Collaborative** Professional development experiences should enhance teacher collaboration.

**1.4 Part of Daily Work** Professional development must both align with and support system-based changes that promote student learning.

**1.5 Ongoing** The effectiveness should be reviewed and assessed in terms of short-term effectiveness (i.e., teacher satisfaction and engagement) and long-term impact (i.e., changes in science teaching, student learning, the school community).

**1.6 Coherent and Integrated** The content of professional learning must come from both inside and outside the learner and from both research and practice. In addition, the designed structures should link professional development in science to other parts of the educational system.

**1.7 Inquiry-Base** Professional development experiences should promote continuous inquiry and reflection.

**1.8 Teacher-Driven** Professional development experiences should respond to teacher needs and interests.

**1.9 Informed by Student Performance** Professional development processes must set student learning to be the core of the process and make it meaningful for all students.

**1.10 Self-evaluation** the professional development process should include procedures for self-evaluation to guide teachers in their ongoing improvement efforts.

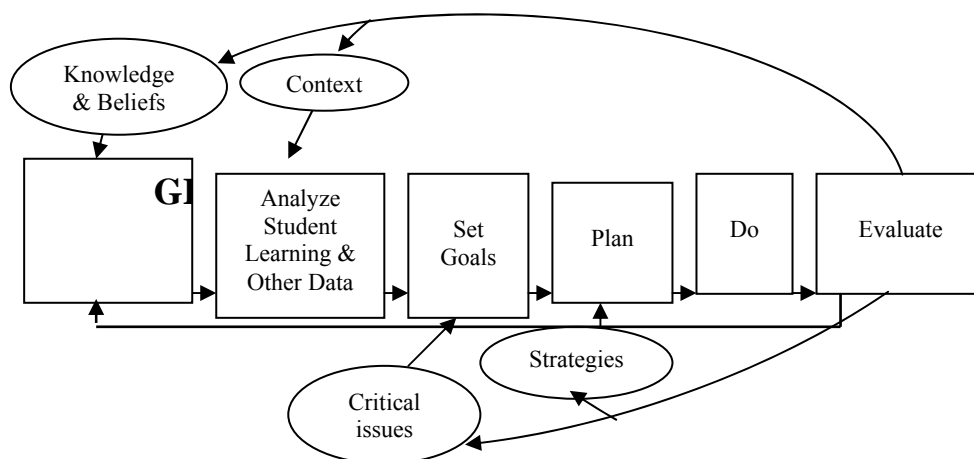
## **2. The Process of Planning for Professional Development**

To design and plan for professional development, Loucks-Horsley *et al.* (2003) modified the prior professional development design framework and presented a six-step cycle to increase effectiveness:

1. Commit to a vision and set of standards by concerning participants' knowledge and beliefs.
2. Analyze learning needs and other data to determine context and identify what kind of data should be considered in the analysis phase.
3. Address the goals by considering critical issues like equity, scaling up, and building capacity.
4. Lay out a plan that carefully considers all elements.
5. Lead the plan into implementation by using a timeline.
6. Evaluate the program and connect back to vision by rethinking the vision, plans, goals, and actions.

The professional development is not a sequential process; it can proceed in a forward direction or in a backward one to develop a professional plan in an effective

way. The four inputs: context, knowledge and beliefs, critical issues, and strategies for professional learning are considerations designed to meet the particular needs of the teacher and students.



**Figure 2.1** Professional Development Design Frameworks

Source: Loucks-Horsley *et al.* (2003: 4)

From theoretical perspectives and epistemology, designing an effective course to enhance pre-service science teachers' professional knowledge should consider using basic aspects of constructivism, reflection, and professional development. Therefore, the capstone course, which is the major intervention in this study, contains the following suggestions from research literature:

- emphasize individual knowledge of the teacher and how the teacher learns (Richardson, 1996; Marx, 1998; Radford, 1998; Bain; 2004);
- emphasize teachers' needs (Eisenhower National Clearinghouse for Mathematics and Science Education, 1998; Rhoton and Bowers, 2001);
- encourage active engagement of teachers (Radford, 1998);
- involve teachers in the realistic context of teaching (Cochran *et al.*, 1993; Eisenhower National Clearinghouse for Mathematics and Science Education, 1998);
- support long term change of teachers (Marx, 1998; Eisenhower National Clearinghouse for Mathematics and Science Education, 1998);

- support teachers to bring theory into practice (Russell, 1993; Hatton and Smith, 1995; Eisenhower National Clearinghouse for Mathematics and Science Education, 1998)
- support individual and group reflection of teachers (Lang *et al.*, 1995; Eisenhower National Clearinghouse for Mathematics and Science Education, 1998; Wise *et al.*, 1999; Andy, 2001)
  - provide a variety of practices for teachers (Peterman, 1993)
  - develop the continuous process of the program (Hatton and Smith, 1995; Eisenhower National Clearinghouse for Mathematics and Science Education, 1998)
  - enhance collaboration between universities and schools (Eisenhower National Clearinghouse for Mathematics and Science Education, 1998)
  - set student learning outcomes as goals of the program (Eisenhower National Clearinghouse for Mathematics and Science Education, 1998)

## **Context of the Study**

### **1. National Requirement for Teacher Production**

To produce quality teachers according to the national requirement, the process of teacher preparation is enormously important (Pongsopon, 2003: 134; Pitiyanuwat, 2004: 1; Roadrangka, 2004: 1).

According to the National Education Act of B.E. 2542 (1999):

...The Ministry shall promote development of a system for teachers and educational personnel, including production and further refinement of this category of personnel, so that teaching will be further enhanced and become a highly respected profession. The Ministry shall, in this regard, take a supervisory and co-coordinating role so that the institutions are responsible for production and development of teachers, faculty, staff, and educational personnel and shall be ready and capable of preparing new staff and

continuously developing in-service personnel (Office of the National Education Commission [ONEC], 1999:52)...

There is a national requirement for developing a system of teacher production and refinement and the aim of the system is to encourage teachers to organize the learning process according to the National Education Act of B.E. 2542 (1999). In Chapter 4 Section 24 of the Act mentions that:

... educational institutions and agencies concerned shall:

(1) provide substance and arrange activities in line with the learners' interests and aptitudes, bearing in mind individual differences;

(2) provide training in thinking processes, management, how to face various situations, and application of knowledge for obviating and solving problems;

(3) organize activities for learners to draw from authentic experience; drill in practical work for complete mastery; enable learners to think critically and acquire good reading habits and a continuous thirst for knowledge;

(4) achieve, in all subjects, a balanced integration of subject matter, integrity, values, and desirable attributes;

(5) enable instructors to create the ambiance, environment, instructional media and facilities for learners to learn and be all-round persons, able to benefit from research as part of the learning process. In so doing, both learners and teachers may learn together from different types of teaching-learning media and other sources of knowledge; and

(6) enable individuals to learn at all times and in all places, cooperation with parents, guardians, and all parties concerned in the community shall be sought to develop jointly the learners in accord with their potential...

To achieve the national requirement for organizing the learning process, teacher should be able to facilitate student's learning and should be encouraged to expand their area of profession (Pillay, 2002).

## **2. Current Thai Science Teacher Preparation Curriculum**

In Thailand, two types of institutions of higher education prepare science teachers. They are the University faculty of Education and the Rajabhat Institutes. The four-year science teacher preparation curricula provided by University Faculties of Education and Rajabhat Institutes (Teacher Training College) enhance pre-service science teacher's professional knowledge with courses and activities. The aims of these courses and activities are for pre-service teachers to acquire and apply professional content or subject matter knowledge, to develop a thorough understanding of the nature of learning and the nature of teaching, and to base their decisions upon appropriate values and attitudes (Roadrangka, 2004). Science teacher education curriculum provided by both university Faculties of Education and Rajabhat Institutes requires from 120 to 150 credit hours. The curriculum consists of three main types of core courses and experiences.

The General Education courses are in areas of Social Science, Humanities, Languages, Mathematics and Science. Total credit hours for university Faculties of Education is not less than 30 hours, but for Rajabhat Institutes is 33 hours.

The specialized courses are in areas of science content and professional education courses. This category the total credit hours for university Faculties of Education is not less than 84 hours, but for Rajabhat Institutes it is 105 hours. The required credit hours for compulsory science content courses are at least 44-46 hours and for selective science content courses at least 10 hours. Of this amount, pre-service science teachers must take 10 hours in every major field. These courses are Calculus 1, Principles of Statistics 1, Principles of Biology, and Laboratory in Biology. Specialized science content courses are divided into six major fields and these are

Physics, Biology, Chemistry, General Science, Environmental Science, and Computer Science. Required credit hours for each major field are 34-36 hours.

At least 30 hours in Professional Education courses are required. These courses are core courses and compulsory specialized education courses. Core courses are Basic Concepts of Education, Curriculum and Instruction, Ethics and Codes for Teachers and Field Experiences, Principles of Education Measurement and Evaluation, Educational Psychology, and Introduction to Educational Technology. Compulsory specialized education courses are for example: Methods of Teaching Science and Technology, Science and Technology Project in School, Seminar in Science teaching, Science and Technology Curriculum.

The elective courses are chosen by students based on their own interests. The total credit hours for university Faculties of Education is 6 hours, but for Rajabhat Institutes it is 10 hours (Roadrangka, 2004)

### **3. Student Teaching Practicum**

After finishing methods courses, pre-service science teachers have a vital opportunity to participate in a student teaching practicum. One semester of a teaching practicum is potentially process of teacher preparation (Northfield, 1998; Jaiswang and Chantawan 2003; Black, 2004; Roadrangka, 2004). It is designed to allow pre-service science teachers to integrate and apply their knowledge of science content and education into teaching practice. In other words, pre-service science teachers must blend their knowledge of content, curriculum, pedagogy, student psychology, instructional media, and assessment to help students understand science.

Field experience or student teaching practicum is the culmination of a series of coordinated activities which advance the pre-service teacher from classroom observation through the fulltime teaching practicum or teaching practice (Schoon and Sandoval, 1997). Teaching practicum is an important aspect of pre-service preparation (Cochran-Smith, 1991; Schoon and Sandoval, 1997; Collier, 1999; Richardson-

Koebler, 1988). Table 2.2 show the details of each program which was provided by the University Faculties of Education and Rajabhat Institute.

**Table 2.2** Field experience model of science teacher education institutes in Thailand

<b>Field experience model of science teacher education institutes in Thailand</b>	
<b>University Faculties of Education (KU,1999)</b>	<b>Rajabhat Institute</b>
1.) Level 1 Field Experiences (Observation and Participation) <ul style="list-style-type: none"> <li>• for 3<sup>rd</sup> student teachers</li> <li>• practice developing lesson plan</li> <li>• practice classroom teacher duties</li> <li>• utilize instructional media</li> </ul>	1.) Full-time field experience in school which compose of <ul style="list-style-type: none"> <li>• observation and participation</li> <li>• microteaching</li> <li>• student teaching</li> <li>• 2 weeks, ½ of semester, full semester</li> <li>• for development of competencies in knowledge, skills, and personal.</li> </ul>
2.) Level 2 Field Experiences (Student teaching) <ul style="list-style-type: none"> <li>• 8-12 hours per week for entire semester (18 weeks)</li> <li>• practice full time teaching in school context</li> </ul>	2.) Occasional field experience. <ul style="list-style-type: none"> <li>• to connect and apply their coursework to the classroom</li> <li>• to practice acquired pedagogical knowledge and skills in classroom</li> </ul> 3.) Supplementary professional experience. provides activities or extra-curriculum to increase student teacher's expertise

Source: adapted from Roadrangka (2004)

University Faculties of Education offer two levels of field experiences. First, Level 1 Field Experiences (Observation and Participation) are provided for the third year student teachers to connect university coursework to classroom practice. In level 2 Field Experiences (Student teaching), students spend an entire semester of the fourth year as a student teacher for 18 weeks in school. They are expected to teach science 8-12 hours per week.

There are three forms of field experiences provided by Rajabhat Institutes. Students are provided field experience activities in the second year to the fourth year

of their programs. First is Full-time field experience, which is composed of 1 credit for observation and participation, another 1 credit for microteaching, and 5 credits for Student teaching. Student time spent varies from 2 weeks, to half of a semester, to a full semester. This form aims to enhance student teacher knowledge, skills and personal competency. The second kind of experience is an occasional field experience. This form aims to connect university course work with classroom practice. Students time spent varies from a few hours, to half or a whole day. The last is a supplementary professional experience. This form aims to increase student teacher expertise in knowledge, teaching skill, and teacher characteristics. This form provides additional activities from the basic curriculum to enhance student expertise

A University that the intervention will be implemented is one of the institutions in higher education that prepares science teachers. Student teachers have to finish all of requirement courses designed by Faculty of Education before student teaching. Seminar course is the last compulsory specialized course that provides opportunities for student teachers to elaborate their teachers' professional knowledge. In this course, student teachers will bring interesting topics, problems in teaching to discuss in two hours per week in class. So, this research aimed to design a capstone course that enhances teacher's professional knowledge before student teaching, and is also designed to be appropriate with the aim of Seminar course.

## **CHAPTER III**

### **METHODOLOGY**

#### **Introduction**

The main purpose of the study is to develop and evaluate the effectiveness of a capstone course to enhance Thai pre-service science teachers' professional knowledge. The purpose of the study was generated from results of a pilot study (Rochanasmita and Roadrangka, 2005) which aimed to investigate opinions of Thai pre-service science teachers about problems in a preparation program for professional experience training and needs assessment in 2003 academic year. As a result of the pilot study, a need for a course to enhance Thai pre-service science teacher's professional knowledge was identified. These essential results were used to design the capstone course to prepare pre-service science teachers before student teaching. To help an audience understand research methodology, at the beginning of this chapter, the researcher explained the background of the study to show how research questions were developed.

Before this research began, the researcher had chances to observe student teachers teaching and had informal discussions with them after classes. After ten hours of classroom observations of middle school classes, the researcher found teaching problems in several classes which included:

- pre-service teachers told answers directly to students,
- they asked students to read knowledge sheets and answered the questions without using probing questions, and
- they didn't ask students to provide the underlying reasons for their answers

Moreover, during informal interviews after class, they suggested they had problems writing lesson plans. Three of the pre-service teachers had the following complaints concerning lesson plan writing:

- they didn't know how to construct appropriate expected learning outcomes for each lesson
- they didn't know which teaching methods that they had learned should be selected to use in each lesson.
- when they showed their lesson plans to the researcher, some of the lesson plans included phrases such as : "Students should understand" and "At the end of the lesson, students should have scientific minds".

So, the general questions that inspired this investigation were, 'What are the perceived problems of pre-service science teachers during student teaching?' and 'How can we help them eliminate these problems?'

To answer these questions, a pilot study was developed to investigate Thai pre-service science teachers' opinions in professional experience training in the 2003 academic year. The pilot study was used to design what characteristics of the course should be emphasized and what kinds of data would help design a course to help pre-service teachers become more accomplished teachers during their student teaching. To generate 'a slice of data' (Taber, 2000: 470) in this research, the researcher collected and analyzed data and used the results to guide the next steps of the research study.

This chapter provides a description of research methodology, research design, and a variety of research methods and techniques that were used to sample, collect, and analyze data in this study. The next paragraphs were divided into two parts. First, research methodology and methods explained about using grounded theory as a research methodology, using case study as a research design, and using a variety of qualitative methods in this study. Second, the pilot study and the current study will be described in the following paragraphs.

## Research Methodology

### 1. Grounded Theory: A Research Methodology

There is confusion in using the words *methodology* and *method* in conducting research. Bogdan and Billen (2003) described “methodology” as a more generic term that refers to the general logic and theoretical perspective for a research project, but “methods” is a term that refers to the specific techniques that you (the researcher) use, such as surveys, interviews, and observation---the more technical aspects of the research”. Moreover, they suggested that good research should use methods that are consistent with the logic of methodology (Bogdan and Billen, 2003).

This study was conducted by using the Grounded Theory methodology. In other words, the researcher used grounded theory as a theoretical perspective in organizing this research project. Grounded theory is described as a research methodology where the researcher uses results to inform how to gather additional data for creating theory (Locke. 2001; Charmaz, 2003; Henwood and Pidgeon, 2003; Dey, 2004). Instead of creating a formal theory, the researcher tried to generate conceptual analyses of particular experiences of participants in the areas of research setting, or the researcher tried to describe natural phenomena by using empirical evidence for generating and refining ideas (Charmaz. 2003; Seale *et al.*, 2004). To explain effectiveness of a capstone course, the researcher used a variety of research methods including interviews, observation, documents, and questionnaires. This variety of methods represented an ‘openness and flexibility of approach’ (Charmaz, 2003) to grounded theory methodology.

To use the methodology of grounded theory in conducting research, data collection and data analysis were core processes that were used to generate and elaborate categories in the study. Glaser and Strauss (1967) and Dey (2004) suggested the stages of research practice in grounded theory which is concluded in Table 3.1.

**Table 3.1** The stages of research practice in grounded theory as suggested by Glaser and Strauss (1967) and Dey (2004)

<b>Stages</b>		<b>Aim</b>	<b>Activities</b>	<b>Results</b>
<b>Glaser and Strauss (1967)</b>	<b>Dey (2004)</b>			
1. Comparing incidents applicable to each category:	Open coding	to assign key words or categories to data.	- name data - compare data in terms of 'coding' - write memo	- a set of categories and related properties
2. Integrating categories and their properties:	Axial coding	to fully develop and organize the conceptual categories	- compare conceptual elements - clarify the relationships between categories	- a framework that accounts for the action in research setting
3. Delimiting the theory:	Selective coding	to settle on the framework's theoretical components and to clarify the story to tell about the phenomenon	- integrate and delimit theory and its constituent categories - clarify analytic story by comparing the developed categories/frame work with related ideas.	- the point of theoretical saturation - draft of theory
4. Writing the theory		to produce a research article for publication	- use memos, coded data to write theory	- research article

From Table 3.1, it can be concluded that in the first stage, called as ‘Comparing incidents applicable to each category’ (Glaser and Strauss, 1967) or ‘Open coding’ (Dey, 2004), the researcher aimed to assign some key words or categories to data. These key words represented a common meaning that was composed into conceptual category. Activities in this stage concern naming or coding and writing memos. A set of categories and some related properties emerged from the first stage.

The second stage was named ‘Integrating categories and their properties’ (Glaser and Strauss, 1967) or ‘axial coding’ (Dey, 2004). This stage aimed to explore the interrelationship of each category and connected them into conceptual framework. Research activities included comparing and clarifying relationships among category. A framework and relationships among categories was produced from this stage.

The third stage was named ‘Delimiting the theory’ (Glaser and Strauss, 1967) or ‘selective coding’ (Dey, 2004). This stage aimed to further refine the categories to develop theory. The researcher integrated and delimited theory from prior information. This stage is the stage of ‘theoretical saturation’ which means ‘subsequent data incidents that were examined provide no new information’ (Locke, 2001) or ‘further data collection and analysis does not significantly change the model being developed’ (Taber, 2000).

The last stage was only described by Glaser and Strauss (1967). In this stage, called “writing of the theory”, the researcher aimed to produce a research article by using memos and coded data in writing theory to describe the research study.

From the stages of using grounded theory methodology in conducting research, coding was an important process to generate categories of data. These categories were gradually elaborated and refined during the process of research (Taber, 2000).

## 2. Case study: A Research Design for the Implementation and Follow Up Study

Case study methodology was used during and after the capstone course. The Case study can be represented by using a funnel model which means “the research starts with the wide end and moves to more specific study” (Bogdan and Biklen, 2003).

The four important properties of case study defined by Mirriam (1988) are *particularistic, descriptive, heuristic, and inductive*.

- particularistic: research focuses on a specific situation or phenomena
- descriptive: the researcher provides a holistic interpretation of situation
- heuristic: an understanding of a situation in the research was generated by participants and the researcher
- inductive: the researcher uses the inductive approach to generate understanding from data

Case study in this research was used to understand the development of professional knowledge of pre-service science teachers who participated in a capstone course. The researcher focused on pre-service science teachers’ underlying professional knowledge by interpreting their conceptions about teaching and learning, lesson plan writing and teaching.

In this research, classroom observation, interviews, and a variety of documents were used as research methods to provide opportunities for participants and the researcher to generate an understanding for a particular situation. Participants presented their underlying teacher professional knowledge through writing lesson plans, teaching, writing journals, and answering or discussing topics in the interview process. An understanding of their teacher professional knowledge was transcribed and explained by the researcher who is using the inductive approach.

There were a variety of case studies explained by Bogdan and Biklen (2003). These included historical organizational case studies, observational case studies, life history, and other types of case studies. This research used *observational case study* where main characteristics are focused on a specific group of people. Moreover, the main data collection was classroom observation supplemented with semi-structured interviews and documents analysis (Bogdan and Biklen, 2003). Details of how case study methodology was used in this research are explained in the second part of this chapter.

In this study, the researcher tried to collect data that could be completed in a certain amount of time and in order to provide an in-depth understanding of the effectiveness of the course. So, some cases were selected from the whole group of pre-service science teachers suggested by information collected during the course.

## **Methods**

### **1. Data Collections**

Utilizing grounded theory in this research, the researcher used data from multi-sources to maximize flexibility and to help generate theory (Conrad, 1993). To construct theory in this research study, triangulation was used to describe the idea that the researcher tries to construct an explanation by using more than one or multiple sources of data. Bogdan and Biklen (2003) suggested that using data from a variety of resources or using more than one method provided a fuller understanding of the study for the researcher.

To provide rich data from a variety of sources, the researcher used field notes as the major organizing tool that helped the researcher collect and analyze data. A short description about field notes is described first. Then, other important research used in each phase of the study is described in the paragraphs that follow.

### **1.1 Field Notes**

In each phase of data collection, the researcher wrote out notes. Field notes were used to record data from interviews, observations, and document analysis (Conrad, 1993). In this study, the researcher used two kinds of field notes called “descriptive field notes” and “reflective field notes” (Conrad, 1993).

The researcher used descriptive field notes to describe what the researcher observed in the field. For example: the physical appearances of subjects; the physical setting; what and who is involved in the study, etc. Reflective field notes were recorded during and after collecting data to document the reflections of the researcher on the data from the field. The reflective field notes constituted the professional interpretation of what the researcher observes.

### **1.2 Questionnaire**

Questionnaires were used in the pilot study, as well as Phase I and Phase II of this research study. There were many types of questions that are suggested by Cohen, Manion, and Morrison (2000). Open-ended questionnaires provide richness or in-depth responses from participants for qualitative data. Rating scale questions are useful in evaluating responses such as: good-bad, valuable-valueless, useful-useless or in evaluating potency responses which include large-small and weak-strong. This kind of question is appropriate for tapping attitudes, perceptions and opinions of the respondents (Cohen *et al.*, 2000).

To provide data for designing a capstone course, in Phase I, open-ended questionnaires were designed to investigate opinions about problems and needs in preparation of pre-service science teachers. The researcher started to investigate problems and needs in preparation by using open-ended questionnaires for gathering a fruitful answer from participants. Copies of questionnaires used in the pilot study and Phase I are in Appendix A.

In Phase II, open-ended questionnaires of teaching and learning conceptions were designed and used the model of the school level epistemologies suggested by Porlan and del Pozo (2004) in reporting the data. The conceptions were divided into rationalist, technical, and constructivist views on teaching and learning. A copy of this questionnaire was in Appendix B. This questionnaire was used together with the weekly journal, interview and classroom observation in evaluating conceptions about teaching and learning science of pre-service science teachers during participating in a capstone course.

Questionnaires were divided into two parts. The first part is an introduction about purpose and the construction of the questionnaires, and the second part is the content section. This layout was suggested by (Cohen *et al.*, 2000).

### **1.3 Documents**

Documents can include personal, official, and popular culture documents (Bogdan and Biklen, 2003). In this study, official and personal documents were used as required data. Bogdan and Biklen described “official documents as the documents that are produced by organizational employees for record-keeping and dissemination purposes” and “personal documents as the first-person narrative that describes an individual’s actions, experiences, beliefs, or written material” (Bogdan and Biklen, 2003).

In Phase I of the study, official documents were analyzed. These official documents describe the teacher preparation curriculum, standards for teacher preparation, and the research literature that describes teachers’ professional knowledge needs to be enhanced in teacher preparation.

In the Phase II and Phase III of the study, personal documents were required data. Lesson plans, individual journals and other written documents were collected from pre-service science teachers.

## 1.4 Interview

An interview is a purposeful conversation involved by two or more people (Bogdan and Biklen, 2003). The specific encouraging processes of verbal and non-verbal techniques were used to help interviewees produce elaborate and detailed answers (Rapley, 2004). Interviews can be set as one-to-one or group interviews, depending on the goals of the research. The one-to-one interview is more open to discussion for the interviewee, but also puts pressure on the interviewee (Macnaghten and Myers, 2004). Focus group interviews provide an atmosphere of comfort where it is easier to talk among the groups of interviewees, but the major problem of a focus group interview is that an individual may not share ideas or experiences because they're embarrassed with their knowledge of the topics discussed by the group (Bogdan and Biklen, 2003). So, the researcher made a decision in selecting type of interview format based on what kind of data needed to be acquired in the interview process and what topics need to be covered in an interview.

In Phase II and Phase III of this research, interviews were employed with other strategies to collect rich data to answer research questions. In Phase II, the researcher aimed to determine whether the capstone course enhances pre-service science teachers' professional knowledge during the course. Focus group interviews were selected to investigate participants' underlying professional knowledge used in their lesson plan writing and teaching in the course. A focus group provided a comfortable situation for participants to talk, respond, and add to the ideas or topics of conversation (Rapley, 2004). Moreover, the researcher can use any themes that emerged from the interview to guide a follow up study in Phase III.

Phase III of this research aimed to investigate the effectiveness of a course to enhance Thai pre-service science teachers' professional knowledge during student teaching. Semi-structured interviews were used in the one-to-one interview process. The problem of pressure between the interviewee and the interviewer was eliminated, because by that point in the study the interviewee will be getting familiar with the interviewer and be used to being interviewed during the focus group.

### **1.5 Observation**

Classroom observation is another research method that was used in the research study. To observe the class, the researcher had to define the role of researcher in each observation. In Phase II of this research, the phase of implementing a capstone course, the researcher was cooperative teaching with a university professor, and also be an observer in the class. The role of the researcher in this phase is defined as *participant as observer* (Crowson, 1993). In this role, a researcher worked with participants during their daily work, but a researcher had to remember that the primary reason for being in the field was to observe, not to participate (Crowson, 1993). Being too much of a participant will lead the researcher to change the action of the participants (Bogdan and Biklen, 2003)

In Phase III, the phase of the follow up study, the researcher observed pre-service teachers' classes. The role of the researcher was *observer as participants* (Crowson, 1993). In this role, a researcher emphasized on observation more than participation, but a researcher had to know when to participate to build rapport and trust among group of participants (Crowson, 1993).

### **1.6 Video and Voice Recorder**

During and after classroom observation during the course, the researcher recorded field notes; moreover, a video recorder was used to increase the potential of collecting data. To minimize the interference of instruments in the classroom, a video tape recording was used from the first class of observation. Bogdan and Biklen (2003) suggested that to provide convenience and fruitfulness of observation, the researcher should use instruments to record on a bulletin board, writing on the blackboard, the arrangement of furniture, and discussion in the class. However, the researcher should establish a comfortable relationship with subjects by "being always present and familiar" (Bogdan and Biklen, 2003). Moreover, in this research, a video recorder was used to record pre-service teachers teaching.

An audio tape recorder was used to help the researcher in an interview process, and the researcher asked permission to record the participants (Rapley, 2004) before using it.

## **2. Data Analysis**

### **2.1 Document Analysis**

Document analysis is a method used to analyze documents including memos, handbooks, evaluations, web-sites, class papers and journals, strategic planning documents, academic calendars, course descriptions, etc. (Love, 2003). In this research, either document data or field notes from interviews, classroom observation and interview transcriptions will be presented in the form of textual data. A powerful way to analyze these textual data is called “content analysis” (Love, 2003).

Content analysis can be classified into sub-categories including discourse analysis, analysis of narrative structures, and ethnography content analysis (Love, 2003). This research was mainly emphasizing discourse analysis which aimed “to understand content, themes, structures, and underlying assumptions in the speaking and writing of people” (Love, 2003). When the researcher analyzed documents in this study, the aim of the analysis was to understand the intention of the documents’ writer and underlying knowledge of participants in speaking and writing.

The analytic procedures that Love (2003) suggested include categorizing, coding, and content analysis. In categorizing, the researcher identified a prior analytic category of documents that defined whether the document was a primary or a secondary document. Love said that these categories will be useful for sorting documents for the research study (Love, 2003). Coding is an important process of breaking down, comparing and contrasting, and also conceptualizing the data contained in documents data (Love, 2003) or interview transcriptions (Rapley, 2004; Macnaghten and Myers (2004)). To start coding Rapley suggested the ‘discursive

approach' where the researcher brings the textual data, reads, re-reads and notes some interesting themes or starts applying some codes, or key words to data. The codes can be words or phrases, letters or numbers; however, the researcher should provide codes and their definitions in a codebook (Love, 2003).

In this research followed the stages of coding data suggested by Dey (2004) that was described in Table 3.1

## **2.2 Sampling Methods**

### **Theoretical Sampling**

Theoretical sampling is a sampling method that a researcher uses to identify emerging ideas or categories of data to decide what or where data should be collected in the following steps to help to generate theory (Conrad, 1993 and Dey, 2004). In this study, the researcher used categories of pre-service science teachers' professional knowledge that emerged from the questionnaire in selecting four cases from the seventeen pre-service science teachers. The Biology and Chemistry students were focused, because of researcher's background and confidence. This facilitated the researcher to evaluate all aspects of pre-service science teachers' professional knowledge. This process provided comparing and contrasting opportunities in a process of data analysis to facilitate the researcher-generated explanation in the study (Dey, 2004)

During a capstone course, pre-service science teachers' background, characteristics and prior knowledge were analyzed. Outstanding information relating to their teachers' professional knowledge was identified and used to guide a selection case.

### **Pilot Study**

An investigation of Thai pre-service science teachers' opinions in professional experience training was conducted in the 2003 academic year. Participants were 25 fourth year pre-service science teachers. Two items on an open-ended questionnaire were used to collect data. Questions in the first part of these questionnaires are about personal information such as name, sex, science major, what level and what science topics that they teach. The last part was about the difficulties that they had in lesson plan writing and teaching. A copy of this questionnaire is in Appendix A. Results from this study suggested that most of the pre-service teachers had to teach science out of their area of expertise like Chemistry student teachers have to teach 'earth and process of the earth', Biology student teachers have to teach 'force and motion', Physics students have to teach 'life and environment'. There were problems that pre-service science teachers encountered including: teaching science concepts; writing lesson plans; and teaching science emphasizing science process skills. Most of the problems concerned writing lesson plans where they were not able to transform science content into classroom activities. Those pre-service science teachers who taught in their area of expertise didn't have problems with scientific content; however, they still had other problems. These problems concerned teaching science emphasizing science process skills, the lack of scientific instruments, and problems in writing lesson plans.

The needs in preparation of pre-service science teachers were identified in their answers. They suggested that they want to improve their knowledge about:

- writing lesson plan
- using methods of teaching science emphasizing scientific process skills,
- using scientific equipment,
- implementing classroom management,
- using instructional media
- assessing student understanding in science

- Understanding scientific knowledge that they had to teach, especially those in Geology and Astronomy.

In addition, they wanted to practice their knowledge in the classroom during methods courses, and they wanted to have a chance to become familiar with a real classroom to support their confidence in teaching science.

While results of the pilot study suggested many problems that pre-service science teachers encountered in teaching practicum, not all of the suggested topics could be adequately addressed in a capstone course. In order to provide a focus for the course and this research, the researcher has chosen to stress teachers' professional knowledge in planning and teaching science lessons.

Planning lessons was selected because it is one of the most important teaching functions. To plan a lesson, a science teacher has to spend time thinking through the lesson and thinking about how to sequence instructional activities that support student learning (Chiappetta and Koballa, Jr, 2006). Teaching science lessons was selected as a focus because it is this aspect of teaching that facilitates student learning (Batten *et al.*, 1993; Chiappetta And Koballa, Jr, 2006). The teacher has to integrate all aspects of teacher professional knowledge including knowledge of educational context, general pedagogical knowledge, subject matter knowledge, and pedagogical content knowledge, knowledge of instructional media and technology, a knowledge of educational philosophy, and a knowledge of research concentrated on the best practices in planning and teaching the lesson.

### **Current Research**

This research aimed to develop and evaluated the effectiveness of a course to enhance Thai pre-service science teachers' professional knowledge. The main research question is: "How does a capstone course designed to enhance Thai pre-service science teachers' professional knowledge affect the pre-service teachers' "

conceptions about science teaching and learning, lesson planning and teaching?” The research was divided into three phases. Phase I involved designing the capstone course. Phase II involved implementing the course and Phase III followed the pre-service teachers into student teaching to determine how well they implement professional knowledge into their teaching.

### **1. Phase I**

Phase I of the study which involved designing the course, occurred during the 2004-2005 academic year. The first research question is: What are the characteristics of a course designed to facilitate Thai pre-service science teachers’ professional knowledge? To answer this research question, the researcher reviewed documents that described the level of expectation of teacher professional knowledge from standards in international and Thai levels. On the international level, the standards for science teacher preparation of the NSTA (2003), GSTEP Framework for accomplished teaching of Georgia Systemic Teacher Education Program (2005) and The Capable Teacher of the ERO in New Zealand (1998) were analyzed. Concerning the Thai context, the researcher analyzed the level of expectation of the Standard for Teacher Profession (4<sup>th</sup>) of Teachers’ council of Thailand (1999) and National plan for reforming in teacher education and development of educational personnel (ONEC, 1995). Moreover, to complete an understanding of effective characteristics of the course, Thai Science teacher preparation curricula and results of research literature in the field of effective preparation courses were analyzed.

In addition to standards and expectation documents, the problems and needs of pre-service science teachers in Thailand are important factors that should be included in the process of the course design. So, questionnaires to investigate needs in the preparation of pre-service science teachers were designed and implemented during the 2004 and 2005 academic year. Three questionnaires were used in this phase. The first questionnaire was developed and implemented in the 2004, 2005 and 2006 academic year. An example of this questionnaire is in Appendix A. Seventeen fourth year pre-service science teachers were asked to complete the questionnaire. The questionnaire

aimed to investigate the perceived needs of pre-service science teachers in a preparation program.

The second questionnaire aimed to investigate the readiness in using the professional knowledge of pre-service science teachers. An example of this questionnaire is presented in Appendix C. This questionnaire was designed and implemented in the 2005 academic year, but with another group of pre-service science teachers who were in the third year of a teacher preparation program. This group was made up of pre-service science teachers who are going to participate in a capstone course as fourth year students in the teacher preparation program during 2006. Details of research questions, data source, required data, data collection, and data analysis were described in the following paragraphs.

**Research Question 1:** What are the characteristics of a course designed to facilitate Thai pre-service science teachers' professional knowledge?

To answer this research question, the data collections methods used in Phase I were documents and questionnaires. The type of data analysis was document analysis.

**X<sub>1</sub>: Data Source:** Science teacher preparation curricula

Two types of teacher preparation curricula are analyzed

1. University faculty of education (Kasetsart University) curriculum (2004)
2. Rajaphat Institutes (Teacher Training College) curriculum (2004)

**Required Data:** Expected levels of teacher' professional knowledge that are being enhanced in the current teacher preparation program in Thailand

**Data Collection Methods:** Documents

**Data Analysis:** Document Analysis

The researcher analyzed data from the detail of each curriculum; course name, credit hour, and characteristics of the practicum. Then, the researcher specifically analyzed the details of each course of Kasetsart University faculty of Education curriculum. Course description of each course was analyzed to determine which components of teacher's professional knowledge are emphasized in each course.

**X<sub>2</sub>: Data Source:** Standard for teacher preparation

Two levels of standards for teacher preparation are analyzed

### **International Level of Expectation**

1. Standard for Science Teacher Preparation of NSTA (2003)
2. GSTEP Framework for accomplished teaching of Georgia Systemic Teacher Education Program (2005)
3. The Capable Teacher of the ERO in New Zealand (1998)

### **Thai level of Expectation**

1. Standard for Teacher profession of Teachers' council of Thailand, 4<sup>th</sup> edition (1999)
2. National plan for reforming in teacher education and development of educational personnel (ONEC, 1995)

**Required Data:** The level of expectation of teachers' professional knowledge as suggested by the standards for teacher preparation

**Data Collection Methods:** Document

**Data Analysis:** Document Analysis

The researcher analyzed data from the details of standards suggested at the international level and Thai level of expectation about which components of teacher's professional knowledge were necessary to become an effective teacher.

To analyze data, the researcher started analyzing each document by reading through it. The coding process was used to identify which area of teachers' professional knowledge was described by the standard. After analyzing all documents, the researcher started to compare and contrast areas of expectation from each standard. To explain similarities and differences suggested by each standard, the researcher constructed a table that describes the level of expectation of teachers' professional knowledge as suggested by each standard

**X<sub>3</sub>: Document:** Research literature

**Data Sources:** Information or suggestions from research articles that identified components of teachers' professional knowledge which are important to include in a teacher preparation program

**Required Data:** Expected levels of teachers' professional knowledge as suggested by research literature.

**Data Collection Methods:** Document

**Data Analysis:** The research results and suggestions that propose essential knowledge and skills of teachers will be analyzed and used to guide the development of the course to enhance pre-service science teacher professional knowledge.

**X<sub>4</sub>: Data Sources:** the 4<sup>th</sup> year pre-service science teachers in the 2004 and 2005 academic year.

**Required Data:** Needs in preparation of the 4<sup>th</sup> year pre-service science teachers (in the 2004-2005 academic year)

**Data Collection Methods:** Questionnaires: the perceived needs in terms of teacher professional knowledge of the 4<sup>th</sup> year pre-service science teachers, in the 2004 and 2005 academic year.

The questionnaires used in the 2004 and 2005 academic year were open-ended questionnaires. An example of the questionnaire was in Appendix A. The aim of these questionnaires was to investigate the perceived needs of pre-service science teachers in terms of teacher professional knowledge.

**Data Analysis:** The perceived needs were categorized into groups and classified according to the components of teacher professional knowledge.

X<sub>5</sub> were the required data from pre-service science teachers who participated in the course. The readiness in using teacher professional knowledge and needs in preparation was investigated when they were in the 3<sup>rd</sup> year of the teacher preparation program. An example of this questionnaire is in Appendix A and C. The first part is three scale of rating scale questions about the readiness in using teachers' professional knowledge.

The second part is an open-ended questionnaire items which aimed to investigate needs in preparation of pre-service science teachers. Details of X<sub>5</sub> are described in the following paragraphs.

**X<sub>5</sub>: Data Source:** the 3<sup>rd</sup> year pre-service science teachers in the 2005 academic year.

**Required Data:** Problems in using teachers' professional knowledge and the readiness in using teacher professional knowledge

**Data Collection Methods:** Questionnaires: (Part 1: The readiness in using teachers' professional knowledge, Part 2: Needs in preparation)

During the 2005 academic year, pre-service science teachers who will participate in the capstone course were in the 3<sup>rd</sup> year of the teacher preparation program. They were asked to identify their readiness of using teacher's professional knowledge in teaching by a three-scaled questionnaire. This part contains questions in areas of using standards to plan science lesson, teaching middle school science topics, writing lesson plans, teaching, using instructional media, problems in the classroom and others topics related to teaching science. Part 2: The questions were developed from X<sub>4</sub>, aimed to investigate need in preparation of the participants.

**Data Analysis:** Answers of pre-service science teachers was analyzed, categorized into groups in the 2005 academic year, and also used to design the capstone course to use in the 2006 academic year.

Data from the first phase was used together with concerning of the guiding principles to design a capstone course.

## **2. Phase II**

The second phase, to implement and determine whether the course enhances pre-service science teacher professional knowledge, was designed to be implemented in the first semester of the 2006 academic year. Seventeen fourth year pre-service science teachers participated in the course. This course was organized by the researcher cooperating with the university professor to teach the course. Activities of the course were designed to be in line with a seminar course, which aimed to help pre-service science teachers understand important topics and issues to discuss these with other peers. Moreover, to be in line with the problems and needs in preparation of pre-service science teachers, activities in the course were related to planning, implementing and reflecting on science lessons. During the course, pre-service science teachers had opportunities to integrate their content knowledge of science together with knowledge about how to teach from prior content and methods courses into teaching practice. Moreover, they had chances to discuss and exchange ideas with other peers in class.

This course was given two hours per week. Data was collected from the beginning until the end of capstone course. The capstone course took place during a sixteen-week semester. Data collection methods that were used in this phase were documents which included lesson plans, case reflections, weekly journal writing, and also focus group interviews.

**Research Question:** 2. In what way does the course enhance pre-service science teachers' professional knowledge during the course?

2.1 In what way does the course influence Thai pre-service science teachers underlying professional knowledge?

In what way does the course influence Thai pre-service science teachers' ability to implement their professional knowledge?

Sub-research question 2.1 aimed to investigate Thai pre-service science teachers underlying professional knowledge. The researcher used information from questionnaires regarding conceptions about teaching and learning science, journal writing, and focus group interview to analyze pre-service teachers' underlying professional knowledge.

The questionnaire regarding conceptions about teaching and learning science was made up of open-ended questions. An example of this questionnaire is in Appendix B. Seventeen fourth year pre-service science teachers were participants. The questionnaires were implemented during the first and last periods of the course.

Journal writing was an important reflective tool that the researcher used to analyze the development of pre-service science teachers' underlying professional knowledge within the course. Pre-service teachers were asked to write weekly journal entries after every class.

Group interviews were used after pre-service science teachers had organized a seminar discussion to capture the development of pre-service science teachers' underlying professional knowledge.

**X<sub>6</sub>: Data Source:** 4 of 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Conceptions about teaching and learning science

**Data Collection Methods:** Questionnaires: Conceptions about teaching and learning science of the 4<sup>th</sup> year pre-service science teachers

Pre-service science teachers' conceptions about teaching and learning science was investigated in the first semester of the 2006 academic year before and after implementing the capstone course.

**Data Analysis:** Pre-service science teachers' conceptions about teaching and learning science before and after implementing the capstone course was described and analyzed.

**X<sub>7</sub>: Data Source:** 4 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** pre-service science teachers' underlying professional knowledge.

**Data Collection Methods:** journal writing

Journal writing was an important tool to allow pre-service science teachers to think about and communicate their understanding of their teachers' professional knowledge. Pre-service science teachers were asked to write in their journals once a

week after discussion in the classroom. The focus for each journal entry should be to answer in the area of these questions:

1. Before the class, what is my expectation from this period?
2. What kind of knowledge did I get from the class?
3. How did activities in the classroom help me achieve my expectation?
4. How will I use that knowledge in my teaching practice?
5. What do I need to learn in the next class?

Pre-service teachers sent each journal no later than two days after each class.

**Data Analysis:** Journal writing was analyzed to identify the changes in pre-service science teachers' underlying professional knowledge during the course. In addition, any suggestions about what they need to learn will be used to modify the activities of the course.

**X<sub>3</sub>: Data Source:** 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Pre-service science teachers' underlying professional knowledge

**Data Collection Methods:** Focus group interviews

After writing lesson plans and practice teaching, each group was interviewed about their understanding of teacher professional knowledge in planning and teaching the lesson. Each group was interviewed one time after they organized the seminar discussion. The researcher used field note to record data from the interview, and audio recorder was used to remind the researcher when some data from field note was missing.

**Data Analysis:** Document analysis

Interview transcriptions were analyzed by using content analysis. The researcher constructed a codebook that provides some key words and meanings of those key words to help the researcher in analyzing data.

X<sub>6</sub>, X<sub>7</sub>, and X<sub>8</sub> were analyzed and used in reporting the results according to the model of the school level epistemologies suggested by Porlan and del Pozo (2004). The conceptions were divided into rationalist, technical, and constructivist views on teaching and learning.

Sub-research question 2.2 aimed to investigate Thai pre-service science teachers' ability to implement their professional knowledge during the course. Documents included field notes, lesson plans, and journal writing. In addition, a focus group interview was used as research methods in this sub-research question.

**X<sub>9</sub>: Data Source:** the 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** the readiness in using teacher professional knowledge

**Data Collection Methods:** Questionnaires

The questionnaire was developed from for capturing X<sub>5</sub> the changing of pre-service science teachers' readiness in using teacher professional knowledge.

**Data Analysis:** Answers of pre-service science teachers was analyzed, categorized into groups in the 2005 academic year, and also used to compare the results from other sources.

**X<sub>10</sub>: Data Source:** 4 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Pre-service science teacher ability to implement their professional knowledge as evidenced from their lesson plan.

**Data Collection Methods:** document (lesson plans and other documents).

**Data Collection:** Each week the pre-service science teachers had a responsibility to design group lesson plans. After the second week, the instructor assigned individual lesson plan homework for pre-service science teachers to practice using knowledge from discussions in the course to design their own lessons.

During seminar session, pre-service science teachers were assigned to design group lesson plan which emphasized in aspect of teaching identifying of each week. Totally group lesson plan were four lessons including two individual and two group lessons plans. Other documents including prior knowledge worksheets, reflection after producing instructional media, reflection after organizing seminar, and rubric assessment were collected during the course.

**Data Analysis:** Document analysis

Each document was analyzed related to topics that were learned that week. For the lesson plan, the lesson plan analysis sheet (Appendix D) in each specific topic was used to help the research to analyze group and individual lesson plans in each week.

**X<sub>11</sub>: Data Source:** 4 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Pre-service science teachers' abilities to implement their professional knowledge.

**Data Collection Methods:** Classroom observation.

**Data Collection:** Activities in the seminar course such as presentation, classroom discussion, or microteaching were observed by the researcher. The researcher acted as a participant observer (Crowson, 1993) where the researcher both participated in class activities such as presenting or discussing some ideas with participants and observed the class.

During and after the class, the researcher wrote descriptive and reflective field notes to provide information from each class.

**Data Analysis:** Field notes were analyzed by using content analysis. Both descriptive and reflective field notes of the researcher were coded and conclusions were drawn about how participants construct their teacher professional knowledge in class.

**X<sub>12</sub>: Data Source:** 4 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Pre-service science teacher ability to implement their professional knowledge as evidenced from their lesson plan.

**Data Collection Methods:** The Online Discussion Board (ODB)

**Data Collection:** The ODB was introduced and was used since the first week of the course. The researcher constructed a seminar website as a main page, which members were able to link to the online discussion board. The aim of the online discussion board was to provide opportunities for pre-service teachers' reflections, and being another learning resource which class members could access any time and from anywhere.

**Data Analysis:** Document analysis

Each week the topic in the ODB was printed out and coded for capturing the

changing of pre-service science teachers' professional knowledge during the course. The conversation was read and coded word-by-word.

**X<sub>13</sub>: Data Source:** 4 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Pre-service science teacher ability to implement their professional knowledge as evidenced from their lesson plan.

**Data Collection Methods:** Artifacts (Instructional Media)

**Data Collection:** At the end of fifteen weeks, one of the seminar course requirements was producing instructional media. Each group of pre-service science teachers selected topics, methods, and designed instructional media base on their selected science topic.

**Data Analysis:** Each artifact, instructional media CD and manual was analyzed and coded according to the domain of the teacher professional knowledge that was enhanced

**X<sub>14</sub>: Data Source:** 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** Pre-service science teacher ability to implement their professional knowledge as evidenced from their lesson plan.

**Data Collection Methods:** Focus group interviews

**Data Collection:** During the course, each group was interviewed. The researcher used field note to record data from the interview, and audio recorder was used to remind the researcher when some data from field note was missing. The interview protocol was shown in Appendix E.

### **Data Analysis:** Document analysis

Interview transcriptions were analyzed by using content analysis. The researcher constructed a codebook that provides some key words and meanings of those key words to help the researcher in analyzing data. The researcher analyzed the data by concerning the ability to implement the professional knowledge of pre-service science teachers.

### **3. Phase III**

The purpose of the third phase was to assess the effectiveness of the course by evaluating pre-service teachers teaching and student learning. Therefore, the last phase aimed to determine whether the course enhance pre-service science teacher professional knowledge during student teaching. This phase occurred in the second semester of the 2006 academic year when pre-service science teachers practiced teaching. Four pre-service science teachers were observed in two local schools. Case study methodology was used to guide the study in this phase. In each case, the development of pre-service science teacher was also be studied by focus on their ability to plan and implement science lesson in classroom. Moreover, the ability of pre-service science teacher was assessed by focusing on how well student of pre-service science teacher work/task had been developed during learning science with the four pre-service science teachers.

**Research Question:** 3. In what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching?

X<sub>15</sub> to X<sub>21</sub> were investigated from four selected pre-service science teachers and their cooperating teachers during student teaching in the school context (second semester). Each pre-service teacher taught two to three classes, but they were asked to select two classes to be observed by the researcher, who observed their classroom totally four times during the student teaching period.

**X<sub>15</sub>: Data Source:** Three 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** ability to use teacher's professional knowledge in writing lesson plans)

**Data Collection Methods:** Document (lesson plans)

In every period of classroom observation, pre-service science teachers will be asked to send lesson plans at least two days before teaching.

**Data Analysis:** the ability of pre-service science teachers to implement their professional knowledge into planning the lesson was determined by analyzing from their lesson plan format, learning outcomes, important science concepts emphasized activities, and assessment strategies. The interrelated of each component was also emphasis.

**X<sub>16</sub>: Data Source:** Three 4<sup>th</sup> year Pre-service science teachers in the 2006 academic year.

**Required Data:** ability to implement pre-service teacher's professional knowledge in the classroom.

**Data Collection Methods:** Classroom observation.

During and after classroom observation, descriptive and reflective field notes will be developed by the researcher.

**Data Analysis:** Field notes were revised after every class to generate the descriptions of how pre-service science teacher implement their teachers' professional knowledge and their ability to implement this professional knowledge in the classroom.

**X<sub>17</sub>: Data Source:** Three 4<sup>th</sup> year Pre-service science teachers in the 2006 academic year.

**Required Data:** ability to implement pre-service teacher's professional knowledge in the classroom.

**Data Collection Methods:** Artifacts (Instructional Media)

**Data Collection:** During the classroom observation, instructional media that were used by pre-service science teachers were collected. These instructional media were including worksheets, graph, model, video and pictures.

**Data Analysis:** The artifacts were analyzed, coded according to the domain of the teacher professional knowledge by using content analysis.

**X<sub>18</sub>: Data Source:** Three 4<sup>th</sup> year pre-service science teachers in the 2006 academic year.

**Required Data:** pre-service science teachers' professional knowledge and their ability to implement this professional knowledge in the classroom.

**Data Collection Methods:** Journal writing

Pre-service science teachers had to write weekly journals after they taught. They sent their journal to the research by email and when the researcher observed the class.

**Data Analysis:** Every week, the journals of pre-service science teachers will be analyzed to make the descriptions about how well they developed underlying teachers' professional knowledge

**X<sub>19</sub>: Data Source:** Three 4<sup>th</sup> year Pre-service science teachers in the 2006 academic year.

**Required Data:** pre-service science teachers' professional knowledge and their ability to implement this professional knowledge in the classroom.

**Data Collection Methods:** Semi-structured interviews: interview protocol (Appendix F) was used to guide semi-structured interviews, which data acquired from classroom observation was used to guide the interview.

**Data Analysis:** The interview was transcribed on that day, and then the transcription was analyzed by using content analysis.

X<sub>20</sub> was gathered during group discussion session. During the student teaching, there were three conferences organized at the University of pre-service Science Teachers. The aim of this activity was to allow pre-service science teachers to exchange knowledge, discuss problems in teaching, and also to help each other to solve these problems. During the discussion, the researcher acted as an observer.

**X<sub>20</sub>: Data Source:** 4 of 4<sup>th</sup> year Pre-service science teachers in the 2006 academic year.

**Required Data:** pre-service science teachers' professional knowledge and their ability to implement this professional knowledge in the classroom.

**Data Collection Methods:** field notes from small group discussion

**Data Collection:** Every conference that occurred at the university. Four of the participants discussed and exchanged their ideas about problem found during their teaching in a real classroom. In addition, they helped each other plan or give some suggestions for their classes during the next week.

**Data Analysis:** Researcher's notes was analyzed and used to generate the descriptions of pre-service science teachers' professional knowledge and their ability to implement this professional knowledge in their classrooms. The discussion was recorded by field notes. This information was used to fulfill data from other sources.

**X<sub>21</sub>: Data Source:** The cooperating teachers of the 4 pre-service science teachers

**Required Data:** pre-service science teachers' professional knowledge and their ability to implement this professional knowledge in the classroom.

**Data Collection Methods:** semi-structure interview

**Data Collection:** Cooperating teachers of the 4 pre-service science teachers were interviewed in the middle of the student teaching practicum period. The aim of interviews was to acquire additional information from the cooperating teachers' perspective about the development of pre-service science teachers' professional knowledge to support data from the researcher perspective. The example of questions included:

1. How do the pre-service science teachers develop their professional knowledge in areas of writing lesson plans, teaching, classroom management, instructional media and assessment?
2. Do the pre-service science teachers teach base on the recommendations of NEA 1999?
3. Do the pre-service science teachers teach by concerning the nature of science, science process skills?

**Data Analysis:** Interview transcriptions were analyzed by using content analysis. The researcher constructed a codebook that provides some key words and

meanings of those key words to help the researcher in analyzing data. The researcher analyzed the data from the cooperating teachers' view in addressing the ability to implement the professional knowledge of pre-service science teachers.

**Research Question:** 4. What learner characteristics result from being taught by the Thai pre-service teachers who have received this special teacher education?

$X_{22}$  and  $X_{23}$  were investigated from the students of the four pre-service science teachers during student teaching in the school context (second semester). The data were used to assess effectiveness of the course through student learning.

**$X_{22}$ : Data Source:** Students of the four Pre-service science teachers during the student teaching.

**Required Data:** abilities of pre-service science teacher that affect student learning

**Data Collection Methods:** classroom observation

During the classroom observation, students' role and interaction in class were observed. This information was used to refer to knowledge and ability of pre-service science teacher teaching in classroom.

**Data Analysis:** Document analysis

**$X_{23}$ : Data Source:** Students of the four Pre-service science teachers during the student teaching.

**Required Data:** abilities of pre-service science teacher that affect student learning

**Data Collection Methods:** Focus group interviews

Three to five students' of pre-service science teacher were selected to participate in focus group interviews. The interview was organized in the science laboratory room after school day. This information was used to fulfill the data from X<sub>22</sub> to refer to knowledge and ability of pre-service science teacher teaching in classroom.

**Data Analysis:** content analysis

Interview transcriptions were analyzed by using content analysis. The researcher constructed a codebook that provides some key words and meanings of those key words to help the researcher in analyzing data.

**Table 3.2** Data collection

Phase	Purpose	Research Question	Subject/Document	Data	Data collection methods					
					Document Data	Questionnaire	Classroom observation	Online Discussion Board	Artifacts	Journal writing
1	To design and implement a capstone course to enhance pre-service science teachers' professional knowledge	1. What are the characteristics of a course designed to facilitate Thai pre-service science teacher professional knowledge?	Science teacher preparation curricula	Expected levels of Teachers' professional knowledge	X <sub>1</sub>					
			Standards for teacher preparation		X <sub>2</sub>					
			Literature Reviews		X <sub>3</sub>					
			4 <sup>th</sup> year Pre-service science teachers	Needs in preparation (in 2004-2005 academic year)		X <sub>4</sub>				
			3 <sup>rd</sup> year Pre-service science teachers	Needs in preparation (participants)		X <sub>5</sub>				
2	To determine whether the capstone course enhances pre-service science teachers' professional knowledge during the course?	2. In what way does the course enhance pre-service science teachers' professional knowledge during the course?		professional						
			2.1 In what way does the course influence Thai pre-service science teachers underlying professional knowledge?	4 4 <sup>th</sup> year Pre-service science teachers	Conception about teaching and learning science (Before and after course)		X <sub>6</sub>		X <sub>7</sub>	X <sub>8</sub>
			2.2. In what way does the course influence Thai pre-service science teachers' ability to implement their professional knowledge?	4 4 <sup>th</sup> year Pre-service science teachers	The readiness to implement professional knowledge (Before and after course)		X <sub>9</sub>			

**Table 3.2** (Continued)

Phase	Purpose	Research Question	Subject/ Document	Data	Data collection methods					
					Document Data	Questionnaires	Classroom observation	Artifacts	Journal writing	Interview
			4 4 <sup>th</sup> year Pre-service science teachers	Documentations of capstone course implementation	X <sub>10</sub>	X <sub>11</sub>	X <sub>12</sub>	X <sub>13</sub>		X <sub>14</sub>
3	To determine whether the capstone course continues to enhance pre-service science teachers' professional knowledge during student teaching	3. In what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching?	4 of 4 <sup>th</sup> year Pre-service science teachers (Second semester of 2006 academic year, during student teaching)	Effects on pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge into teaching	X <sub>15</sub>	X <sub>16</sub>	X <sub>17</sub>	X <sub>18</sub>	X <sub>19</sub>	X <sub>20</sub>
			Cooperating teachers of the 4 pre-service science teachers							
		4. What learner characteristics results from being taught by the Thai pre-service who have received the special teacher education?	pre-service science teachers' students	Effects on pre-service science teachers' students Learning		X <sub>22</sub>		X <sub>23</sub>		

## **Trustworthiness of Data Collection and Analysis**

### **1. Credibility**

Credibility is a strategy used to demonstrate the internal validity in qualitative research. The credibility of this research is enhanced by prolonged engagement in the field to build the rapport and trust with the participants. This allows the researcher to be able to avoid getting misinformation from the field. Moreover, resistant observation helps the researcher understand and be able to identify characteristics relevant to the research study. Triangulation is another method which was used in the study. The variety of data sources provided opportunities for the researcher to confirm and contrast one source of information with another. Member checking is used to provide opportunities for participants to confirm or provide additional information of the results.

### **2. Transferability**

Transferability is used to present external validity or generalisability of the qualitative inquiry. In the nature of qualitative or inductive methodology, the researcher does not aim to generalize the results. However, it does not mean that this research neglects the ability to transfer the results to the other situations. The transferability of this research is enhanced by providing “a thick description”. This study provides context and a detailed description of methodology and interpretation. So, the readers can determine if the findings are relevant to their own situation.

### **3. Dependability**

Dependability is equivalent to reliability in the quantitative research. The dependability of this research was enhanced by having a science educator who was a course instructor and colleague to observe the course at the same time as the researcher. The results from different observers were used to determine whether another observer observes and interprets the same way of the researcher.

#### **4. Confirmability**

Confirmability is the strategy used to ensure that the result of the study is not influenced by the researcher. In this study the objectivity of the researcher was reduced during the grounding of the findings in the raw data. During this process, coding, labeling, categorizing, and reorganizing data happened simultaneously in the process of data collection and analysis.

## **CHAPTER IV**

### **A CAPSTONE COURSE: FINDINGS OF THE STUDY IN PHASE I**

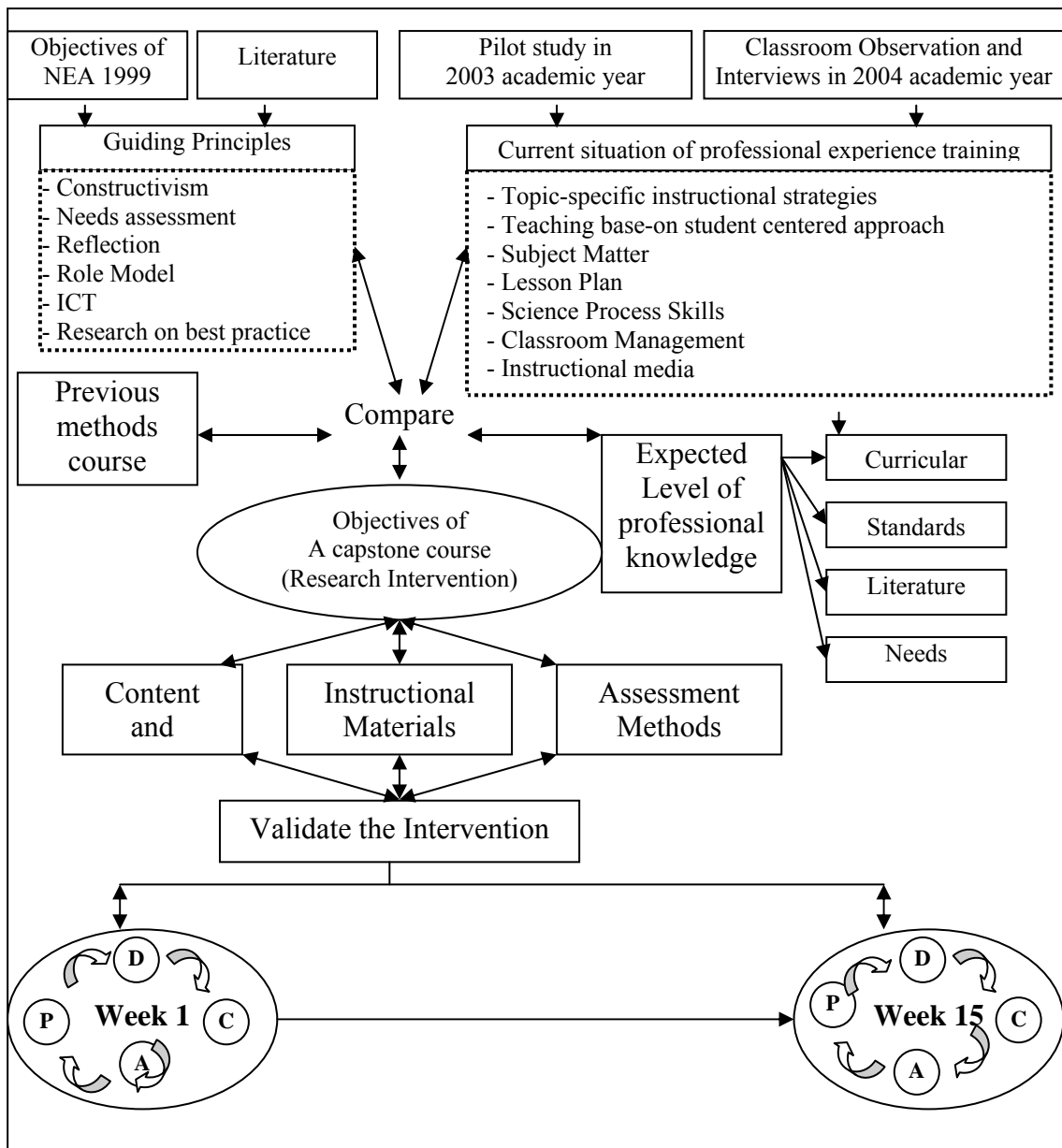
#### **Overviews of the Chapter**

This chapter aimed to answer the sub-research question what are the characteristics of a course designed to facilitate Thai pre-service science teachers' professional knowledge? This chapter provides a description of the research intervention which refers to a 15-week capstone course that was implemented in the first semester of the 2006 academic year in the Faculty of Education at an institution in central Thailand. The course was a one-credit compulsory course in the Teacher Preparation curriculum.

In the flowing paragraphs, the various steps taken to construct the course are outlined and described in detail.

#### **Process of Developing a Capstone Course**

The learning activities and experiences in a capstone course were designed to develop pre-service science teachers' professional knowledge. The process of developing a capstone course was shown in Figure 4.1



**Figure 4.1** The Process of Developing a Capstone Course

In the process of designing a capstone course, there were many issues including: the guiding principles which were abstracted from objectives of the NEA 1999, suggestions from literature; the current situation of professional experience training which was gathered from the pilot study (Rochanasmita and Roadrangka, 2005); classroom observations and interviews; expected level of professional knowledge drawn from the science teacher preparation curriculum, the teacher preparation standards, literature, the needs assessment; and objectives of the previous methods course.

## **1. Construction of the Guiding Principles**

The researcher analyzed Objectives of the National Education Acts (NEA) 1999 and suggestions from literature in the area of developing a course in construction of the guiding principle.

The objectives and principles of the NEA 1999 aim to enhance learners in all aspects including knowledge, skills, and attitude. The desirable characteristics that should be enhanced in all learners include: competency; creativity; a keenness for acquiring knowledge; self-learning; and happiness. The teaching-learning process, identified in Chapter 4, aims to facilitate the learners to develop themselves to the best of their ability, and to enhance scientific and technological knowledge of the learners. Organizing the learning process includes arranging activities, creating the learning environment, using instructional media, and facilities for learners, and should be based on the constructivist perspective.

In the process of designing a course, experts suggested to conduct a needs assessment as the first step. The program's characteristics will emerge from participants' perceptions. Moreover, in the current teacher preparation, knowledge and skills in using technology, knowledge of research on best practice, and reflective thinking, were suggested to prepare the teacher in the 21<sup>st</sup> century. Role models were suggested as a way to demonstrate how to teach lessons for pre-service teachers.

A capstone course was designed to be compatible with the NEA 1999 and suggestions from the literature by taking into consideration individual prior knowledge and skills to help them develop themselves to the best of their abilities. Pre-service science teachers were provided opportunities to see examples of how to teach, develop their professional knowledge, scientific and technological knowledge, creativity, inquiry, planning and teaching skills, and reflective thinking through the course activities. Moreover, their satisfaction, attitude toward teaching profession, and technology was encouraged during the course. A needs assessment was conducted and the results will be reported below.

In summary the key guiding principles used in this study were:

## **Guiding Principals**

### **1.1 Designing Professional Development Program Based on Constructivism**

Using constructivist epistemology in a teacher preparation program, pre-service teachers enrolled into the program with different backgrounds, personalities, motivation levels, and skills which influenced individual ways of learning how to teach. So, activities and experiences in the course were designed by concerning and challenging participants' existing knowledge, enhancing active engagement of participants, social interaction for participants to construct knowledge, and providing long term supporting knowledge construction.

### **1.2 Conducting Needs Assessment in the Course Designing Process**

An essential first step in revising the content and strategies of a teacher education curriculum is to assess participants' perceptions of the program's strengths and weaknesses. A needs assessment of pre-service teacher education students regarding their preparation and readiness for teaching was conducted in the 2004-2006 academic years respectively

### **1.3 Using a Variety of Reflective Tools to Develop Professional Knowledge**

Reflective thinking was aimed to enhance course activities. Journals and other reflective tools including lesson planning, microteaching, group seminars, and case-based pedagogy were used as reflective tools during the course. Journal writing was a weekly task for pre-service science teachers to reflect on what they learned or did from the course. This aimed to promote the continuous process of reflection.

Lesson planning and formative-evaluations from teachers, (self and peer) were aligned within activities of the course. This provided situations for pre-service science teachers in implementing each domain of professional knowledge in planning teaching units, and analyzing their own and their peers' lesson plans.

Moreover, some lesson plans will be implemented in the microteaching activities that were used for enabled pre-service teachers to practice and reflect upon specific aspects of their teaching practice before engaging with the greater complexity in school experiences.

A seminar was another effective strategy used to enhance learners to revise, construct, and share knowledge thorough a process of critique and discussion. The seminar was not only used for promoting knowledge construction and distribution, but also used for enhancing pre-service science teachers' ability to search for information online and from other sources.

Case-based pedagogy provided opportunities for pre-service science teachers to develop awareness of how they made sense of dilemmas they faced in their professional lives. When reflecting on the case, pre-service science teachers were enhanced to revise, explicate, and compare their current knowledge and belief with the provided situations.

#### **1.4 Using Role Models**

Base on the constructivist perspective, pre-service teachers individually and socially construct knowledge. Moreover, they can learn some aspects of how to teach science by seeing examples or model from a science educator. The researcher acted as course instructor who not only facilitated pre-service science teachers learning about teaching during the course, but also served as a role model who presented teaching practice for promoting student meaningful learning

### **1.5 Integrating ICT as a Tool to Prepare Teachers for the 21<sup>st</sup> Century**

As teachers have been encouraged to use technology in their subject teaching, in the 21<sup>st</sup> century, ICT became an important tool for supporting teaching and learning, and the nature of the teachers' profession. So, in the course, activities were designed to enhance pre-service science teachers' knowledge of instructional media and technology including the online discussion board, technology-based search for organizing seminar discussions and movie production.

### **1.6 Implementing Knowledge of Research on Best Practice**

In the era of knowledge based society, an understanding of the process of teaching, learning, and schooling has improved. Future teachers should be provided opportunities for analyzing and reflecting on knowledge about effective pedagogy, student learning of science, instructional media and new technology, and assessment in science from the research findings of the particular context. The sharing of knowledge not only enhances the development of all students but also guide the way for practice and future research. In the course, pre-service science teachers were enhanced in analyzing research done in Thai context and integrated knowledge of research on best practice into their planning and teaching.

## **2. Identifying the Current Situation of Professional Experience Training**

The data from the pilot study and classroom observations and interviews was used to identify the current situation of professional experience training. In the 2003 academic year, a pilot study was conducted in a department of the faculty of education in a central Thailand university about problems found in professional experience training. The results revealed that pre-service science teachers encountered problems which included topic-specific instructional strategies, subject matter knowledge, lesson plans, science process skills, classroom management, and producing instructional media (Rochanasmita and Roadrangka, 2005). Moreover,

from classroom observation and interviews during the 2004 academic year, it was found that pre-service science teachers could not teach using a student centered approach.

So, the topic-specific instructional strategies, subject matter knowledge, lesson plans, science process skills, classroom management, producing instructional media and teaching based on student centered approach were taken into consideration to design a capstone course.

### **3. Determining the Expected Level of Teacher Professional Knowledge**

The science teacher preparation curriculum, the teacher preparation standards, the literature, and needs assessment data were analyzed to determine the expected level of Teacher Professional Knowledge. In a prior study, the four-year science teacher preparation curricula and needs of the 4<sup>th</sup> year pre-service science teachers during 2004-2006 were analyzed. To obtain a description of the national four-year science teacher preparation curricula, syllabi and course descriptions were analyzed to identify goals and the content of the courses. The goals and content of the courses were categorized into each domain of teacher professional knowledge. Moreover, to fulfill requirements of participants in the particular place, needs assessments were investigated by using open-ended questionnaires. The researcher collected data at the end of the first semester of the 2004 and 2005 academic years, and before the first semester of the 2006 academic year. Answers were analyzed, first, the researcher read all of the pre-service science teachers' answers and tried to understand the underlying needs of participants as expressed in their writing. Then, their answers were analyzed line-by-line to generate pre-categories. The data supporting each pre-category in each year were analyzed to confirm that each data source contributed to the shared characteristics within a category. These final categories of needs were classified according to the domains of professional knowledge, as cited in available literature, and compared with results from extant data that emerged from analysis of the four-year science teacher preparation curricula

In the process of constructing the course, expected levels of professional knowledge (both international and national levels) were identified from the content and recommendations of standards for teacher preparation. The documents used were Standards for Science Teacher Preparation of NSTA (2003), GSTEP Framework for accomplished teaching of Georgia Systemic Teacher Education Program (2005), the Capable Teacher of the ERO in New Zealand (1998), Standard for Teacher Profession of Teachers' Council of Thailand, 4<sup>th</sup> edition (1999), and the National Plan for Reforming in Teacher Education and Development of Educational Personnel (ONEC, 1995).

In addition, research and literature in the area of professional knowledge development were analyzed to find out which domains of professional knowledge from educators' or researchers' perspectives should be the focus of enhancement in this study. The results are reported in Appendix G.

From Appendix G, the results from extant four-year science teacher preparation curricula indicate that most domains of professional knowledge were well covered, except knowledge of research on best practices. Concerning PK in both curricula, most sub-domains were recommended except classroom management. This was present only in Rajaphat Institutes' curriculum. Concerning PCK, Specific Science Curricula, Topic-Specific Instructional Strategies, and the Purpose of Teaching Science were emphasized in the Faculty of education curricula, but Rajaphat Institutes' curriculum put an emphasis only on Topic-Specific Instructional Strategies. The sub-domain of Student Misconceptions was not presented in syllabi and course descriptions in both curricula. The difference between the curricula of the two types of Thai teacher education institutions was that The Rajabhat University mainly emphasized the domain of General Pedagogical Knowledge (PK), while University Faculties of Education emphasized the domain of Pedagogical Content Knowledge (PCK).

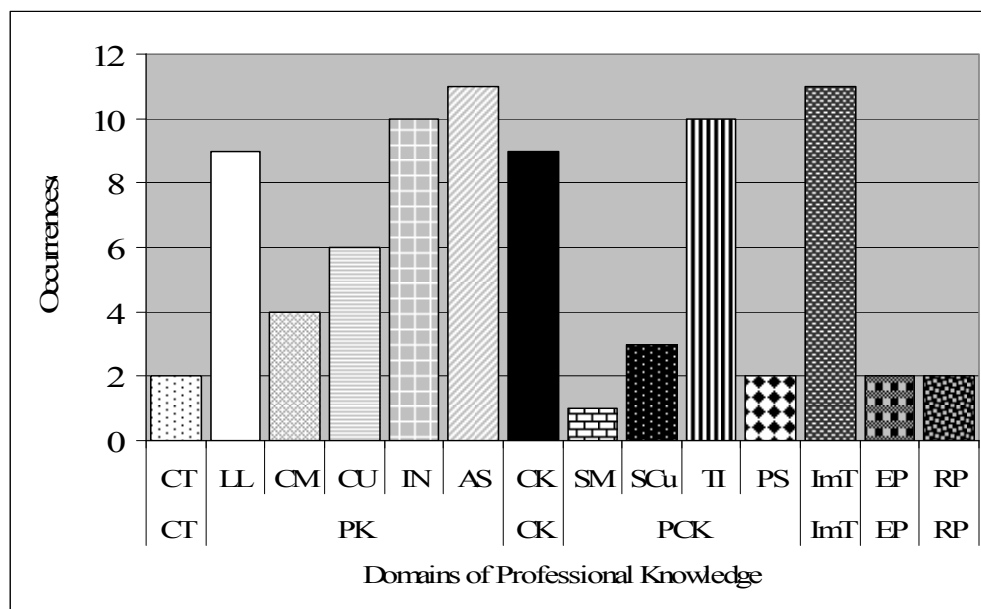
The standards for teacher preparation on the national and international level recommended enhancing most domains of teachers' professional knowledge. These

included PK, CK, PCK, Instructional Media and Technology and Research on Best Practice. All standards recommended enhancing CK and Instructional Media and Technology. Concerning PK, the sub-domains of curriculum knowledge were emphasized in the documents from NSTA (2003), GSTEP (2005) and ERO (1998), but not from Teacher Council of Thailand (1999) and ONEC (1995). PCK included knowledge of Specific Science Curricula, Topics-Specific Instructional Strategies, and Purpose of Teaching Science was only recommended from Standard for Science Teacher Preparation of NSTA (2003). Knowledge of research on best practice was presented in *The Capable Teacher* of the ERO (1998). In conclusion, the difference between teacher preparation standards for general and science education was that the NSTA (2003) recommendations for preparing teachers in science education put more emphasis on the PCK. Comparing international and Thai national levels, the international standards put an emphasis on knowledge of Curriculum.

Literature reviews in the area of professional knowledge development suggested enhancing the domains of PK including Learner and Learning (Penso, 2002), Assessment (Goodnough, 2002); PCK including Student Misconceptions (Halim and Meerah, 2002), Specific Science Curricula (Goodnough, 2002), Topic-Specific Instructional Strategies (Coble and Koballa, Jr., 1996; Goodnough, 2002; Halim and Meerah, 2002; and Zembal-Saul *et al.*, 2002); Instructional Media and Technology (Coble and Koballa, Jr., 1996); and Research on Best Practice (Goodnough, 2002).

The needs assessment recommended enhancing the domain of PK (Learner and Learning, Classroom Management, Curriculum, Instruction, and assessment), CK, PCK (Topic-Specific Instructional Strategies), and Instructional Media and Technology. Moreover, another aspect that represented an integration of domains of all of professional knowledge into lesson planning was one of the highest needs of pre-service science teachers in the three following years.

In conclusion, the expected level of professional knowledge from the science teacher preparation curricula, needs of pre-service science teachers, standards for teacher preparation, and research literature is presented in Figure 4.2



Note: CT = Educational Context  
 LL = Learner and Learning  
 CM = Classroom Management  
 CU = Curriculum  
 IN = Instruction  
 AS = Assessment  
 CK = Subject Matter  
 SM = Student Misconceptions  
 SCu = Science Curricular  
 TI = Topic-specific Instructional strategies  
 PS = Purpose of teaching Science  
 ImT = Instructional media and Technology  
 PH = Educational Philosophy  
 RP = Research on Best Practice

**Figure 4.2** An Expected Level of Professional Knowledge Recommended by the Science Teacher Preparation Curricula, Needs of Pre-service Science Teachers, Standards for Teacher Preparation, and Research Literature

The results revealed that all domains of professional knowledge were suggested by the science teacher preparation curricula, the needs assessments, the standards for teacher preparation, and the literature reviews. The top three high levels of recommendations included instructional media and technology, assessments, and instruction were taken into consideration to design a capstone course.

#### 4. Analysis of a Previous Methods Course

A previous methods course was analyzed and compared with the guiding principles, current situation, and expected levels of Teacher Professional Knowledge.

The previous methods course aimed to enhance pre-service science teachers' professional knowledge by bringing interesting issues in science education to discuss in class. When compared with the guiding principles, current situation, and expected levels of professional knowledge, a capstone course was designed to provide opportunities for pre-service science teachers revising each domain of professional knowledge, integrating all domains into planning and teaching practice through the process of seminar discussion. Strategies suggested from the guiding principles including reflection and role models were used in the course.

### **5. Setting the Objectives of a Capstone Course**

The objectives of the course were constructed based on the guiding principles, current situation of professional experience training, expected level of professional knowledge, and objectives of the previous methods course. The course goal is to enhance Thai pre-service science teachers' professional knowledge and abilities to integrate the domains of professional knowledge into lesson planning and transforming science content into effective teaching with respect to the National Education Acts 1999. The specific objectives included:

1. Analyzing the vision of learning of science, aim of science teaching, and the nature of science from the national science curriculum framework
2. Identifying components including expected learning outcomes, main idea, teaching and learning activities, instructional media, assessment and use appropriate format in lesson plan writing
3. Identifying expected learning outcomes aiming at the full development of the learners in all aspects: knowledge, process, and scientific attitude
4. Designing lesson plans considering the national science curriculum, prior knowledge and learning style of learners, a variety of instructional media and technology, classroom management strategies, and formative assessments to effectively assess the development of learners
5. Designing lesson plans considering science process skills

6. Teaching particular science content by selecting effective teaching strategies, questioning techniques, classroom management strategies to enhance learners' learning of science in the Microteaching activities.

7. Analyzing, evaluating, and sharing important concepts of lesson planning, teaching strategies, learners and learning, assessment from research or articles in science education, and apply that concepts into teaching practice.

8. Critiquing and accepting the commentary used to develop their own teaching

9. Working cooperatively with others

10. Developing reflective behavior in planning and teaching science lessons

## **6. Designing Content, Learning Activities, Instructional Materials, and Assessment**

The content, learning activities, instructional materials and assessments were designed based on the course objectives. The details were identified in topic of Outline and Scope of the Intervention.

## **7. Validate the Research Intervention**

In the process of constructing the course, the researcher worked with an American science education professor. The English course description, lesson plans, worksheets, and instructional media were validated again by the science education professor. After that, the documents were translated into Thai by the researcher. The Thai documents were validated by university professors which included: a science and technology educator, a science educator, a biological scientist, and a physical scientist who were supervisors of the researcher; and a science educator who was an instructor of a previous method course. A meeting was set before the implementation to validate the course description, lesson plans, worksheet, and other materials. The feedback from experts suggested adapting the sequence and adding some content of activities. Suggestions included: adding the microteaching 1 activity at the beginning

of the course; moving the research results presentation to integrate with the microteaching 2; and constructing an online discussion board.

Moreover, during implementation, the researcher worked cooperatively with the prior instructor of the method course. Weekly lesson plans, worksheets, and materials were adapted during each week of implementation. Changes mainly consisted in the language used in the documents. However, some activities were reduced because of time limitation. These classroom case reflections were reduced from four to two cases. Instead of the six lesson plans originally required, pre-service science teachers only had to design four.

### **Outline and Scope of the Intervention**

A capstone course was constructed based on suggestions from the guiding principles, current situation of professional experience training, expected levels of professional knowledge, and objectives of the previous methods course and implemented during the first semester of the 2006 academic year. Two hours a week, for fifteen weeks, the capstone course provided opportunities for pre-service science teachers to organize seminar discussion activities, practice their abilities in writing and implementing science lessons, reflecting ideas on classroom cases and the online discussion board, producing instructional media to support their teaching, observing and analyzing classroom problems, and integrating knowledge from research results into their teaching practice. The course syllabus that provides details, course descriptions, course objectives, contents, activities, instructional media and technology, assessments are presented on the following page.

## Course Syllabus

**Faculty:** Education

**Department:** Education

**Subject:** Seminar

**Code:** 159497

**Unit:** 1 (1-0)

**Semester:** 1

**Academic Year:** 2006

**Time:** 15 weeks: 2 hours/week

**Date and Time:** Tue 4:00 pm – 6:00 pm

---

### Course Description

The purpose of this course is to enhance pre-service science teachers' professional knowledge in lesson planning and transforming science content into effective teaching through the seminar process. During this course, the professional knowledge of student teachers will be developed especially in aspects of General Pedagogy Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Knowledge of Instructional Media and Technology and Knowledge of Research on Best Practice. This course will involve student teachers in various activities that let them plan, implement, and reflect on their lesson plans through the microteaching activities. During the course, they will have opportunities to integrate their content knowledge of science together with knowledge about how to teach from prior content and methods courses into teaching practice. In addition, they will have chances to read and reflect on issues critical to successful science teaching.

### Course Objectives

A course aimed to enhance pre-service science teachers' professional knowledge in lesson planning and transforming science content into effective teaching with respect to the National Education Acts 1999. The specific objectives included:

1. Analyzing the vision of learning of science, aim of science teaching, and the nature of science from the national science curriculum framework

2. Identifying components including expected learning outcomes, main idea, teaching and learning activities, instructional media, assessment and use appropriate format in lesson plan writing

3. Identifying expected learning outcomes aiming at the full development of the learners in all aspects: knowledge, process, and scientific attitude

4. Designing lesson plans considering the national science curriculum, prior knowledge and learning style of learners, a variety of instructional media and technology, classroom management strategies, and formative assessments to effectively assess the development of learners

5. Designing lesson plans considering science process skills

6. Teaching particular science content by selecting effective teaching strategies, questioning techniques, classroom management strategies to enhance learners' learning of science in the Microteaching activities.

7. Analyzing, evaluating, and sharing important concepts of lesson planning, teaching strategies, learners and learning, assessment from research or articles in science education, and apply that concepts into teaching practice.

8. Critiquing and accepting the commentary used to develop their own teaching

9. Working cooperatively with others

10. Developing reflective behavior in planning and teaching science lessons

## **Topics**

1. lesson plan components and writing learning outcomes

2. national science curriculum framework and the nature of science

("What are you planning to teach?")

3. teaching strategies ("How are you planning to teach?")

Cooperative learning

Inquiry

Lectures, discussion, demonstration and questioning techniques

4. prior knowledge and learning of learners

("Whom are you planning to teach?")

5. formative assessment in science  
(“When and how will you assess student learning”)
6. Instructional media and technology
7. Classroom management
9. Teaching and assessing science process skill

### **Classroom Activities**

1. investigate and present important concept by individual and group
2. analyze and criticize important ideas and group, classroom discussion
3. reflect own thought by weekly journals, classroom cases and Online Discussion Board (ODB)
4. write and teach science lessons
5. produce instructional media
6. observe and record classroom management strategies

### **Instructional Media and Technology**

1. Transparency/Overhead projector
2. White Board
3. Online Discussion Board (ODB)
4. Video camera, web-camera, computers, speakers and microphones
5. Window Movie Maker Program
6. Classroom case (1-2)
  - 6.1 case 1 The Enemy of Understanding is Coverage
  - 6.2 case 2 The Rubrics Assessment

### **Criteria for Assessment**

- |                            |      |
|----------------------------|------|
| 1. Classroom participation | 15 % |
| 2. Paper presentation      | 10 % |
| 3. Lesson plans            | 30 % |

4. Microteaching	30 %
5. Journal writing	10 %
6. Case reflection	5 %

## Assessment

**Table 4.1** Rubrics scales

Criteria	Rubric scales			
	Excellent (4)	Good (3)	Fair (2)	Poor (1)
Classroom participation (15 %)	Activities that represent students <i>always</i> participating in classroom activities include discussion, doing classroom activities, asking questions, expressing opinions and representing their enthusiasm.	Activities that represent students <i>always</i> participating in classroom activities include discussion, doing classroom activities, asking questions, expressing opinions	Activities that represent students' <i>partial</i> participation in classroom activities.	Activities that represent students absent or late, students <i>rarely</i> participating in classroom activities.
Paper presentation (10 %)	All tasks are handed-in in time. The tasks present <i>excellent</i> quality including: a reasonable analysis of the main idea, a further investigations, using own languages, clearly and correctly identifying references. Carrying out an interesting and understandable presentation, leading a classroom discussion and doing a critical reflection on the paper.	All tasks are handed-in on time. The tasks present <i>good</i> quality including: a reasonable analysis of the main idea, using own languages, clearly and correctly identifying references. Carrying out an interesting and understandable presentation, proving a classroom discussion and doing a critical reflection on the paper.	All tasks are handed-in on time. The tasks present <i>fair</i> quality including: a complete main idea, identifying references. Carrying out presentation by providing a classroom discussion and doing reflection on the paper.	All tasks are handed-in. The tasks present <i>deficient</i> quality main idea. Carrying out presentation by providing a classroom discussion and doing reflection on the paper.

**Table 4.1** (Continued)

Criteria	Rubric scales			
	Excellent (4)	Good (3)	Fair (2)	Poor (1)
Lesson plan (30%)	All lesson plans are handed-in <i>on time</i> . The lesson plans present criteria including: the use of the appropriate structure and components; the use of appropriate language; constructing learning outcomes and managing time and organizing learning activity, appropriately; and learning activities are interrelated with and the expected learning outcomes.	All lesson plans are handed-in <i>on time</i> . The lesson plans present criteria including: the use of the appropriate structure and components; the use of appropriate language; constructing learning outcomes and managing time and organizing learning activity, appropriately; and learning activities are interrelated with and the expected learning outcomes.	The 80% of lesson plans are handed-in. The lesson plans present the use of the appropriate structure and component.	The 70% of lesson plans are handed-in. The lesson plans present the use of the appropriate structure and component.
Microteaching (30 %)	Teaches complete scientific concepts by emphasizing learner-centered approach, present an enthusiasm in teaching, <i>excellent</i> prepare the lesson before teaching including: select or produce instructional media by concerning limitation of the learning environment; and use a variety of assessment strategies compatible with expected learning outcomes. Assess their own teaching, accept the assessment from the others, and find the way to develop their own teaching.	Teaches complete scientific concepts by emphasizing learner-centered approach, <i>well</i> prepare the lesson before teaching, and use a variety of assessment strategies compatible with expected learning outcomes. Assess their own teaching, and accept the assessment from the others.	Teaches complete scientific concepts by emphasizing learner-centered approach, and use a variety of assessment strategies. Assess their own teaching, and accept the assessment from the others.	Teaches complete scientific concept, sometimes presents alternative concepts, try to emphasize learner-centered approach

**Table 4.1 (Continued)**

Criteria	Rubric scales			
	Excellent (4)	Good (3)	Fair (2)	Poor (1)
Journal writing (10 %)	Handed-in all weekly journals. Present analytical, critical and reflective thinking in both positive and negative way.	Handed-in all weekly journals. Present analytical and critical thinking.	Handed-in 80% of weekly journals. Present analytical and critical thinking.	Handed-in 70% of weekly journals. Present analytical and critical thinking.
Case reflection (5 %)	Handed-in all case reflections. Presents <i>excellent</i> reflective thinking. Express an enthusiasm in asking, answering the questions, and present their own thought in classroom discussion.	Handed-in all case reflections. Presents <i>good</i> analytical and critical thinking. <i>Always</i> participates in classroom discussion.	Handed-in all case reflections. Presents an attempt to analyze and criticize the situation. <i>Sometimes</i> , participates in classroom discussion.	Handed-in all case reflections. Presents an attempt to analyze and criticize the situation. <i>Rarely</i> , participates in classroom discussion.

### Evidences for Assessment

Students will use a portfolio to present their own work. The portfolio content should consist of following components

1. cover page
2. table of contents
3. about me: to introduce the author which consists of history of education, strong and weak points of self, and expectations from this course
4. lesson plans: 4 lesson plans
5. content
  - 5.1 report and reflect on seminar organizing activity (preparation, conclusion, and assessment)
  - 5.2 conclude and reflect on a study of the research or literature

5.3 classroom management worksheet

5.4 homework such as reflection on the case and rubric assessment.

6. weekly journals: reflection on teaching and learning activities, opinions or feelings about participating in classroom activities, understanding of content.

7. Assessment

7.1 self-assessment on their own lesson plans, teaching, and other tasks

7.2 peer (at least 3) assessment on lesson plan and teaching

7.3 Suggestions for the activities in course

## Grading

Grade A	points 90-100
Grade B+	points 80-89
Grade B	points 70-79
Grade C+	points 60-69
Grade C	points 50-59

## Course Activity

**Table 4.2** Course activity

Week	Objectives	Topics	Teaching and learning activities
1	1. investigate prior knowledge 2. explain learning objectives, and activities of the course	Course syllabus and prior knowledge	1. learners develop lesson plans by using existing knowledge 2. learners answer conception about teaching and learning questionnaires 3. learners and instructors study the course syllabus together and analyze learning objectives, activities, and assessment strategies 4. learners select group and select topic to lead seminar organization and present ideas from research/literature 5. learners works in group to design lesson plan for microteaching 7. learners was communicated to record classroom

**Table 4.2 (Continued)**

Week	Objectives	Topics	Teaching and learning activities
			management worksheet for using in week 11 activity 8. the online discussion board (ODB) activity was introduced
2	investigate prior knowledge and	Microteaching 1	Group 1-4 (25 minutes/group)
3	ability in planning and teaching		Group 5-8 (25 minutes/group)
4	revise and fulfill knowledge in writing lesson plan, and reflective behavior in planning and teaching	lesson plan components and writing learning outcomes (Group1)	1. learners finish the prior knowledge worksheet (expected learning outcomes) 2. Group 1 lead seminar discussion on topics including format, and components of effective lesson plan, and effective learning objective 3. Case 1 was distributed to be homework
5.	revise and fulfill knowledge in utilizing national science curriculum framework and the nature of science	national science curriculum framework and the nature of science	1. discussion on the Case 1 2. learners work in group in analyzing and presenting vision for learning of science from the IPST framework 3. learners divide into home group, and then expert group to study each aspect of the nature of science and discuss in class
6.	revise and fulfill knowledge of teaching strategies and methods	Cooperative learning (Group 2)	1. learners finish the prior knowledge worksheet (cooperative learning) 2. Group 2 lead seminar discussion on topics including principles, advantages and weakness, and implication cooperative learning in science classroom
7.	revise and fulfill knowledge of teaching strategies and methods	Inquiry (Group 3)	1. learners finish the prior knowledge worksheet (inquiry learning) 2. Group 3 lead seminar discussion on topics including principles, advantages and weakness, and implication inquiry-based learning in science classroom
8	revise and fulfill knowledge of teaching strategies	Lectures, discussion, demonstration and	1. learners finish the prior knowledge worksheet (lectures, discussion, demonstration) 2. Group 4 lead seminar discussion on topics

**Table 4.2 (Continued)**

<b>Week</b>	<b>Objectives</b>	<b>Topics</b>	<b>Teaching and learning activities</b>
	and methods	questioning techniques (Group 4)	including principles , advantages and weakness, and implication lectures, discussion, demonstration and questioning techniques in science classroom 3. Individual lesson plan was assigned as homework
9	revise and fulfill knowledge of student's prior knowledge and formative assessment	Learners and learning and formative assessment (Group 5)	1. learners finish the prior knowledge worksheet (student's prior knowledge) 2. Group 5 lead seminar discussion on topics including importance prior knowledge and learning style of students, and formative assessments in science teaching 3. analyze and critique on VDO case : the rubric assessment 4. Individual lesson plans and a rubric assessment were assigned as homework
10	revise and fulfill knowledge of instructional media and develop knowledge of technology	Instructional media and technology (Group 6)	1. group 6 lead seminar discussion on topic of instructional media 2. instructor group teach the Window Movie Maker program 3. learners practice producing instructional movie in group 4. Individual media were assigned as homework
11	revise and fulfill knowledge of classroom management	Classroom management (Group 7)	1. group 7 lead seminar discussion on topics of classroom management 2. learners discuss classroom management worksheet
12	revise and fulfill knowledge of classroom management	Teaching and assessing science process skill (Group 8)	1. learners finish the prior knowledge worksheet (science process skills) 2. group 7 lead seminar discussion on topics of teaching and assessing science process skills.
13	assess knowledge and ability in	Microteaching 2	Microteaching and present research (group 1-3)
14	planning and		Microteaching and present the research (group 4-6)
15	teaching, and present research		1. Microteaching and present the research (group 7-8) 2. Conclusion and assessment

The course started with the first microteaching activity to provide an opportunity for pre-service science teachers to present their prior professional knowledge in planning and teaching. After that, the pre-service science teachers were organized into groups to revise and fulfill each domain of the professional knowledge. The seminar required groups of pre-service science teachers to search for information from online and other sources and to be responsible for being a leader for a weekly seminar. Each group, consisting of two to three people, planned, searched, concluded, and presented information in the form of a seminar discussion activity. At the end, the second microteaching activity was provided for pre-service science teachers to implement and present the professional knowledge again after the course had been implemented.

The topics of discussion included: lesson plan components and writing learning outcomes; national science curriculum framework and the nature of science; teaching strategies such as cooperative learning, inquiry, lectures, discussion, demonstration and questioning techniques; prior knowledge and the learning of learners; formative assessment in science; instructional media and technology; classroom management; and teaching and assessing science process skills. A variety of activities were provided. The main activities were investigation, discussion, presentation and reflection.

Case reflections and other activities in the course were designed to enhance the conception of teaching and learning of pre-service science teachers. Moreover, the researcher constructed a seminar website as a main page, through which members were able to link to the Online Discussion Board (ODB). The ODB was introduced and was used from the first week of the course. The aim of the online discussion board was to provide opportunities for pre-service teachers' reflections, and to act as another learning resource which class members could access any time and from anywhere.

At the end of fifteen weeks, the course requirements included: constructing four lesson plans (2 in groups, and 2 individually); producing instructional media

based on their selected science topic; reporting and reflecting on a seminar organizing activity (preparation, conclusion, and assessment); concluding and reflecting on a study of the research or literature; classroom management worksheet and other homework.

### **Summary**

In the process of designing a capstone course, analysis of available literature suggested that a methods course should (1) be concerned with individual prior knowledge and skills (2) provided opportunities for pre-service science teachers to see examples of how to teach (3) enhance scientific, technological, and research on best practice knowledge (4) enhance inquiry, planning and teaching skills, and reflective thinking (5) encourage the happiness, attitude toward teaching profession (6) enhance knowledge of topic-specific instructional strategies, subject matter knowledge, lesson plans, science process skills, classroom management, producing instructional media, utilizing technology, assessment and teaching based-on student centered approach (7) provide opportunities for pre-service science teachers to revise and implement domains of professional knowledge into planning and teaching practice through the process of seminar discussion (8) integrate reflection and role models were used as activities in the course. The course objectives, content, learning activities, instructional materials, and assessment of a capstone course were designed based on the results. The course aimed to enhance pre-service science teachers' professional knowledge in lesson planning and transforming science content into effective teaching with respect to the National Education Acts 1999. The course started with the first microteaching activity, followed with a seminar organizing activity, and a second microteaching activity. The topics of the course included: lesson plan components and writing learning outcomes; national science curriculum framework and the nature of science; teaching strategies such as cooperative learning, inquiry, lectures, discussion, demonstration and questioning techniques; prior knowledge and the learning of learners; formative assessment in science; instructional media and technology; classroom management; and teaching and assessing science process skills. The Online Discussion Board (ODB) was constructed and used from the first week of the course.

At the end of the course pre-service science teachers constructed individual and group lesson plans, produced instructional media, reported and reflected on the seminar organizing activity, concluded and reflected on a study of the research, and finished the classroom management worksheets and other homework.

## **CHAPTER V**

### **FINDINGS OF THE STUDY IN PHASE II: DURING THE COURSE**

#### **Introduction**

This chapter provides close-up realities of participants. This section provides answers for sub-research questions namely:

In what way does the course enhance pre-service science teachers' professional knowledge during the course?

Two guiding questions were developed: "In what way does the course influence Thai pre-service science teachers underlying professional knowledge?" and "In what way does the course influence Thai pre-service science teachers' abilities to implement their professional knowledge?" The development of the professional knowledge during the course was considered in two aspects. The first sub-research question, the influence on pre-service science teachers' underlying professional knowledge was determined by conceptions about teaching and learning. The second, pre-service science teachers' abilities to implement their professional knowledge was captured by monitoring the abilities of the participants in planning and teaching the lesson. The story was divided into four cases. Each case provided general information which included: sex, age, grade point average, and the readiness in implementing the professional knowledge into teaching practice. After that, changes of professional knowledge and conceptions about teaching and learning through a capstone course were reported. The story ended up with a summary of common findings that emerged from a cross-case analysis. To protect the identity of participants, the following pseudonyms were used: Prangwalai; Korapin; Sintu; and Sasithorn.

### **The Background of Participants and the Theoretical Sampling for Case Study**

Prangwalai, Korapin, Sintu, and Sasithorn (pseudonyms) were student teachers in the 4-year science teacher preparation curricula in the faculty of education of one university in central Thailand. All were majoring in Teaching Science and minoring in Chemistry except Korapin who minored in Biology.

Of eighteen students who majored in three different science majors (Physics, Chemistry, and Biology), there were a variety of reasons used for selecting cases. First of all is the willingness to participate in long term professional development both in a capstone course and student teaching practicum of pre-service students. Secondly, because of the background and confidences in Biology and Chemistry of researcher, so Chemistry and Biology students were monitored at the beginning. This facilitated the researcher to evaluate all aspects of pre-service science teachers' professional knowledge. The aim of the course is to enhance pre-service science teachers' professional knowledge in lesson planning and teaching, so the group of pre-service science teachers who want to prepare their lesson plan and teaching were monitored.

Along the course, the researcher looked for outstanding information that guided a case selection. Prangwalai and Sintu were pre-service teachers who had clearly aim in science teaching and science education. Korapin and Sasithorn were interested in area outside of science teaching and science education. The reflective ability was another factor that supported the case selection. This chapter starts with reporting from each case, the case of Prangwalai, the case of Korapin, the case of Sintu and the case of Sasithorn, and follows with the thematic findings emerged from the cross-cased analysis.

## **The Case of Prangwalai**

### **1. Prangwalai's Stories**

#### **1.1 Background and Expectations**

Prangwalai was a 21 year-old female student. She was a superior student with a 3.60 G.P.A (out of 4.0). Her major was Teaching Science and her minor was in Chemistry. Her expectation was that she was going to be a good teacher. She also wanted to earn a Master's Degree in Science Education.

#### **1.2 Readiness in Implementing the Professional Knowledge**

At the beginning of the course, Prangwalai presented her feelings and readiness in a questionnaire and interview that she was not ready for her student teaching practicum yet. She did not feel comfortable with her classroom management, scientific content, using technology, and teaching in a real classroom. However, she believed she could develop through experiences yet to be had. Nevertheless, the areas that she felt confident in were in weekly lesson plans and identifying learning outcomes and assessing student learning outcomes.

### **2. Prangwalai's Development of Professional Knowledge**

In the course designed by the researcher, Prangwalai worked in a group with her friend, a Chemistry student teacher. They planned, taught, and organized a seminar in topics of inquiry together. The development of professional knowledge of Prangwalai is reported in section 2.1 on underlying professional knowledge or conception about teaching and learning science and section 2.2 on implementation of professional knowledge.

## **2.1 Underlying Professional Knowledge**

### **2.1.1 Prangwalai's Early Conceptions of Teaching and Learning**

At the beginning, Prangwalai's journal showed her conceptions about teaching and learning in contradictory ways. Even though she believed in constructivism, the way she thought students learned best was through rigorous procedures. In her constructivist views, she said "Students learn by constructing their own knowledge".

Prangwalai believed in hands-on activities, however in her views, hands-on activities or any teaching and learning activities happened with rigorous processes. This indicates a technical view of teaching in which a teacher sets the procedures for students to follow. The following paragraph describes two examples of Prangwalai's ideas.

In most topics in science, a teacher teaches by using experiments, because good science teaching is allowing students to do experiments.....When doing activities, a teacher should explain in detail for students what to do and what to do next to avoid confusion in class (weekly journal: week 2).

One important thing in teaching is questioning, the teacher should know how to ask questions in every science topic and let students answer those questions by themselves (weekly journal: week 3).

There were some traditional views that emerged from Prangwalai's weekly journal. She believed in knowledge transmission where a teacher corrected students' misconceptions by explanation.

When students give a wrong answer or misunderstand, the teacher should find a way to explain the correct concept to them and change their ideas (weekly journal: week 3).

### **2.1.2 Compared to the National Framework, Conceptions Gradually Changed**

There were many activities in the course that provided opportunities for Prangwalai to analyze visions for learning of science and nature of science in the science curriculum framework and the National Education Act (NEA) 1999. These activities included case reflection (week 4) and analyzing science curriculum framework (week 5).

In week 4, Prangwalai clarified her conception about teaching and learning through classroom cases. The case was on the topic “The enemy of understanding is coverage” Prangwalai proposed the following ideas on the case.

After I analyzed the National Education Acts and science curriculum framework, I thought, he (the teacher) organized the classroom compatible with the national requirement in the NEA. His teaching was based on a learner-centered approach which let students question, design, investigate, read, analyze, and synthesize data by themselves. This is also compatible with the objectives of teaching science that aim to develop student scientific knowledge, science process skills, and student attitudes. “He organized learning activities based on students’ interests and abilities. By being concerned about individual differences, the knowledge that students construct will last longer and they can adapt that into their real lives (weekly journal: week 4).

Prangwalai revised the recommendations from the NEA and science curriculum framework for analyzing the classroom case. She found that the framework aimed to enhance the ability of students to construct their own knowledge, developing their science process skills and attitudes by mainly participating in the learning process.

In week 5, Prangwalai cooperatively analyzed a vision for learning of science and the nature of science in a curriculum framework with her classmates. In the activities, her group presented a concept map for representing the aspects identified in the science curriculum framework. She explained that:

With regard to learners, they should be taught to develop their thinking processes, their ability to inquire, and their problem solving skills. This is to help them construct their own knowledge (classroom observation: week 5).

By comparing her ideas with the recommendations, she showed her ideas were changing about the learning process in her weekly journal by writing:

This week after we analyzed, discussed, and presented our understanding of the vision for learning of science, I found that it was not just letting students only do the hands-on activities, but we as teachers should be concerned about what student's are thinking and how to help them construct knowledge from those activities. We have to develop students in all aspects: knowledge, science process skills, and morality (weekly journal: week 5).

Prangwalai's conception shifted more after finishing the second activity, analyzing the nature of science in the curriculum framework. She presented her new conception in the weekly journal with this entry:

The teaching and learning process that enhanced students' nature of science is the learner-centered approach that provides students hands-on activities and practice with the thinking process. The students will be provided opportunities in designing their own investigation. This enhances their thinking process, investigative process, problem solving skills, which a variety of activities including science projects or inquiry laboratory can be used in and outside the classroom. The teacher takes the role of a facilitator of each activity (weekly journal: week 5).

### **2.1.3 Prangwalai's Changing Views of the Teacher's Role**

Prangwalai noticed that the instructor used learning activities to help students change their misconceptions. Prangwalai agreed with the objective of providing activities to help students correct their misconceptions, or providing activities for students to discuss and clarify each others ideas. She presented what she noticed from the activities in her weekly journal with this entry:

First, I expected the instructor to answer our misconceptions from last week, but she set up an activity which provided resources and information for each group to analyze and discuss until we got the right answer, I think this is a good idea for helping students correct their ideas themselves or to compare ideas with other friends instead of the teacher telling students the right answer (weekly journal: week 5).

Prangwalai's views of the teacher's role in dealing with student misconceptions changed from transmission of knowledge to helping students construct knowledge.

### **2.1.4 The Conceptions Consistent with Constructivism During the Course**

Prangwalai's constructivist view was consistently presented in her weekly journals during the course. She presented her views on the aim of teaching, and on teacher and students' roles in the classroom.

The aim of teaching is for practicing students to think, practice, enhance their observations and question and find out information by themselves, so the teacher should often ask questions to engage students' thinking or encourage students to ask questions in the classroom (weekly journal: week 7).

Whichever teaching strategies a teacher uses should engage student participation. When students plan and manage their own learning, they will know the meaning of what and how they learned (weekly journal: week 8).

When students do experiments, the teacher should let students design the experiment and practice doing the experiment by themselves, while the teacher works as a helper. If time allows, the teacher should let students discuss the results from each group and make conclusions from these results (weekly journal: week 13).

Moreover, at the end of the course, Prangwalai's group lesson plan (microteaching 2) was consistent with constructivism. The lesson plan was on the topic of heat that affects changes in substances and it used a variety of activities to assess students' prior knowledge. The teacher let students design, present, and conclude their own group experiment. The conclusion came from the results of whole class discussion.

In summary, the underlying professional knowledge or conception about teaching and learning science of Prangwalai gradually changed from a combination of constructivist, rationalist, and technical views in the first three weeks to be more consistent with constructivism by the end of the course. She still believed in student construction of knowledge, but her view on the teacher's role changed from knowledge transmitter to that of a knowledge construction facilitator. She still believed in hands-on activities, but teaching and learning processes that were set in the rigorous procedures changed to become more flexible. Instead of using fixed procedures, having students design investigations became more acceptable in her view. She became concerned more with student thinking processes, learning activities becoming hands-on and minds-on processes.

## **2.2 Implementation of Professional Knowledge**

Prangwalai's revision of professional knowledge is reported in the following sections in each domain and followed with how each domain is implemented into planning and teaching practice.

### **2.2.1 Prangwalai's Professional Knowledge Revision**

#### **A. Knowledge of Educational Context and Science Curriculum**

##### **Framework**

Before the course, Prangwalai was familiar with the National Education requirements identified in the NEA1999 and the national science curriculum. She said almost every methods course emphasized these documents (interview). Prangwalai participated in analyzing these documents again in this course (week 4 and week 5). She revised her prior understanding and developed a newer, deeper knowledge through the course activities. She concluded that the aim of educational context both in general and in science is the following:

In general views the NEA 1999 identified that the teaching and learning process should be organized on the principle that all learners are capable of learning and self-development and are regarded as being most important. The teaching-learning process shall aim at enabling the learners to develop themselves at their own pace and to the best of their potential. In science, the learner should be enhanced in knowledge, process and attitude toward science, and the learning process should be a life-long process that uses local learning resources.

She presented her ideas that the activities in the course were different than activities that she had done before through her weekly journal and interview:

I discussed the conclusions of this document (the NEA 1999) in many courses, but this time, it is not just for conclusions. I had to revise my former understanding and use that for analyzing the classroom case, analyzing other teacher's teaching in the classroom. I did revise my knowledge, and also brought that knowledge to analyze teaching practice whenever it fits with the requirements (interview).

I analyzed the science curriculum framework many times, but I didn't know why it was important. In this activity, I revised what is the requirement and how that can be changed to be a guide for my teaching. When we plan the daily lesson plan, we have to be concerned about individual differences, student prior knowledge and when we set the expected learning outcomes all three aspects (knowledge, process, and attitude) should be covered. When I looked closely at the science curriculum framework, I saw the hierarchy of concepts in each grade level. This can be used to measure students' prior knowledge before learning in the next level" (weekly journal: week 5).

Prangwalai had prior understanding of educational context and the science curriculum framework from her methods courses. The activities of the course provided opportunities for her to revise and implement her knowledge into teaching practice analysis and planning the lesson.

### **B. Knowledge of General Pedagogical Knowledge (PK)**

Prangwalai had already learned all aspects of general pedagogy in her methods courses. She was confident in aspects of learner learning, teaching strategies, and assessment, but she was not confident in aspects of classroom management, scientific content, using technology, and teaching in a real classroom.

On the prior knowledge worksheet, Prangwalai presented her understanding about student prior knowledge that directly affected learner learning. There were a variety of assessments used for investigating students' prior knowledge

(week 9). She provided some examples of the assessment strategies including paper examinations, students' tasks, and self assessment. Moreover, in her methods courses, she learned a variety of strategies for teaching science including cooperative learning, inquiry, lecture, demonstration, and discussion (interview). Prangwalai also studied some classroom management strategies, but she said she had never seen or used them in a real classroom. She would like to know more about techniques, and had chances to see or practice her classroom management techniques (open-ended questionnaire).

Through the activities of the course, Prangwalai's general pedagogical knowledge was extended based on her prior knowledge. She revised and expanded her prior understanding, especially related to topics for which she led seminar discussion (inquiry).

I revised my prior knowledge on topics related to seminar discussion activities, especially the inquiry topic where we were the lead group. Our group had to revise this topic (inquiry) for teaching our friends; first, we revised our knowledge by reading from a variety of sources, and searching for more information. This helped us have a deeper knowledge about the process of inquiry learning, so that we could transform it into a learning activity to present the inquiry process for classmates to analyze (weekly journal: week 7).

In other weeks, when participating in seminar discussions, Prangwalai sharpened her knowledge by seeing more examples and had opportunities in using that knowledge to design lesson plans or learning activities.

The activity from this week made my understanding of cooperative learning more clear in the strategies. I saw examples of classroom activities and had a chance to design science lesson plans by using this strategy (weekly journal: week 6).

I remembered that I learned rubric assessment when I was in the 2<sup>nd</sup> or 3<sup>rd</sup> year. In this course I revised my knowledge about rubric assessment. I

experienced designing rubrics to assess students in my lesson plans. Moreover, I saw a short video of teacher Jim's classroom; he made assessments relevant to students. By letting students create a rubric score together, they will know what the meaning of the score is. This can enhance student's willingness to learn (weekly journal: week 9).

Not only did Prangwalai participate in seminar discussions on the topic of classroom management organized by her classmates, but she also observed classrooms at one laboratory school. This was an activity of another companion course. As part of the capstone course, Prangwalai had to finish recording a classroom management worksheet. She had to record the problems or achievement situations that happened in class, and identify how a teacher responds to those situations. After finishing activities, Prangwalai presented her feelings in weekly journal with this entry:

I saw many examples of classroom problems and the strategies that the teacher used to manage those problems from seminar discussions. This group used role play to present. I also noticed real situations happened in the classroom. After observing, each of us brought individual sheets to share in class. I saw many problems that I never expected to happen in class; this reminded me that anything can happen in a classroom (weekly journal: week 11).

Prangwalai's prior knowledge of general pedagogy was revised through the course including learner learning, teaching strategies, assessment, and classroom management techniques. Her confidence in classroom management improved and she used more appropriate language and provided more positive feedback, but her concerns about unexpected students' misbehaviors still exist in her journal from the last week.

I feel more comfortable with grouping students in class, and the teacher's role including using appropriate language and providing positive feedback for students who are well behaved. I know appropriate ways to prevent students

who do show respect and pay attention, but I am still concerned about unexpected students' misbehaviors in class (weekly journal: week 14).

### **C. Subject Matter Knowledge**

Before the course, Prangwalai said that she needed better understanding of content knowledge that she had in order to complete her student teaching. She wanted to know more about details of her practicum school such as grade levels, topics of science, so she would be able to prepare herself in the specific science content area (open-ended questionnaire).

After participating in a microteaching activity, Prangwalai showed that she realized she had a deficiency with some scientific concepts, so she started studying by herself and used her new scientific knowledge to analyze her friends' teaching in class.

In my own teaching, when a friend asked me questions and I could not answer, I knew that my content knowledge is weak. I went back home to review the topic myself. I am afraid that I can't answer these kinds of questions again in my class. For analyzing friends' teaching activity, I also revised my scientific concept by using them to analyze my friend's lesson plans and teaching (interview)

In the nature of science, Prangwalai felt that her knowledge about the nature of science had deepened during the course. She revised her conception of the nature of science in all aspects including her scientific world view, scientific enquiry, and scientific enterprise. An example of her reflection from her weekly journal was presented in the following paragraph.

For me, even though I already studied the nature of science in other courses, sometime I just forgot about it. Today, it is like a revision of my knowledge in topics of scientific world view, scientific enquiry, and scientific enterprise. I

have become more understanding about the nature of science (weekly journal: week 5).

In addition, Prangwalai presented her views on scientific knowledge that affect teaching and learning in classroom:

Scientific knowledge is not absolute truth; it is stable but can be changed if we have new supportive information. To do scientific experiments is not for proof of the scientific idea that we already have, but we do scientific experiments to observe what happens and why it happened and then make conclusions about those concepts (weekly journal: week 14).

#### **D. Knowledge of Instructional Media and Technology**

Knowledge of technology was the most difficult for Prangwalai. She said that she was not computer literate (weekly journal). Throughout the course there were many activities used to enhance this domain of professional knowledge including a seminar organizing activity, an online discussion board, and the designing instructional movies activity.

In the seminar organizing activity, Prangwalai was forced to be the leader of the group who organized activities for friends to discuss topics of inquiry. She learned from her mistakes about searching for information through internet that:

We started searching for information from a variety of sources 3 weeks before our group started. At that time, I just read topics and printed out a bunch of information without going into the details. I learned it did not work, because some internet sources were not reliable. Sometimes I want to go back to the source, but I can't because I didn't record the address of documents....I learned that next time I will be more critical in searching" (reflection on the seminar organizing activity).

For her presentation, Prangwalai revised her knowledge and ability in producing a PowerPoint presentation.

I am appreciating my group work, in the process of planning. My friend and I talked about the layout, selected important information, and put them together in a PowerPoint presentation. Even though, my colleague did most of the work, I helped her along the process and learned some techniques from her (reflection on the seminar organizing activity).

When the online discussion activity was introduced to the class, there was only one pre-service science teacher that posted a question about formative assessment, and none of the others joined the discussion at the beginning. Therefore, the instructor brought the topic that was posted to the next class and reminded the other class members of the importance of reflection and discussion. After that, Prangwalai participated in the discussion. She presented her personal feelings and resized and uploaded the pictures.

I am so tired; I have a lot of work to do including preparing lesson plans, and a seminar discussion activity....and I am also concerned that I will not be able to control the class (topics 59).

At first, Prangwalai tried to upload the picture, but her picture was too big. So, it was not shown on the board. Her friend suggested that she should resize the picture. Finally she knew how to resize the picture before uploading.

I posted the picture....but it did not work, now I can resize and post it on the board, how great is that?! (Topic 11)

In the designing instructional movies activity, Prangwalai was purposely asked to participate in the training activity using the Window Movie Maker program. She had never used the program before, but she was willing to learn about the program. After training and practicing, Prangwalai and her other two friends

taught the other students in the class. By participating as an instructor, Prangwalai expressed her feelings in the weekly journal that:

I am very proud that I could be in one of the instructor groups that explained how this program worked for my friends. In the training, I learned this program by practicing importing video and picture files, capturing picture and video from a web cam, and recording voices. After that, I participated in the classroom as one of the instructors and an assistant of one group in producing a movie...I feel more familiar with using computers and other accessories (weekly journal: week 10)

After she participated in seminar discussion and practiced producing an instructional movie, Prangwalai expressed what she learned in her weekly journal that:

Today, I learned that selecting or producing instructional media should be concerned about the aim and activities of the lesson, number and characteristics of students, content and context of the lesson..... A teacher is not the only one who prepares the instructional media for student to learn, but the teacher can provide opportunities for student to produce instructional media which can be also used to assess an understanding of student concepts” (weekly journal: week 10).

### **E. Knowledge of Research on Best Practices**

For her Microteaching 2 lesson, in addition to planning and teaching, Prangwalai analyzed research done in a Thai context and integrated knowledge of research on best practice into her planning and teaching.

From her reading, Prangwalai analyzed the findings about the current situation in teaching science in school, teacher characteristics, and techniques

that were suggested to enhance student participation in classroom activities. Prangwalai said that:

Our research was about teaching science by emphasizing student participation in the class activities including stating a hypothesis, planning an investigation, controlling variables, discussion, and conclusions to achieve the national requirement. The findings revealed that there were many schools that did not emphasize this strategy. To use this strategy, teachers can use a variety of activities and a variety of probing questions to enhance students' interests in the topics (classroom observation)

Moreover, being the listener when the other groups presented, Prangwalai expanded her knowledge of research on best practice and saw implications of this knowledge for practice. She presented this in her weekly journal:

Today, my friends' research was about the student-centered approach, using local resources to support teaching, and the function of instructional media in teaching science. I gained more knowledge of research findings from last week, and I saw the way that they apply to the teaching practice (weekly journal: week 14).

Prangwalai presented her feelings toward a particular research-based activity in her weekly journal with the following entry:

I thought it was a very good activity. If we only read and conclude the researches, we will know only main ideas or parts of theories. We may not know how to apply it to teaching practice. In the activity, I saw the way to apply this towards teaching specific science content. When I tried to use this, it helped me think about the benefits and deficiencies of the application. Moreover, none of us read the entire research findings, but we read our own research and brought the knowledge to share with friends in class. This was known from theory and bringing it into practice (weekly journal: week 13).

In summary, participating in reading and implementing knowledge of research on best practice, Prangwalai perceived the current status of teaching and learning science, what techniques or strategies are suggested from the research, saw applications of knowledge from her own and friends' planning and teaching, and shared knowledge with friends.

### **2.2.2 Prangwalai's Implementation of Each Domain of Professional Knowledge**

An integration and implementation of each domain of professional knowledge was presented in Prangwalai's lesson plans, her teaching practice, and her instructional media.

#### **A. Lesson Plans**

##### **1) Incomplete Prior Knowledge and Ability Presented in the First Microteaching**

Concerning Prangwalai's ability to integrate the domain of professional knowledge and implement it into lesson planning in the microteaching activity 1(Week 1), Prangwalai planned the lesson together with her friend. Their group selected the Chromatography topics to teach grade 7 students (which was organized in the university campus and had their friends as students).

In lesson plans, their group presented the constructivist perspective by being concerned with student prior knowledge and letting students design and do experiments by themselves. In the closure, students in each group made conclusions with a discussion activity. However, this lesson plan was not written in detail. For example, the introduction part identified that the teacher would ask questions to inquire about students' prior knowledge, but there were not specific questions written in the lesson plan. Each component of the lesson plan included: expected learning outcomes, main ideas, learning activities, instructional media, and

assessment, but these were not interrelated. For example, she identified expected learning outcomes for students to understand concepts of chromatography and be able to calculate the Rate of flow ( $R_f$ ), but in the section of main ideas, it identified only concepts of chromatography method, but the concept behind the Rate of flow ( $R_f$ ) was not presented. Moreover, Prangwalai's group lesson plan presented an understanding of the closure component that was the conclusion of an experiment, not the conclusion about the concepts of Chromatography.

## **2) Knowledge and Skills in Lesson Planning Corrected and Extended**

Prangwalai's first lesson plan was handed in two days before her microteaching. The lesson plan was corrected by her classmates, instructor, and the researcher. Prangwalai said she found her mistakes when she read the feedback. She also compared the feedback with knowledge gained from the seminar discussion activity, on the topic of lesson plans, and used it to develop the next lesson plan.

The first lesson plan, used for microteaching 1, we planned and wrote it together. We checked the components of the lesson plan before we handed it in to you (the researcher), but after we got feedback from you and our friends, a lot of incomplete parts were found. An outstanding mistake that I noticed which was compatible with suggestions from the seminar discussion of group 1 (lesson plan) was that each component of the lesson plan should be interrelated (interview).

Moreover, her misunderstanding about the closure part was corrected and presented in her next lesson plan and expressed in her last weekly journal.

First I thought when we did the experiment, the closure part of the lesson was the conclusion of the experiment. Actually, the experiment and conclusion of the experiment should be written in part of the teaching and learning activity.

The closure of the lesson should contain activity that helps students to acquire the concept from the lesson (weekly journal: week 14).

Prangwalai corrected and extended prior knowledge and skills in lesson planning by using feedback and knowledge gained from seminar discussion.

### **3) Gradual Development of Prangwalai's Lesson Plans**

Prangwalai's lesson plans gradually developed. She integrated several domains of professional knowledge into lesson planning. During the course, Prangwalai constructed individual lesson plans by integrating knowledge gained from the seminar discussion activity. Gradual changes occurred in each of her lesson plans. Her lesson plans became more detailed and components became more interrelated. She used her content knowledge, both in and out of areas of her expertise and identified important concepts which related to the expected learning outcomes of the lessons.

In her first individual lesson plan, Prangwalai planned to teach grade 9 students on the topic of reflection of light in one period (50 minutes). She integrated her knowledge of inquiry, expected learning outcomes, and lesson planning into designing the lesson. Students' knowledge and ability to do experiments on the reflection of light were aimed to enhance in the lesson. In the introduction part, she engaged students with pictures and questions that started students thinking. One such question was "What do you think will happen when the light is pointed to a mirror?" Prangwalai let students write down their answers on the picture, and followed with the exploration step. Students designed and did an experiment in groups by using equipment provided in class. In the explanation step, Prangwalai let each group of students present, explain, discuss, and conclude the concept from their experiment in class. In the elaboration step, Prangwalai engaged students with more complicated pictures and questions like "What do you think will happen when using two mirrors?" At the closure, the evaluation step, Prangwalai provided each group a

worksheet to conclude and revise the group concepts before making conclusion from the whole class.

In the second lesson plan, Prangwalai planned to teach grade 7 students on the topic of separating substances by distillation in one period (50 minutes). She integrated knowledge of teaching methods and techniques including discussion, demonstration, and questioning into the lesson plan. Prangwalai appropriately identified expected learning outcomes to enhance students' knowledge, processes, and attitudes. She specified the main ideas of simple and fractional distillation. In the learning process, Prangwalai used questions to investigate students prior knowledge, demonstrated the experiment, and let students conclude what they observed from the experiment. In the conclusion section, students wrote in a learning journal and constructed a mind map. Prangwalai provided opportunities for students to investigate more about other methods used for separating substances. She integrated knowledge of rubric assessment to evaluate students' learning journals and their investigation conclusion sheets.

In the final lesson plan, Prangwalai planned the lesson together with her colleague to be used in microteaching 2. The grade 9 lesson was on the topic of the change of state of substances. The lesson plan contained appropriate expected learning outcomes which enhanced student knowledge and science process skills. The lesson plan was written in detail and the components were interrelated. Prangwalai utilized her knowledge of science content, the nature of science, pedagogy, instructional media, the learner and learning, science process skills and assessment in designing the lesson. Moreover, the learning process presented Prangwalai's integrated knowledge of research on best practice. The research emphasized the role of students including stating hypotheses, planning investigations, control variables, discussion, and drawing conclusions, which the lesson plan was designed based on the suggestions of the research. The lesson plan also emphasized students' science process skills including observation, measurement, constructing hypothesis, experimentation, and data representation.

In summary, participating in lesson planning activities helped Prangwalai revise and integrate knowledge into practice. Prangwalai's individual and group lesson plans presented the gradual changes in the writing of details, checking for interrelation of each component, correcting misunderstanding, and integrating each domain of professional knowledge.

## **B. Teaching Practice**

### **1) Teaching Practice Compatible with Her Conceptions**

During her microteaching 1, teaching practice, Prangwalai taught the lesson by herself. At first, she followed the lesson plan by asking questions to inquire about students' prior knowledge as identified in the lesson. Even though the lesson plan was based on constructivism, Prangwalai didn't do what she identified as her goal for the lesson. Her teaching was based on rationalism where the teacher's explanation is step by step. Prangwalai explained the materials to the students and followed with each step of the experiment. In the closure part, Prangwalai didn't organize the discussion activity for students. Instead, she drew conclusions by explaining to the students what happened and what the reasons behind what happened were. When she was asked about the reason for this teaching behavior, she said she was not confident with the concept that she was teaching, and she was concerned about the students understanding the topics.

I didn't feel confident in the concept, and also Thep (one of students and her classmate) presented his confusion in the topic, so I felt it is better to explain to them how to do it and help them understand the concept (interview).

Prangwalai's teaching practice was not compatible with her lesson plan. When she was not confident in the topic, her teaching was compatible with traditional conceptions. During the course, Prangwalai's progress in terms of teaching could not be observed because of time limitation. There were two microteaching sessions provided, one at the beginning and one at the end of the

course. In the first microteaching class, Prangwalai acted as a teacher, but in the second, Prangwalai and her colleague switched roles. Nevertheless, Prangwalai's teaching practice was observed again during her student teaching.

## **2) Through Microteaching Activity Prangwalai Ready for the Real Classroom**

Prangwalai presented her feelings about the microteaching activity and that it provided her an opportunity to encounter and think about problems.

I thought this activity (microteaching) was very beneficial for us to practice teaching before the student teaching practicum. Even though the environment is not exactly the same, ...this activity also provided opportunities for me to encounter problems, revise the problems, and think about how can I manage those problems ahead before the real teaching (week1)

Moreover, the feedback from classmates and instructors helped Prangwalai revise her own teaching.

When I came back to review myself and compare the feedback that I got, I found that I presented many mistakes such as not speaking smoothly and directly telling students the steps of the experiment and conclusion (week1).

The microteaching activity provided Prangwalai an opportunity for practicing her teaching and providing feedback to help her revise and develop her teaching before the student teaching practicum.

## **C. Producing Instructional Media**

To fulfill one of the requirements of the course (producing instructional media), Prangwalai implemented her knowledge of Windows Movie

Maker in producing an instructional movie, to use as a supplemental resource on the topic of “trees.”

### **1) The Integration of Knowledge Presented in the Process of Planning**

Prangwalai’s integrated knowledge of science in specific content areas (content knowledge: CK), pedagogical knowledge (pedagogical knowledge: PK) or methods of teaching and learning into the idea of knowing what teaching approaches fit the content (pedagogical content knowledge: PCK). She presented the integration of each domain in the process of planning.

Before getting started, we discussed what scientific concepts can be presented by using instructional videos, and how we could make the topic interesting, cover the science curriculum standard, and be appropriate for students in the middle school level (reflection on instructional media production).

### **2) Knowledge of Technology Used in Filming and Editing Movies**

Prangwalai integrated her knowledge and skills in using technology (TK) to produce instructional movies. Her practice included operating software and hardware, and filming and editing movies.

After planning, we started the process of filming by using a video camera, importing the video to a computer, and editing it with Windows Movie Maker. We all participated in the whole process of production (reflection on instructional media production).

### **3) Prangwalai Used Critical Reflection in Analyzing Artifacts**

Even though, the interweaving of the domains of content, pedagogy, and technology knowledge was presented in her artifact. Prangwalai reflected that the final product needed to be more developed in some points.

The instructional media was not completely perfect. I thought we should select a bigger size of flowers and fruits and provide different kinds of trees for providing complete information about the compositions of trees (reflection on instructional media production).

In summary, Prangwalai integrated the domains of her science content, pedagogy, technology in the process of planning, filming, editing and reflecting in her instructional media.

## **The Case of Korapin**

### **1. Korapin's Stories**

#### **1.1 Background and Expectations**

Korapin is a 22 year-old female student. She was born in a province next to Bangkok, in the central part of Thailand. She is a good student with a 3.05 G.P.A (out of 4.0). Her major is in Teaching Science and her minor was in Biology. Korapin doesn't want to be a science teacher; she would like to work in the field of business.

#### **1.2 Readiness in Implementing the Professional Knowledge**

At the beginning of the course, Korapin presented her feelings and readiness in a questionnaire that she was not ready for her student teaching practicum yet. She did not feel comfortable with her scientific content, writing lesson plans and

assessment. She would like the course to prepare her in these areas before her student teaching.

## **2. Korapin's Development of Professional Knowledge**

In the course, Korapin worked in a group with her friend, a biology student teacher. They planned, taught, and organized a seminar on the topics of learner and learning and formative assessment. The development of professional knowledge of Korapin was divided into two parts: underlying professional knowledge or conception about teaching and learning science, and the implementation of professional knowledge.

### **2.1 Underlying Professional Knowledge**

#### **2.1.1 Korapin's Early Conceptions of Teaching and Learning**

At the beginning, Korapin showed her conceptions about teaching and learning in a constructivist perspective, and there was some technical view also presented. Korapin expressed her view on teaching and learning in the questionnaire that her class was based on hands-on activities. She believed that students can construct knowledge through activities by conducting an experiment. The teacher acted as a facilitator. However, she thought that a teacher should start the lesson by asking questions to engage students in the learning activity. Students acted as answerers who listened to what the teachers asked, and then designed and conducted an investigation to answer those questions. She presented her view in the weekly journal with this entry:

I thought the heart of teaching science is questioning technique; a teacher should ask questions to engage students in the learning activities and the students should design and do experiment to find out the answer by themselves (weekly journal: week 3)

Korapin's view on the teacher's role was presented in the prior knowledge sheet that the teacher acted as a facilitator that helped students correct their misunderstandings by using a variety of activities. She presented her answer with the following entry.

When a teacher found students' misconceptions, he/she should provide them with activities that help them correct their misconceptions (prior knowledge sheet)

Korapin's view on reflective learning was presented in her weekly journal. She thought that reflection was not effective to enhance the learning of students who dislike expressing their ideas. Korapin presented her ideas on reflection based on her personal feelings with these entries.

I like the learning activity this week, because I don't have to reflect on my thoughts. I think reflection is not effective for a student like me (weekly journal: week 2)

I don't think reflection works with students who don't like to express their ideas. For example, I am not good at reflective writing or speaking. I don't think reflection enhances learning (weekly journal: week 4)

### **2.1.2 Compared to the National Framework, Conceptions Changed**

Korapin analyzed objectives of the National Education Act (NEA) 1999 and compared those with the classroom case. Korapin extended her conception about teaching and learning. She proposed the following ideas on the case:

I thought the teacher organized the classroom compatible with the national requirement in the NEA 1999. The teacher used a learner-centered approach, provided a variety of learning activities, and aimed to enhance students in all aspects. Moreover, in the acts, it also suggested the learning process should

aim to enhance students' thirst for knowledge and ability to preserve natural resources and the environment. In the case, students started their learning by asking questions. After that they designed and conducted an investigation for answering the questions by themselves. Students practiced their thinking process while asking questions and their curiosity was enhanced by asking the questions about the world around them. Moreover, their awareness was also developed through the activity (weekly journal: week 4)

Korapin's idea was compared to the aim of national education. She found that by starting the lesson with students asking questions, the curiosity and awareness can be enhanced.

### **2.1.3 Receiving Feedback, Korapin changed views on Reflective Learning**

It is important for learning to see the importance of students' reflections through weekly journals. During the course, the researcher who acted as a course instructor, provided feedback in every weekly journal. Korapin's weekly journals contained feedback to encourage her reflective thinking.

Throughout the course, Korapin's journal changed from half a page long from the first week to be one and a half to two pages long with a fruitful content at the end of the course. The changing of Korapin's view on reflective learning was presented in her weekly journal with this entry.

First, I feel I am the kind of person that doesn't like to reflect upon what I learned. I don't think reflecting will help develop my own learning, but, after I handed in the first week journal and got detailed feedback, it surprised me. I had never thought that my voice was important. You (instructor) provided me encouragement, suggestions, and guidance how to reflect on what I had learned. I have learned how to reflect my ideas since then. From the first week until now, I noticed that my reflections were more detailed. I thought about

what I learned and what factors that effect my learning. I think writing learning journals works! Students should be encouraged their reflective learning ability and the teacher should suggest them how to do so (weekly journal: week 12)

Korapin's reflective thinking was encouraged through the course by receiving feedback and suggestions. She noticed the development of her reflection, and the effectiveness of the learning journal.

#### **2.1.4 Korapin's Conceptions Continue During the Course**

During the course, Korapin's constructivist view was continuing. The aim of science education was suggested in the IPST science curriculum framework. When Korapin analyzed the framework, she presented the reflection with this entry:

Vision for learning of science was set as a way of looking for the future about what and how to develop teaching and learning process in science education. After I analyzed the vision, I found that the curriculum should be designed to enhance the ability of students to construct their own knowledge, develop their science process skills and attitudes, and their awareness in using science for the good of environment and society (weekly journal: week 5).

In the microteaching activity, Korapin presented her ideas on the aim of teaching and learning science when providing feedback for her friend's teaching with this entry.

Whichever strategies the teacher used, he/she should be concerned with the national requirements in student construction of knowledge. The teacher should provide the hands-on activities that enhance the student thinking process, science process skills, and attitudes toward science (weekly journal: week 14)

Moreover, Korapin's conception that the teacher's role was to help students change their misconceptions by providing activities continued. She used her conception to assess her friend's teaching in the microteaching 2 activity. She presented her suggestions in the weekly journal with this entry:

For group 3, I thought that when students presented their misconceptions, the teacher should not say that their ideas are wrong. The teacher should provide the activities that help them compare their misunderstanding with friends or scientific knowledge (weekly journal: week 13)

In summary, at the beginning, Korapin's conception was based on constructivism that students constructed knowledge through conducting hands-on activities. The teacher acted as a facilitator that helped students fix their misconceptions by using the learning activity, however, Korapin presented that the teacher should start the lesson by asking questions, and the students should design and conduct an investigation to answer those questions. In learning, Korapin thought that the learning journal was not effective for students who disliked expressing their ideas. Throughout the course activities, some of Korapin's conceptions continued as before including students' construction of knowledge, utilizing hands-on activities, developing students in all aspects, and correcting students' misconceptions by learning activities. There were some aspects of Korapin's conceptions that changed which included starting science lessons with students' questions and the effectiveness of reflective learning.

## **2.2 Implementation of Professional Knowledge**

Korapin's revision of professional knowledge is reported in the following sections in each domain and followed with how each domain is implemented into planning and teaching practice.

## **2.2.1 Korapin's Professional Knowledge Revision**

### **A. Knowledge of Educational Context and Science Curriculum Framework**

Before the course, Korapin was moderately familiar with the National Education requirements identified in the NEA1999 and the national science curriculum (questionnaire). Participating in the NEA and the curriculum framework analysis helped Korapin revise and continue her knowledge of educational context and science curriculum framework. The aim of educational context both in general and in science were concluded in Korapin's weekly journal. The understanding of general education objectives and vision for learning of science were revised and presented in week 4 and week 5 journals respectively (presented in the first topic). Moreover, Korapin expressed that participating in the national standard analysis helped her implement the national recommendations into classroom practice.

Participating in analysis of the national requirements revised my prior understanding about students' construction of knowledge. Moreover, I implemented my understanding of the national framework to reflect on the classroom case, assessing other teachers' teaching. I think this is what we call bringing the national requirement into classroom practice (weekly journal: week 5)

### **B. Knowledge of General Pedagogical Knowledge (PK)**

In the prior knowledge worksheet, Korapin presented her understanding about student prior knowledge that is important for a teacher using to design each science lesson (prior knowledge sheet: week 9). She said every course emphasized the students' prior knowledge that affects teacher's lesson planning (interview). She provided some examples of the assessment strategies including question and answer, observation, interview, rubric assessment, etc. Moreover, in her methods courses, Korapin learned a variety of strategies for teaching science

including cooperative learning, inquiry, lecture, demonstration, and discussion but not in details of each method and technique. However, Korapin felt that her methods courses did not emphasize classroom management strategies (weekly journals).

Through the activities of the course, Korapin's general pedagogical knowledge was extended based on her prior knowledge. She revised and expanded her prior understanding, especially in the area of classroom management and topics for which she led seminar discussion (learner and learning, and formative assessment).

In the area of classroom management, Korapin felt that she gained new knowledge because the methods courses did not emphasize this topic.

Today the seminar is on the topic of classroom management, and I feel that I gained a lot of new knowledge. The former methods courses did not emphasize this topic. Classroom management helps the process of teaching and learning go smoothly. The teacher can also organize the classroom atmosphere to enhance student learning science such as organizing desks or bulletin boards. Moreover, there are a lot of techniques used to encourage students' learning and managing students' misbehavior in the classroom (weekly journal: week 11)

Regarding learners and learning, Korapin stated that participating in an organizing seminar on this topic helped her revise her prior knowledge about students' prior knowledge.

Every course of my curriculum emphasized students' prior knowledge. Instructors always remind us that it was very important for teachers to use prior knowledge to design the lesson. In the seminar, it is like a revision of prior understanding. Some parts I already forgot, but becoming organizers helped us to revise some things that we forgot (interview)

Some knowledge, such as formative assessment, was shaped by receiving more information. Korapin presented her deepened knowledge about rubric assessment in the interview with the following entry:

By investigating and watching a video of Teacher Jim's classroom, it changed my idea about Rubric assessment. I used to think that only the teacher could design the rubric; actually the teacher can let students know the meaning of assessment by designing criteria for being the classroom rubric (interview)

For teaching strategies, Korapin presented the knowledge that she revised from participating in seminar discussion. There were some examples of her reflections presented in the following paragraphs:

Today my friend organized a seminar on the topic of cooperative learning, I participated in a Jigsaw learning activity which was which helped teach me how to use it in the real classroom. We acted as an expert who investigates in-depth knowledge and brings back knowledge to share in the home group. I think this group did very well (weekly journal: week 6)

I used to study about inquiry in the methods course, but this week the activity helped me understand more about implementing in the real classroom, and advantages and limitations of this strategy. I think inquiry is a strategy that is used to empower students' thinking processes and investigation (weekly journal: week 7)

Korapin's prior knowledge of general pedagogy was revised through participating in and organizing the seminar discussion. The knowledge included learner and learning, teaching strategies, assessment, and classroom management techniques. Korapin's prior knowledge that was mostly enhanced included classroom management and topics for which she led seminar discussion (learner and learning, and formative assessment).

### **C. Subject Matter Knowledge**

Before the course, Korapin was very confident regarding biological and chemical concepts respectively, but in physical and earth science, she needed better understanding of those concepts (open-ended questionnaire).

After participating in a microteaching activity, Korapin said that she revised her scientific knowledge by preparing her lesson plans and participating in the microteaching activity.

I revised my scientific content knowledge when preparing science lessons. In the process of writing the lesson plan, after I set the expected learning outcomes, I need to revise the scientific content from reading a variety of textbooks (interview)

Watching and reflecting on my friends' teaching in the microteaching activity, I revised many topics in science such as soil, acid-base, and air pressure. This reminded me that in some topics I don't have an in-depth understanding. So, I need to revise my own knowledge before the student teaching practicum (weekly journal: week 14)

In the nature of science, Korapin felt that she revised her understanding of the nature of scientific knowledge from the course activity.

This group work activity helps me revise knowledge of the nature of science that scientific knowledge is stable but can be changed if we have new supportive information. It is not an absolute truth, but we can use the scientific knowledge to predict some phenomena in the future (weekly journal: week 5).

Participating in the course, Korapin revised her scientific concepts from the lesson planning and the microteaching activities. Her knowledge of the nature of science had deepened after participating in the group work activity.

#### **D. Knowledge of Instructional Media and Technology**

Korapin felt confident in her knowledge of instructional media and technology. After participating in seminar discussion, she revised her knowledge of instructional media and how to select it for science teaching. She presented her feelings in the weekly journal with this entry:

I feel fun with the seminar organizing by my friend. I recovered knowledge about what is instructional media, its types, and how to select the instructional media in science teaching (weekly journal: week 10).

Participating in the designing instructional movies activity, Korapin gained satisfaction and knowledge from the Window Movie Maker Program. She thought it was easy to understand and not boring.

I feel very joyful with this activity. This is the first time I know the Windows Movie Maker program and its uses. I feel that it is not as hard as I thought. It is much easier to produce than CAI which I learned from other courses. For me it is not boring at all, I feel that two hours of class passed so fast! (weekly journal: week 10)

Korapin participated in the online discussion board only one time. When she was asked about the reason, she said she did not have computer at home.

I don't have a computer at home and don't have time to go to the internet café. So, I just keep asking my friends who participated in the online discussion about what topic they discussed about (interview)

### **E. Knowledge of Research on Best Practices**

In Microteaching 2, Korapin analyzed research done in a Thai context and integrated knowledge of research on best practices into her planning and teaching. Korapin read and analyzed the findings about utilizing local learning resources for teaching science in the classroom. Korapin said in her weekly journal that:

I got research on the topic of utilizing local learning resources for teaching science in the classroom, so I wrote the lesson plan on the topic of the relationships of organism in an ecosystem. First, I would like to take students (her colleagues) downstairs and observe a real garden under this building, but we have time limitation. So, I just let them observe the artificial garden in the classroom (weekly journal: week 14)

Korapin thought observing her friends integrated knowledge from science education research in planning and teaching made her think about integrating in her own class.

I love group 2 that used music video as an instructional media, I thought this is different than other groups. They analyzed and integrated knowledge from their reading into lesson plan and taught very well. I thought about my own teaching. I may use this technique in my classroom in the next semester (weekly journal: week13)

Moreover, Korapin thought that this activity provided the sharing of knowledge of research on best practice. She saw many implications of this knowledge for practice. She presented her opinion in the weekly journal:

I saw many implications from all groups teaching such as using music video clips and inquiry process. This is like a collection of knowledge, which I don't have to read all of that research, but each group read one and shared with the

other. I may use some techniques in the student teaching (weekly journal: week 13)

## **2.2.2 Korapin's Integration of Each Domain of Professional Knowledge**

### **A. Lesson Plans**

#### **1) Incomplete Prior Knowledge and Ability Presented in the First Lesson Plan**

Korapin's first lesson plan was designed to be used in the microteaching activity 1 (Week 1). Korapin planned the lesson together with her friend. Their group selected the Classification of Organisms according to its food. The lesson was planned to teach grade 7 students (which was organized in the university campus and had their friends as students).

In the lesson plans, their group concerned the development of students in all aspects which identified expected learning outcomes. However, the lesson plan did not identify expected learning outcomes with a measurable behavior. For example, she set the expected learning outcomes that enhanced student attitudes as being "aware of an important of each organism in ecology". Their group presented the constructivist perspective by being concerned with student prior knowledge and letting them design and do experiments by themselves. However, the lesson plan started with teacher's questions which aimed to engage student in learning activity. These questions included: "Which animal can produce food like a plant?" and "Where do animals get their food?" (lesson plan 1). The questions they used were not related to the learning activities. Therefore, the introduction and the learning activity were not related to each other.

This lesson plan was not written in detail. For example, there were two questions, but no answers, identified in the introduction part. In the learning activities and conclusion part, none of the questions and answers were identified.

Moreover, Korapin did not provide opportunities for students to design an experiment. A table was provided in the lesson plan. Students just recorded data within groups.

Each component of the lesson plan included: expected learning outcomes, main ideas, learning activities, instructional media, and assessment, but these were not interrelated. For example, she identified expected learning outcomes for students to explain the role and the relationship of each organism in ecology and to be aware of the importance of each organism in ecology. There were no learning activities that were designed to enhance those aspects of students. Moreover, Korapin's group lesson plan used only worksheets as instructional media. There was not real life or interesting instructional media used in the lesson.

## **2) Knowledge and Skills in Lesson Planning Corrected From Many Perspectives**

Korapin's first group lesson plan was handed in before the microteaching. The lesson plan was corrected by her classmates, instructor, and the researcher. Korapin said that first she thought she knew how to write the lesson plan well, but after she received feedback she said that:

First, I wondered why we have to write the lesson plan over and over in many courses. I already know how to write it. Before handing it in, we both checked it, but after I got feedback, I still found many mistakes. It showed me that we are not good at all, and we need more improvement. Writing lesson plans is not easy (interview)

Korapin felt that receiving feedback from a variety of sources provided many perspectives of what she saw.

Receiving feedback from friends and instructors helped me find out my bad points. It is like when we look at something by ourselves, we can not see it

from all perspectives. When we have many people seeing the same thing, it provides many perspectives for what we see (interview)

### **3) Development of Korapin's Lesson Plans during the Course**

During the course, Korapin developed two individual lesson plans. The lessons were planned based on the area of her expertise (biology). Her individual lesson plans included topics of the relationship of organisms in an ecosystem and genetic inhabitants.

Her lesson plans became more detailed and components became more interrelated. When she identified expected learning outcomes, she constructed with measurable behaviors.

Korapin's first individual lesson plan was on the topic of the relationships of organisms in an ecosystem. She planned to teach 7<sup>th</sup> grade students for 50 minutes. She integrated her knowledge of inquiry, expected learning outcomes, and lesson planning into designing the lesson. In expected learning outcomes, students' knowledge, skills, and attitudes were designed to be enhanced. Korapin identified measurable behavior in the expected learning outcomes such as "explain and give an example of the relationship of organisms in an ecosystem", "investigate the relationship of organisms in the school garden", and "propose strategies used to conserve the stability of ecosystem and take care of it". In the introduction part, she engaged students with questions to students involved in the learning activity, and then let students raise questions to guide their investigation. Students designed and did an investigation in groups in the exploration step. In the explanation step, Korapin let each group of students present, explain, discuss, and conclude the concept from their exploration. In the elaboration step, Korapin let students compare the results from each group and propose the way to keep stability in the ecosystem. At the closure, in the evaluation step, Korapin assessed students' learning from their discussion and methods used to keep ecosystem stable. To present the details of each step, Korapin also identified the specific time to be used in each step of inquiry.

In the second lesson plan, Korapin's plan was on the topic of genetic inheritance. She planned to teach 9<sup>th</sup> grade students for 50 minutes. In this plan, Korapin integrated knowledge of rubric assessment in the lesson plan. She integrated knowledge of teaching methods and techniques including lectures, discussion, and demonstration into the lesson plan. Korapin aimed to enhance students in all aspects. Korapin appropriately identified the main idea part which covered the meaning of genetic inheritance, Medallion's rule, and test cross and back cross techniques. The only suggestion provided to Korapin was that she should also provide English words such as "(Genotype)" in parenthesis in her lesson plan and introduce those words to students. Korapin planned to assess student's prior knowledge, and demonstrate to them how to do back cross and test cross. After that she provided students a word problem to calculate by themselves. In the conclusion, Korapin let students do an discussion activity to conclude the concepts together.

In the final lesson plan, Korapin planned the lesson together with her colleague to be used in Microteaching 2. She revised her first individual plan, which was on the topic of relationships of organisms in an ecosystem. She planned to teach 7<sup>th</sup> grade students for 50 minutes. She developed this lesson plan based on suggestions she got from the course instructor. Moreover, Korapin integrated knowledge of research done in Thai context about utilizing local learning resources for teaching science in the classroom. She planned for students to observe the school garden.

#### **4) The Difference from Other Methods Courses**

Korapin also presented her feeling that writing lesson plans in the course was different than writing lesson plans in other courses. Her opinion was presented in an interview.

In other courses, mostly there was a format provided, which is not found in this course. The instructors in other courses emphasized only in expected learning outcomes that checked the covering of student development in all

aspects. In this course (a capstone course), we emphasize details including using measurable behavior, and the interrelation between each topic (interview)

In summary, in the first lesson plan, Korapin presented concerns of the development of students in all aspects, but she did not identify the measurable behavior. Her lesson plan was deficient in details and each component was not interrelated. Korapin did not let students design their own investigation. This gradually changed in her following lesson plans. They became written in details, interrelated between each component, and identified measurable behavior in the expected learning outcomes. Korapin presented the difference between writing lesson plans in the course (a capstone course) and from other methods courses.

## **B. Teaching Practice**

### **1) Teaching Practice Compatible with the Lesson Plan**

From the two microteaching sessions, one at the beginning and one at the end of the course, Korapin taught only the second one, so the first microteaching could not be observed. During her Microteaching 2, teaching practice, Korapin taught the lesson by herself. Her teaching was compatible with the lesson plan which was on the topic of relationships of organisms in an ecosystem. Korapin started the lesson by presenting pictures of an eagle and a rat, and a Myna bird which was on the back of a buffalo. She asked students to compare the similarities and differences between the pictures. After that, she let each group of students set the questions to guide their observation of the garden. She started the activity with this question. “What do you want to know about the garden observation? Please set at least three questions to lead your observation”.

In the teaching Korapin presented her confidence in scientific concepts in the area of her expertise and confidence when teaching was based on a

well developed lesson plan. Korapin expressed her feelings in her weekly journal with this entry

I feel very comfortable with the teaching. This may be because I feel confident with biology concepts and this lesson plan that I developed from your suggestions in the last lesson plan. Conducting teaching based on a well-written lesson plan makes me feel confident to teach (weekly journal: week 14).

## **2) Integrating Domains of Professional Knowledge in Teaching**

### **Analysis**

Korapin utilized each domain of professional knowledge for analyzing her friends' teaching. She identified outstanding and weak points of her friends in the teaching assessment sheet and weekly journals. There are some examples of her critiques presented in the following paragraph:

A member from group 1 taught on the topic of testing acid-base by using litmus paper. They implemented knowledge of research on the topic of inquiry process. In the engagement step, she used soda water, soap solution, and water that pork meat was put in, and asked students to observe. In the exploration step, she let student do the experiment by using litmus paper. Then, the students analyzed and presented data in the explanation step. In the elaboration, she expands concepts of acid-base testing from using litmus paper to the universal indicator. She evaluated students' learning by using a variety of assessments. This group designed the lesson related to the research suggestions and information gained from the seminar discussion. An outstanding part of her was the classroom management, the weak point was that she spoke so fast (weekly journal: week 13)

Group 4 taught on the topic of the growth of plants; this group used knowledge of research on the topic of learning science through the learner-centered

approach. I think they presented an integration of the research knowledge that was not clear. Their outstanding part was confidence in teaching, but the weak point was using effective questioning techniques (weekly journal: week 14).

Moreover, Korapin utilized her professional knowledge to evaluate her own teaching. She presented her evaluation with this entry:

Group 5, which was my own teaching, taught on the topic of relationships of organisms in an ecosystem. I analyzed a paper about the importance using local learning resources for teaching science in classroom. My outstanding part was confidence in teaching, and I used appropriate language for students. My weak point was making an agreement with students about the rules while conducting the questions and answers activity (weekly journal: week 14)

In summary, Korapin presented her confidence in teaching practice. The teaching practice was compatible with her lesson plans which were based on constructivism. The microteaching activity enhanced her teaching practice by providing her opportunities to analyze and think about an outstanding and a weak point of her friends' and her teaching.

### **C. Producing Instructional Media**

Korapin implemented knowledge of instructional media, content knowledge, and educational context to fulfill one of the requirements of the course (producing instructional media).

#### **1) The Integration of Knowledge Presented in the Process of Production**

Korapin and her colleague produced the artificial garden that consisted of pictures of animals and plants. They used this instructional media in the

Microteaching 2 that teaching topics of “relationship of organism in an ecosystem”. Korapin talked about the process of producing the instructional media that:

To produce the media, first, I thought about the classroom context which we can not bring students downstairs to observe the real garden. Then, I thought about constructing an artificial garden that could be used in class. I analyzed the content to find out what organism should be in the garden, and then drew, colored the picture, and put them together. Our garden consisted of frogs, trees, river, bugs etc. Our group is proud of this instructional media” (reflection on instructional media production)

## **2) Korapin Used Critical Reflection in Analyzing Artifacts**

Korapin was proud of the instructional media that students interacted with in the classroom; however, she was concerned about its limitations. Korapin would rather use the real ecosystem to teach in her class.

While I used it in class, the students interacted with the artificial garden. They observed, recorded, and discussed about the data in group. However, when learning this topic, it is better to use the real ecosystem. In nature the ecosystem is dynamic. This instructional media can not provide the dynamics for the ecosystem. If it is possible, I would rather bring students to observe a real garden (interview)

In summary, Korapin integrated the domains of science content, instructional media, and educational context in the process of producing and analyzing her instructional media.

## **The Case of Sintu**

### **1. Sintu's Stories**

#### **1.1 Background and Expectations**

Sintu is a 21 year-old male student. He was born in Bangkok, the capital of Thailand. He is a good student with a 2.92 G.P.A (out of 4.0). His major is Teaching Science and his minor was in Chemistry. Sintu expected to be a good and professional science teacher. He plans to continue his Master's Degree in Science Education.

#### **1.2 Readiness in Implementing the Professional Knowledge**

At the beginning of the course, Sintu presented his feelings and readiness in a questionnaire that he was moderately ready for the student teaching practicum. He thought that he felt comfortable with most domains of science teachers, except in the domains of scientific content and lesson plans.

### **2. Sintu's Development of Professional Knowledge**

In the course, Sintu worked in a group with his friends, two Chemistry student teachers. They planned, taught, and organized a seminar on the topics of lesson plans and expected learning outcome. The development of professional knowledge of Sintu was presented in two parts: one in the underlying professional knowledge or conceptions about teaching and learning science, and one on the implementation of professional knowledge.

## **2.1 Underlying Professional Knowledge**

### **2.1.1 Student-Centered Approach Presented in the Early Conception**

Sintu presented his view in the second week journal that teaching science should be based on the student-centered approach. He said the student-centered approach is the one that provided students opportunities for mainly participating in the learning activities.

A teacher should teach science based on the student-centered approach, because this approach provides opportunities for students to take the main role in the learning activity. The teacher should select a teaching strategy that is student-centered based to teach by being concerned with the learner's existing ideas and individual differences (weekly journal: week 2)

### **2.1.2 Conception about Teacher's and Student's Roles Presented**

In the open-ended questionnaire that Sintu completed in the first week of the course, he presented his view on the teacher's role.

A teacher should use a variety of teaching strategies such as experiments, games, and discussion by being concerned with the nature of the topic. The teacher needs to be concerned with individual differences, and find out students' prior knowledge. Because sometimes students have misconceptions, a teacher has to create activities to help them change or better understand the concept before learning the next topic (Open-ended questionnaire)

Sintu's conception about students' roles was presented in the same questionnaire in which he related to the teacher's role.

Students should take main roles in learning activities. They should think, be responsible, and do the learning activity by themselves. They can not learn by the teacher giving them knowledge directly (Open-ended questionnaire)

### **2.1.3 Sintu's View on the Nature of Science Related to the Student-Centered Approach**

In the interview after a seminar organizing activity, Sintu expressed his meaning of student-centered approach from his view that in the student-centered approach, students don't need to learn science by conducting experiments. Other strategies can be used for learning science. It depended on the nature of topic. In his view, the student-centered approach means students take the main role in learning activities.

By the nature of the subject, students should learn science by doing experiments. Sometimes, the students can learn through observation and investigation. So, in the meaning of the student-centered approach, I don't think students should always do the experiment. They can learn by other strategies; it's up to the nature of topic. However, students need to take main action in the learning activities, not the teacher (interview after seminar)

At the beginning of the course (week 1 to week 3), Sintu's early conception was based on constructivism. Even though he did not mention about students' construction of knowledge, it can be implied from his reflections that his early ideas in the weekly journal presented a constructivist perspective. In his view, teaching science for students should be based on the student-centered approach.

### **2.1.4 Analysis of the Aim of General and Science Education**

During the course, Sintu analyzed the aim of education in general and specifics in science from the NEA1999 and Science Curriculum framework. In

the classroom case reflection, Sintu analyzed the recommendations from the NEA1999 that:

To organize learning activities based on the recommendations from the NEA 1999, the teacher should be concerned with learners' interests, capability, and individual differences (case reflection)

He used the results from analysis of the national education aim to analyze a teacher's teaching in the classroom case.

I thought that the teacher conducted learning activities based on the NEA 1999. He let students design their own learning, select the topic they were interested in, and it made the learning meaningful for them. I think teaching for understanding is more important than coverage (case reflection)

Moreover, in week 5, Sintu participated in science curriculum framework analysis. He concluded the vision for learning of science identified in the IPST standard that:

The vision for learning of science aims to enhance students' learning in all aspects, life long learning, utilizing local learning resources, emphasizing science process skills, individual differences, related to real life, and the use of a variety of teaching strategies (weekly journal: week 5)

### **2.1.5 Analyzing Activities Confirmed Early Conceptions**

Sintu stated that analyzing the national requirement and science curriculum framework confirmed his understanding about teaching and learning science that he learned from his methods course.

I think these activities confirmed my understanding of the goal of teaching science, and the process of organizing learning activities in the classroom (weekly journal: week 5)

### **2.1.6 Consistency of Student-Centered Presented during the Course**

Sintu's constructivist perspective continued during the course. The student-centered approach was recommended by Sintu as the course went on.

I thought teaching science in the classroom should be based on a variety of teaching strategies. Sometimes in the same period the teacher has to use two strategies; it's up to the content and student differences. Whatever strategies the teacher uses should be based on the student-centered approach and be concerned about student's prior knowledge (weekly journal: week 7)

For the teaching of science, the student-centered approach should be used by teachers selecting appropriate teaching strategies, and instructional media, and letting students participate or take main action in the learning activity (weekly journal: week 13)

Sintu still believed in using a variety of teaching approaches to enhance students' learning. Another example of his idea was presented in his weekly journal with the following entry. Sintu presented that students should be enhanced in all aspects by the learning activities.

By the nature of science, students' science process skills should be enhanced by using learning activities. Even though there is not an experiment used in the learning activities, there is for example an observation or investigation used; students' observation, predictions, and skills can be enhanced. The teacher should help students construct knowledge, science process skills, and attitudes (weekly journal: week 12)

In summary, Sintu's early conception presented the constructivist perspective. He relied on the student-centered approach. He believed in using a variety of teaching activities to help students learning science; not giving them knowledge directly. The analysis of general and science education aims assured his early conception. During the course, Sintu consistently presented his view on the student-centered approach.

## **2.2 Implementation of Professional Knowledge**

During the course, Sintu revised each domain of professional knowledge and integrated them into planning and teaching practice. The revision and integration of professional knowledge is reported in the following section.

### **2.2.1 Sintu's Professional Knowledge Revision**

#### **A. Knowledge of Educational Context and Science Curriculum Framework**

At the beginning of the course, Sintu was familiar with the National Education Act and the IPST science curriculum frameworks (questionnaire). In the course activity, analyzing the IPST science curriculum framework helped him revise his knowledge that was used to design lesson plans.

After analyzing the IPST standard, I revised how to use the science standard to design the lesson. I know that we can use the standard to help design expected learning outcomes, but when I designed the first lesson plan, I did not use it. This activity reminded me to be concerned about the national requirement when designing the lesson (weekly journal: week 5)

Moreover, Sintu presented how to use recommendations in the NEA 1999 and science curriculum standard to design the daily lesson plans in his journal.

To design the lesson, we should concern the recommendation of the NEA and IPST curriculum framework. Writing daily lesson plans, we can adapt the standard to write expected learning outcomes in the lesson plans. We can also use the lower level standard as criteria for assessing students' prior knowledge before learning the new concept (weekly journal: week 5)

### **B. Lesson Plan Writing**

Sintu and his colleagues organized the seminar on the topic of lesson plan. He talked about his prior knowledge that he realized his deficiency when writing the first lesson plan.

In the writing lesson plan activity, I was shocked at first. Even though I already wrote many lesson plans in many courses, I didn't know where I should start. These activities reminded me that I am not ready for student teaching yet (weekly journal: week 1)

Sintu showed the development of his knowledge in lesson plan writing when preparing for seminar discussion.

Before the seminar, we understood that in the lesson plan, the assessment and expected learning outcomes should be interrelated. I had never thought about other parts. I just know when we study indebt for preparing seminar discussion (interview)

Sintu added that teaching others forced him to prepare himself more than regular and sharing of knowledge to fulfill the prior understanding of everybody in class.

To teach others I need to prepare my knowledge more than usual; the situation forced me to know more than the others. If they don't understand some points, we can help them. Everybody brings prior knowledge into the class, into the

discussion activity; we talk and exchange some knowledge from each other. So, we gain more knowledge from that. (interview)

After the seminar organizing activity, Sintu presented his understanding of lesson plan writing in the weekly journal with this entry:

To write the lesson plan, it should be in details. Each component such as expected learning outcomes, main ideas, and assessment should be related. The expected learning outcomes should cover students' development in all aspects (knowledge, process, and attitude). The lesson should be planned related to students' real life, it will make more sense to them." (weekly journal: week2)

### **C. Pedagogical Knowledge**

Sintu presented his pedagogical knowledge on the learner and learning and assessment that the student prior knowledge is very important and should be used to design the lesson. Moreover, he provided some examples of strategies used to assess students' prior knowledge.

Student prior knowledge is extremely important for teaching and learning in science class. The teacher needs to find out student's prior knowledge and use it to design the lesson. There are many strategies that can be used such as pre-tests, questions-answers, concept maps, etc. (Prior knowledge worksheet: week 9)

Sintu said that the teacher can use results from assessments to improve the learning activity.

Assessment is the way to tell how student achieve the standard in content skill area. The teacher can use the results from assessments to improve the teaching and learning activity (questionnaire)

After participating in the seminar activity, Sintu presented the reflection on his weekly journal with the following entry:

From this week, the seminar discussion helps me gain more knowledge especially, on the topic of rubric assessment. I thought using rubric is a good way to assess student's performance task, however, the teacher should use a detailed rubric to avoid bias.....Moreover, watching the video of Teacher Jim, I just know that the teacher can let students design their own rubric, it makes the learning meaningful for them. This looks like an effective strategy, but one factor of using it in a Thai classroom is a lot of students in class. It will take a lot of time

The activities of the course deepened his knowledge and expanded his views on using assessment in classroom. However, he presented his concerns about using this strategy with the Thai classroom context.

In classroom management, Sintu stated that he gained knowledge about classroom setting that he can use in his student teaching.

My prior knowledge on this topic is about using reinforcement and punishment in classroom. From this week's seminar, I gained new knowledge about the classroom setting. The teacher can also organize the learning atmosphere in science classroom. Today, I saw organizing real classroom desks for enhancing student's participation in group work, which I can adapt to use in the next semester (weekly journal: week 11)

In teaching strategy, at first, Sintu identified the inquiry process in the student's prior knowledge worksheet as a process that consists of engagement, exploration, and the conclusion step. He wrote each step in the direct line pattern. The following graphic presented Sintu's prior idea about inquiry process.



**Figure 5.1** Sintu's Prior Idea about Inquiry Process

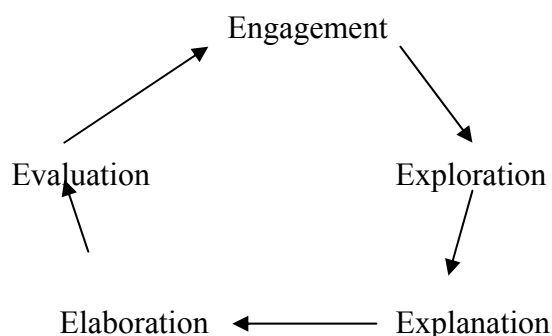
Sintu did not explain more in detail about the inquiry process. He said that he used to study about cooperative learning, inquiry, discussion, demonstration and lecture before, but did not study each strategy in detail. During the course, Sintu presented what he learned from the seminar discussion.

I used to study cooperative learning in other courses; I know that there are STAD, and Jigsaw, but I don't know these in details. From the seminar, this group organized the learning activity by using jigsaw techniques. I see the real example of how the teacher runs the learning activity, and how students participate in the activity. It makes me clearly understand how to use it in the real classroom (weekly journal: week 6)

Sintu gained the deep knowledge about cooperative learning strategy. He presented that participating in the real learning activity helped him to understand more uses of it in the real class. Moreover, on the topic of inquiry, he presented the same as suggested in cooperative learning.

This group presented the inquiry process by letting us be students who participate in the activity first. After that, we analyzed the activity that we did by using the concept of inquiry. I thought seeing or participating in the real activity helped me understand the strategy more (weekly journal: week 7)

Moreover, Sintu's misunderstanding about the inquiry process changed during the course. He presented complete details of engagement, exploration, explanation, elaboration, and evaluation in his weekly journal. The new diagram that he used to describe the inquiry process is presented below.



**Figure 5.2** Sintu's Idea about Inquiry Process after Participating in the Course

In summary, Sintu had complete pedagogical knowledge on the aspect of learner and learning and assessment, but he had an incomplete knowledge on the aspect of classroom management. Sintu presented his misunderstanding about the inquiry process. In the process of the course, Sintu's pedagogical knowledge on the aspect of learner and learning and assessment was sharpening. The knowledge of classroom management was expanding, and some misunderstanding about the inquiry process changed.

#### **D. Subject Matter Knowledge**

Scientific content knowledge was the most difficult area for Sintu. He stated that he was concerned about scientific concepts, especially in the area outside of his expertise.

I am really concerned about my content knowledge. I feel that I am weak in scientific concept, especially in Physics and Biology. If I have to teach Chemistry concept, it is easy to do. Whenever I have to teach Physics and Biology, it makes me nervous (questionnaire)

During the course Sintu revised his content knowledge while participating in the microteaching activity.

I feel that microteaching helped me analyze myself, my friends, and evaluate how ready I am in both content and teaching. Participating in my friends' teaching in a variety of concepts in middle school science, revised my understanding about those concepts. When I struggle with any concept, I can ask my friends who were teachers. It is like we shared knowledge in the areas that we are confident in (weekly journal: week 13)

Sintu's journal presented that the microteaching activity helped him revise his knowledge by sharing with his friends who were experts in those topics.

### **E. Knowledge of Instructional Media and Technology**

Sintu was familiar with using the computer. He said he loved chatting with friends online. When participating in the activity that used computers to design an instructional media, Sintu presented his feelings with the following entry:

I think instructional media can be used to enhance student learning in science. Today we used the Window Movie Maker, which I used before, but I never thought about using it to produce instructional media. Some processes I already knew, so I did it quickly, and I could also teach my friends in group. There are some process that I just learned from today, it fulfilled my knowledge and skills in using this program. I think it is a good idea to use this program; it is easy to use (weekly journal: week 10).

Sintu presented that he already knew and used the program, but never thought about using to design and instructional media. He said the activity enriched his understanding and skills in using the program. In the online discussion board, Sintu participated almost every day. He presented his feeling about this activity in the interview that:

The online discussion board is a very good way to share knowledge. For example, we used it to discuss and exchange learning resources like the formative assessment PDF file. There were just some students that loved using computers that participated and got advantages, but some didn't, I thought they lost a good opportunity (interview)

### **F. Knowledge of Research on Best Practices**

For the Microteaching 2 lesson, Sintu analyzed research done in a Thai context and integrated knowledge of research on best practice into the lesson planning and teaching. From his reading, Sintu analyzed using the inquiry process. He clarified his prior understanding about inquiry process that:

Process of inquiry consists of engage, explore, explain, elaborate, and evaluate. The process of inquiry is non-ending; it consists of many cycles that a teacher can connect from one topic to the other” (research)

Moreover, Sintu presented that participating in analysis of research done in Thai context and integrating the knowledge gained from research into teaching provided him examples of how to use knowledge from research into teaching practice.

I like this activity, it showed me examples of how every group integrate the knowledge from the reading of research into their teaching. These are good examples that we can use in our career of teaching (weekly journal: week 13)

In summary, Sintu revised each domain of professional knowledge including knowledge of educational context and science curriculum framework, lesson plan writing, pedagogical knowledge, subject matter knowledge, knowledge of instructional media and technology, and knowledge of research on best practice. Moreover, he presented the correction of his understanding in inquiry process, and

seeing examples of integrating knowledge gained from research into teaching practice.

## **2.2.2 Sintu's Integration of Each Domain of Professional Knowledge**

### **A. Lesson Plans**

#### **1) Incomplete Student-Centered Approach Presented in the First Lesson Plan**

Even though Sintu's conception of teaching and learning presented the student-centered approach, the science lesson plan presented an incomplete student-centered approach. The lesson plan aimed to enhance student development in all aspects, and provided opportunities for students to do an experiment by themselves. However, when Sintu designed lesson plans with his colleagues, the group lesson plan presented a combination of student-centered and teacher-centered approaches. For example, in the student-center approach, he provided students an opportunity in conducting an experiment, discussion and conclusion by themselves. In the teacher-centered approach, the students were provided laboratory direction, and the teacher started the learning activity with questions and examples (lesson plan 1).

#### **2) Feedback Helped Sintu Learn from Mistakes**

After teaching, Sintu's group received feedback from friends, the researcher and the instructor. He stated that he learned from mistakes in the weekly journal with the following entry:

From the feedback we got, our lesson plan was not completely based on the student-centered approach. I learned from this mistake and will use it to develop the next lesson plan (weekly journal: week 3)

### **3) Feedback Different than Other Methods Courses**

Sintu presented the differences of feedback he got from this course from other methods courses.

The feedback I got from this course comes from different perspectives. In other courses, it just came from the course instructor. It may be because many people looked at the same lesson plan, so we got the feedback in details, but the other courses emphasized only in the learning activity and assessment strategies (interview)

### **4) Development Shown in the Following Lesson Plans**

Sintu's lesson plans showed gradual development. He integrated several domains of professional knowledge into lesson planning, especially on the topic on which he organized the seminar discussion (lesson plan and expected learning outcome).

Sintu's individual and group lesson plans presented an interrelation among each component, and were detailed in writing. Sintu designed the lesson by using the same topic, acid-base, during the course.

Sintu planned to teach 7<sup>th</sup> grade students in one period (50 minutes). He integrated his knowledge of inquiry, expected learning outcomes, and lesson planning into designing the lesson. Sintu aimed to enhance students' knowledge, process, and skills in the expected learning outcomes. He set the expected learning outcomes by using a measurable behavior. He aimed for students to explain the meaning, the differences, and advantages of acid and base in daily life. In the engagement step of the lesson, he engaged students with daily life examples such as soda water, water, tamarind juice, acetic acid, detergent, and bathroom cleaner. He asked students to classify the examples by themselves, and compare with the other groups. In the exploration step, Sintu provided litmus paper for students to design and

do experiments, and record the data. In the explanation step, Sintu let each group of students present, explain, discuss, and conclude the concept from their experiment in class. In the elaboration step, Sintu provided documents about using universal indicator and other methods to test acid and base solution. At the end, the evaluation step, Sintu used the exercise of acid-base testing for assessing student learning together with classroom observation.

In the second lesson plan, Sintu brought the feedback he got from the first lesson plan to design the second plan together with implementing knowledge of rubric assessment into the lesson. The second lesson plan presented the gradual change based on feedback Sintu got from his first lesson. The rubric he designed in the second lesson plan was not detailed. He divided the criteria into four levels; the characteristic in each level was roughly identified. In his second lesson plan, the main suggestion he got from the instructor was in the rubric assessment part to be more specific and provide more detailed criteria.

The last lesson plan, which Sintu used in the microteaching 2, presented more details and interrelation of each component. Moreover, this lesson plan provided the knowledge sheet, work sheets, self assessment and group work sheets. Also, in this lesson plan, Sintu provided a mind mapping assessment in the rubric form and corrected the last rubric in the second lesson plan to be more detailed. He still divided the criteria into four levels, but added more information and details regarding the expected characteristic in each level.

In summary, along the course Sintu designed the group and individual lesson plan by using the same topic. Sintu revised and integrated the knowledge from feedback and, seminar discussion into practice. He showed the gradual development in the writing of details, interrelating of each component, and integrating each domain of professional knowledge.

## **B. Teaching Practice**

In the course, Sintu did not have a chance to present his teaching practice. This was because their group consisted of three members. One taught in the microteaching 1, and the other taught in the microteaching 2. Sintu presented his feeling that

I think the microteaching is a good activity for us to practice implementing all knowledge we learned into the real teaching situation, but, in this course we don't have enough time for everybody to teach. I am the one who did not teach, but I did help my friends in the planning process and being a teaching assistant in the microteaching activity (weekly journal: week 13)

However, Sintu provided opportunities in analyzing other friends' teaching practice. He used the domain of professional knowledge such as knowledge of teaching strategies and knowledge of classroom management to analyze his friends' teaching.

Group 4 taught on the topic of the growth of plants by implementing knowledge from a research on the topic of the learner-centered approach. I think this group implemented knowledge gained from the research pretty good; they started the lesson by acquiring students' prior knowledge. The learning activities let students mainly participate in and enhance student science process skills, such as predicting what part of plant will grow first, observe, and record the results. After that the students made a presentation and conclusion....The good point that I observed was how the teacher made a content representation, but the weak point of this group was classroom management. She did not have a class rule to control students, so the students made too much noise (weekly journal: week 14)

In Group 6, she taught the precipitation topic. She read the research on the topic of selecting an instructional media in the science classroom. I thought

she used an appropriate teaching strategy which was an experiment for students to observe the precipitation process. Her good point was discussing the rules with students before starting the experiment which she controlled her class very well. Whenever student wanted to talk, they raised their hands up (weekly journal: week 14)

Moreover, Sintu's analysis of his friends' lesson plan was presented in the microteaching and lesson plans analysis. He analyzed the lesson plan format, the details of each lesson plan, and the interrelation of each part of the lesson. He presented his feelings and the changes in his planning process in the interview that:

When I checked and gave feedback to my friends' lesson plans, I found that I had more analytical ability. It was continuing to affect my thinking when I planned my own lesson. I was more careful when I wrote the lesson plan (interview)

The microteaching activity provided Sintu an opportunity for analyzing his friends' teaching practice and lesson plans. This helped him in his process of planning.

### **C. Producing Instructional Media**

Sintu was in the same group as Prangwalai in producing instructional media. Sintu revised his knowledge and skills in using the Windows Movie Maker in producing an instructional movie. Sintu produced an instructional CD as a supplemental resource on the topic of "trees".

### **1) The Sharing and Integrating of Knowledge in the Production Process**

Sintu was an expert in the Window Movie Maker program and he had used this program before. Sintu presented the sharing of knowledge and skills with his colleagues in the process of editing the movie.

In the planning process, we selected topics, the strategies to teach students at the middle school level together. We wanted it to be interesting and funny, so we selected the TV program style. In the process of filming, we used the video camera, filmed it many times and selected the best in process of editing. In this project, I tried so hard to make it perfect. I am the one who was familiar with this program, so I can help my friends, and give them some suggestions when they want to put some special effect (reflection on instructional media production).

Moreover, his reflection and the instructional CD presented an integration of Sintu's professional knowledge including knowledge of science in specific content areas (content knowledge: CK), pedagogical knowledge (pedagogical knowledge: PK) or methods of teaching and learning into the idea of knowing what teaching approaches fit the content (pedagogical content knowledge: PCK).

### **2) Pride Presented After Finishing the Movie**

Sintu analyzed the group product and presented his pride of technological knowledge. He thought the instructional movie can enhance students' learning science.

When it was finished, I was so proud that I can distribute my computer and technology knowledge and skills to help my friends produce an instructional movie. The end product was lively, and I think it will help student learn science with happiness (reflection on instructional media production)

In summary, in the process of producing instructional movies, Sintu presented an integration of professional knowledge, distributing his knowledge and skills for his friends. Moreover, he presented his pride in his knowledge distribution.

## **The Case of Sasithorn**

### **1. Sasithorn's Stories**

#### **1.1 Background and Expectations**

Sasithorn is a 22 year-old female student. She was born in Bangkok, the capital of Thailand. She is a good grade student with a 3.19 G.P.A (out of 4.0). Her major is Teaching Science and her minor is in Chemistry. Sasithorn wanted to continue her master degree outside the area of teaching and wants to have more confidence while teaching.

#### **1.2 Readiness in Implementing the Professional Knowledge**

At the beginning of the course, Sasithorn presented her feelings and readiness in a questionnaire that she was not ready for her student teaching practicum yet. She felt that she was not confident in all areas of professional knowledge. She would like to prepare herself in all areas, especially lesson plan writing.

### **2. Sasithorn's Development of Professional Knowledge**

In the course, Sasithorn worked in a group with a Chemistry student teacher. They planned, taught, and organized a seminar in topics of classroom management together. The development of professional knowledge of Sasithorn was divided into two parts: underlying professional knowledge or conceptions about teaching and learning science and the part of implementation of professional knowledge.

## **2.1 Underlying Professional Knowledge**

### **2.1.1 Early Conceptions Presented as Students' Construction of Knowledge**

At the beginning of the course, Sasithorn stated her views in the open-ended questionnaire and first week journal by saying that she believed in student construction of knowledge. She said students learn well with hands-on activities including experiment and investigation. She believed that working in groups helped students construct individual knowledge. Sasithorn presented her conceptions about students' learning science through hands-on and minds-on activities. She said when students do and think about what and why they did something, it was meaningful for them to learn science. The example of her answer in the open-ended questionnaire is shown in the following paragraph.

Learning science was meaningful when students' construct their own knowledge. They should learn through hands-on activities such as doing experiment or investigation. Students should not only do activities, but think about what and why they did the activities. This will make learning meaningful and relevant to their life (open-ended questionnaire).

Sasithorn's views presented her belief in individual differences and student's prior knowledge. She presented her idea in the prior knowledge worksheet with the following entry:

The students' prior knowledge is important because the individual student is different in basic knowledge and learning style. So, the teacher should investigate the student's prior knowledge and use this to design the instructional activities that related to their prior knowledge. (prior knowledge worksheet)

From her words, it can be implied that Sasithorn's early conception was based on constructivism. She believed in student's construction of knowledge and that a teacher needs to acquire student prior knowledge to design instructional activities related to individual differences.

### **2.1.2 Analyzing the Educational Aims Expanded Early Conceptions**

During the course, Sasithorn analyzed visions for the learning of science and the nature of science in the science curriculum framework (week 5) and the National Education Act (NEA) 1999 (week 4). From these activities, Sasithorn presented her analysis of general and specific educational aims, and used it to reflect on classroom case.

In week 4, Sasithorn expressed her thinking on the classroom case by using recommendations from the NEA1999. She talked about the objective of general education in Thailand that:

The NEA1999 recommended that learning content and activities should be organized to be related to learners' interests and individual differences. The learners should practice their thinking processes as well as their hands-on practices. Moreover, they should be enhanced in the aspects of morality and positive attitudes towards their subjects (case reflection: week 4)

Sasithorn used the general recommendations to reflect on classroom case that

I thought the teacher organized his classroom based on the recommendations of the NEA1999. His lesson plan provided students opportunities to control their own learning; not the teacher controlling them. This makes learning meaningful for them and enhances student's enthusiasm to learn science....If I were him, I would do the same thing. I thought teaching science should aim

to enhance students' understanding, but in the same time we should balance between the understanding and curriculum coverage (case reflection: week 4)

In week 5, Sasithorn presented her understanding of the vision for learning of science that:

Teaching science is aimed to enhance students in all aspects (knowledge, process and attitude), life long learning, and relevance to their lives. Moreover, the teacher should be concerned with individual differences by using a variety of teaching and assessing strategies. The students should practice their hands-on processes and thinking processes (weekly journal: week 5)

Sasithorn presented her feelings that analysis of the general and scientific aim in the documents helped her confirm and deepen her prior conceptions. She presented her feelings in the weekly journal with the following entry:

Analyzing aim of education in the NEA and science curriculum framework help me understand more about the aim of teaching science, science curriculum framework. Moreover, discussing the analysis with friends showed me the similar and conflicts in individual interpretation. This helps me confirm and expand my understanding of teaching and learning science in classroom (weekly journal: week 5)

### **2.1.3 Constructivism Presented along the Course**

During the course, Sasithorn's conceptions were consistent with the constructivist perspectives. For example, she emphasized that students should be enhanced through both hands-on and minds-on processes with the following entry.

After we discussed the strategy (inquiry), I thought this strategy can help the students learned science as recommended in the national requirement. Both

hands on processes and thinking processes were enhanced (weekly journal: week 7)

Sasithorn presented her views on the learner's and the teacher's roles in the classroom that learners should control their own learning and the teacher should facilitate the students to do so. An example journal entry presented her reflection on the weekly journal.

Whichever teaching strategies the teacher uses, students should be the one who takes control of their own learning. The teacher acts as a facilitator that helps them to achieve the goal (weekly journal: week 8)

Moreover, Sasithorn presented her views on the importance of students' prior understanding that the teacher should use to design an instructional activity.

The student prior understanding should be acquired and used to design the instructional activities (weekly journal: week 9)

In summary, Sasithorn holds the constructivist view on teaching and learning science. She believed in student construction of knowledge, hands-on and minds-on activities, group work, individual differences and the importance of student's prior knowledge. During the course, her views were confirmed and expanded by comparing with the standard and discussing with friends who had both similar and different views on the teaching and learning of science. Her constructivist view continued and was presented in the weekly journals during the course.

## **2.2 Implementation of Professional Knowledge**

Sasithorn's revision of professional knowledge is reported in the following sections in each domain and followed with how each domain is implemented into planning and teaching practice.

## **2.2.1 Sasithorn's Professional Knowledge Revision**

### **A. Knowledge of Educational Context and Science Curriculum Framework**

At the beginning, Sasithorn presented her feelings in the questionnaire that she was moderately familiar with the National Education requirements identified in the NEA1999 and the national science curriculum. Sasithorn participated in analyzing these documents in this course (week 4 and week 5). From the weekly journal, Sasithorn said she revised her prior understanding by discussing the general and specific educational aims with her friends. The similarities and differences of views from her friends helped her confirm and deepen her prior conception.

Sasithorn stated that she revised her prior understanding in the course activities by comparing documents and her friends' views. She presented her feeling in the weekly journal that was shown in the underlying professional knowledge part. Her answer was shown again in the following paragraph.

Analyzing the aims of education in the NEA and science curriculum framework helped me understand more about the aim of teaching science and science curriculum framework. Moreover, discussing the analysis with friends showed me the similarities and conflicts in individual interpretations. This helps me confirm and expand my understanding of teaching and learning science in the classroom (weekly journal: week 5)

In summary, Sasithorn's knowledge of educational context and science curriculum framework was revised and extended through the course activities. Analysis of the documents sharpened her understanding of the context and the national requirement.

## **B. Knowledge of General Pedagogical Knowledge (PK)**

Even though Sasithorn had already learned all aspects of general pedagogy in her methods courses, she stated that she was not confident in all aspects of general pedagogical knowledge which included teaching strategies, classroom management, student's prior knowledge, and assessment.

In the aspect of teaching strategies, when Sasithorn participated in a seminar discussion on the topic of inquiry (week 7), she presented the deficiency of her understanding of inquiry with the following example:

“Inquiry process consists of

1. Introduction and student prior knowledge
2. Student's Doubt
3. Doing experiment
4. Analyzing the results
5. Conclusion” (prior knowledge worksheet: week 7)

From her understanding, it can be concluded that Sasithorn used her own words to describe the inquiry process. Her answer presented the step of engagement (Introduction and student prior knowledge and Student's Doubt), exploration (Doing experiment), and explanation (Analyzing the results and Conclusion). She failed the step of elaboration and evaluation.

In the prior knowledge worksheet, Sasithorn also presented her understanding about student prior knowledge that directly affected learner learning. There were a variety of assessments used for investigating students' prior knowledge (week 9). She provided some examples of the assessment strategies including questions and answers, and pre-tests. Sasithorn also presented that she learned many teaching strategies. Sasithorn also studied some classroom management strategies. She said before she organized the seminar discussion, she thought it would not take a long time to prepare herself (interview).

During the course, Sasithorn both participated in and organized seminar discussion activity (classroom management). Her general pedagogical knowledge was extended based on her prior knowledge. She revised and expanded her prior understanding, especially related to topics for which she led seminar discussion (classroom management).

I think the topic that I understand the most is classroom management. This is because I revised more after the seminar. Actually I felt comfortable at the beginning, this topic we already studied. So, I did not prepare well at first. Our group just started one week before the seminar, and we found out that it was not easy as we thought. There were many things that we did not know and many things that we just understood at the basic level. Being the leaders, we had to know deeper than the others. So, we were a little bit serious about this. After finishing the activities, it reminded me that I need to study more. I went back to revise the prior course and found out more information about some questions that my friends asked, but we could not answer to prepare to answer them in the following week (interview)

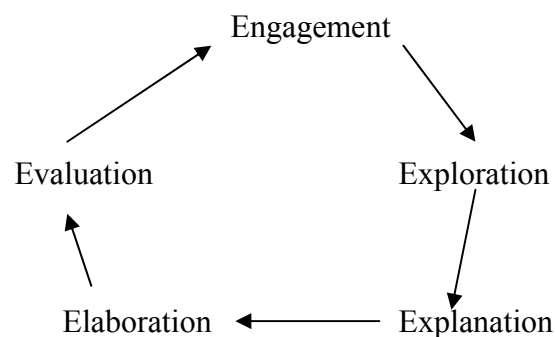
Her reflection stated that she learned from what she knew and what she did not know. She felt that being a leader of a seminar discussion, she needed to know more than the others. She took the responsibility to revise more knowledge and find out some answers for her friends after the activity.

In the aspect of teaching strategies, she revised her knowledge of cooperative learning and other teaching strategies. Sasithorn stated that seeing the real example of learning activities helped her understand its implementation in classroom.

This week I revised my understanding of cooperative learning including strategies of Student Teams-Achievement Division (STAD), Teams- Games-Tournaments (TGT), and Jigsaws. For me, I understand the Jigsaw strategy well, because I see the example of the real learning activity organized by the leader group. However, with the STAD and TGT, I understand them more in

details, but want to see more example in the real classroom (weekly journal: week 6)

Moreover, participating in the seminar discussion on the topic of inquiry fulfilled and expanded her prior understanding of the inquiry process. She said she got essential data and saw the real example in the class on the inquiry process. Sasithorn presented the inquiry process in the weekly journal with the diagram below



**Figure 5.3** Sasithorn's Prior Idea about Inquiry Process

She said the inquiry process consisted of engagement, exploration, explanation, elaboration and evaluation.

In engagement, the teacher can use questions, role play, news, and models to engage students to learn science and to acquire the students' prior knowledge. In the exploration, the students plan their investigation or experiment, set the question and hypothesis, and investigate or experiment in groups. In the explanation, the students interpret the results and transform it to be another form such as graphs, diagrams, pictures, or words to explain to the other. In elaboration, they use the finding to correct or confirm the prior understanding and related to the further relating topic. At the end, in evaluation, a variety of assessments should be used in every step of inquiry (weekly journal: week 7)

The deficiency of Sasithorn's understanding of the inquiry process was remediate through the seminar discussion activity. Her current knowledge was presented in the diagram and in the explanation.

In the aspect of student prior knowledge and assessment strategies, Sasithorn confirmed the importance of student prior knowledge, and presented more assessment strategies in the weekly journal.

From this week's seminar, it confirmed that students' prior knowledge is very important. There were many strategies that can be used to investigate students' prior knowledge such as question-answers, tests, worksheets, observation, interviews, and discussions. Moreover, to assess student's achievement, the teacher can use these strategies and other strategies in the process of formative assessment (weekly journal: week 9)

In summary, Sasithorn's pedagogical content knowledge was enhanced through the process of participating and organizing seminar discussion activities. She revised and expanded her knowledge of teaching strategies, classroom management, student's prior knowledge, and assessment through seeing the implementation of them into the real learning activities, discussion, and preparing to be a leader of a seminar discussion.

### **C. Subject Matter Knowledge**

Before the course, Sasithorn stated that she would like to prepare herself in specific science content area, especially in the area outside of her expertise such as Biology and Physics concepts (questionnaire).

The activities that helped Sasithorn revise her content knowledge were planning the lesson, teaching, and analysis of her friends' teaching. She presented her feelings in an interview:

I thought writing the lesson plan helped me revise my content knowledge. When I write the lesson plan in the course, first, I have to revise my content knowledge. I cannot write it if I don't understand the concept. Moreover, participate in the microteaching activity, I have a chance to get feedback and provide feedback to my friends. So, in aspect of teaching correctly science content, we know from feedback whether we misunderstand some concept (interview)

In the nature of science, Sasithorn presented that she revised her conception of the nature of science in all aspects including her scientific world view, scientific enquiry, and scientific enterprise. An example of her reflection from her weekly journal was presented in the following paragraph.

The nature of science is complex and hard to understand. Many courses emphasized this topic and so does this course. My understanding was revised. I understand more in each aspect including scientific world views, scientific enquiry, and scientific enterprise. I think I became more understanding about the nature of science (weekly journal: week 5)

In summary, Sasithorn's revision of content knowledge happened when she participated in the microteaching activities. She had a chance to revise her knowledge through activities including lesson plan writing, teaching, and analyzing her friends' teaching. Her knowledge of the nature of science was also revised from the seminar discussion activities.

#### **D. Knowledge of Instructional Media and Technology**

Before the course, Sasithorn stated that she felt moderately ready to produce, select, and use instructional media and technology in her class (questionnaire). She was not confident in using local learning resources to support her science teaching.

In the seminar discussion, Sasithorn stated that she revised her knowledge of instructional media and technology. She presented her feelings in the following entry:

The instructional media helps students easily understand science concepts; the real samples like leafs, animals, and substances are the best instructional media. However, if the teacher cannot bring the real examples, he/she can think of illustrations, photographs, models, slide shows, and videos. This week, I revised the effectiveness of each instructional media and its limitations. Moreover, in the Window Movie Maker, this is the program that I have never noticed on my computer can be used in the science classroom (weekly journal: week 10)

In addition, Sasithorn presented her feelings when she participated in the movie production activity that:

First, I felt it would be hard to do the movie production, but after my friend taught me and we practiced at the same time, I felt that it's easy. I think it is easier than Flash program. This program is easy to use and can be applied in the real classroom. The video can make students interested in learning that topic (weekly journal: week 10)

In summary, Sasithorn revised her knowledge of instructional media and technology through seeing the examples of using local learning resources in the classroom, participating in seminar discussions, and practicing producing instructional movie.

### **E. Knowledge of Research on Best Practices**

Sasithorn analyzed research done in a Thai context and integrated knowledge of research on best practice into her planning and teaching in the Microteaching 2 activity. Sasithorn's group selected the topic of organizing classroom

environment to support science teaching. From reading and implementation of the findings, Sasithorn said that:

In the classroom setting, the teacher can decorate classroom to build up the science classroom atmosphere. I decorated the bulletin board, and put up the students' work to decorate classroom (weekly journal: week 15)

Moreover, Sasithorn felt she learned the application of knowledge from her reading about planning and teaching in the real classroom. She felt that the teachers need to use the knowledge with concern of their own classroom context.

I think reading, analyzing, and using knowledge from research was a good activity. In the prior course, I used to analyze the research in science teaching, but I had never implemented it into lesson plans and teaching. This activity showed me that using knowledge from research; we need to adapt some aspects to be appropriate for our classroom setting, content, time and available resources (weekly journal: week 14)

In summary, Sasithorn revised her knowledge of research on best practice when participating in research analysis and implementation. Moreover, she learned how to apply knowledge into planning and teaching practice.

### **2.2.2 Sasithorn's Integration of Each Domain of Professional Knowledge**

An integration and implementation of each domain of professional knowledge was presented in Sasithorn's lesson plans, her teaching practice, and her instructional media.

## **A. Lesson Plans**

### **1) First Week Lesson Plan Showed Incomplete Knowledge and Ability**

Even though Sasithorn's conception presented her view of constructivism, her lesson plan failed to inquire about student prior knowledge. Sasithorn planned the lesson together with her friends. Their group selected the origin and composition of soil topics to teach 8<sup>th</sup> grade students (which was organized in the university campus and they had their friends as students). In lesson plans, their group presented the constructivist view such as student design and did observation, answered the question, and concluded the lesson by themselves. However, the lesson plan did not identify an activity that student's prior knowledge was acquired.

The expected learning outcomes were aimed to enhance students' knowledge, and process skills. However, there were some non-measurable behaviors presented in the first lesson plan. The following paragraph presents the expected learning outcomes of Sasithorn's first lesson plan.

#### **Expected Learning Outcomes**

1. observe and tell the composition of the soil
2. understand the process of soil formation, and composition of soil
3. work together in groups (lesson plan 1)

Sasithorn's first lesson plan had poorly written expected learning outcomes. The redundancy was presented in the first and second expected learning outcomes. Moreover, the non-measurable behavior was presented in the expected learning outcomes.

Each component of the lesson plan was identified which included: expected learning outcomes, main ideas, learning activities, instructional

media, and assessment, but these were not interrelated. For example, in the expected learning outcomes, they planned for students to understand the process of soil formation, but there were no learning activities that enhanced students in this aspect. In the part of assessment, there was no assessment strategy used to identify students working together in groups. Moreover, the first lesson plan was written roughly. There were no worksheets, knowledge sheets, expected questions or answers identified in the lesson plan.

## **2) A Gradual Change Presented in the Second Lesson Plan**

After Sasithorn got feedback from her classmates, her instructor, and the researcher, the following lesson presented a gradual development of her knowledge and skills in lesson plan writing.

In the second lesson plan, Sasithorn integrated knowledge of inquiry and also adapted her first lesson plan on the topic of the origin and composition of soil based on the feedback she got. The following paragraph shows expected learning outcomes identified in her individual plan.

### **Expected Learning Outcomes**

1. observe and describe the composition of the soil
2. explain the process of soil formation
3. present science process skills when doing activity (lesson plan 2)

Sasithorn developed expected learning outcomes from the first lesson plan; she used measurable behavior in the expected learning outcomes, but the last expected outcomes still showed no specific science process skills. The instructor suggested identifying the specific science process skills that she aimed to enhance students in this lesson.

Soon, other gradual changes were shown. Her lesson plans became more detailed and components became more interrelated. She used her content knowledge to identify important concepts which related to the expected learning outcomes of the lessons. The learning activities and assessment strategies were related to the expected learning outcomes.

In the learning activities, Sasithorn integrated her domain of inquiry into the lesson plan. In the engagement, the students' prior knowledge was investigated by presenting the example of soil and asking the following questions: In your home, how does soil look like? Is the soil in your home similar or different than this soil? In your opinion, how many types of soil are at your house? And how can you know that? After that, in the process of exploration, the students were provided the beakers of soil, tray, water, a stirring tube, a magnifying glass, and recycled paper to do the experiment. The students were asked to design the experiment, do it, and record the results. In the process of explanation, each group presented the results and made discussions. In elaboration, students were provided with a variety of information resources on the topics of the composition of soil and the process of soil formation. In an evaluation, the teacher assesses students during the experiment searching for information. The concept map was used to assess students' understanding soil formation.

In the second individual lesson plan, Sasithorn showed gradual change and improved her knowledge and ability in lesson plan writing. The lesson plan was on the topic of the changing of status of substances. Sasithorn wrote the expected learning outcomes as presented below:

### **Expected Learning Outcomes**

1. explain the process of the changing of the status of ice
2. compare the properties of substances in solid, liquid, and gas form
3. observe the changing of the status from ice to water and water to gas  
(lesson plan 3)

Sasithorn showed gradual change in identifying the expected learning outcomes and continued presenting the detail and interrelation of each component of her lesson plan. Moreover, Sasithorn integrated the rubric assessment in this lesson. Her rubric assessment was constructed and identified in details of the characteristics of students in each score level.

In the last lesson plan, Sasithorn planned to teach 8<sup>th</sup> grade students on the topic of digestion. She set the expected learning outcomes as presented below:

### **Expected Learning Outcomes**

1. explain the process of human digestion
2. design an experiment and table to record the results for the experiment
3. suggest the good habit for consuming food to maintain the digestive system (lesson plan 4)

Sasithorn's expected learning outcome was to enhance students' learning in all aspects including knowledge, science process skills, and attitudes. Each component of the lesson plan was written in detail and was interrelated. The students' prior knowledge about the human digestive system was investigated. The experiment was connected to the students' prior knowledge and the students were divided into groups to design and do the experiment. After that, each group wrote the result on their white board and discussed the results to make a conclusion.

In summary, the lesson planning activities helped Sasithorn revise and integrate knowledge into practice. Sasithorn learned from receiving feedback from a variety of sources, and the gradual changes were presented in the details of writing, interrelation of each component, and integrating each domain of professional knowledge.

## **B. Teaching Practice**

### **1) Teaching Incompatible with the Lesson Plan and Views**

During the microteaching 1, Sasithorn taught the lesson by herself. She presented that she was not confident to teach. Her face was pale and she showed concern at the beginning of the lesson. Even though Sasithorn's conception and lesson plan presented her view of constructivism, she conducted the learning activity by telling students to do the experiment. The following paragraph emerged from the classroom observation of Sasithorn's teaching.

OK, now we will do the experiment. I will distribute to each group an example of the soil and you should observe what you find in the soil sample (classroom observation)

### **2) Teaching Practice Affected from a Poorly Prepared Lesson**

#### **Plan**

Sasithorn wrote the lesson plan roughly and it affected her teaching practice. There were no specific questions identified in the lesson, so she could not think about a question that connected the introduction to the learning activity. She designed the lesson plan to tell students how to do the experiment step by step.

I am not confident to teach; I don't know what should be the next question that I should use to connect the introduction activity with the experiment. As you know, my lesson plan did not identify in-detail questions and answers. So, I just know that I have to ask questions, but I don't know what question I should ask. When I don't know what I will do next, I just tell the students what to do step by step (interview)

### **3) Sasithorn's Students Conducted Experiment by Themselves**

When Sasithorn taught for about 10 minutes, she became more relaxed. She started smiling sometimes. Her serious face disappeared. At that time, she began to let students conduct their own experiments in each group. Sasithorn, as a teacher, walked around the room to see and help students when they needed it. In the interview, she presented her feelings that:

After a while, I felt more comfortable in front of the classroom. I realized that I did not let students do the experiment by themselves. I told them how to do it. So, I started walking around and just helped them when they asked for help (interview)

When Sasithorn was nervous with the teaching situation and was concerned with her poor lesson plan, she told students things step by step. However, when she became more comfortable with being a teacher, she realized that she should let students do the experiment by themselves and she just acted as a facilitator.

In the conclusion part, Sasithorn provided an opportunity for students to conclude the lesson. Sasithorn asked the students the following questions:

Now, we will conclude what we have learned from the activity.  
- From the activity, what is the component of the soil that you observed?  
- So, from your observation can you predict how the soil formed?  
(Classroom observation)

While the students answered, she recorded the students' answers on the white board. At the end she asked students to conclude the concept that they have learned by using their answers on the board.

In summary, Sasithorn's teaching practice was not compatible with her views when she was nervous, because her lesson plan was not well prepared. However, when she became more relaxed, Sasithorn's teaching practice became more related to her constructivist view. During the course, Sasithorn's progress in terms of teaching could not be observed because of time limitations. In the second microteaching activity, Sasithorn and her colleagues switched roles. Nevertheless, her teaching practice was observed again during her student teaching.

### **C. Producing Instructional Media**

Sasithorn implemented knowledge of instructional media, content knowledge and educational context to fulfill one of the requirements of the course (producing instructional media). Sasithorn worked with two other friends to produce a good word game.

#### **1) The Integration of Knowledge Presented in the Process of Production**

Sasithorn produced the word game that consisted of a big board and adhesive English letters. She presented an integration of content knowledge, curriculum, teaching strategy, and instructional media to produce the artifact. Sasithorn's reflection was shown in the following paragraph.

In the process of production, we discussed the aims of this instructional media. We would like to produce instructional media as a game for students to review the knowledge when finishing the lesson. So, we selected the topic of plants because there are a lot of English words that students have to know and remember such as xylem and phloem. We reviewed keywords in this topic for the middle school level. We came up with this idea because of the crossword game. We constructed the board and adhesive English letters, and example of clues in Thai. This instructional media can be used for other science topics.

The teacher just creates the new clues set related to the new topic (reflection on instructional media production)

## **2) Time Limitations Cause Changes**

Sasithorn also presented the first plans to integrate technology to produce an instructional movie. However, she talked about time limitation that changed the early plan of the group. She presented her plan in the reflection below:

First, we planned to use the Window Movie Maker program that we learned from the course to produce an instructional media, but our group did not have enough time to meet and plan to film the movie. So, we changed our minds to produce an easy and adaptable instructional media. A fun word game was produced for students' reviewing knowledge after they finished each lesson (reflection on instructional media production)

In summary, at first, Sasithorn planned to use technology to support her teaching. But, because of time limitations, she changed to produce instructional media in the form of a reviewing knowledge game. In the process of production, Sasithorn integrated domain of professional knowledge including content knowledge, curriculum, teaching strategy, and instructional media to produce the artifact.

## **Thematic Findings Derived among the Cases**

During the course, the findings from each case were compared and contrasted. The thematic findings emerging from the cross-case analysis are presented below. Each case presented individual differences of pre-service science teachers. They brought in their prior underlying professional knowledge, and the readiness in each domain to the course.

There were a total of ten themes that emerged. In the part on underlying professional knowledge, there were three major sections: “General conceptions expressed by pre-service science teachers”, “Clarifying their conceptions by comparing with the national standard and others”, and “Perceiving role models of pre-service science teachers”. In the part on implementation of professional knowledge, there were seven major sections: “Empowering the pre-service science teachers”, “Sharing of professional knowledge in the professional group”, “Providing relevant situations for implementing knowledge into practice”, “Utilizing technology in teacher education needs supporting factors”, “Feedback provided by a variety of sources supported them to think differently”, “Advantages of microteaching activity emerged from the cases”, and “The confidence issue”.

### **1. General Conception Expressed by Pre-service Science Teachers**

In all of the four cases, all pre-service science teachers who were educated and trained in the same teacher preparation program expressed their early agreement with the idea of “student construction of knowledge”. However, when they were investigated in-depth, there were some hidden beliefs presented in their views.

At the beginning of the course, Prangwalai and Korapin expressed that they believed in student construction of knowledge. In the construction of knowledge, Prangwalai thought students learned best through rigorous procedures. Korapin believed that the starting point of learning was the teacher’s questions and that students tried to find the answers for the teacher.

Sasithorn also presented her view on student construction of knowledge. When her views were analyzed in detail, she showed aspects of constructivism such as believing in individual differences, hands-on and mind-on activities, group work, and students’ prior knowledge.

There was one case that did not present the “student construction of knowledge” view; this was the case of Sintu. In his case, it can be implied that he

believed in constructivism. His ideas presented the student-centered approach, not believing in teacher's transmission of knowledge, and using a variety of teaching strategies to support individual learning. From the general finding of this aspect, it can be said that all pre-service science teachers interpreted the meaning of "student construction of knowledge" differently. So, they came to the course with different conceptions or different underlying professional knowledge.

## **2. Clarifying Conceptions by Comparing with the National Standard and Others**

The conception about teaching and learning science was implicit inside each person. There were activities during the course that aimed to help pre-service science teachers clarify their underlying professional knowledge. Comparing their conceptions with the national standard both in general education, the NEA 1999, and in science education, science curriculum framework of IPST helped them clarify their conceptions.

In the cases of Prangwalai and Korapin, the activity helped them shift their conceptions. Earlier, Prangwalai presented a combination of constructivist, technical, and rationalist views. When she compared her views with the standards, she became consistent in constructivism. In the case of Korapin, first she presented that learning should start with teachers' questions. When she compared her views with the standards, she saw the importance of the student's questions and curiosity. In the case of Sintu and Sasithorn, comparing their view with the standard helped them fulfill, extend, and prolong their prior conceptions. Moreover, in the case of Sasithorn, there was another factor that confirmed and contradicted with her conception. Social interaction, comparing her view with others friends, opened her view wider. She saw both similarities and differences between her views and others.

The general finding revealed that clarifying the underlying professional knowledge by comparing with standards and the others helped pre-service science teachers change, and prolong their prior knowledge.

### **3. Perceiving Role Models of Pre-service Science Teachers**

There were some findings that showed that the role model from an instructor affected the gradual change of pre-service science teachers' conceptions. In the case of Prangwalai, at the beginning, she believed that the teacher changed students' misconceptions by transmission of knowledge. By seeing the role of the instructor, she accepted that organizing specific learning activities should be used for students to encounter their own misconceptions and change them by themselves.

In another case, the case of Korapin, in the beginning she did not believe in the importance of learning journals on student learning. After an instructor stated the importance by presenting the meaning, providing support and feedback, she became a more reflective person and realized the importance of the learning journal.

### **4. Empowering Pre-service Science Teachers**

When pre-service science teachers were empowered, they learned more and better. There were a variety of positions expressed by each case such as "teaching friends"(the case of Prangwalai) or "teaching the others" (the case of Sintu), "being an organizer" (the case of Korapin), and "being a leader" (the case of Sasithorn). They indicated that being in these positions pushed them to search for more knowledge. The findings from all cases showed that all pre-service science teachers revised and deepened the domain of professional knowledge when they organized and led the seminar discussion. Prangwalai showed the most revision of her knowledge on the topic of inquiry. Korapin showed her changes on the topic of learner and learning and assessment strategy. Sintu expressed his top revision of the professional knowledge on the topic of lesson plans, and Sasithorn showed that her views changed on the topic of classroom management. Moreover, Prangwalai presented another domain of her professional knowledge that was instructional media and technology. Prangwalai was empowered by being part of the instructor group. She was proud of her knowledge and thought that this area was the most revised during the course.

## **5. Sharing of Professional Knowledge in the Professional Group**

The sharing of knowledge emerged from the cross-case analysis. In the case of Prangwalai, the sharing of knowledge was presented in the domain of classroom management. She thought when every member brought problems found and classroom management strategies to the class, the discussion enhanced the sharing of knowledge among the members. In the case of Korapin, she thought observing her friends integrating knowledge of research from their readings expanded her knowledge. Everybody exchanged knowledge with the others. In the case of Sintu, he stated that the movie production activity provided him opportunities to share his knowledge to his colleagues.

## **6. Providing Relevant Situations for Implementing Knowledge**

Relevant situations, which mean situations that related to their professional lives, were provided in the course. These included: video and paper classroom cases, inquiry and cooperative learning in the classroom, analysis of classroom management, and analysis of research done in science education in Thai context.

When pre-service science teachers encountered real situations that affected them personally, some saw examples of professional knowledge implementation in the classroom. In the case of Korapin, she saw examples of using rubric assessment in a class of teacher Jim's (the video case). She realized that giving power to students to design their own rubric was acceptable and saw examples of how to implement it in her class. Prangwalai saw examples of classroom management strategies from the classroom observation. She saw problems and how the teacher dealt with those problems. Prangwalai, Korapin, Sintu and Sasithorn stated that they saw real examples of using inquiry and cooperative learning in the classroom which helped them understand how to apply the effective teaching strategies in a real classroom.

In the course, they saw examples from their friends, and implemented their own professional knowledge in the real situations. Prangwalai and Korapin implemented their knowledge of educational context and science curriculum

framework to analyze and reflect on a classroom case. Sintu implemented this knowledge into his lesson planning activities. Prangwalai, Korapin, Sintu, and Sasithorn implemented knowledge of inquiry and rubric assessment into the lesson plan writing activity. Prangwalai and Korapin implemented their knowledge of research on best practices

## **7. Utilizing Technology in Teacher Education Needs Supporting Factors**

Korapin, Sintu, and Sasithorn were familiar with using technology, but Prangwalai was not computer literate. Even though some of them already knew about the Window Movie Maker, none of them realized its use for producing instructional media. One factor that enhanced using the Window Movie Maker in Science teaching was that it was user friendly. Korapin said this program was easy to use and it was not boring. Sasithorn compared this program with another program and said it was easier to produce and use in the real classroom. Even Prangwalai, who had never used the program before, felt it was user friendly. She was able to understand and produce a movie.

Another factor was presenting its usefulness through a real situation. All cases presented that participating in producing instructional movies to teach science, helped them see its usefulness in the classroom.

In the online discussion activity, the important factors were supporting the flow of activities and the participation of class members. In the case of Prangwalai, she stated that at the beginning of online discussion activities, the discussion was not flowing. The researcher encouraged members' participation by encouraging the other class members. Moreover, in the case of Sintu, he stated that some pre-service science teachers were not participating or rarely participated in the online discussion. These factors affected the flow of the activity.

## **8. Feedback Provided by Variety of Sources Support Different Thinking**

The microteaching activity and lesson plan writing aimed to provide opportunities for pre-service science teachers to integrate all domains of professional knowledge into practice. There were important factors, such as receiving, and providing feedback, that helped pre-service science teachers think differently. In the case of Korapin, Sintu, and Sasithorn, they stated that giving feedback to the others and receiving feedback from a variety of sources provided them many perspectives on how they saw their own lesson plan and teaching. Moreover, Korapin stated that this was different when compared to other methods courses that she had taken.

## **9. Advantages of Microteaching Activity Emerged from the Cases**

Not only did the microteaching activity provide feedback for pre-service science teachers, it also provided a situation for encountering their deficiency of knowledge. In the case of Prangwalai, she stated that participating in the microteaching activity helped her realize her deficiency of content knowledge and encounter her own misunderstanding.

In the case of Sintu, the microteaching activity enhanced his analytical thinking. Sintu participated in microteaching analysis. He integrated domains of the professional knowledge into the activity. He said this enhanced his analytical thinking with his own planning and teaching.

## **10. The Confidence Issue**

Confidence was another issue that emerged from the case of Prangwalai and Sasithorn. When pre-service science teachers were not confident, they tended to provide students with directions for conducting an experiment instead of questions to guide them. In the case of Prangwalai, when she was not confident in her content knowledge, she delivered the lesson by telling students directions. In the case of

Sasithorn, when she was not confident in her lesson plan, she told students how to do the experiment step by step

In summary, the course enhanced pre-service science teachers' professional knowledge both on the aspects of underlying professional knowledge and ability to implement their professional knowledge. As pre-service science teachers held different conceptions on teaching and learning science and could somewhat implement the professional knowledge before the course, their conceptions were clarified and shaped by comparing with standards and with the others during the course. The role model of an instructor also affected the gradual change of pre-service science teachers' underlying professional knowledge. In the cases of pre-service science teachers who held partial constructivist views, such as the cases of Prangwalai and Korapin, their conceptions were changed to be more complete in constructivism. In the cases of pre-service science teachers who held constructivist views such as the cases of Sintu and Sasithorn, their views were prolonged and confirmed along the course.

The abilities to implement the professional knowledge into planning and teaching of pre-service science teachers were also enhanced by the course activities. Each domain of the professional knowledge was revised during the course. All participants wrote lesson plans more carefully. Their lesson plans became written with details and showed interrelations between components. Some pre-service science teachers such as Prangwalai, Korapin, and Sasithorn practiced their teaching in the microteaching activity. However, in the case of Sintu, he did not have a chance to practice teach in the microteaching activity. Their teaching will be presented in the next chapter.

The thematic finding from the cross cases analysis can be summarized into factors that influenced the development of professional knowledge which included: perceiving the role model of the instructor; empowering them to teach the others; sharing the professional knowledge with peers; implementing their professional knowledge in a relevant situation; participating in using technology to support their

careers; receiving feedback from a variety of sources; encountering their own deficiency of knowledge in the microteaching, and enhancing their confidence in their teaching careers.

## **CHAPTER VI**

### **FINDINGS OF THE STUDY IN PHASE III: DURING THE STUDENT TEACHING**

#### **Introduction**

This chapter provides data on participants during their student teaching and provides answers to sub-research questions, namely:

In what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching?

What learner characteristics result from being taught by the Thai pre-service who have received the special teacher education?

The development of professional knowledge during student teaching was considered in two ways including their conception about teaching and learning and their ability to plan and teach lessons. The characteristics of the students of the pre-service science teachers, and other influencing factors relating to the development of professional knowledge are explained. The chapter begins by discussing the background of participants, then relates the story of each case, and ends with the thematic findings among the cases.

#### **Prostrating Background of Participants**

Prangwalai, Korapin, Sintu, and Sasithorn (pseudonyms) had participated in a capstone course in the first semester of the 4<sup>th</sup> year before practice teaching in the second semester. At first, they didn't know where, what grade or what subject that

they would have to teach. They found out more about their student teaching during the 10<sup>th</sup> week of the course (about 3 months before the student teaching practicum).

Prangwalai and Korapin selected a laboratory school of their university in which to do practice teaching. This school was established about 35 years ago. The school aims to be a field base for student teachers from the Faculty of Education, a laboratory for educational research, and an institute to provide general education from grade 1-12 for boys and girls according to their abilities, intelligence, skills, and interests. There are 300 teachers and 3000 students in the school. There is an average of 40 students in each class.

Sintu and Sasithorn selected a public school in which to do practice teaching. This school was established about 60 years ago. The school aims to develop learners to be good, healthy, happy and intellectual persons and be able to live in Knowledge - based Society. There are 200 teachers and 3000 students in the school. There is an average of 50 students in each class.

By comparing the context of each school, the laboratory school was different from the public school. In the laboratory school, there were 40 to 45 students in the class, and 2 to 3 classroom teachers always sat in the back of the class. In the public school, there were 50 to 55 students in each class, and the students were less enthusiastic to learn science than the laboratory school students. For example, one day the researcher sat in the back of a classroom in the public school, the students in the back row brought out a make-up set and hair brushes to use during their science class. When the researcher asked the pre-service and in-service teachers, the researcher found that this situation always happens in other classes.

Prangwalai had a university advisor, Dr. Ken, who finished his doctoral degree in Science Education. He is about 29 years old and taught in both high school and in the Faculty of Education at the university for 2 years. His background was in Biology-General Science. This year was the first year that he supervised a student teacher during teaching practice.

Sintu, Korapin, and Sasithorn had the same university advisor, Dr. Sangprapha. She is about 55 years old and has taught at the University level for more than 20 years. She has a doctoral degree in Curriculum and Teaching, a Master's degree in Science Education, and a Bachelor Degree in Chemistry.

The following pages provide stories of each case including the case of Prangwalai, the case of Korapin, the case of Sintu, and the case of Sasithorn respectively.

## **The Case of Prangwalai**

### **1. Student Teaching Environment**

#### **1.1 Prangwalai's Responsibility and Working Environment**

Prangwalai taught Science for 7<sup>th</sup> grade students in Room 1 and Room 6, for 8 periods a week (4 periods in each room) in a laboratory school for 18 weeks. There were about 40 to 45 students in each class. She also took the responsibility of being the homeroom teacher for the students in Room 7/6. In the morning, she lined up the students and checked the student cleaning schedule in the afternoon. She also paid attention to the development of each student in her homeroom. In this school, the homeroom teacher sits behind the students almost every period. Prangwalai thought that this was a good location for the teacher to observe each student during the class. Prangwalai noticed the differences from the first week's observation between students in Room 7/1 and 7/6. The students in 7/6 were more enthusiastic to learn science than the students in Room 7/1. Prangwalai was under the supervision of her university advisor, Dr. Ken.

Prangwalai had a colleague who taught in the same grade level and in the same school. Her colleague was the same woman that she worked with during the course. Even though they had different cooperating teachers, they sometimes worked together during lesson planning.

## **1.2 Prangwalai's Cooperating Teacher**

Prangwalai had a 45-year old cooperating teacher who she called "Arjarn Jintana" (a pseudonym). Arjarn Jintana graduated with a Master's Degree in Science Education with a minor in Biology. She had taught middle and high school students for 28 years, but this was her first year in this particular school and her first year being a cooperating teacher for a pre-service teacher. Arjarn Jintana read the duties of the cooperating teacher from the documents provided by the student teaching practicum center. There was no special meeting that informed cooperating teachers about their responsibilities and duties. Arjarn Jintana observed Prangwalai during every class, but she didn't provide feedback for Prangwalai after every class. She said she only made suggestions to Prangwalai when she saw some problems. Concerning lesson plans, Arjarn Jintana said Prangwalai always handed in her lesson plans before teaching. She sometimes gave Prangwalai feedback which mostly was concentrated in the main ideas section.

Prangwalai started her first week of student teaching by observing Arjarn Jintana's science classroom. After that she started teaching by having Arjarn Jintana as a classroom observer. In Prangwalai's student teaching, she taught the following learning units: Science and Technology; Living Things and Living Process; Life and Environment; Matters and Properties; and Processes that Shape the Earth. The researcher observed her classes and interviewed her after the classes four times. The researcher observed the classes that Prangwalai taught on the topics of the Food Chain, Environmental Problems, The Classification of Substances, and The Calculation of Humidity in the Air respectively.

## **2. Prangwalai's Development of Professional Knowledge during Student Teaching**

To determine whether the capstone course continues to enhance pre-service science teachers' professional knowledge during student teaching, Prangwalai's conceptions about teaching and learning and the implementation of professional

knowledge into lesson plans and teaching were explored during her practicum. The development of the professional knowledge of Prangwalai during student teaching is reported in section 2.1 on underlying professional knowledge or conception about teaching and learning science in section 2.2 on implementation of professional knowledge.

## **2.1 Underlying Professional Knowledge**

### **2.1.1 Hands-on Activities Presented in Prangwalai's Views of Teaching Science**

Prangwalai presented her conceptions about the teaching and learning process that hands-on experiments were suitable for science topics in the area of Chemistry. In her view, students were enhanced in both the thinking process and science process skills by the hands-on activities. Prangwalai let students design their own experiments and emphasized students' enthusiasm and thinking processes. She presented her conception in the weekly journal with this entry:

This topic was in the area of Chemistry. I provided opportunities for the students in my classes to design and conduct the experiment by themselves, because I think the nature of science is suitable for conducting experiments. The students were enhanced in many science process skills such as defining variables, measuring, and designing and conducting the experiment. From my observation, most of students were interested in the activities and were enthusiastic. They effectively participated in the experiment and in the discussion of the results. The hands-on experiment is very effective for this area of science and enhanced student thinking (weekly journal: week 7)

### **2.1.2 Students' Understanding More Than the Curriculum Coverage**

When Prangwalai encountered the issue of time limitation in school, similar to a story that she read from the classroom case during the course, she

presented the same view that students' understanding of science is better than curriculum coverage in her weekly journal.

When the class encountered problems with time limitation, I preferred to cut some topics, but I didn't have the authority to do that. When Arjarn Jintana made the decision to cut some topics, I was very happy, and felt more relaxed in designing activities for students. To rush is not good for student understanding. I feel that students don't have to hurry finishing all topics; they gradually develop their understanding of topics through activities. The knowledge that they constructed is deeper and lasts longer (weekly journal: week 8)

### **2.1.3 The View of Students' Learning Science**

Prangwalai's view of students' learning science was presented in the interview when she was asked if students' learning happened in her class.

Even though my class was noisy, I don't think this is a problem. This is the nature of students' learning, especially using games in class. Students had fun and also understood the scientific concept. If they were quiet, it means they didn't learn anything, right?!...I know that they understand from the conclusion of the lesson. They made conclusions about the meaning of the food chain and had group discussions (Interview 1)

Prangwalai thought that noise in the classroom is not a classroom problem; she viewed this was the nature of students' learning when using games in classroom.

### 2.1.4 Conception Shaped by the Cooperating Teacher's Conception

Arjarn Jintana, Prangwalai's cooperating teacher, presented her view that not only hands-on activity, but also other strategies can be used to enhance student's learning science.

I think Prangwalai's teaching relied on the recommendation of NEA1999. She used a variety of teaching strategies which were suitable with each scientific concept. Her learning activities emphasized students working in groups and taking responsibility for their own learning. However, she was always concerned when she didn't have a hands-on activity or experiment in the lesson, but I suggested to her that we can use other strategies to enhance students' learning (Interview)

Prangwalai's conception that learners only construct knowledge through a hands-on activity was shaped by the cooperating teacher's suggestions. She realized that a teacher could use activities other than experiments to help students construct their own knowledge. She presented her conception in the weekly journal with this entry:

This week I had to teach about calculating humidity in the air. First, I felt that I can't design a hands-on activity for students. So, I went to talk with Arjarn Jintana. She said the student-centered method does not mean students always have to do an experiment. This reminded me about what I learned that some content is not suitable for students to do experiments with, and that we can use other strategies to help students construct knowledge (weekly journal: week 16)

In summary, Prangwalai's conception presented student construction of knowledge; she strongly believed in hands-on activities which enhanced the student thinking process, and the ability to design investigations. She emphasized students' understanding scientific concepts more than curriculum coverage. She accepted that

the nature of student learning is sometimes noisy. Moreover, Prangwalai's conceptions were also influenced by her cooperating teacher's conceptions.

## **2.2 Implementation of Professional Knowledge**

The ability to implement professional knowledge during student teaching was captured in Prangwalai's lesson planning and teaching in the real classroom.

### **2.2.1 Lesson Plans**

During Prangwalai's teaching practice, she consulted her cooperating teacher about the long-range plan. She received the school long-range plan consisting of units that she had to cover which included: Science and Technology; Living Things and Living Process; Life and Environment; Matters and Properties; and Processes that Shape the Earth. She designed her daily lesson plans based on the long-range plan and handed-in her lesson plans to the researcher at the same time that her classrooms were observed. There were some findings that emerged from the coding process of lesson plan analysis.

#### **A. Consulting the National Science Standard, Textbooks in Planning Process**

After Prangwalai got the long-range plan from her cooperating teacher, she studied it in detail to find out what topics in each unit that she had to teach. Prangwalai planned the daily lessons by consulting IPST curriculum standard and many science textbooks. She consulted the IPST curriculum standard to understand the scope and the depth of scientific concepts for setting expected learning outcomes in the lesson plans. Prangwalai aimed to fulfill her understanding of scientific content by studying from a variety of textbooks.

## **B. Lesson Plans Designed Based on Constructivism**

All of the lesson plans were designed based on constructivism. The learning activities presented the concern of student prior knowledge. For example, on the topic of the food chain, she planned an introductory activity to investigate students' prior knowledge about the function of each organism in an ecosystem and its food before introducing the concept of the food chain. On the topic of the classification of substances, Prangwalai set an activity that let students classify their everyday life substances by using their own criteria before studying the scientific classification.

Prangwalai planned all the lessons by letting students mainly participate in the learning activity by using the group process to help students' learning science together. For example, on the topic of environmental problems, she provided learning resources for each topic. Each student selected the topic that he/she was interested in and they were divided into groups according to the topic. Each group investigated the topics which included water, air, soil, and waste pollution. After that, each group prepared, presented, asked and answered the questions. In the closure, students discussed and made conclusions about pollution in their society together in class.

In the other lesson plan, on the topic of The Calculation of Humidity in the Air, Prangwalai planned to revise students' existing knowledge about reading humidity by using a Hygrometer and connecting it with the concept of calculating humidity in the air. In the learning activities, Prangwalai let students study the formula, practice basic calculation in groups, and then compete between groups to calculate more complex word problems. In the closure, Prangwalai used questions to help students conclude the lesson by themselves.

All of Prangwalai's lesson plans were designed by being concerned with students' prior knowledge, emphasizing group work, students' participation, and the construction of knowledge.

### **C. Using Appropriate Format, and Interrelating Each Component**

All lesson plans used the appropriate format. The header of the lesson plans consisted of the subject, the name of unit, the grade level, the semester, and the duration of the lesson. The content consisted of standard, expected learning outcomes, main ideas, learning activities, instructional media, and assessment and these were interrelated.

All lesson plans were written in detail. The learning activities, duration, questions or expected answers were identified in the lesson plans. For example, on the topic of Calculating Humidity in the Air, Prangwalai planned to ask a question to assess students' prior knowledge. She identified the specific question, and also wrote the expected answer in parenthesis. An example of Prangwalai's lesson plan was presented in the following paragraph.

#### **Introduction (10 minutes)**

Students revise the prior concept from the last period by answering the questions:

- "What did we study in the last period?"

(Humidity in the air and measuring humidity by using a hygrometer)

- "If we don't have a hygrometer, can we tell the humidity by using other methods?" (Yes, we can calculate the humidity by using the formula)

(lesson plan 4)

All of her lesson plans consisted of the learning outcomes that identified measurable behavior. Each of the components was interrelated. For example, on the topic of environmental problems, Prangwalai set the expected learning outcomes to enhance students' knowledge and skills used to explore causes and effects of pollution, and awareness of the results that affect the ecosystem. Prangwalai addressed a main idea which covered the learning outcomes including the

causes and effects of environmental problems (related to water, soil, and waste pollution), and its results and strategies used to protect the environment. The learning activity was designed by letting students in groups select, explore and present each of the environmental problems. Prangwalai planned assessing students' achievements by using journals, investigation sheets, and presentation sheets. She designed a rubric for students to assess their own and other groups' presentations.

#### **D. Problem in Identifying Learning Outcomes that Enhance Students in all Aspects**

Most of the lesson plans aimed to enhance students in all aspects including knowledge, process and skills, and attitudes; except one lesson that did not identify students' attitudes. The lesson plan was on the topic of the food chain. Prangwalai planned to teach this in one period (50 minutes). The learning outcomes attempted to enhance students' knowledge of energy transfer and function of organisms in the food chain, and their skills in constructing diagrams representing the relationship and energy transfer in the food chain of an ecosystem. The aspect of attitude was not presented in this lesson plan. Prangwalai presented the reason behind this in the first interview after teaching.

I brought knowledge and skills from seminar course to use in my planning and teaching, I tried to use the appropriate format, check the interrelation of each component, and construct learning outcomes that cover students' KAP (knowledge, attitude, and process). But in some lessons, like this lesson, I missed learning outcomes that aim to enhance students' attitudes. It is not because I wasn't concerned about it, I did and want to enhance students' awareness of an importance of the food chain in an ecosystem. It is very hard to construct a measurable behavior in the learning outcomes to present students' concerns (interview)

Prangwalai stated that she designed the lesson that aimed to enhance students in all aspects, but in some lessons, she had problems with

identifying students' measurable behavior in the learning outcomes to present students' attitudes.

### **E. Planning to Use Appropriate Topic-specific Instructional Strategies**

Prangwalai planned to use instructional strategies that fit with specific science concepts. She used hands-on activities to enhance students' science process skills. For example, on the topic of the food chain, Prangwalai let students describe eating relationships by drawing a diagram of a food chain. On the topic of the calculation of humidity in the air, Prangwalai let students explore the meaning of the formula before calculating the word problems. On the topic of the classification of substances, Prangwalai provided real-life substances for students to classify by using their own criteria and comparing them with scientific criteria.

In the topics that can be divided into small sub-topics, such as the topic of environmental problems, Prangwalai designed learning activities by using an investigation strategy for students to investigate each topic and combined them together in the whole class discussion strategy.

In summary, Prangwalai started the planning process by studying the long-range plan, consulting the IPST science curriculum standard for understanding of the scope and the depth of the concepts, and consulting a variety of textbooks for fulfilling her content knowledge. Her lesson plans represented constructivism in that they monitored students' existing knowledge, provided opportunities for them to construct their own knowledge and concluded concepts of the lesson by themselves. The lesson plans were written in detail, presented in an appropriate format, and showed the interrelation of each component. All of Prangwalai's lesson plans aimed to enhance students' learning in all aspects, however, in some lessons Prangwalai encountered problems in identifying the expected learning outcome that enhance students' attitudes. Prangwalai planned the lessons by using the appropriate instructional strategies with each scientific concept.

### **2.2.2 Teaching Practices**

Prangwalai's teaching practices were observed four times by the researcher. However, there were some classes that were not observed, but were reported about in her weekly journals, as well as interviews with her, her cooperating teacher and her students. There were some findings that emerged from the data analysis.

#### **A. Teaching Practice Compatible with Underlying Professional Knowledge**

Prangwalai's teaching practice was compatible with her lesson plans which relied on her underlying professional knowledge. The results from the course revealed that Prangwalai's conceptions were gradually changed. She began to believe in the hands-on activities in which students designed and did the activities by themselves. During student teaching, Prangwalai's lesson plans were consistent in constructivism and used hands-on activities, and were concerned about student's thinking and planning process. In the teaching practice, Prangwalai's teaching was compatible with her views. Prangwalai let students design their own experiments and emphasized students' thinking processes. For example, on the topic of the classification of substances, Prangwalai used questions to engage students designing their own classification procedure.

From the samples of substances, how can you put them into groups? Please discuss with your friends, write down your plan and criteria that you will use to classify them. After that, I will give each group 3-5 minutes to present the results to other groups (classroom observation: week 3)

In addition, on the topic of environmental problems, Prangwalai gave students the freedom to design their own presentations about their investigation of environmental problems. The scope of the presentation had to cover the cause and effect, and the place that the environmental problems happened. Students in each

group presented in different styles such as news reporting about waste in society and role play of water pollution. Prangwalai reflected in an interview after teaching that students can design the process of doing hands-on activities themselves.

I let students design their investigation about the environmental problem and come talk to me before they started. In this period, they designed their presentations, which they did very well. It is fun and I think it helps students understand the concepts (interview: week 2)

### **B. Integrating Knowledge of Learners and Learning into the Teaching Practice**

Prangwalai showed her professional knowledge in the area of learners and learning in her teaching practice. Throughout Prangwalai's teaching practice, she realized the importance of the students' existing knowledge and backgrounds. During the first week, she noticed the differences between students in each room. She presented her observation in her weekly journal.

Students in Room 7/6, which is my homeroom, are eager to answer the questions and show enthusiasm more than the students in Room 1 (weekly journal: week 1)

Moreover, Prangwalai conducted activities to acquire students' prior knowledge including revising the prior knowledge from the previous period, using questions-answer activities, organizing pictures and sorting cards. Prangwalai presented her views on the importance of student prior knowledge that effects her planning and teaching in her weekly journal.

This week we are on the topic of the classification of substances, I need to find out students' basic knowledge of substance and its properties before they study the classification. This will be basic information that I will use to design an activity to fit with their prior knowledge (weekly journal: week 7)

### **C. Adapting Lesson Plans Based on School Context**

Prangwalai learned from her experiences to adapt herself when her teaching was affected by the school context. Even though she planned many interesting activities for students, she adapted by combining or canceling some activities in the lesson plans based on time availability. She presented what she learned in the weekly journal.

I found some problems in combining some lesson plans together when some learning activities were canceled or adapted. This made me feel sorry for the students, because some activities that I designed were very fun and can be used well to engage students' learning. However, I learned how to adapt my plan to fit with the school context (weekly journal: week 3)

### **D. Content Knowledge Affected Prangwalai's Confidence and Teaching Practice**

Prangwalai who has a chemistry background presented her confidence in the area of chemistry and biology. When she taught the concept of the classification of substances and the food chain, she conducted the lesson smoothly. She answered students' questions confidently. Prangwalai presented her confidences in her weekly journal with this entry:

The first topic is classifying producer based on their food, which is not a hard topic for me, so it didn't make me concerned about the topics at all (weekly journal: week 2)

Even though she presented her confidence in the area of Biology, she presented the misconception about the function of hydra in the ecosystem in her teaching practice. She understood that hydra is a producer in the ecosystem because it's green. She presented her understanding when students answered that hydra, planarian, and amoeba were producers. She helped students change their concept that

only hydra was the producer in an ecosystem. Prangwalai didn't understand that the reason that hydra is green is because they live in symbiosis with the green algae who is a producer. When Prangwalai misunderstood the concepts that were outside her area of expertise, she organized activities that also caused students' to have misconceptions.

In the area of earth science, when she was not confident in scientific concepts, Prangwalai consulted with the cooperating teacher to confirm her understanding of the concept and the activities that she planned to use.

This week I have to teach on the topic of the calculation of humidity in the air. First, I feel I can't design a hands-on activity for student. So, I went to talk to Arjarn Jintana. I would like her to confirm my understandings and the activities that I planned to use before I use it (weekly journal: week 16)

### **E. Integration of Classroom Management Strategies during Student Teaching**

In classroom management, Prangwalai said that at first she was concerned about classroom management. She stated that she brought some ideas from the course (the capstone course) to use with students in her class. Before getting started, she made an agreement with the students about the rules of the classroom which she presented in the weekly journal.

I was concerned with classroom management, but I found that I did very well this week. One strategy I bought from the course is to make an agreement with learners before starting teaching; I think this will help me with classroom management (weekly journal: week 2)

At first Prangwalai encountered problems with not all of the students handing in their tasks. She realized a strategy used to deal with this problem from the seminar discussion.

Finally, I got the best way for my students to hand-in their tasks. I realized the strategies that we discussed in the course. I printed out students names and marked students who handed in each of the four tasks this month. I attached it on the wall next to my desk. I told students to keep their eyes on this paper to see what they handed-in already, and what they didn't. The results came out surprisingly well. They bought the tasks that they missed to me and asked me to mark them for them (weekly journal: week 5)

Sometimes, she talked to the cooperating teacher to ask her suggestions about how to control the classroom. She found that she had to change strategies when students became familiar with a strategy.

The problem in this week is about classroom management again, students are very talkative. I tried to change many strategies; my cooperating teacher suggested to me to stay quiet instead of speaking out loud to them. I found that I have to use a lot of strategies to deal with one problem, because once students are getting familiar with the strategies, they are not controlled any more (weekly journal: week 8)

In Prangwalai's teaching practice, she presented an integration of knowledge and experience on classroom management from discussion in the course and her cooperating teacher's suggestions.

## **F. Integrating Teaching Strategies and PCK in the Teaching Practice**

Prangwalai integrated a variety of teaching strategies into her teaching practice. She used instructional strategies that fit with specific science concepts which included: using hands-on activities to enhance students' science process skills; letting students discuss topics when content is suitable; implementing a jigsaw technique when the content can be divided into small sub-topics and each sub-

topic was not a prerequisite concept for the other. She presented her opinion in the weekly journal and interview with the following entry.

The reason that I use investigation and discussion is because I thought the concept is suitable with discussion activities; students can investigate knowledge about their environment, and bring that to discussions. The students can express ideas and their concerns about the environment (interview: week 5)

When Prangwalai had a limit of time and the topic could be divided into sub-topics, she utilized jigsaw techniques for the content presentation. She presented the reason behind the strategy that she used in her weekly journal.

This week I was concerned about my lesson. As we have lots of activities and we lost some periods, I had to put many topics in one lesson. So, I used the Jigsaw techniques to help students learn lots of topics in a limited amount of time; it helps a lot (weekly journal: week 6)

Prangwalai stated that the hands-on activity was not used as her teaching strategy because of the time limitation. She talked about the reason in the weekly journal.

Because of a lot of topics that we have to teach in a limited amount of time, I can't let students do the hands-on activity, so the teaching strategy that I use the most is demonstration (weekly journal: week 10)

### **G. Integrating Knowledge of Instructional Media and Technology in Teaching**

Some activities that were not observed by the researcher showed that Prangwalai used knowledge of instructional media and technology in her teaching. She talked about utilizing of a global warming video when teaching the

topic of environmental problems. She presented her feelings in her weekly journal with this entry:

I think using the global warming video helped students understand and be concerned more about environmental problems. I think this is up to date knowledge that students should know in this time (weekly journal: week 8)

#### **H. Using Formative Assessment Learned from the Methods Course**

Throughout practice teaching, Prangwalai stated that she was concerned with assessing students in all aspects. She presented the concerns in the expected learning outcomes and teaching practice. From the classroom observation, she used a variety of assessments which included: learning journals; students' answers, exercises, concept maps, students' presentations, participation and discussions. She realized that from the methods courses (capstone and other courses), a variety of strategies should be used to assess students. She presented her understanding in the weekly journal.

I use data from tests, tasks, classroom observations, and activities. I do not just assess knowledge, but I assess process and attitude. This practice related to what I have learned from my methods courses (weekly journal: week 14)

Moreover, she implemented a rubric assessment to assess her students' presentations. She said she could not get students to design their own rubric like she saw in teacher Jim's classroom (the capstone course); this is because she does not have enough time to do so.

I used a rubric assessment, but did not let students design the criteria like what I saw in the seminar. We have just only 50 minutes for this topic, so I just let the students read the criteria to understand them before assessing and being assessed (Interview 2)

In summary, Prangwalai's teaching practice was compatible with her lesson plans and the underlying professional knowledge. She was concerned with students' backgrounds and prior knowledge, and the school context. Her content knowledge, prior knowledge, and knowledge gained from her methods courses affected her teaching practice.

Prangwalai presented the implementation of each domain of professional knowledge into lesson planning and teaching including knowledge of: educational context and science curriculum framework; general pedagogical knowledge (PK); subject matter knowledge; pedagogical content knowledge (PCK); and knowledge of instructional media and technology.

### **3. Prangwalai's Students**

To determine the results from being taught by the Thai pre-service teacher who received the special teacher education, a group of Prangwalai's students were randomly selected. The results are reported in section 3.1 on the background of the students and in 3.2 on students' characteristics after they have been taught by Prangwalai. The students' characteristics consist of conceptual understanding, science process skills, and attitudes toward science and the teacher's teaching.

#### **3.1 Students' Background**

All students in both classes were students who had a medium-high grade in science (2.90-3.50 out of 4). Six students from the two classes were randomly selected to participate in a group interview. The interview was organized about 3 weeks after they had been taught by Prangwali. Three from each class consisted of one boy and two girls.

Students in Room 7/1 consisted of a boy (B1) who liked Science. The other two girls liked Social Studies (G1-1) and English (G1-2), respectively.

Students in Room 7/6 consisted of a boy (B6) who liked English. The other two girls liked Science (G6-1) and Thai (G6-2), respectively.

### **3.2 Students' Characteristics after Being Taught by Prangwalai**

The students' characteristics were divided into conceptual understanding, skills, and attitudes toward science and the teacher's teaching

#### **3.2.1 Conceptual Understanding**

When students were asked about the concepts that they learned, they talked about ecosystem and substances. When they were asked the meaning of ecosystem and food chain, they presented an understanding of the definition of ecosystem.

Researcher: "Could you tell me what topics that you have learned with Arjarn Prangwalai?"

B1: "Component of ecosystem"

G1-1: "Food chain and food web"

G1-6: "Producer, consumer, decomposer"

Researcher: "What do you mean by ecosystem?"

B1: "A place that consists of living and non-living thing living together"

G6-2: "It consists of living things such as plants and animals and non-living things like rocks"

Researcher: "The living things in the ecosystem, what is a producer?"

G1-2, G1-1 "The producer was something that can produce food by themselves"

B1: "For example, plants or something that has green color"

B6: "Hydra"

Prangwalai's students presented the understanding of the definition

of ecosystem, however they misunderstood that hydra was a producer because it has green color. This understanding was affected by Prangwalai's understanding on this concept.

In the concept of the classification of substances, students stated that the classification of substances can be done by using criteria, comparing the same or differences of colors, textures, status and acid-base.

Researcher: "What about substances, what did you learn?"

B1: "The classification of substances"

Researcher: "How did you classify the substance?"

G6-1: "We used our criteria and scientific criteria to divide them into groups"

G6-2: "Use the same or differences"

B2: "We used color, texture, status, acid-base to be criteria"

B1: "We compared and classified the substances by using criteria"

### **3.2.2 Science Process Skills**

From classroom observation, the results showed that Prangwalai's students science process skills were enhanced. For example, the students observed and classified everyday substances when learning the topic of Classifying Substances. Students designed, investigated, and communicated the results on the topic of environmental problems.

Some students presented the skills that they gained from other activities that had not been observed by the researcher.

G6-1: "I love that the teacher let us explore the school ecosystem, I observed many thing such as plants, animals, and the way they live together and wrote the report and present it to the class"

B2: "Yeah! I used the instrument....what is the name of it? (look around)... to measure the cloudy of water. I remember putting it into

the water until we can't see it well, and measure the depth of the water”

They presented the skills including observing and measuring metrically from the activities.

### **3.2.3 Attitudes toward Science and the Teacher's Teaching**

Students of Prangwalai stated their enthusiasm and eagerness to learn science when participating in the hands-on activity such as on the topic of the classifying of substances.

The students who were participants presented their feelings on the subject of Science in the interview.

B1: “Science is a subject where the learner does not have to remember the truth as social subject. The learner has to learn science with an understanding and fun”

(G1-1): “Science is a subject that I have to concentrate in. Some topics are easy but some topics are difficult to understand”

(G1-2): “I think Science is fun to learn”

B6: “Science is a difficult subject, but doing experiment helps me understand more”

(G6-1): “Science is a subject that studies about investigating for knowledge and I love the activities that let me investigate an ecosystem”

(G6-2): “Science is fun to learn and always has experiments”

Most students thought that science is fun to learn. Some thought science is hard but understandable. In science, there are always experiments, and the experiments help the student understand concepts.

When the students were asked about activities they like that were provided by Prangwalai, some students stated that they had fun in the learning

activities. These activities were consisted of group work, presentations, games, investigations, and watching videos.

B1: "I love when the teacher lets us do group works, talk, discuss and present in front of the class"

G1-1: "I love playing games"

G6-2, B6: "Me too!"

G6-1: "I love the ecosystem investigation"

B1: "I love watching the global warming video. I saw some things that I had never seen before. Factories, burning things, and cars are factors that affect this"

When the students were asked to talk about Prangwalai's teaching, both what they liked and what they did not like, most of them replied in a positive way.

B1: "I used to learn with a student teacher, they did not help me understand the subject. But learning with Arjarn Prangwalai makes me understand more"

G1-1: "I feel her intention; she prepared a lot of instructional media even though sometimes I thought she can just use the white board"

G1-2: "The teacher explains clearly has a variety of interesting activities"

G6-2: "Sometime when we talk too loud, she was very serious"

G6-1: "I thought she is good and cares about students"

B6: "I feel like everybody; she is good"

In summary, the students that had been taught by Prangwalai presented positive characteristics in all aspects including knowledge, process, and attitude toward science. There were some misconceptions presented by the students; this was because they had been taught in the content out of areas of Prangwalai's expertise.

#### **4. Factors Influencing Professional Knowledge Development**

There were three main factors, which influenced the development of Prangwalai's professional knowledge during student teaching that emerged from the study. These factors affected the development or Prangwalai's professional knowledge as enhancing and prohibiting factors. The factors were the cooperating teacher, school context and workload, and the university advisor.

##### **4.1 Cooperating Teaching**

From the first week of classroom observation, Prangwalai presented in her weekly journal that her cooperating teacher's lessons were based on constructivism which provided opportunities for students to do investigations by themselves. This confirmed that what Prangwalai learned from the methods courses can be used in the real classroom.

Arjarn Jintana used effective questioning techniques in which the questions engaged students' thinking and further investigation. She engaged students' learning by using a variety of interesting activities. Her teaching was based on constructivism, enhanced student science process skills, and provided them to take control of their own learning....from Arjarn Jintana's teaching, I found it related to some things that we discussed in class. This confirmed to me that it was useable in the real classroom (weekly journal: week 1)

The cooperating teacher's teaching enhanced Prangwalai's development of professional knowledge by presenting the implementation of theory into practice. However, the cooperating teacher's role also was an obstacle for integrating Prangwalai's professional knowledge into writing the lesson plans.

Arjarn Jintana suggested that when identifying expected learning outcomes, a teacher doesn't have to identify measurable behaviors which are not what we

discussed in class (the capstone course). This makes me wonder which one I should rely on (interview 4)

When the cooperating teacher's opinion was different from what Prangwalai learned from her methods course, this caused problems in the development of her professional knowledge. Moreover, Prangwalai needed more feedback on her lesson plans, but she didn't receive it from her cooperating teacher. She presented her feelings in the journal entry below.

Even though Arjarn Jintana took care of me well, she rarely gave me feedback on my lesson plans. So, I don't know what is my good or bad points and what should I do to improve my lesson. I think this also affects the ability of my teaching in that period (weekly journal: week 4)

Prangwalai stated that she needed lesson plan feedback to improve her ability in planning and teaching science lessons. The reason that her cooperating teacher didn't provide her feedback was because the cooperating teacher did not completely understand her role. Arjarn Jintana talked about her feelings during an interview:

I do not quite understand the role of a cooperating teacher from my reading. So, I just do what I understand from the documents that were given to me. It will be better if the department (education) organized a meeting for all cooperating teachers. We will know more about our roles and be able to ask some questions (interview)

When Prangwalai's cooperating teacher was asked about her understanding and actions of being a cooperating teacher, she said she did things from what she understood from the documents.

## 4.2 School Context and Workload

The practicum school provided Prangwalai enough equipment and learning resources to use in her class. Prangwalai presented the readiness of the school in the interview.

As we know, the school (laboratory school) has plenty of laboratory equipment and learning resources such as the library, and the garden for students to learn science. I think this is an advantage for the students in this school more than other government schools. Many of my friends had problems about lesson preparation, but for me I didn't have any problems in the preparation for teaching (interview)

Even though Prangwalai had freedom to use school equipment and resources, she had limitations in identifying learning activities in some lessons.

There were two or three topics where the school already has activities designed. For example, on the topic of pollution, there was an activity designed already. So, I don't have to create the new lesson plan, just follow the school lesson plan. In this case, I preferred planning my own, but I couldn't (interview)

Moreover, her workload prevented her from designing lessons or producing instructional media. Prangwalai started talking about her workload both in and outside the classroom and also stated her exhaustion at the beginning of her student teaching.

I feel so tired and exhausted because of a lot of work to do; writing the memos asking for printing the documents or using the school equipment. This week, besides teaching I have to prepare a lot of things for the school fair. I have to rehearse my students for the show, decorate the booth, and create the game. I feel sad that I don't have enough time for preparing the lesson or any instructional media." (weekly journal: week 3)

My students lost 1 period for learning science because of the preparation (the school fair). I feel my teaching is not effective; I don't have enough time to prepare my teaching. I still have to be responsible for the booth decoration, controlling the students show, and also have to prepare my lesson, worksheets and knowledge sheets, and the examination for students" (weekly journal: week 4)

Prangwalai's frustration and exhaustion improved in the middle of her student teaching when she was familiar with her workload.

This week I still have a lot of work to do such as the preparation for my teaching, instruction media, and also special projects.....I appreciate my teaching, I am getting familiar with teacher's work. I can organize time for my planning and the results of my teaching helps student in learning science (weekly journal: week 12)

### **4.3 University Advisor**

Prangwalai stated that her university advisor was one of the enhancing factors for the development of her professional knowledge.

The suggestions from all teachers such as cooperating teacher, you (the researcher), and Dr. Ken (the university advisor) helped me develop myself. Every time I got feedback, I used it to revise and develop myself" (interview)

Prangwalai stated that she appreciated feedback on lesson plans from the university advisor. However, she got feedback about once a month. She preferred her cooperating teacher to do the same thing that her university professor did.

I didn't have a relationship with Dr. Ken (the university advisor) as much as I had with Arjarn Jintana (the cooperating teacher). I stayed with Arjarn Jintana everyday, but Dr. Ken came to observe my class once a month. Every time Dr.

Ken comes, he always give me a detailed comments on my lesson plans, which I greatly appreciated. If Arjarn Jintana could do the same as Dr. Ken does, it would be much better (interview)

#### **4.4 Methods Course (Capstone Course)**

Prangwalai stated her assessment of the course in the last interview when she was asked about the factors that enhanced and inhibited the development of her professional knowledge. One outstanding enhancing factor was often practicing writing lesson plans during the course.

The important factor that helps me develop myself to be a professional teacher was often practicing. Writing lesson plans is an outstanding one. In other courses, we just write the lesson plan, but do not go into the details. In this course (the capstone course), we discussed in detail each part of the lesson. We practiced writing like....3 or 4 lesson plans and then went to student teaching. It was not long before student teaching, so I can write it easily, still remember and be familiar with the format and details (interview 4)

Moreover, she thought the course helped her feel more confident when standing in front of a classroom.

The other advantage was I feel more confident in front of the class. In the seminar (the capstone course), I often went out in front of the class; speaking and teaching. I feel more confident, because I speak more knowledgeable and more fluently (interview 4)

Prangwalai utilized some activities in her lessons that her friends used in the organizing seminar.

On the topic of the food chain, first I tried to think what strategy will help students have fun in learning science. I remembered using games that Nan's

group used in the organizing seminar; I had a lot of fun. So, I planned the lesson plan by using this game as a learning activity. I noticed the students had fun and also understood the scientific concepts (interview)

However, she made some suggestions for improving the course. She talked about duration and time for adding activities in the teacher preparation program.

I thought 2 hours a week is not enough, to make it better, it should be about 3 hour a week. And if it possible, the program should provide seminar 1 in the last semester of the 3<sup>rd</sup> year, seminar 2 in the first semester of the 4<sup>th</sup> year, and then go to student teaching. It will be very effective

In summary, during the student teaching Prangwalai worked as a teacher in a laboratory school. She worked both inside and outside the classroom and she was one of the homeroom teachers of the school. The capstone course continued enhancing Prangwalai's professional knowledge during student teaching. Her conceptions about teaching and learning and the implementation of professional knowledge into lesson plans and teaching were reported. Prangwalai's students presented the positive characteristics in all aspects including knowledge, process, and attitudes towards science. However, the students also presented misconceptions on some topics. There were many factors that affected Prangwalai's development of professional knowledge including the cooperating teacher, school context and workload, the university advisor, and the methods course (the capstone course).

## **The Case of Korapin**

### **1. Student Teaching Environment**

#### **1.1 Korapin's Responsibility and Working Environment**

Korapin taught Science subject for 8<sup>th</sup> grade (Mathayom 2) students for 9 periods a week (3 periods/ room) in the laboratory school for 18 weeks. She taught

room 8/2, 8/3 and 8/4. There were about 40 to 45 students in each class. She also took responsibility in being the homeroom teacher for students in room 8/2. She sits behind the classroom almost every period. Korapin was supervised by her university advisor, Dr. Sangprapha.

### **1.2 Korapin's Cooperating Teacher**

Korapin had a 29-year old cooperating teacher who she called "Arjarn Janjira" (a pseudonym). Arjarn Janjira graduated with a Bachelor's Degree in teaching middle school (general science). She had taught middle and high school students for 3 years, and this was her first year in this particular school and her first year being a cooperating teacher for a pre-service teacher. Arjarn Janjira participated in a cooperating teacher conference that was organized in school by a head teacher of grade 8 level. She received the documents, and information like every cooperating teacher in grade 8 about the details of being the cooperating teachers.

Arjarn Janjira observed Korapin in every class, and asked Korapin to observe her in class every period. Arjarn Janjira always asked Korapin to reflect on what she observed and learned from each class. Arjarn Janjira provided feedback and suggestions for Korapin in aspects of writing lesson plans, classroom management, teaching, instructional media and assessments.

Korapin started her first week of student teaching by observing Arjarn Janjira's science classroom. After that she continue observed the classroom of Arjarn Janjira, and started teaching by having Arjarn Janjira as a classroom observer. During Korapin's student teaching, she taught two learning units including heredity and diversity of living things, and life and formation of pictures. The researcher observed her classes and interviewed after the classes for four times. The first to the last were on topic of genetic disorders, genetic technology, diversity of animals, and reflection of light.

## **2. Korapin's Development of Professional Knowledge during Student Teaching**

To determine whether the capstone course continues to enhance pre-service science teachers' professional knowledge during student teaching, Korapin's conceptions about teaching and learning and the implementation of professional knowledge into lesson plans and teaching were explored during her practicum. The development of professional knowledge of Korapin during student teaching is reported in section 2.1 on underlying professional knowledge or conception about teaching and learning science and section 2.2 on implementation of professional knowledge.

### **2.1 Underlying Professional Knowledge**

#### **2.1.1 Korapin's Constructivist View Continues to be Presented**

Korapin presented a constructivist view of learning during student teaching. She expressed her feeling in the interview which implied that she believed in hands-on and minds-on activity.

A teacher prepared the content and comes to class and speak...speak...speak in front of the class made the students bored to learn science. It is not the way to teach, it's the way to compress content knowledge into student's head which does not work. For me, I believed in effective learning activities that let students do by hand, think by head (interview 1)

Moreover, she expressed more about the importance of students' curiosity in the science classroom. She thought it was an important factor that enhanced student learning of science.

I think students' curiosity is important, it is the first step in enhancing them to learn science. When they asked me what and why we did a particular activity,

I did not tell them directly. I asked them to notice, question and try to find out the answer from the activity instead (interview 2)

From the interviews, Korapin presented aspects of students' constructing their own knowledge. She thought that the transmission of knowledge would not work for teaching science. Instead, she encouraged students to observe, question and find out the answer by themselves.

### **2.1.2 Sometimes the Teacher Switched from Student-Centered to Teacher-Centered**

During the student teaching period, Korapin expressed that the student-centered approach was sometimes not working. Whenever students needed help, the teacher should change her role to become an explainer. She presented her view in the last interview.

Some period, the whole process of student-centered is not work. Today, first, I let students designed the experiment by themselves. The students presented the confusions and needs my explanation. In the limitation of time, I have to change my role to be an explainer (interview 4)

### **2.1.3 Korapin's Conceptions Changed**

Korapin stated what she observed from her cooperating teacher's classroom. She showed that Arjarn Janjira taught based on a student-centered approach. However, she used lecture together with question and answer techniques on the complicated topics.

Arjarn Janjira showed an effort in organizing a student-centered classroom, she was always concerned about individual student prior knowledge. She let students think, do an experiment or investigation by themselves. However, in the content that was complicated to understand, she used a lecture but always

asked students the questions to track their understanding in that period (interview 4)

In summary, Korapin's conception was presented as constructivism. Students constructed knowledge through hands-on and minds-on activity. However, in some complicated topics, a teacher can change the role to be an explainer. Her conceptions were influenced by what she observed from the cooperating teacher's classroom.

## **2.2 Implementation of Professional Knowledge**

The ability to implement professional knowledge during student teaching was captured in Korapin's lesson planning and teaching in the real classroom

### **2.2.1 Lesson Plans**

During the process of planning, Korapin received the course syllabus and the long-range plans from her cooperating teacher. These plans were adapted from last year and were constructed by all teachers in grade 8 levels based on the IPST curriculum standard. In some learning units, there were activities and lesson plans already provided in the school plan. However, the cooperating teacher suggested to her to adapt those plans and recreated to be her own lesson.

After Korapin got the long-range plan, she planned the lessons by consulting many science textbooks. She consulted the textbook to confirm her understanding of those topics. Korapin rarely consulted IPST curriculum standard because the school plan already provided the translation from IPST standard to expected learning outcomes.

Korapin's planning and teaching that were observed by the researcher were on topics of genetic disorders, genetic technology, diversity of animals, and reflection of light. The researcher received the lesson plan at the same

time of observing the classroom. Some findings emerged from the coding process of lesson plan analysis and the interviews.

### **A. Collaborative Working with the Cooperating Teacher in Planning Process**

Korapin was given the power to design her own lesson plans, she discussed with her cooperating teacher before starting to write lesson plans. Arjarn Janjira and Korapin showed the process of lesson planning in the interview with the following paragraphs.

She (Korapin) came to talk to me about the lesson. I gave her some suggestions. Sometimes, she changed the lesson base on my comments. If she has some different ideas, she told me directly. We planned together before she started writing (interview Arjarn Janjira)

The school already provided some learning activities, but Arjarn Janjira suggested for me to design my own lesson. Almost every plans, I came up with idea and went to talk to her (Arjarn Janjira), she gave me suggestions. I wrote the lesson plan and bring for her to check again before teaching. (interview Korapin)

### **B. Process of Planning the Lesson Explained by Korapin**

Korapin discussed her systematic thinking while planning the lesson. She showed the process of planning and writing a lesson plan was much easier than the period before the course.

In the first semester (during the course), when I started writing lesson plan, I don't know where should I started. I spent all day to get start. Now, my feeling changed. I thought about what I want the student to know, which aspects of students I aim to enhance, and write it in form of a measurable behavior. After

that think about the learning activity that can be used to help student achieve the learning outcomes, and assessment strategies will be used (interview 4)

Her answer presented the systematic planning process and interrelations between each components of the lesson plan

### **C. Lesson Plans Designed Based on Constructivism**

All of the lesson plans were designed based on constructivism. The learning activities presented her concerns of student prior knowledge. She put an emphasis on group work, students' participation, and construction of knowledge.

For example, in topic of genetic technology, Korapin investigated students' prior knowledge of the genetic technology that students already know by using the question "What are the genetic technologies that you have heard about?" and "what are those technologies used for?" She let students present the techniques they knew before introducing more techniques with the learning activities. Students were asked to divide themselves into small groups and participate in a "techniques for a secrete code of life" learning activity. In 50 minutes of activity, each group studied or/and did a hands-on activity for 10 minutes per topic. The topics included: genetic engineering, cloning, GMOs, tissue culture and DNA finger print. After finishing each technique, students drew conclusions by doing a group exercise. At the end, students and teacher made a conclusion together (lesson plan 2).

On the topic of reflection of light, she asked students about how humans can see things to introduce students to a keyword, which was "reflection". After that she showed students a diagram of a flashlight pointing to a mirror, and asked the students that "What do you think will happen with the pathway of light after it hits the mirror?" before she let them do the experiment. After the experiment, each group presented the results, and discussed the results together to make a conclusion (lesson plan 4).

#### **D. Detailed Writing, Using Appropriate Format, and Interrelating Each Component**

Korapin's lesson plans during student teaching were written in details. The learning activities, duration, questions or expected answers were identified in the lesson plans. The entire lesson plans used an appropriate format. The header of lesson plans consisted of subject, name of unit, grade level, semester, duration. The content consisted of standard, expected learning outcomes, main ideas, learning activities, instructional media, and assessment and these were interrelated. Korapin used measurable behaviors in constructing the expected learning outcomes. The example of expected learning outcomes in topic of diversity of animals is shown in the following paragraph.

##### Standards 2.2: Life and the Environment

Investigate and analyze degree of local environmental problem and natural resources, propose ideas for maintaining balance in the eco-systems, sustainable usage of natural resources based on knowledge of science and technology, also protecting the environment and solving its problems.

##### Expected Learning Outcomes

1. explain characteristics of animals in each phylum
2. classify animals' pictures by using scientific criteria
3. explain the benefit of using animal in each phylum
4. suggest the way to conserve species diversity in the society

##### Learning Activities

##### Introduction (10 minutes)

1. Students answer the question "What is the name of a phylum in kingdom Animalia?" (Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Anthropoda, Mollusca, Echinodermata, Chordata)

Learning activities (70 minutes)

2. Each student picks a small piece of paper and they divide themselves into group according to their picture.
3. ...
4. ...

Conclusion (20 minutes)

5. Students classify the pictures of animals into group by using scientific criteria in form of concept mapping and present to the class.
6. Each group proposed the way to conserve a species diversity of animal in the society (lesson plan 3)

Moreover, the cooperating teacher expressed her feeling on Korapin's lesson plans that:

I think she (Korapin) writes a detailed lesson plan, sometime is too much in details of main ideas. Her lesson plan presented an interrelation of each component. From the first day until now, she (Korapin) developed her planning ability a lot (Interview with cooperating teacher)

In summary, during the course Korapin collaboratively planned the lessons with her cooperating teacher. The school provided some lesson plans, but Korapin's cooperating teacher suggested to her to construct her own lesson plan. Korapin's lesson plans were designed based on constructivism, were written in detail and in interrelating form. Moreover, Korapin presented her systematic thinking in planning the lesson plans.

## **2.2.2 Teaching Practice**

### **A. Confidence in Teaching Practice Presented**

Korapin presented her confidence in the last teaching practice, even though she taught in an area out of her expertise. She compared her feeling at the beginning and almost the end of student teaching with the following entry.

I feel that during the student teaching I gained more confidence. During the first time I taught on the topic of species diversity, which is an area of my expertise, I feel more insecure. Today, I taught on topic of reflection of light, I feel very confident in front of the class (interview)

### **B. Integrating Teaching Strategies and PCK in the Teaching Practice**

Korapin integrated a variety of teaching strategies into her teaching practice. She used instructional strategies that fit with specific science concepts including: using the hands-on activities to enhance students' science process skills on the topic of reflection of light and diversity of animals; implementing the jigsaw technique when the content can be divided into small sub-topics on the topic of genetic disorders (classroom observation).

Korapin presented the reason behind selecting hands-on activity for students on the topic of diversity of animals. She thought that the topic should be taught by letting students classify animals in the real situation.

For this lesson plan I designed my own lesson, because the activity in the school lesson plan was not interesting. The school lesson plan provided a table for students to record the characteristics of animals in each phylum. I thought students will understand better if they classify the animals by themselves. So, I

designed the activity which aimed to enhance students' science process skills in classifying animals in group (interview 3)

On the topic of genetic disorders, Korapin stated the reason of using jigsaw techniques. She appreciated using this technique on this particular topic.

The reason I selected Jigsaw techniques, because the content can be divided into a small topic. The students can first separately study about each disease, and come back home to listen to their friend's disease. I am appreciating with the results of using this technique on this topic (interview 1)

### **C. Integration of Classroom Management Strategies During Student Teaching**

Korapin used classroom management strategies in her class. For example, on the topic of genetic technology, Korapin made agreement with student at the beginning of period before giving them a bonus point.

Korapin: "If I ask a question and you all compete to answer what will happen?"

Students: "Noisy"

Korapin: "Yes. What should I do?"

A Student: "Raise up my hand first" (raise up his hand)

Korapin: "Do you all agree with him?" (classroom observation: week 2)

To decrease the amount of noise in the class, Korapin made an agreement with students by discussing about the rule at the beginning of the class period. She provided an opportunity for students in making the rule together, so they became responsible for their own rule.

Korapin showed that she integrated some techniques she learned from the course in her classroom. That technique was positive reinforcement.

Instead of punishing students by subtracting points, I used positive reinforcement by adding an extra point if they finish their work in time or not talk during the class. The student became more active. I think it also built up a positive attitude of student toward subject and their teacher” (interview)

#### **D. Using Questioning Techniques to Help Student Understand Science**

Questioning techniques were observed in Korapin’s teaching. She was not suddenly telling student the right answer. Instead, she used many investigating questions to help students understand a science concept. The following paragraph presents an example of Korapin’s classroom, on the topic of genetic technology.

Korapin: “Do you know why in the cloning process, we need to take out the nucleus of egg cell?”

A student: “follow the step of experiment”

Korapin: “follow the step for what reason?”

Students: (in silent)

Korapin: “OK. Now think about the dolly sheep, does it have the same character with the egg cell?”

A student: “No”

Korapin: “Why not?”

A student: “Because the egg cell was taken out the nucleus, and put the new nucleus in”

Korapin: “So, now do you know why in cloning process, we took out the nucleus of egg cell?”

A student: “Ahh!..” (classroom observation 2)

## **E. Variety of Assessment Strategies Observed during Korapin's Teaching**

Korapin used a variety of assessment strategies in her teaching practice including: mind mapping; observing; learning journals; students' answering; the exercise; students' presentation, participation and discussion. Korapin checked and provided feedback for students' learning journal.

However, Korapin did not construct her rubric assessment. She used the rubric assessment provided by the school plan. She said she did not have time to do all the preparation in the limited time.

Designing a rubric assessment that we discussed and practiced in the seminar is good, but I did not have time to do it. In some lesson, the school already provided the rubric assessment, I just used it. I reconstructed just lesson plan, and some time an instructional media, I don't have time to also design the rubric. It will take me a long time to finish all of that (interview 3)

In summary, Korapin taught science in and out of the area of her expertise during student teaching. She gained more confidence at the end of the student teaching period. The content knowledge did not have an affect on Korapin's confidence in teaching. She improved her professional knowledge during the student teaching by integrating knowledge of teaching strategies, PCK, classroom management, questioning techniques, and assessment strategies.

### **3. Korapin's Students**

#### **3.1 Students' Backgrounds**

Seven of Korapin's students were randomly selected from two of her classes. All students in both classes were students who had a medium-high grade in science (2.00-4.00 out of 4). They were interviewed by the researcher after lunch on a

school day. The interview was organized about 3 weeks after they had been taught by Korapin. The interview participants consisted of a boy (B1) and three girls (G1-1, G1-2, and G1-3) from room 8/1, and a boy (B2) and two girls (G2-1, and G2-2) from room 8/2.

### **3.2 Students' Characteristics after Being Taught by Korapin**

The students' characteristics were divided into conceptual understanding, skills, and attitude

#### **3.2.1 Conceptual Understanding**

There were some conceptual understanding presented during the interview. An Example of conversation about the meaning of the terms gene and chromosome is presented below.

B2: "We learned species diversity and genetics"

G1-1: "We learned hormone, gene, and chromosome"

Researcher: "What do you mean by gene and chromosome?"

Students: (Silent)

Researcher: "Are they same or different?"

G1-2: "They are different. Gene is on chromosome, which uses to determine human characteristic. Chromosome is.....how I can explain this"

B1: "Chromosome is bigger unit which consist of many genes on the chromosome"

From the conversations with the researcher, the students explained the meaning of chromosome and gene and told the difference between them by using their own words. When the students were asked to explain what will happen if a human lost his gene or chromosome, they presented their understanding with the following paragraph.

G2-2: “A man will show some characteristic like down syndrome”

Researcher: “How can this character happen?”

G2-2: “Because he has excessive chromosomes”

G1-1: “The 21<sup>st</sup> chromosome”

G1-3: “There were a lot of abnormal characteristic we learned. These come when a person has extra or less chromosome or disorder of gene inside chromosome”

Korapin’s students presented their conceptual understanding on the topic of heredity during the interview.

### **3.2.2 Science Process Skills**

Many activities were designed by Korapin to enhance student science process skills, for example, designing an experiment (reflection of light), drawing a graph (phenotype and genotype), and observing and classifying animals (diversity of animals). These activities were observed by the researcher and also were told by students.

B1: “She (Korapin) give each group the pictures of animals and noticed the characteristic of each picture”

G1-1: “We classified them into groups as we learned about the characteristic of each group. We constructed a map and presented to the class at the end”

Moreover, on the topic of genotype and phenotype, the students were asked to record their height information on the white board, and then construct a graph from each group. Korapin aimed to provide students’ understanding of quantitative characteristics that can not be divided into phenotype.

B2: “After we record data together on the white board, each group construct the graph to present data”

G1-2: “We saw a continuous of the graph that the height can not divided into phenotype other characters such as have and not have dimple”

### **3.2.3 Attitude toward Science**

Korapin’s students presented a variety of their attitudes toward science and toward learning science with Korapin

#### **A. Students Presented Different Attitudes toward Science**

In the group of Korapin’s students, there were three students who loves learning science (G1-2, G1-3, and B1), three students who were apathetic (G1-2, G2-1, and B2), and one student who doesn’t like science (G2-2). The students presented their feelings on Science Subject in the interview. The science lover group presented their feeling with the following answers.

G1-2: “I think Science is fun to learn. It is one of my favorite subjects because it keeps my attention, and reasonable”

G1-3: “Science is a subject that I have a chance to observe things, do experiments”

B1: “I love science because I have a chance to do interesting activities”

In the apathetic group, they presented their feeling that:

G1-1: “I think Science is a subject that I have to concentrate in”

G2-1: “Science contains an attractive content”

B2: “Science is difficult, but fun to learn”

The only one student who doesn’t like science expressed her feeling that:

G2-2: “I think Science is very difficult, learners have to have a good brain”

### **B. A Variety of Attitudes toward Learning Science with Korapin**

After learning with Korapin, students were asked to talk about learning science with Arjarn Korapin. All students presented that they love learning science with Arjarn Korapin with different reasons.

G1-2: "I like Arjarn Korapin's class, because I can ask her many questions. She never stops my questions, instead she helps me find out the answer"

G1-3: "I love when she uses games, and experiments in science class"

B1: "When she explains me something, she uses an easy word. It makes me understand easily"

G1-1: "I love when she has many activities for us to do"

G2-1: "Arjarn always asked questions, first I don't dare to answer, but now I want to answer because I can get an extra point"

B2: "She teaches very well. Whenever I did not understand I can go ask her outside classroom"

A student who doesn't like science said she preferred group work activities that she learns from her friend.

G2-2: "I like when she divided us into small groups, and lets one student teach the other student. It is easy to understand and I can ask the question to my friend"

She also showed her feeling that science is difficult, but she likes to learn from a variety of funny strategies.

G2-2: "Even though science is difficult, I like to learn when Arjarn let us play a matching picture game, work in group, and do the experiments.

In summary, the students that had been taught by Korapin showed their conceptual understanding on the topic heredity, presented science process skills such

as designing an experiment, drawing a graph, observing and classifying animal into group. Korapin's students who like science expressed their positive attitude toward learning science with Korapin. The students who did not like science showed she preferred learning science taught by her friends, and interesting strategies.

#### **4. Factors Influencing the Development of Professional Knowledge**

##### **4.1 Cooperating Teaching**

Observing the cooperating teacher's classroom affected Korapin's conception and teaching in her own classroom (an example was presented in part of Korapin's development of professional knowledge). In addition, Korapin expressed her feeling that the open-mindedness of her cooperating teacher supported the development of her professional knowledge.

"I think I am very lucky being under supervision of Arjarn Janjira, our age is not much different. This makes me not much concerned about seniority. And also her open-mindedness, I can put full effort in my planning and teaching. I am not scared when presenting my ideas. We can actually discuss when we work together" (weekly journal: week 13)

##### **4.2 University Advisor**

During Korapin student teaching, some obstacles emerged from her answers. Korapin expressed that:

I planned the lesson plan by using 5E learning steps. After I taught, my university advisor said it was not the right step. She just said that with no more details about what was not right, what I needed to correct. So, next period that she comes, I just do the simple step of teaching: introduction, teaching, and conclusion. I don't want to take any risk by don't know how to improve myself (interview 4)

From Korapin's answer, it can be implied that the university advisor also affected on Korapin's creativity. It obstructed the development of Korapin's professional knowledge.

### **4.3 School Context**

The school context that affected the case of Korapin was the power of a head teacher in the school. She expressed that the power of this teacher prevented her to create new instructional media.

Some lessons, I constructed my instructional media by discussing with my cooperating teacher earlier. I planned to use in my classroom. A head teacher saw it, and she did not let me use my own. She wants all classrooms to use the same instructional media that she designed. I just feel exhausted. I don't want to think or create any thing new, because I knew that it may be not used if this teacher did not like it (interview)

### **4.4 Methods Course (Capstone Course)**

Korapin stated that she gained much knowledge from the capstone course, especially her ability to design lesson plans.

I thought participating in the course (the capstone course) allowed me to put the prior knowledge together. I practiced writing a lot of lesson plans. I feel more fluent in writing lesson plans during the course. Now, when I started teaching in the school context, I started writing so fast, this may be because it is not long from the time that I wrote the lesson plan during the course. I think it is because of my familiarity in writing the lesson plans (interview)

Another aspect was classroom management that Korapin gained and saw some example from the method course. Her application of classroom management

technique from the course into student teaching was in positive reinforcement. It was presented earlier on the topic of teaching practice.

However, Korapin suggested the main difference between the course and a real classroom was contextual difference.

The main difference I thought about was contextual differences. For example, in the microteaching activity, we did not teach the real students, we taught our friends who had already grown up. We delivered the lesson plan very well in time. When I taught in the real classroom, I found that I had to adapt my plan. The students sometimes not understand, struggle with some problem. So, the lesson plan could not be delivered on time (interview)

## **The Case of Sintu**

### **1. Student Teaching Environment**

#### **1.1 Sintu's Responsibility and Working Environment**

Sintu taught Science for 8<sup>th</sup> grade (Mathayom 2) students, in Room 4, Room 8 and Room 14, for 9 periods a week (3 periods in each Room) in a public school for 18 weeks. Each class consisted of 50 to 55 students. Sintu was provided a table in a science teachers' Room with his colleagues. Sintu noticed the differences from the first week of observation between students in Room 8/4, 8/8 and 8/14. The students in Room 2/4 were more enthusiastic about learning science than the students in Room 8/8 and 8/14. Sintu was under the supervision of his university advisor, Dr. Sangprapha. Sintu taught in the same grade level and in the same school with Sasithorn.

## 1.2 Sintu's Cooperating Teachers

Sintu had two cooperating teachers, Arjarn Bancha and Arjarn Nadda. Arjarn Bancha was a former science teacher for students in Room 8/4 and taught the high school students in Chemistry. Arjarn Nadda was a former science teacher for the students in Rooms 8/8 and 8/14.

Arjarn Bancha graduated with a Bachelor's Degree in Science Education with a major in Chemistry and a minor in Biology. He had taught middle and high school students for 26 years, and had been one of the cooperating teachers for pre-service science teachers for about 5 years. He said he didn't take a main role as a cooperating teacher as the other cooperating teacher did. He helped in observing his classroom that was taught by Sintu. Arjarn Bancha said he knew how to be a cooperating teacher from being the cooperating teacher last year. It was like a school tradition that teachers had done the same thing every year. Nobody told him how to do it, but he did what he thought he had to do. He asked Sintu to send his lesson plans to the other cooperating teacher, he just helped take care of him during the real teaching in class. Arjarn Bancha observed Sintu teaching in every class, but only gave him suggestions occasionally. Most of his suggestions were in scientific concepts.

Arjarn Nadda graduated with a Bachelor's Degree in Science Education with a minor in Chemistry. She had taught high school students for 27 years, but this was her first year being a cooperating teacher for a pre-service teacher. Arjarn Nadda read the duties of the cooperating teacher from the documents provided by the student teaching practicum center. There was no special meeting that informed cooperating teachers about their responsibilities and duties. Arjarn Nadda said that Sintu sent his lesson plans every week, but she did not provide him feedback. She said that Sintu already did a good job. From the observation, the researcher found that Arjarn Nadda had never come to observe Sintu's classroom; she wanted him to have privacy in his class.

Sintu started his first week of student teaching by observing the cooperating teachers' science classrooms. After that he started teaching by having Arjarn Bancha as a classroom observer when teaching Room 8/4. When he taught Rooms 8/8 and 8/14, Arjarn Nadda just stopped by for about 5 to 10 minutes and left the classroom for him to teach by himself.

Sintu's student teaching covered the learning units including: Matter and Properties and Processes that Shape the Earth. The researcher observed her classes and interviewed her after class five times. The researcher observed Sintu when he taught on the topics of the Components and Properties of Elements, System and Change of States and the Dissolution of Substance, Chemical Reaction, Reflection of Light, and Process of Geological Transformation respectively.

## **2. Sintu's Development of Professional Knowledge during Student Teaching**

To determine whether the capstone course continued to enhance pre-service science teachers' professional knowledge during student teaching, Sintu's conception about teaching and learning and the implementation of professional knowledge into lesson plans and teaching were explored during her practicum. The development of professional knowledge of Sintu during student teaching is reported in section 2.1 on underlying professional knowledge or conception about teaching and learning science and section 2.2 on implementation of professional knowledge.

### **2.1 Underlying Professional Knowledge**

#### **2.1.1 Strong View on Constructivism Presented**

Sintu presented his strong view on constructivism during his student teaching, for example he was concerned about students' prior knowledge. When he found that the students' prior knowledge was not complete, he did not continue to the next topic. He revised the lesson for students.

For checking students' worksheets, I found that the students in Room 8/14 miscalculated the atomic numbers, I challenged them with a question. Nobody was able to do it. So, I revised the same topic again for them until I was sure that they can go on to the next topic (weekly journal: week 4)

Sintu presented the activities that provided opportunities for students to conduct scientific experiments.

This week I taught on the topic of change of states and dissolution of substance for all 3 classrooms. My plan was to provide opportunities for students in all groups to conduct their own experiments. Everybody shared responsibility within the group. I noticed that students in every Room loved to do experiments in class; they were excited when seeing that something happened (weekly journal: week 4)

If the experiment was dangerous for students or there were limited instruments, Sintu demonstrated the experiment by asking some students for help, and then did the discussion together. For example on the topic of the change of states and dissolution of substance, he talked about his classroom with the following entry:

Today I taught by demonstrating the changing of states and dissolution of substance. I checked the laboratory Room. There were two sets of instruments for this experiment that worked. However, I asked some students to help me conduct the experiment, and called every group to come observe the experiment, read the temperature, and record the temperature in their notebooks (weekly journal: week 8)

### **2.1.2 Sintu's View Not Based on Cooperating Teacher's Views**

Sintu presented his view in contrast with the cooperating teacher's view. He believed in students' ability to learn science. He expressed his feelings in the following journal entry:

Arjarn Bancha suggested to me that letting student do presentations needed students' knowledge. So, students that can do presentations were in the groups of good and wise students. I don't think that is the right idea. In my opinion, all students can do activities and learn by themselves, the lower students needed more attention and help. If all teachers thought like this, how can we help the lower student to learn science? (weekly journal: week 14)

### **2.1.3 Different Levels of Student-Centered Methods Presented in Each Class**

By classroom observation, Sintu presented the difference between students in each class in his weekly journal with the following entry:

The first week classroom observation helped me know that students in Room 8/8 were better than I thought. They put more emphasis on their own learning. They worked harder than the students in Room 8/14. The Room 8/14 consisted of students who wanted to learn and did not want to learn science. The numbers of students who wanted to learn were less than the numbers of students who wanted to learn. For the 2/4, they were similar to the students in Room 8/8.” (weekly journal: week 2)

Sintu presented that because of the differences of students in each class, his teaching strategies and methods were different to support the students' needs.

When I planned the lesson, I did not use an activity from the textbook or the teachers' guide book. I just designed my lesson by being concerned with my students in different rooms. I tried hard to use the student-centered approach, and used a variety of activities, but using the student-centered approach for Room 8/14 was different than Rooms 8/4 and 8/8. There were a number of students in Room 8/14 that needed the teacher's guidance (interview)

In summary, Sintu presented his strong conceptions on constructivism. He believed in students' abilities in constructing knowledge. He was concerned with students' prior knowledge in teaching. Even though his views were different than his cooperating teacher, he still believed in students' ability. Sintu presented the different level of students' participation in the class room activities among his classes. He provided more attention and help for students who needed it.

## **2.2 Implementation of Professional Knowledge**

The ability to implement the professional knowledge during student teaching were captured in Sintu's lesson planning and teaching in the real class room

### **2.2.1 Lesson Plans**

#### **A. Consulting a Variety of Sources in the Planning Process**

Sintu talked about his planning process which started with Arjarn Nadda giving him a textbook and a teacher handbook that already had activities. He said he looked at them and compared them with the IPST national standard. He defined the IPST standard in each lesson, and followed with the expected learning outcomes.

I designed my own learning activity. I started with using the IPST standard as a guideline, and set expected learning outcomes based on the standard. In learning activities, I thought about each topic and how I could teach this topic by not just only me speaking (weekly journal: week 1)

### **B. Concerning the Differences of Students in Each Class in Planning the Lesson**

Sintu showed that the students in his classes were different. He used a variety of teaching strategies for students in each class. In the planning process, Sintu had to think about many strategies.

When I plan lesson for my students, I need to think about many strategies such as games, presentations, experiments, etc. Students in each class can learn differently. For my class, the students in Room 8/4 can often do student presentations, but this does not work well with my students in Room 8/8 and 8/14 (weekly journal: week 1)

### **C. Lesson Plans Designed Based on Constructivism**

Sintu's lesson plans presented his constructivist view of learning. In the introduction part, Sintu started with a student's prior knowledge activity. For example, on the topic of the Components and Properties of Elements, Sintu planned to find out students' prior knowledge by writing the chemical formula such as Na, NaCl, CuO, Cl<sub>8</sub> on the board and asking students to classify which one is an element, and which one is a compound. After that, in the learning activities, Sintu planned for students to study about elements and compounds and their properties in groups. Sintu designed a matching game that provided name cards (names of element or compounds) and properties cards (properties and usefulness) for students to find the matching buddy between the name cards and the properties cards. The buddy was planning to fill out the worksheet together and present it to the class. After that he planned for students to conclude the lesson together (Lesson Plan 2).

### **D. Detailed Writing, Using Appropriate Format, and Interrelating Each Component**

Sintu used an appropriate format for lesson plans which included the subject, the name of unit, grade level, semester, and the duration. The content consisted of standard, expected learning outcomes, main ideas, learning activities, instructional media, and assessment and these were interrelated. Sintu wrote every lesson plan in detail. There were specific questions and expected answers provided in the lessons. In the lesson plans, Sintu set expected learning outcomes from the national standard that aimed to enhance students' learning in all aspects including knowledge, process, and attitude. There is an example of the expected learning outcomes presented below.

#### Expected learning outcomes

1. describe usefulness of elements or compounds from the given cards
2. classify elements and compounds
3. conduct presentations with correct concepts
4. emphasize responsibility in working as a group (lesson plan 2)

Sintu planned the learning activity related to the expected learning outcomes. The example of the learning activity was presented in the top paragraph.

However, there were some unclear words, or confusing sentences presented in Sintu's lesson plan. When he was asked if he sent the lesson plan to his cooperating teacher, he said he sent it but did not receive feedback.

### **E. Importance of Lesson Planning Shown**

Sintu showed how important lesson planning was for being a teacher. He showed his feelings in the interview after teaching:

I thought that for being a good teacher, lesson plans were so important. The lesson plans allowed me to see how my teaching was going to be. I used to teach with no plans, and I felt so blank!! I wasn't confident on what I would do next (interview 3)

### **F. Time and Practices Affected Lesson Planning Ability**

Sintu expressed his creativity in the process of planning and revising the lesson plan when he had time. He thought lesson planning was like looking ahead before it happened. He showed his feelings in the second interview:

Now, I have a lot of time to think when I plan a lesson. I feel relaxed and so I feel creative. I think and write, write and think. I have time to revise the lesson plan before using it. I like thinking about what will happen in the future (interview 2)

Sintu compared his planning process from the beginning when he had more time, and when he had a limited amount of time.

During the first month I felt fine with writing lesson plans, I had a lot of time to think about what I will do and what students will do. I wrote it out automatically. It had not been long since the seminar (a capstone course), and I had plenty of time. Now, there are a lot of things I need to do, so sometimes I teach with no lesson plans written ahead of time. When I came back and started writing again, it was so hard for me to do it (interview)

Sintu thought that time and practice affected his ability in the process of planning the lesson.

### **G. Problems in Lesson Plan Writing**

Sintu said he felt that writing lesson plans was not difficult, but the most difficult part of the lesson was creating expected learning outcomes to enhance students' attitudes.

I feel that writing lesson plans is not hard, but the hardest part is defending expected outcomes for enhancing students' attitudes. I spent most of the time

to think about which measurable behavior that I would use in the lesson. For example, I wanted student to be concerned about advantages and disadvantages of using some elements or compounds in their lives. I tried to think am I able to measure the students' concerns or should I use some other words? (interview 3)

Another problem found was writing lesson plans in areas outside his expertise. Sintu said planning the lesson outside his area of expertise was time consuming. He presented his feelings in the paragraph below:

The first two lessons were in the Chemistry concept, and I could write it easily. The last lesson was about the Reflection of Light, and the Process of Geological Transformation. It was hard for me to think about learning activities. I spent more time. I had to think and go back to the textbook for content, and came back for writing (interview 3)

In summary, Sintu consulted a variety of sources including textbooks, teacher handbooks, and the IPST standard in the planning process. His lesson plans presented his constructivist views by concerning students' prior knowledge and participation in classroom activities. His lesson plans were written in detail, presented in an appropriately format, and showed the interrelation of each component. The lesson plans aimed to enhance students' learning in all aspects. However, in some lesson Sintu encountered problems with identifying the expected learning outcome that enhances students' attitude. Sintu's was not receiving feedback from the cooperating teacher on his lesson plans. Time and practices were other factors that affected Sintu's planning ability. Sintu showed that lesson plans were very important to guide teachers' teaching.

### **2.2.2 Teaching Practice**

Sintu's teaching practices were observed five times by the researcher. However, there were some classes that were not observed, but were

reported about in his weekly journals and interviews. Some findings emerged from the data analysis.

### **A. Integration of Classroom Management Strategies during Student Teaching**

There was some classroom management strategies presented in Sintu's classroom. At the beginning, Sintu had problems with remembering students' names. He showed the researcher a flip chart where he put students' pictures and names on to help him remember students in each class. He talked about an idea he got from talking to a friend that:

I heard somebody suggest this technique; I used it and found it works well. I started remembering the students who always caused problems, called out their names or asked them to help me demonstrate the experiment (interview)

Another technique Sintu brought to his class was using a leader student to control class. In that period, Sintu prepared white stickers that had "A group leader" written on them. He asked one from each group to put those stickers on their shirts. Those students acted as group leaders who controlled the misbehaviors of other members in that class. This technique worked well. There was less noise during that period. (classroom observation)

### **B. Integrating Teaching Strategies and PCK in the Teaching Practice**

Sintu let students think about learning objectives before starting lessons. In his teaching on the topic of elements and compounds for Room 8/4, he asked students to read an activity in the textbook. After that he asked students to help define learning objectives of the activity together. In learning activities, Sintu asked students to predict what would happen with a copper wire and demonstrated burning the wire. After that, he asked every group of students to observe the wires before and

after burning. Sintu asked a volunteer of students to write the chemical formula and equation of burning a copper wire on the board. He helped those students finish it and started a discussion activity (classroom observation).

Sintu presented his ability in organizing learning activities. He started the lesson with students setting the learning objectives and participating in experiments by seeing the real situation. He let students predict outcomes and observe a copper wire before and after burning and brought that into the scientific formula and equation. Moving from a real example to a scientific formula helped students to understand the science concept easily.

### **C. Integrating Knowledge of Instructional Media and Technology in Teaching**

Sintu presented the use of a video presentation on the topic of the Process of Geological Transformation. He expressed the feeling and reason behind using video as an instructional media that:

In this topic, I did not have time to produce my own video. I selected a video clip from a movie or a documentary and put them together to introduce this topic to students. I wanted students to see the real situation, and students enjoyed watching the video. They were interested in the video and they asked me many questions. Next period, I plan for them to find out their answers in the school library

Sintu selected video presentation for capturing students' interests, and after that he planned to use the school library as a place for learning resources for students to search for more knowledge.

#### **D. Integrating Knowledge of Learners and Learning and Assessment into the Teaching Practice**

Sintu thought about student's prior knowledge by starting the lesson with activities, and questions to investigate students' prior understanding before starting the new topics. Moreover, sometimes he asked students informally about their understanding. Every period Sintu asked students to write in their learning journals and hand them in before leaving the science classroom. This showed Sintu's use of formative assessment in his teaching practice.

#### **E. Teaching Outside Area of Expertise Affected Sintu's Teaching**

Sintu integrated his content knowledge both in and outside the area of his expertise into his teaching practice. However, when he taught on the topic of the reflection of light, he showed that he was not confident in teaching. When Sintu asked students to draw pictures of what had happened with concave and convex mirrors on the board, he looked in the teacher's handbook to check students' answer (classroom observation). He showed that he was not confident in physics concepts with the interview entry below:

I am not sure some pictures were right or wrong, so I opened my key book to check it. It was not like teaching chemistry concept. I don't have to use a textbook or teacher's guidebook as much as teaching physics concepts" (Interview)

In summary, Sintu's teaching showed an integration of domains of professional knowledge including: content knowledge; classroom management; teaching strategies and PCK; instructional media and technology; learners and learning and assessment. However, teaching outside the area of his expertise affected Sintu's confident teaching.

### **3. Sintu's Students**

To determine what learner characteristics resulted from being taught by the Thai pre-service who received the special teacher education, Sintu's students were randomly selected. The results are reported in section 3.1 on students' backgrounds and in 3.2 on students' characteristics after they had been taught by Sintu. The students' characteristics consist of conceptual understanding, science process skills, and attitudes toward science and the teacher's teaching.

#### **3.1 Students' Backgrounds**

Sintu's students who volunteered to be interviewed consisted of four students: three girls (G1-G3), and one boy (B1). They were students from Room 8/8. All students had a medium grade in science (2.50-2.80 out of 4). The interview was organized about 3 weeks after they had been taught by Sintu.

#### **3.2 Students' Characteristics after Being Taught by Sintu**

The students' characteristics were divided into conceptual understanding, skills, and attitudes

##### **3.2.1 Conceptual Understanding**

When students were asked about the concepts that they learned, they talked about the elements and compounds, system and change of states, and dissolution of substance. When they were asked the meaning of elements and compounds and their difference, they could not define them scientifically, but they used their own words to describe and give some examples. Here is an example of a conversation presented below:

Researcher: "Do you remember what topics you learned from Arjarn Sintu?"

G2: "Elements and compounds"

G1: “System and changing of ice to water, water to steam”

Researcher: “What is an element and what is a compound?”

B1: “Element was...one substance...like Aluminum, Chlorine or Copper”

Researcher: “How about compounds?”

G2: “Put two elements together”

Researcher: “If I put three together?”

B1: “It’s a compound. Compound consisted of two or more elements together”

The students used their own word “substance” to describe an element, instead of using scientific words like “atom”. However, they presented their understanding of elements and compounds by giving some examples.

On the topic of System, the students were asked to provide examples of open and closed systems. They used diluting salt in water as an example.

G1: “When we put some salts in water and stir it. We call the solution in a beaker a system, and we call outside the beaker the environment.”

G3: “When the experiment produces some smoke and we did not cover the beaker, like Arjarn Sintu showed us, we lost some substance when it turned into smoke. We call this an open system, but if we cover it, we call it a close system”

Sintu’s students presented their understanding on scientific concepts. They explained their understanding with their own words which were different from scientific terms. However, they provided correct examples together with the answers. It can be said that they understood the content that was taught by Sintu.

### **3.2.2 Science Process Skills**

Student’s presented learning activities that Sintu used to enhance their science process skills

G3: “We did an experiment by helping the teacher set objectives”

B1: “Sometimes, he asked us to predict what would happen before doing the experiment, or asked us to think about what steps should be done during the experiment”

G1: “We did the experiment in groups”

Researcher: “Can you give me an example of an experiment you did?”

G1: “Put salt in the water and stir”

G2: “Another one, he showed us the experiment but called us up to read the temperature.”

The students’ answers showed that Sintu provided learning activities that supported students’ development of science process skills. He let students do the experiment or demonstrated an experiment and let students be part of it.

### 3.2.3 Attitudes toward Science

When the students were asked if they liked to learn science, they said they liked to learn science because of the experiments.

G1: “I love every subject when the teacher lets us do activities like this”

G2: “It was fun. I got a chance to do some experiments. Some experiments are so exciting such as having smoke coming out of the beaker.”

G3: “I like science because I like to do experiments, and like a matching game.”

B1: “Me too. Arjarn Sintu let us do more experiments than the other teacher.”

The students showed the reason that they liked to learn science was because of the experiments and games. One student stated that Sintu provided him more activities that let him do experiments than the other teacher.

In summary, Sintu’s students presented their conceptual understanding by using their own words. Science process skills enhancing activities were shown in the

students' answers. Moreover, they presented a positive attitude toward learning science with Sintu.

#### **4. Factors Influencing Professional Knowledge Development**

##### **4.1 Cooperating Teachers**

The cooperating teachers were not present in Sintu's conversation during interviews or journal writing. When he talked, his talks indicated that his lesson plan writing ability had not improved, because nobody helped him correct the lessons. He needed some feedback from the cooperating teacher.

By having nobody check your lesson plans or observe your class, you can do your own style, but I found out that it also spoiled me. I felt that my lesson plans did not improve. I prefer feedback from my cooperating teachers” (weekly journal: week 14)

From Sintu's journal and classroom observation, the cooperating teacher did not provide feedback for Sintu's lesson plan. This factor was one of the important factors that affected the continuum of Sintu's professional knowledge during student teaching.

##### **4.2 School Context, Workload, and Time**

On the topic of planning, Sintu stated that limitation of time prevented him from being creative when planning the lesson. This factor was related to the school context and his workload. Sintu indicated that some school activities including school fair, replacing some teachers that were absent, sport days, etc. affected his science teaching.

There were a lot of school activities, some activities like sports day; we lost time for science class because the school schedule changed from fifty to forty

minutes. Sometime, students in some room just missed my class the whole week. Finally, I needed to change all plans. All content was compacted in one period. This affected the teaching and learning activity in class (weekly journal: week 13)

#### **4.3 Number of Students and Students' Motivation in Learning Science**

Sintu showed that students' motivation was one factor that supported or reduced his professional knowledge development. The students' feelings supported him in creating new activities that enhanced students' participation. He showed his feelings in his weekly journal.

There was one student who came to me and told me that I am the first teacher that let him do the experiment in science class. His words encouraged my practice a lot. It made me think about the new activity that I would let my students participate in (weekly journal: week 8)

However, there were some negative factors such as the number and motivation of students in learning science.

I feel so tried, when letting more than fifty students conduct their own experiment. It is very hard to control and manage the class. Sometimes the instruments were destroyed. I feel that students did not have motivation to concentrate in the class, because they thought that there was no way they could fail. If they failed, they can redo the test and get a grade 1(out of 4). They were not like me when I was student. I was scared to be failed, so I put more emphasis on my own learning (weekly journal: week 9)

#### **4.4 Methods Course (Capstone Course)**

Sintu talked about the methods course that affected his student teaching. His confidence was enhanced when he practiced by doing before the student teaching

time. The following paragraph presented his feelings about writing lesson plans and teaching.

Before student teaching, the seminar course (the course) provided me opportunities for integrating all domains of my knowledge such as assessment, writing lesson plans, content in the middle school level into lesson plans, designing rubrics, and teaching in class. This helped me be confident in my ability to do that. (interview)

Moreover, Sintu showed what he got from a capstone course and brought those aspects to his student teaching. Sintu used some aspects such as rubric assessment in the beginning of student teaching.

I used rubric assessment at the beginning of my student teaching, but when I had lots of work and not enough time, I rarely used it. When I used the rubric assessment, I designed just a holistic assessment; I did not divide the rubric into small aspects that represented students' behavior like we talked about during the seminar (a capstone course) (interview 3)

Sintu's answers showed that he adapted knowledge and practice from the course to his student teaching. However, his answers showed that time limitation did not allow him to design a detailed rubric during student teaching. Sintu also presented his appreciation of providing feedback in the students' learning journals during the course. He also provided his feedback to the students during the student teaching period.

For providing feedback in students' learning journals or any task, I was appreciating when I got feedback from the teacher (in a capstone course). For my class, even though I had lots of students, I tried my best to write my feedback on their work. I thought this helped learners know their good parts or some parts that needed to be developed (interview 3)

## **The Case of Sasithorn**

### **1. Student Teaching Environment**

#### **1.1 Sasithorn's Responsibility and Working Environment**

Sasithorn taught Science for 8th students for 9 periods a week (3 periods in each room) in a public school for 18 weeks. There were about 50 to 55 students in each class. Sasithorn taught students in room 8/2, 8/3, and 8/7. In the first week, Sasithorn observed her cooperating teachers' science classroom. The students in three classrooms were of mixed abilities. She said in three classrooms, the good students sat in the first two rows in the front of the classroom. The students in the back were not paying much attention. They sometimes did not bring books or notebooks to the class. Sasithorn practiced her teaching in the same school as Sintu. Sasithorn was under the supervision of her university advisor, Dr. Sangprapha.

#### **1.2 Sasithorn's Cooperating Teacher**

Sasithorn had two cooperating teachers, Arjarn Udom, and Arjarn Anog. Both of them came to observe her classes almost every time that she taught. Arjarn Anong was the one who took responsibility for correcting Sasithorn's lesson plans.

Arjarn Udom graduated with a Bachelor's Degree in Science Education with a major in Biology. He had taught middle and high school students for 40 years, and had been one of the cooperating teachers for pre-service science teachers for about 7 years. He said he observed Sasithorn's teaching every class, but did not stay in the classroom for the entire period. Sometimes, he walked in at the beginning of the class, and sometimes he walked in at the end of the class. He gave Sasithorn suggestions occasionally on how to manage students' misbehaviors in the class. Arjarn Udom was familiar with being a cooperating teacher.

Arjarn Anong graduated with a Bachelor's Degree in Science with a major in General Science. She had taught middle and high school students for 25 years, and had been one of the cooperating teachers for pre-service science teacher for about 7 years. Arjarn Anong checked lesson plans and prepared laboratory equipments together with Sasithorn. Sometime, she went to observe Sasithorn's teaching in class. The feedback that Arjarn Anong provided for Sasithorn was in the section of main idea and learning activities by emphasizing scientific concepts.

Sasithorn's student teaching covered the same learning units as Sintu which included: Matter and Properties and Processes that Shape the Earth. The researcher observed her classes and interviewed her after the classes four different times. The researcher observed Sasithorn when she taught on the topics of the System and Environment, Change of States and the Dissolution of Substance, Chemical Reactions, and the Refraction of Light respectively.

## **2. Sasithorn's Development of Professional Knowledge during Student Teaching**

To determine whether the capstone course continues to enhance pre-service science teachers' professional knowledge during student teaching, Sasithorn's conception about teaching and learning and the implementation of professional knowledge into lesson plans and teaching were explored during her practicum. The development of professional knowledge of Sasithorn during student teaching is reported in section 2.1 on underlying professional knowledge or conception about teaching and learning science and section 2.2 on implementation of professional knowledge.

### **2.1 Underlying Professional Knowledge**

#### **2.1.1 Individual Differences Present in the Conceptions**

Sasithorn showed her belief in individual differences of her students. She thought the teacher's role should be finding out students' prior knowledge and

interest, and using these to design the lesson. She expressed her feeling in her weekly journal.

A Teacher should understand individual students because each student had something that they are interested in differently, and also they had different levels of knowledge. So, the teacher should find out about this, and try to find the way to help them learn as much as they can (weekly journal: week 5)

### **2.1.2 The Nature of Students' Learning Science**

Sasithorn showed that she believed in classroom dynamic. She preferred her students to talk and discuss during the class activity. She thought this is how learning happens. The following paragraph presented her writing in weekly journal.

I thought when students were doing an experiment, they need to discuss what they see and what they find from the experiment. I don't expect students to be quiet all the time of my class. This shows that learning is happening (weekly journal: week 7)

She believed in a group work process that can help individual students to learn science. She said the group work process will work well when they have objectives to achieve together.

I organize students to sit in groups to work together, and help each other to learn. The collaboration in groups was outstanding when they try to finish their group work or compete with other groups when we play a game. I think group work is very good for helping each other learning

### **2.1.3 Hands-on Activities Presented in Sasithorn's View**

There were many times that Sasithorn showed her belief in hands-on activities. The following paragraphs were examples of her expressions in the weekly journals. On the topic of chemical reactions she showed that:

On this topic, I feel students should do experiments, because it's about chemical reactions. In some experiments where we had a limitation of laboratory equipment, at least, I demonstrated one or two experiments and asked some students to come to help do the experiment, or at least to observe what is happening (weekly journal: week 8)

Sasithorn thought students should doing experiments by themselves, but if the classroom had limitation of equipment, she demonstrated the experiment and asked students to observe the experiments. Moreover, on the topic of refraction of light, Sasithorn thought students needed to participate in hands-on activity.

This week, I taught students how to draw pathway of light. They needed to draw with their hands. Providing all pictures for them could save me time, but it's not help them learning (weekly journal: week 13)

### **2.1.4 Understanding Help Student Remember the Concepts**

Sasithorn showed that students needed to understand the science concepts before remembering them.

In this week I taught students how to write the chemical equation, I thought first the students have to understand where the formulas of elements come from, such as Cl comes from Chlorine, Al comes from Aluminum. Then, I repeat the formula and the name for them, let them read out loud and write in their worksheet. This will help them understand and then they will be able to remember the formula of the element

In summary, Sasithorn presented that she believed in students' individual differences. The teacher should find out student's prior knowledge and interesting for using to design the lesson. In the nature of students' learning, Sasithorn's conceptions presented the dynamic process. She believes in effectiveness of hands-on activities, discussion process and group work. Sasithorn showed that she believed student's understanding should come before remembering scientific concepts.

## **2.2 Implementation of Professional Knowledge**

The ability to implement the professional knowledge during student teaching was captured in Sasithorn lesson planning and teaching in the real classroom.

### **2.2.1 Lesson Plans**

#### **A. Process of Planning the Lesson Presented**

Sasithorn talked about her process of planning the lesson in the first interview with the following entry:

I started with looking at the IPST standard, content in school textbook, and teacher handbooks. After that I set the expected learning outcomes to be interrelated to the recommended standard, content, activity, and students in each class. After that I wrote the lesson plan, checked the interrelation between each part, and send it to my cooperating teachers (interview 1)

In her planning process, she related the national standard together with content and students. Moreover, she presented that she checked the interrelation between each component before sending the lesson plans to her cooperating teachers. Moreover, in the planning process, Sasithorn find out what the school had or not have. After that she found extra resources in case she needed.

“I explored resources of our school, after that I design the lesson plan. I selected some resources from school, searched more from internet, or sometimes created my own such as a transparency” (Interview 2).

### **B. Constructivist View and Confusing in Organizing Learning Activities Presented**

In the first lesson plan, Sasithorn planned to teach on the topic of System. The researcher received the lesson plan when observing the class. In her first lesson plan, Sasithorn aimed to enhance students' understanding of the meaning of system and environment, and the differences between an open and closed system. She presented her constructivist view by concerning students' prior knowledge, providing hands-on activities for students to do, and used a discussion activity to help students conclude the concept. However, confusion in organizing learning activities in an introduction, learning activities, and closure was shown in her lesson plan. In the introduction, Sasithorn started the lesson with student prior knowledge and the learning activity together. She asked students to put water in a beaker that contained salt and to stir it. She asked students many questions to determine their prior knowledge and helped them understand the meaning of system and its environment (lesson plan 1). In this part, Sasithorn put the student prior knowledge and learning activities together. This lesson plan was already sent to Arjarn Anong, but Sasithorn said she did not give her any comments. The researcher provided her feedback and asked her to rewrite the new lesson plan for use in the next class and to send it to the researcher by email.

The new lesson plan was better. Sasithorn planned to use a blank paper and asked them what the meaning of system is by using the student's prior knowledge. She also asked students to give an example of system in their life. Sasithorn moved the experiment into learning activities part of her lesson plan. In the closure part, she planned for students to compare their first meaning in the blank paper with the worksheet after experiment and conclude the lesson with discussion activities.

### **C. Detailed Writing, Using Appropriate Format, and Interrelating Each Component**

All of Sasithorn's lesson plans were detailed, for example defining: specific questions and expected answers; duration of each step; instructional media; experimental methods; and assessment strategies. Sasithorn used an appropriate format of lesson plan including subject, name of unit, grade level, semester, duration. The content consisted of standard, expected learning outcomes, main ideas, learning activities, instructional media, and assessment and these were interrelated. The expected learning outcomes were defined based on the national standard, and aimed to students' learning in all aspects including knowledge, process, and attitude. For example, on the topic of refraction of light, Sasithorn set expected learning outcomes as shown below:

Expected leaning outcomes

1. identify type, position of pictures that happened from concave and convex lens
2. draw pictures that represented the picture formation from concave and convex lens in each situation
3. provide suggestions from using of lens in their everyday lives (lesson plan 4)

From the example and others lesson plans, Sasithorn wrote expected learning outcomes with measurable behaviors and identified learning and assessment strategies that interrelated with them.

### **D. Confidence Presented in Ability to Write Lesson Plans**

Sasithorn's lesson plans presented appropriate format, content and learning activities. In the last interview, Sasithorn showed her confidence in writing lesson plan with the following speech:

I feel more confident in writing lesson plans. By practicing during the course (the capstone course) and bringing it into the real teaching in school I feel that I can do it. My lesson plan was not good yet, but I feel comfortable in writing and adapting it in the class (interview 4)

In summary of process of planning, Sasithorn consulted a variety of sources such as the national standard and textbook. She concerned the differences of students in each class, and interrelation between each component of her lesson plan. Her lesson plans presented the constructivist view, details and interrelation in writing, and enhanced students' learning in all aspects. However, in the first lesson plan, she confused the steps in learning activities.

### **2.2.2 Teaching Practice**

Sasithorn's teaching practices were observed four times by the researcher. However, there were some classes that were not observed, but were reported in his weekly journals and interviews. There were some findings that emerged from the data analysis.

#### **A. Classroom Management Strategies Emerged During Student Teaching**

There was some classroom management strategies presented in Sasithorn's class. To enhance students' attention in classroom, Sasithorn always found hands-on experiments, games for the students (classroom observations) because she noticed that students like to do activities more than sitting in their seat (Weekly Journal: Week 5). When she demonstrated an experiment, she asked students to come sit in the front row. Moreover, Sasithorn rotated groups of students in every class that was observed. She provided reasons behind her action in the weekly journal.

My classroom was narrow and deep, I found the problem that the students in the back row did not pay attention to the class. This may be because their seat

is too far from the teacher table. I realized one strategy from the classroom management seminar that we can rotate the class. I also walked around classroom, from one to the other group to show students to pay attention in every group (weekly journal: week 4)

Another classroom problem that Sasithorn encountered was students not handing in homework or tasks. Sasithorn used the progression list strategy that showed students name, progression in each task or homework, and grade point. She thought this strategy helped, but there were some students who did not pay attention on their point.

I used the progression list to help me enhance student handing in of tasks and homework. There were some students who handed in their left over tasks, but still some students who did not care about points. I went to talk to them, but they still did not care, they said if they got zero, they will do the extra work (interview 3)

### **B. Delivering Content Knowledge by Using Appropriate Teaching**

Sasithorn organized learning activities that provided opportunities for students to mainly participate in the learning process. At the beginning, she investigated students' prior knowledge by using questions or activities. During the class, Sasithorn let students do experiments, or demonstrate some experiments, or calculation method. In the demonstration, Sasithorn always asked some student to help prepare, and conduct experiments in front of the class. All students were asked to observe the results from demonstration and make conclusion by themselves.

For example, on the topic of change of state of substance, Sasithorn started the lesson with question-answer activity. She asked students what state of substances that students can think of, and asked them to give some examples

of changing state of substance in their every day life. She asked students to think about factors that effect changing stage of substance. In the learning activities, before starting the calculation, Sasithorn demonstrated changing state of ice to water and water to steam. She asked students to measure, and record the temperature of the system when changing happened. After the experiment, she discussed with students, and let students read some information in the textbook. After that, Sasithorn gave example, and demonstrated how to calculate the energy in the process of changing state of ice to water and water to steam. In closure, Sasithorn discussed with students about the concept of changing state of water, and how to calculate the problem question and let students finish the conclusion worksheet. Moreover, Sasithorn gave more problem questions to students as homework (Classroom Observation 2)

Sasithorn organized learning activities by starting with investigating student's prior knowledge and presenting students with real situations. After that, she demonstrated students how to calculate the problem question, and provided more examples for students to do their own calculation. Sasithorn used the same strategies when she taught students how to draw pictures on the topic of refraction of light (Classroom Observation 4). Sasithorn's teaching showed appropriate strategies to transform content knowledge into specific teaching strategies. This showed an integration of her knowledge of scientific concept and specific teaching strategies in Sasithorn's teaching practice.

### **C. Utilizing Instructional Media and Technology in Sasithorn Classes**

The instructional media that Sasithorn used in her class was laboratory equipment, game set, and books in the library. Sometimes she used the transparency and video player in her class. There was no computer use in her class. When the researcher asked her about the reason she said she did not have time to produce her own video but she used the same school resource on the topic of processes that shape the earth together with Sintu's classroom.

I did not have time to prepare an extra instructional media, but I used the same video of Sintu's classroom. For computer, there was not computer in the classroom to use. Sometime, I asked student to search information from internet resources at home and present in the class (interview 4)

#### **D. Concerning Learners and Learning and Using Formative Assessment**

From classroom observation, Sasithorn was concerned with student's prior knowledge. She used some assessment strategies to investigate students' prior understanding such as question-answer and quiz. Moreover, during the class, she walked around the classroom, looked at students' worksheets on the table in each group to assess student's learning during the class activity. At the end of the lesson, she assessed students by using question-answer, worksheets, learning journals, and mind mapping. She talked about use of students' journal as an assessment tool in her class.

I evaluate students by walking around the class, check their worksheet during the class activities. At the end, I use their learning journal together with worksheet to assess how much they learn, and how well I teach in each class" (nterview 1)

Sasithorn presented the using of formative assessment by integrating the process of assessment inside her teaching process. The results from the assessment were used to assess students' learning and also her teaching.

In summary, Sasithorn's teaching practice showed an integration of each domain of professional knowledge including: classroom management strategies; content and PCK; learners and learning and using formative assessment in her class. Sasithorn presented use of knowledge of instructional media to select and create instructional media in her class. However, she did not present her knowledge and ability in utilizing technology such as computer in her classroom.

### **3. Sasithorn's Students**

#### **3.1 Students' Backgrounds**

All students in both classes were students who had a medium-high grade in science (2.50-4.00 out of 4). Five students from the two classes were randomly selected to participate in a group interview. The interview was organized about 3 weeks after they have been taught by Sasithorn. Three from room 8/2 were girls (G2-1, G2-2, and G2-3) and three from room 8/3 were two girls (G3-1, G3-2, and G3-3) and one boy (B3). All of them like to learn science.

#### **3.2 Students' Characteristics after Being Taught by Sasithorn**

The students' characteristics were divided into conceptual understanding, skills, and attitude

##### **3.2.1 Conceptual Understanding**

There was some conceptual understanding presented on the topic of system. Students discussed about open and closed systems. Even though the students did not give a definition of closed or open systems, they provided examples and answered the researcher's question correctly. The following paragraph presented some examples of students' answers during the interview.

G2-1: "When we conduct experiments in the closed area, or the experiment that did not produce gas out of the beaker, we call this a closed system"

Researcher: "How about we dilute salt in water but have nothing to cover the beaker?"

G2-1, G2-2, G3-1: "Closed system"

G2-1: "There was no gas or anything coming of the beaker, the system did not lose anything"

G3-2: “We just observe the system, if the system lost energy to environment, that we call open system”

On the topic of elements and compounds, there were some students who provided definitions of element and compounds by using scientific term.

G3-2: “An element is a single substance that consists of the same molecule. Compounds are substances that consist of more than one different molecule, but it still will be a pure substance”

Researcher: “How about Oxygen?”

G3-1: “It’s an element. It consists of two atoms of the same element”

Sasithorn’s students presented their conceptual understanding by using the scientific term such as atom or molecule.

### **3.2.2 Science Process Skills**

From classroom observation, Sasithorn enhanced students’ science process skills such as how to read the temperature from thermometer and how to pour the solution in the beaker correctly. Moreover, Sasithorn showed students that safety was important and needed to be considered when doing an experiment. For example, she brought a sand can to put the lighted matches in. Before conducting or an demonstrating experiment, Sasithorn always asked students to predict what will happen from the experiment. In the interview, Sasithorn’s students talked about the process of conducting experiments as presented below.

B3: “Before doing an experiment, Arjarn sometimes let us design the experiment, sometime let us read the direction.

G2-1: “During the experiment, she asked us to observe and record the result. After that we make conclusion together”

Moreover, the students enhanced their science process skills in conducting and discussing experiments. When the results were not the same as scientific ideas, the students presented their discussion. The examples of students' answers are presented below.

B3: "We help Arjarn do experiments, and measure temperature."

Researcher: "What were the results you found?"

G3-2: "In the experiment of boiling water the temperature was more than a hundred degrees, this is because of other factors like purity of water, cleaning of beaker, or thermometer"

G3-1: "Actually, we should do a repeat experiment, but we didn't have time. So, we wrote the discussion on the experimental worksheet"

### **3.2.3 Attitudes toward Science**

During the interview, students showed their attitude toward science subject in a positive way. All students loved science for a variety of reasons including: being like a scientist; using their thinking process; doing experiments; learning from experiences; and group work. The students answers are presented below:

G2-2: "I like science subject because I feel like I am a small scientist"

G3-2: "I like to learn science because I can use my thinking all the time. I am not bored at all"

G3-1: "It is fun to learn because I do experiments by myself such as boiling water, measuring temperature. I saw the temperature getting higher and higher. It is interesting"

G2-1: "I like learning by my experiences such as doing, knowing, and thinking.

B3: "I like an experiment that we do in group"

When the students were asked to talk about Sasithorn's teaching, they said they like her class. There are some examples provided in the next paragraph.

G3-2: "I like her teaching because she was never bored with my questions"

G3-1: "She cared about students' understanding, she tried to set the experiment for us almost every class"

G2-1: "She always smiled in the class, and taught up to date content for example talking about our king project on artificial rain, this made me adore scientific knowledge"

B3: "She explained clearly and I understand the topics that she taught"

G2-2: "She made the science classroom different from last year. I did not have chance to do experiments as much as in her class"

In summary, data from classroom observation and interviews showed that the students of Sasithorn presented an understanding of scientific knowledge. They enhance science process skills including using of laboratory equipment, predicting the results, conducting experiments with safety. The student's attitude toward science and learning of science were enhanced from Sasithorn's classroom.

#### **4. Factors Influencing Professional Knowledge Development**

##### **4.1 Cooperating Teachers**

Sasithorn talked about how her cooperating teachers helped her by correcting scientific concept of her lesson plans, and visiting her class. They had never sat down and talked after her teaching. Sasithorn's reflection was presented in the second interviews.

Arjarn Anong takes care of me with the lesson plan, laboratory equipment, and test. After I got the lesson plans back from her, she gives me suggestion sometime on the scientific concept. Arjarn Udom, he was nice. He often

walked to see me teach in the classroom for 10 to 15 minutes, but we did not sit down and talk after my teaching (interview 2)

Sasithorn showed that her cooperating teacher's suggestion influenced her planning process. Her cooperating teacher suggested to her to just cover textbook. However, she still was concerned with the national standard in her planning process.

The cooperating teacher told me to teach based on covering content in the textbook. I did use the textbook to plan the lesson, but I also used IPST standard to be a standard that I should be concerned with and I used them to establish the expected learning (interview 1)

#### **4.2 School Context and Workload**

Sasithorn presented her workload in her weekly journals, but she did not state that it affected her planning or teaching process. In Sasithorn's case, she talked about the limitation of school resources. Sometimes, instead of letting each group of students do an experiment, she had to demonstrate the experiment because there was not enough equipment.

Today I taught in room 8/2 and we could not do the experiment because the school did not have enough equipment for every group. So, I demonstrated burning of copper wire and let students observe and discuss after the experiment (weekly journal: week 2)

Sasithorn showed another situation of limitation of the school equipment in the interview.

I used to prepare the transparency because I know in school we had four transparency projectors to use. But, when I check them, there were two that were broken, and the other two were used by the classroom teachers. So, that period I did not use the transparency in my class (interview)

### **4.3 The University Advisor**

Sasithorn said her university advisor also was another enhancing factor that helped develop her professional knowledge. The university advisor made suggestions mostly on the teaching process, but did not emphasize the details of lesson plans. Sasithorn presented her reflection in the second interview.

Dr. Sangprapha suggested to me in the period that she came to observe. Most of her suggestions were on my teaching and learning activities. In the lesson plan, she gave me feedback on using an appropriate word. I noticed that she did not much emphasize details or interrelating each component” (interview)

### **4.4 Methods Course (Capstone Course)**

Sasithorn stated that the most important thing she brought from the course was writing lesson plans and providing feedback for students.

I thought the most things I got from seminar (the course) is writing lesson plans. I felt that my lesson plans were improving a lot. The other thing was writing feedback for students about their tasks or journal. When students wrote what they learn and how they feel, I wrote back like the way you wrote it for me (Interview)

### **Thematic Findings Derived among the Cases**

During student teaching, findings from each case were compared and contrasted to find common themes. For the pre-service science teachers’ working environment and cooperating teachers, the results revealed that in general, pre-service science teachers had at least one cooperating teacher at the school. In the first week of student teaching, pre-service science teachers had to observe the cooperating teachers’ classrooms. Most of them, such as Prangwalai, Sintu, and Sasithorn noticed the

differences among the students in each class. Korapin did not show that she noticed the difference among her classes.

The differences between practice teaching in a laboratory school and a public school included: the number of students; the responsibility of the cooperating teacher; and school resources. In the laboratory school, there were about 40 to 45 students in each class, but in the public school there were about 50 to 55 students in each class. The cooperating teachers in the laboratory school observed pre-service teachers' teaching for a whole period in every class, but in the public school, some teachers observed every class, but did not stay the whole period. Some teachers came to visit just a short time of the class period. In the laboratory school, there were enough learning resources for students and pre-service science teachers to use which included laboratory equipment and computers. In the public school, school resources were limited.

Most cooperating teachers provided feedback only when they noticed problems; except the cooperating teacher of Korapin who always provided her feedback and also asked her to reflect on what she observed or learned. The cooperating teachers did not emphasize the lesson plans in detail; they mostly emphasized the science content part.

The common finding of the development of professional knowledge during the student teaching was considered in two aspects including conceptions about teaching and learning and the ability of participants in planning and teaching the lesson. Moreover, the characteristics of students and influencing factors were compared and contrasted among the cases. The thematic findings are presented below.

### **1. Underlying Professional Knowledge: Teaching and Learning Science Conceptions**

During the student teaching, all pre-service science teachers presented their constructivist views of learning. All of them believed in hands-on and minds-on

activities. They believed in students' abilities to construct their own knowledge from learning activities. However, in some cases, the cases of Korapin and Sintu, they showed that the students in different classes needed different levels of hands-on activities. Sintu provided more attention and help for students who needed it. Korapin thought sometimes, especially with complicated concepts that the teacher had to be an explainer.

All pre-service science teachers were consistent with their prior conceptions. When they observed classrooms of the cooperating teachers that were taught based on constructivism, their conceptions were enhanced by seeing the constructivism that works in the real classroom like the case of Prangwalia and Korapin. In Sintu's case, the cooperating teacher's view was different than his. He was not relying on his cooperating teacher. Instead, he was consistent in his view. There were some cases including Pragwalai's and Sasithorn's that presented their beliefs in classroom dynamic. They accepted the dynamics of classroom and students' active learning.

## **2. Implementation of Professional Knowledge in Planning Lesson**

In the process of planning the lesson, all pre-service science teachers consulted a variety of resources including cooperating teacher/s, the IPST national standard, textbooks, and the teacher handbook. Most of them used the IPST standard to compare with content in the school textbook, except Korapin. Korapin used the school lesson plans that already identified each national standard for each topic. Most pre-service science teachers planned the lesson by themselves, and sent it to the cooperating teacher before teaching at the end of the process of planning. In the case of Korapin, she planned the lesson together with her cooperating teacher, which affected the development of her professional knowledge in planning the lesson. Korapin expressed her systematic planning process by thinking about each component and the interrelation between each component while she planned the lessons. Other pre-service science teachers wrote the lesson plan first and at the end they checked the interrelation between each component. All pre-service science teachers wrote the

lesson plan in detail by defining each part of the lesson plan, specific questions, and expected answers.

Most of pre-service science teachers' lesson plans were written in a good format and content. There were some lesson plans of pre-service science teachers who taught in the public school including Sintu's and Sasithorn's lesson plans that presented some incomplete parts. Sintu wrote the lesson plans by using his own words which sometimes presented an unclear meaning. Sasithorn showed confusion by writing learning activities in the introduction part.

All pre-service science teachers planned the lesson based on constructivism. They planned to investigate students' prior knowledge in the introduction, and planned mainly to enhance students' participation in class. Most of their lesson plans aimed to enhance students' learning in all aspects including knowledge, science process skills, and attitude. However, in the case of Prangwalai and Sintu, they presented that they had problems with constructing expected learning outcomes that aimed to enhance student's attitudes by using measurable behavior. In Sintu's case, he presented the difficulty when planning on the topic outside the area of his expertise.

### **3. Integration of Professional Knowledge into Teaching Practice**

All pre-service science teachers selected appropriate teaching strategies for teaching specific science content. They tried to emphasize students' hands-on activities in their teaching practice. However, in the school context that had limited laboratory instruments like in the case of Sintu and Sasithorn, sometimes they had to demonstrate the experiment instead of letting students do the experiment by themselves. In their demonstration process, they asked some students to help in front of the class, asked all students to come to observe the experiment closely, and let students conclude the lesson by themselves.

All pre-service science teachers integrated each domain of professional knowledge into teaching practice including: science content, teaching strategies,

classroom management; instructional media and technology; and formative assessment. However, when pre-service science teachers taught out of the area of their expertise, some of them such as Prangwalai and Sintu stated that they were not confident to teach. Prangwalai presented her misconceptions in the teaching practice.

All of them stated that they brought some classroom management strategies from the course (capstone course) into their teaching practice. Prangwalai and Korapin made an agreement and set up the class rules with students at the beginning of their classes. Moreover, Korapin used positive reinforcement with the students in her class. Sintu used strategies to help remember students' name, and Sasithorn used an interesting learning activity and rotated students around the class.

#### **4. The Characteristics of Students**

Most students of the pre-service science teachers stated a complete conceptual understanding in scientific concepts that were taught by their teachers, except Prangwalai's students. Prangwalai's misconceptions were transferred to her students. Most of the students used their own words which were not scientific words to describe their understanding except the students of Sasithorn. The students of Sasithorn used scientific terms to explain their understanding.

Students of all pre-service science teachers were enhanced in science process skills including: observing (Prangwalai, Korapin): predicting (Sintu, Sasithorn); classifying (Prangwalai, Korapin): designing and conducting experiments/investigation (Prangwalai, Korapin, Sintu, Sasithorn): communicating the results (Prangwalai, Korapin): measuring metrically (Prangwalai, Sasithorn).

Most of students of the pre-service science teachers presented a positive attitude toward science except a student of Korapin. She thought science is difficult to learn. However, she presented a positive attitude toward learning science with Korapin because of the interesting activities. All students presented positive attitudes towards learning science with the pre-service science teachers, because they let students do and experience real experiments in the classroom.

## **5. Influencing Factors Affected Development of Professional Knowledge**

The cooperating teachers were the main factor which acted both in the enhancing and reducing factors. When the cooperating teacher worked cooperatively with pre-service science teachers like in the case of Korapin by providing feedback and chances for her to reflect on what she learned, she increased her professional knowledge in planning and confidence in teaching. When pre-service science teachers observed the cooperating teachers' classes that were based on constructivism such as the case of Prangwalai, it confirmed to her that constructivism works in the real situation. However, when the cooperating teacher did not provide detailed feedback on lesson plans or teaching as in the case of Prangwalai, Sintu, and Sasithorn, it interfered with the development of their professional knowledge.

The school context including workload, pre-service science teacher's authority, number of and motivation of students and limitation of resources were other factors that effected the development of professional knowledge. In the case of Prangwalai, Korapin, and Sintu, they stated that workload prevented them from creating the learning activities. In Sasithorn's case, her workload and limitation of school resources affected her ability to create instructional media. In the case of Korapin, even though her cooperating teacher gave her freedom, her authority was obscured by the other teachers in school. In the case of Sintu, and Korapin, the numbers and motivation of students in class affected the way they designed learning activities.

The university advisor was another factor that partly effected the development of their professional knowledge. Prangwalai said she got detailed suggestions from the university advisor, but he just came to observe her class about once a month. In some cases, the university advisor obstructed pre-service science teachers from creativity. In the case of Korapin, she said her university advisor only commented on her teaching when it was not correct, but did not provide any more suggestions. This discouraged Korapin from designing the new creative activities.

All students stated that the main influence they got from a course was on lesson plan writing. They had chances to practice integrating domains of professional knowledge before their student teaching. In Prangwalai's case, she gained more confidence while teaching in front of the class. Korapin gained classroom management strategies. Sintu and Sasithorn were appreciative of the role model of the instructor in providing feedback for student's learning journals, and they brought the idea to use with their students. However, there were some suggestions from some pre-service science teachers. Prangwalai suggested adding more time in each class period. She felt that two hours was not enough. Korapin talked about the contextual differences, the course should provide more of the real school context for them to participate in and experience.

## **CHAPTER VII**

### **CONCLUSIONS, DISCUSSIONS AND RECOMMENDATIONS**

#### **Introduction**

This chapter is divided into two parts. The beginning of the chapter consists of conclusions and discussion of the results. The second part provides recommendations for science educators, instructors, curriculum developers, and related stakeholders in Thai teacher preparation in science and others subject areas.

#### **Conclusions and Discussions**

This chapter provides the conclusions of ideas resulting from this study, together with comparing and contrasting these results to those of other studies. This chapter aims to answer the main research question: How does a course designed to enhance Thai pre-service science teachers' professional knowledge affect the pre-service teachers' conceptions about science teaching and learning, lesson planning and teaching? To answer the question, the report is divided into three parts according to phases of the study.

The first phase aims to answer the first research question which is (1) What are the characteristics of a course designed to facilitate Thai pre-service science teacher professional knowledge? The second phase aims to answer the second research question which is (2) In what way does the course enhance pre-service science teachers' professional knowledge during the course? The third phase aims to answer the third and the fourth research questions which are (3) In what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching? and (4) What learner characteristics results from being taught by the Thai pre-service who have received the special teacher education?

## 1. Designing a Course

In the designing process, the first research question is what are the characteristics of a course designed to facilitate Thai pre-service science teacher professional knowledge? The results from analysis of the literature, previous methods courses, the current situation and needs of pre-service science teachers revealed that the characteristics of a course included that it: (1) be concerned with individual prior knowledge, skills and needs; (2) provide opportunities for pre-service science teachers to see examples of how to teach; (3) enhance scientific and technological goals, and research on best practice; (4) enhance inquiry, planning and teaching skills, and reflective thinking; (5) encourage the happiness and attitudes toward the teaching profession; (6) enhance knowledge of topic-specific instructional strategies, subject matter knowledge, lesson plans, science process skills, classroom management, producing instructional media, utilizing technology, assessment and teaching based on a student centered approach; (7) provide opportunities for pre-service science teachers to revise and implement domains of professional knowledge into planning and teaching practice through the process of seminar discussion; (8) integrate reflection and role models used as activities in the course.

The results revealed the importance of the first step of the designing process. A needs assessment was an essential outstanding process for designing or revising a professional development program. This process was used and suggested from previous studies in the United States (Greene, 2000; Halim, Osman and Meerah, 2004) and developing countries such as Malaysia (Halim *et al.*, 2004) and the Philippines (Pontiveros, Jr., 2004). The results of the assessment can be used to improve courses and make them better correspond to participants' needs. Moreover, the participants backgrounds should be concerned as one of the important factors that affected how pre-service teachers learn to teach in the program. This idea supports suggestions of Howes' (2002) study.

## **2. Implementation of a Course**

In the implementation phase, the second research question is: In what way does the course enhance pre-service science teachers' professional knowledge during the course? To answer this question, the professional knowledge of pre-service science teachers was concerned with two aspects related to the sub-research questions. First, in what way does the course influence Thai pre-service science teachers' underlying professional knowledge? Secondly, in what way does the course influence Thai pre-service science teachers' abilities to implement the professional knowledge during the school based portion of a companion course?

### **2.1 Influence of the Course on the Underlying Professional Knowledge**

In the aspect of the underlying professional knowledge, it can be concluded that at the beginning of the course, pre-service science teachers' conceptions about teaching and learning science ranged from the rationalist to the constructivist view. This is similar to prior studies (Skamp and Mueller, 2001; Faikhamta, 2007). They found that at the beginning of their program, pre-service teachers held conceptions on teaching and learning that ranged widely. The current results revealed that even though all pre-service teachers said they believed in constructivism, their conceptions were quite different. Sintu and Sasithorn presented their views on the teaching and learning processes related to constructivism. Prangwalai and Korapin presented a combination of constructivism with technical and rationalist views. The possible reason for this was that pre-service science teachers held different prior conceptions before coming to the program. When they were trained and educated in the same teacher preparation program, they combined their prior conceptions with the conceptions enhanced by the program. Like many teacher preparation programs in Thailand which aimed to enhance concepts of student construction of knowledge, very many preservice students presented their views on "student construction of knowledge" but they interpreted these ideas diversely. This claim is supported by the study of Bruce *et al.* (1997), Skamp and Mueller, and

Faikhamta which showed the linkage of prior conceptions to the conceptions that the program aimed to enhance.

By providing reflective opportunities for pre-service science teachers to clarify their conceptions through a variety of activities, some of them shifted their conception to be more consistent with constructivism like in the case of Prangwalai and Korapin. Some of them fulfilled, extended, and prolonged their prior constructivist views like in the case of Sintu and Sasithorn. This finding supports the study of Bryan and Abell (1999), Bryan and Atwater (2002), and Barrantes and Blanco (2006). Bryan and Abell found that the process of reflection during professional training helped pre-service elementary teachers become more cognizant of their own views and this affected the changes. Moreover, Bryan and Atwater said providing activities that provided teachers an opportunity to confront and refine their views facilitated changing of their beliefs. Barrantes and Blanco also found this effect from reflective experience. They found that reflection helped geometry student teachers become more explicit about their conceptions. They found that their traditional views did not lead to improved achievement of students in their class. So, this process helped them shift their conceptions about teaching and learning in the classroom (Barrantes and Blanco, 2006).

In this study, the reflective opportunities provided for pre-service science teachers which included comparing their views with recommendations of the national standing, comparing with their friends and examples of the classroom case. Most pre-service teachers' conceptions changed when compared with the national standard that pointed out how to organize the teaching and learning process based on constructivism. This is related to Faikhamta's (2007) study. He found that comparing views with the national standard affected the changing of the beliefs of pre-service science teachers. There was one case in the current study, the case of Sasithorn, that revealed that the changes in her conceptions were affected by a social interaction and comparing her views with that of her friends. This finding is similar to the results of Bruce *et al.* (1997). The study of elementary student teachers from the SEARCH

project found that interaction among student teachers affected the changes of their conceptions.

The results of this study showed the influences from a course on pre-service science teachers' underlying professional knowledge. The course encouraged them to become to be more consistent with constructivist-based views of teaching and learning science. The results support previous studies in Canada and Australia (Skamp and Mueller, 2001) and Thailand (Faikhamta, 2007)

## **2.2 Influence of the Course on the Ability to Implement the Professional Knowledge**

Relative to the ability to implement professional knowledge into lesson planning, the results showed that practicing and receiving feedback from a variety of sources helped pre-service science teachers develop their abilities in planning. The results support the findings of Bruce *et al.* (1997) who found that collaborative planning among participants of their study enhanced the ability to plan science activities to be rich and full. During the course, lesson plans were critiqued by the course instructor, the students themselves, and their peers. This helped many of them, (e.g., Korapin, Sintu, and Sasithorn) look at their lessons more critically. This study shares the same results with Ozogul *et al.* (2006) study. In their study, the results showed that feedback improve pre-service science teachers' lesson plans. Thus, they suggested implementing all kinds of feedback to support the development of pre-service science teachers' lesson plans.

Relative to their teaching practice, the relevant situations such as cases reflections, classroom management analysis, microteaching, and application of knowledge from research into their lesson plans and teaching provided the picture of how they use the professional knowledge in a real classroom. The results support the ideas of previous studies (Hatton and Smith, 1995; Ginns and Watters, 1999; Goodnough, 2001; and Amobi, 2005). The studies of Hatton and Smith (1995) and Amobi (2005) found that using microteaching in pre-service science teachers

education was effective. They found that microteaching provided the concrete experiences that enhanced pre-service teachers' self-correcting teaching skills. Hatton and Smith also suggested the use of microteaching activities together with journal writing to encourage thinking about the action of pre-service teachers. Goodnough studied enhancing professional knowledge of pre-service elementary teachers. The adoption of multiple intelligences theory into teaching practice was investigated. The results suggested an application of knowledge from research into teaching practice. In order to develop professional knowledge, the program should put an emphasis on research based strategies to help teachers in curriculum development and implementation, selecting effective instruction and assessment strategies, and utilizing knowledge in using educational research (Goodnough, 2001). The relevant learning experiences that were provided for pre-service teachers helped them connect theory to their practice (Ginns and Watters, 1999).

There were some findings that emerged from the study that revealed factors that affected the development of the professional knowledge during the course which were student empowering, sharing knowledge, utilizing ICT, and confidence in content knowledge.

The results from this study showed that students' empowerment, sharing of professional knowledge, and utilizing ICT enhanced the development of pre-service science teachers' professional knowledge during the course. When pre-service science teachers were empowered, they became more earnest. Many of them gained more knowledge when they became leaders. Moreover, when the sharing of their professional knowledge was built, it enhanced the sharing and developing of professional knowledge. This supports the findings of Manouchehri (2002), who studied the effects of peer discourse on the development of pre-service Mathematic teachers. The results described the development of pre-service Mathematic teachers' professional knowledge during peer interaction (Manouchehri, 2002). Utilizing ICT in teacher education enhanced the development of instructional media and technology knowledge. All pre-service science teachers became more familiar with using technology to support their teaching and this helped them see its usefulness in the

classroom. The results support the former studies of Pedro da Ponte *et al.* (2002) and Bahr *et al.* (2004). The use of technology provided helpful insights into preparing teachers to use technology in the classroom to support instruction (Bahr *et al.*, 2004); this helped pre-service teachers gain more confidence in using computers (Pedro da Ponte *et al.*, 2002).

It was found that lack of confidence of pre-service science teachers obstructed the development of professional knowledge. In the case of Prangwalai and Sasithorn, they tended to provide students with directions for learning, when they were not confident in the science content. The results support prior researches (Hewson *et al.*, 1999; Gess-Newsome and Lederman, 1993; Faikhamta, 2007).

In summary, the course influenced pre-service science teachers' underlying professional knowledge by enhancing them to be more consistent in constructivist-based views of teaching and learning science. Moreover, the course also affected the ability to implement professional knowledge during the school based portion of a companion course by having some influencing factors emerge from the study.

### **3. Follow Up Study**

In the phase of the follow up study, there are two research questions that guided the study. These are: In what way does the course influence Thai pre-service science teachers' underlying professional knowledge and their abilities to implement the professional knowledge during student teaching? and What learner characteristics results from being taught by the Thai pre-service who have received the special teacher education?

#### **3.1 Influence of the Course on the Underlying Professional Knowledge during Student Teaching**

In the student teaching, each pre-service science teacher was in a different school context and was under the supervision of different cooperating teachers. These

environments affected their underlying professional knowledge and their abilities to implement their professional knowledge during student teaching. During student teaching, all pre-service science teachers presented their constructivist views of learning which continued from their prior conceptions shown in the course. All of them believed in hands-on and minds-on activities. They believed in students' abilities to construct their own knowledge from learning activities.

However, during the complexity of the school context, there were some cases like that of Korapin and Sintu that showed that teaching and learning is not the only level of hands-on activities. Instead, they thought about the different levels of hands-on activities in their classes. Sintu provided more attention and help for students who needed it. Korapin thought sometimes, especially in the complicated concept that the teacher had to be an explainer. This result is the same as in the study of Bryan and Abell (1999) and Buraphan (2005), who found during school experiences, a pre-service science teacher began to understand the complexity of teaching (Bryan and Abell, 1999; Buraphan, 2005).

All pre-service science teachers were consistent with their prior conceptions. When they observed classrooms of the cooperating teachers that taught based on constructivism, their conceptions were enhanced by seeing the constructivism that works in the real classroom like in the case of Prangwalai and Korapin. This result is different than the study of (Lotter, 2004) which found the pre-service teachers' views usually differ from their cooperating teachers. In Sintu's case, the cooperating teacher's view was different than his. He was not relying on his cooperating teacher. Instead, he was consistent in his view. This part supports the findings of Lotter. A possible reason for supporting this result was that the pre-service science teachers did not see that teaching and learning activities of the cooperating teacher was fruitful. This claim supported the study of Hewson and Mariana (1987). They found that the change in conceptions of teaching was hard to change if the student teachers saw that it was not fruitful for them. The disagreements were claimed by Hollingsworth (1989) cited in Lotter as an effective factor fostering disequilibrium to push forward the science education reform.

### **3.2 Influence of the Course on the Ability to Implement the Professional Knowledge During Student Teaching**

The pre-service science teachers were able to plan a lesson during their student teaching. In the process of planning, all pre-service science teachers thought about the content that should be taught first. These results support previous findings of Sanchez and Valcarcel (1999) who studied the planning process of science teachers in Spain. However, there were some contradictory results. In this study, pre-service science teachers consulted a variety of resources. Korapin consulted textbooks; Prangwalai, Sintu, and Sasithorn consulted textbooks comparing with the IPST curriculum standard to understand the scope and the depth of scientific concepts for setting expected learning outcomes in the lesson plans. In the study of Sanchez and Valcarcel, the students' textbook is the principal reference in the planning process. In this study, the pre-service science teachers not only were concerned with the content that should be taught, they all realized hands-on activities that enhanced students' learning in all aspects. This finding was similar to the ideas of Brickhouse (1993) that found content and learning activities were concerned in the planning process of a chemistry teacher.

By realizing the role of hands-on activities and students' science process skills in lessons, it can be implied that pre-service science teachers were concerned with the nature of science in their planning process. For example, on the topic of the classification of substances, Prangwalai planned for her students to observe and classify everyday life substances. Korapin planned for her students to predict the results of shining a light into a mirror on the topic of the reflection of light. Sintu and Sasithorn planned for students to observe the changing of a copper wire after burning it on the topic of chemical reaction. They allowed their students to use scientific processes to construct knowledge; they did not force their students to receive the knowledge directly from the teachers. The result is unlike the previous findings of Duschl (1989) who stated that teachers were not concerned about the nature of science in the planning process.

By being concerned with the details of lesson plans, the results showed that pre-service science teachers' lesson plans were written using good format and content. There were some specific questions and answers, duration, and activities that were planned in the lesson plans. By comparing the planning process of this group of pre-service teachers with in-service teachers in the study of Sanchez and Valcarcel (1999), the result was different. In-service science teachers wrote short documents in their planning process for teaching (Sanchez and Valcarcel, 1999). The main factor that had positive and negative affects on pre-service science teachers' lesson plans were the cooperating teachers. In the positive way, for example in the case of Korapin, she planned the lesson cooperatively with her cooperating teacher. Korapin expressed her systematic thinking about each component and the interrelationships in the planning process while the others did not. Other pre-service science teachers wrote the lesson plan first and at the end they checked the interrelation between each component. In the negative way, some lesson plans that were written by Sintu and Sasithorn showed some incomplete parts. This result showed the relationship with their lesson plans was not being approved by their cooperating teachers as much as the others. These results are related to the results of Ozogul *et al.* (2006) who found that feedback on evaluation from the teacher of pre-service teacher affected their ability to plan. Good suggestions helped pre-service science teacher develop good lesson plans (Ozogul *et al.*, 2006).

The lesson plans indicated that all pre-service science teachers were concerned with students' prior knowledge. They used questions and answers, quizzes, and activities to find out students' prior knowledge. This is similar to Pringle's (2006) findings. He found that a group of pre-service science teachers took the students' prior knowledge into consideration in their process of planning. Most of their lesson plans aimed to enhance students' learning in all aspects including knowledge, science process skills, and attitudes. However, in the case of Prangwalai and Sintu, they stated that they had problems with constructing expected learning outcomes that aimed to enhance student's attitudes by using measurable behavior. The results are different from the findings of Bumen (2007) who found that the Turkish pre-service teachers encountered problems in determining learning objectives in the dimension of

knowledge and cognitive process. He said most pre-service teachers said it was a time consuming task (Bumen, 2007).

Another problem found in the study was familiarity with the scientific content. When pre-service science teachers planned the lesson on a topic outside the area of their expertise, some such as in the case of Sintu reported difficulty, and another case such as in the case of Prangwalai indicated misconceptions. This finding supports what Pringle (2006) said that pre-service science teachers became uncomfortable with their planning when they did not know the topic well or they felt unfamiliar with the concept.

In aspects of integration of professional knowledge into teaching practice, all pre-service science teachers selected appropriate teaching strategies for teaching specific science content. They tried to emphasize students' hands-on activities in their teaching practice. These results concur with Black's (2004) study. He found that students effectively use classroom instruction based on constructivism that emphasized hands-on activities (Black, 2004). However, in a school context that had limited laboratory instruments like in the case of Sintu and Sasithorn, sometimes they had to demonstrate the experiment instead of letting students do the experiment by themselves. In their demonstration process, they asked some students to help in front of the class, asked all students to come to observe the experiment closely, and let students conclude the lesson by themselves.

All pre-service science teachers integrated each domain of professional knowledge into teaching practice which included: science content, teaching strategies, classroom management; instructional media and technology; and formative assessment. However, when pre-service science teachers taught out of the area of their expertise, some of them such as Pragwalai and Sintu stated that they were not confident to teach. Prangwalai presented her misconceptions in the teaching practice. These results are opposite from the study of (Howitt, 2007). His study showed factors that influenced pre-service elementary teachers' confidence in teaching science. The

results from his study revealed that science content knowledge did not contribute greatly to the confidence toward science and teaching of science (Howitt, 2007).

Most pre-service science teachers stated that they brought some strategies such as classroom management and providing feedback in students' learning journals from the course. The finding on role modeling was one of the enhancing factors presented during the course. Sintu and Sasithorn said they were appreciative with the role model of the instructor in providing feedback for student's learning journals. So, they brought the idea to use with their students. These results support the previous studies about using a role model for enhancing pre-service teachers' professional knowledge (Adam and Krockover, 1997; Lemberker *et al.* 1999; Faikhamta, 2007). Other factors that affected the development of pre-service science teachers' professional knowledge include the supervision of cooperating teachers, the school context, and the university advisor. These factors were also presented in the study of Yee Fan Tang (2003). She studied about challenges in supporting student teachers professional learning in field experience in Hong-Kong. The results showed the effects of the action context, socio-professional context, and supervisory context in her study (Yee Fan Tang, 2003).

There were some suggestions presented from the pre-service science teacher about the different context between methods courses and teaching practice. This result is related to the study of Black (2004). In this study, he found some student teachers did not prepare for the real classroom context and for students' behavior (Black, 2004).

In summary, the course continued to enhance pre-service science teachers' underlying professional knowledge. They were consistent with their prior conceptions from the course; the conceptions were not changed because of the school environment. The school experiences helped them understand the complexity of teaching and to make some adaptations. The ability to implement professional knowledge was presented during student teaching. An outstanding factor was the role

model from the course that pre-service teachers brought to use with their students during student teaching.

### **3.3 Characteristics of Learners Resulting from Being Taught by the Pre-service Science Teachers**

Most students of the pre-service science teachers presented the complete conceptual understanding in scientific concepts that were taught by their teachers, except Prangwalai's students. Prangwalai's misconceptions were transferred to her students. Most of the students used their own words which were not scientific words to describe their understanding except for the students of Sasithorn. The students of Sasithorn used scientific terms to explain their understanding.

Students of all pre-service science teachers were enhanced in science process skills including: observing (Prangwalai, Korapin): predicting (Sintu, Sasithorn); classifying (Prangwalai, Korapin): designing and conducting experiments/investigation (Prangwalai, Korapin, Sintu, Sasithorn): communicating the results (Prangwalai, Korapin): measuring metrically (Prangwalai, Sasithorn).

Most of students of the pre-service science teachers presented a positive attitude toward science except one student of Korapin. She thought science was difficult to learn. However, she presented a positive attitude toward learning science with Korapin because of the interesting activities. All students presented positive attitudes towards learning science with the pre-service science teachers, because the teachers let students do and experience real experiments in the classroom.

In summary, the students' characteristics including knowledge, process, and attitude toward science tended to be in a positive direction. This supported the results of the underlying professional knowledge and ability of pre-service science teachers. These results support the claim that the course continued to enhance pre-service science teachers' underlying professional knowledge and their ability to implement the professional knowledge during student teaching.

## **Recommendations**

This conclusion provides recommendations for science educators, instructors, curriculum developers, and related stakeholders in the Thai teacher preparation in science and others subject areas.

First, in the process of developing a course, needs assessment should be implemented in order to design or revise a preparation course. The assessment should be conducted before planning objectives or activities for a course or for a program. The activities of the course should be designed using the participants' needs and suggestions from the current research findings in national and international standards. The program designer or curriculum developer can use this information to improve courses and make them better correspond to participants' needs and fit with the current situation. Moreover, the participants' background including their prior conceptions about teaching and learning, or professional knowledge should be investigated. The individual differences can affect the development and understanding of pre-service science teachers about how to teach science from the preparation program.

Second, even though the four-year science teacher preparation curricula covered almost all domains of teacher professional knowledge, they still needed opportunities for implementing those domains into their teaching practice. The results show a potential of a capstone course and offers some recommendations for organizing a capstone course before field experiences. This will provide them an opportunity to connect each small piece of their professional knowledge together.

Third, the preparation course should provide practical experiences for them to integrate teaching with other domains of teacher knowledge into the areas of their teaching. Reflection, supporting feedback, and role modeling of the instructor were essential factors that affected the development and learning process of pre-service science teachers.

Fourth, over several decades, many learning resources such as educational documents and instructional media have been produced in electronic formats. This is causing the learning process to change from paper resources to electronic resources. To prepare professional teachers for this century, the teacher should be prepared for helping students to use technology for finding out the most current knowledge. So, the science professional development and institutes responsible for producing science teachers should consider integrating knowledge of instructional media and technology and knowledge of research on best practice into teacher education courses.

Fifth, the long term professional development program should be conducted to connect what pre-service science teachers learned from their methods courses to their practical experiences in school context. There were many factors that can act as supporting or diminishing factors on the development of pre-service science teachers' professional knowledge during field experiences. So, the institutions responsible for the production and development of teachers should set the meeting of related people including the cooperating teachers, university advisors, school administrators and pre-service science teachers to understand their responsibilities during student teaching.

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## **APPENDICES**

## **Appendix A**

### Needs in Preparation Questionnaire

### Needs in Preparation Questionnaire

\*\*\*\*\*

**Objectives:** To investigate needs in preparation of pre-service science teachers

**Structures:** This questionnaire consists of two open-ended questions

**Time:** 15 minutes

#### Background Information of respondents

Name/Lastname

Major (Please make an "X" in  below)

Physics

Chemistry

Biology

General Science

Others \_\_\_\_\_

**Description** Please write your answers that best describe your opinion

1. How prepared are you? Please explain what areas you are ready in and what areas you have problem with?

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2. What do you need to prepare before your student teaching?

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## **Appendix B**

### Conceptions about Teaching and Learning Science Questionnaire

**Conceptions about Teaching and Learning Science Questionnaire**

\*\*\*\*\*

**Objectives:** To investigate conceptions about teaching and learning science of pre-service science teachers.

**Structures:** This questionnaire consists of three open-ended questions

**Time:** 15 minutes

**Background Information of respondents**

Name/Last name \_\_\_\_\_

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Major (Please make an “X” in  below)

<input type="checkbox"/> Physics	<input type="checkbox"/> General Science
<input type="checkbox"/> Chemistry	<input type="checkbox"/> Others _____
<input type="checkbox"/> Biology	

**Description** Please write your answers that best describe your opinion

1. How will you plan to teach during your student teaching? (Please explain)

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2. When you teach in class, how do you want your students to be?

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3. How will you use the assessment strategies in your class?

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## **Appendix C**

The Readiness in Implementing Professional Knowledge Questionnaire

### The Readiness in Implementing Professional Knowledge

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**Objectives:** To investigate the readiness in implementing professional knowledge of pre-service science teachers

**Structures:** This rating scale questionnaire consists of 8 main items which each item consist of sub-questions.

**Time:** 15 minutes

#### Background Information of respondents

Name/ Last name

Major (Please make an "X" in  below)

Physics

Chemistry

Biology

General Science

Others \_\_\_\_\_

**Description:** Please make an X in the table of answer that best describe your opinion on the following questions

Questions	(1) Low/Not very                      (2) Medium/Fairly                      (3) High/Very		
	1	2	3
1. How familiar are you with these documents?			
1.1 National Education Act 1999			
1.2 Basic curriculum			
1.3 National Science Curriculum Standard (IPST)			
2. How confident are you to teach the following middle school science topics?			
2.1 Forces and Motion			
2.2 Electricity			
2.3 Light			
2.4 Basic Electronics			
2.5 Matters and Properties of Matters			
2.6 Life and environment			
2.7 Genetics			
2.8 Biodiversity			
2.9 Atmosphere			
2.1 Earth and processes that shape the earth			
2.2 Astronomy			
3. How confident are you in these areas of writing lesson plans?			
3.1 an understanding of school science curriculum			
3.2 writing long range lesson plan			
3.3 writing period lesson plan			

**Description** Please make an X in the table of answer that best describe your opinion on the following questions

(1) Low/Not very

(2) Medium/Fairly

(3) High/Very

Questions	Answers		
	1	2	3
3.4 writing expected learning outcomes			
3.5 writing scientific concepts			
3.6 learning resources used to plan a lesson			
3.7 determine assessment and evaluation methods appropriate with expected learning outcomes.			
4. How confident are you in these areas of teaching processes?			
4.1 create activity appropriate with scienc content and student ability			
4.2 choose teaching strategies and methods for each science concepts			
4.3 dealing with student misconceptions			
5. How confident are you in these areas of teaching processes?			
5.1 Introduction			
5.2 Using special techniques for Slow or fast learners			
5.3 Using language in teaching			
5.4 Questioning Techniques			
5.5 use everyday life example for teaching			
5.6 Technique for induce student interesting and student participations			
5.7 Using reinforcement strategies			
5.8 Conclusion			
6. How confident are you in these areas of instructional media?			
6.1 produce instructional medias			
6.2 choosing appropriate instructional medias with science content, time, activity and classroom.			
6.3 Using ICT in science classroom			
6.4 Using local resources			
7. How confident are you in dealing with these problems?			
7.1 Unruly students in class			
7.2 Timid and introverted students			
7.3 students who do not complete their homework/class assignments			
7.4 Teaching wrong science concepts			
7.5 Classroom management			
7.6 Punishments			
8. How confident are you in these following topics?			
8.1 Assessment and Evaluation strategies			
8.3 Fitting in with faculty and students			

☺ ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹ Thank You ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹

**Appendix D**  
Lesson Plan Analysis Sheet

### Lesson Plan Analysis Sheet

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Name: \_\_\_\_\_ Topic of lesson: \_\_\_\_\_

Date: \_\_\_\_\_

#### Lesson plan analysis in general teaching

<b>Understanding or skills in lesson Planning</b>	<b>Example</b>	<b>Not done</b>	<b>Adequate</b>	<b>Well done</b>
1. used appropriate consequences and format of lesson plan				
2. identified a science lesson topic and content to be addressed in the lesson.				
3. examined the content standards for the science course and clarified the relationship between the standards and the content of lesson				
4. wrote an learning outcomes that is aligned with the end-of-lesson assessment				
5. plan to use appropriate time and space				
6. identified instructional activities and teaching strategies that be able to help student learn the content of lesson				
7. complete aim of teaching strategy by using appropriate activity				
8. plan to monitor student's existing knowledge				
9. plan for ways to monitor student learning during the lesson.				
10. plan to use appropriate instructional media and technology to enhance student learning				
11. plan to share learning outcomes with student at the beginning of lesson				
12. developed an end-of-lesson assessment that shows what students know or can do relative to the content standard for the lesson				
13. lesson plan contain the alignment between the standard, lesson assessment, learning outcomes, and lesson content				

**Suggestions:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## **Appendix E**

Interview Protocol for Pre-service Teachers  
After Organizing Seminar Discussion

## Interview Protocol for Pre-service Teachers After Organizing Seminar Discussion

\*\*\*\*\*

Date: \_\_\_\_\_ Start time: \_\_\_\_\_ finish time: \_\_\_\_\_  
Topic of seminar discussion: \_\_\_\_\_

### Introduction

Hi Everyone. Thanks so much for coming. First, I have to ask permission to use a voice recorder; this tool will help me revise your answers. Please feel free to speak out your opinion, I confirm that this recorder will be secrete, just only me who will listen to our conversation. We will spend about 20 minutes to have conversation.

Before start interviewing, let me explain my purpose of this interview. The reason that I interview you is not for grading, but is for survey in my research. I am interested in how pre-service science teachers' professional knowledge during seminar course. This means that we have to look at what you learn and feel when you learn in this course.

I am interested in details that might seem unimportant to you. And we'd really like your stories. I've developed a series of preliminary questions that will start out following, but we'll also let our conversation determine where the questions will go.

### Preliminary questions

1. Before start organize seminar discussion, how well you know about topic of \_\_\_\_\_(put the topic)? If you know well, how did you know?

#### Probing question

Tell me more about

- name of course that you learned this topic
  - where did you study about this topic
2. If you didn't know well, how did you prepare yourself to organize this topic?

#### Probing question

- Where did you find information?

3. Did you have any problem in preparing your seminar session?
4. Did your classmate learn anything? If so, why? If not, why not?
5. After discussion with your classmate, what knowledge did you acquire more?
6. What did you learn more when designing lesson plan after seminar discussion?
7. Was the strategy I used to organize seminar discussion effective? If so, what is evidences that present effectiveness?
8. As a result of this session, what have I learned? And how will I use in my teaching?
9. Do you have some more ideas or suggestion?

### Closing

Thank you very much for your help, your answer will be very useful for science education research. Moreover, it will be fundamental information used to develop preparation course for pre-service science teachers in the future.

## **Appendix E**

Interview Protocol for Pre-service Science Teachers  
During Student Teaching

## Interview Protocol for Pre-service Science Teachers During Student Teaching

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Date: \_\_\_\_\_ Start time: \_\_\_\_\_ finish time: \_\_\_\_\_  
 Name: \_\_\_\_\_ Class \_\_\_\_\_ Time: \_\_\_\_\_  
 Topic of science lesson: \_\_\_\_\_

### Introduction

Hi \_\_\_\_\_ (name). Please feel relax after teaching. Do you want me to start interviewing? If no, tell me when you are ready. First, I have to ask permission to use a voice recorder; this tool will help me revise your answers. Please feel free to speak out you opinion, your answers will not right or wrong. I am interested in details of your teaching. I confirm that this recorder will be secrete, just only me who will listen to our conversation. We will spend about 15 minutes to finnish conversation.

Before start interviewing, let me explain my purpose of this interview. This interview aims to continue capture your knowledge and feeling after seminar course. This interview will not effect your grading of student teaching, so feel free to talk with me.

I've developed a series of preliminary questions that will start out following, but we'll also let our conversation determine where the questions will go.

### Preliminary questions

1. Why did you select this lesson to be observed?
2. Did the student learn anything? If so, how can you know?
3. Did anything significant occur in your classroom? If so, what and why?
4. Was the strategy you used the most effective one? What other strategies might have been effective?
5. Did you know student existing knowledge?
  - If so, how can you know? And how well did you relate the lesson to the student's knowledge, experience, and interests?
  - If not, how might I have done this better?
6. How well did you manage classroom behavior? Did you use any strategies to control classroom? If so, what technique worked best and what didn't work?
7. What connections were there between teaching strategies and students' learning? What does this tell you about what you need to do in the future?
8. Did you consider learning theory in preparing and implementing the lesson? If so, what theories worked? If not, what theories should I have considered?
9. Did you use any strategies of assessment that you learned from seminar course in your classroom? If so, what is it and how it works?
10. Did you use ideas from seminar course to help you plan and teach this lesson? If so, please give me some example.

### Closing

Thank you very much for your help, your answer will be very useful for science education research. Moreover, it will be fundamental information used to develop preparation course for pre-service science teachers in the future.

## **Appendix G**

Expected Levels of Teachers' Professional Knowledge



Appendix Table G1 (Continued)

Expected levels of Teachers' professional knowledge presented in Subject/Document	Teacher Professional Knowledge														
	Educational Context	General Pedagogy Knowledge (PK)					Subject Matter Knowledge	Pedagogical Content Knowledge (PCK)					Instructional Media and Technology	Educational Philosophy	Research on Best Practice
		Learner and Learning	Classroom Management	Curriculum	Instruction	Assessment		Learner and Learning	Classroom Management	Curriculum	Instruction				
3.3 Zembal-Saul <i>et al.</i> (2002)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
3.4 Goodnough (2002)	0	0	0	0	0	1	0	0	1	1	0	0	0	1	
3.5 Coble and Koballa, Jr. (1996)	0	0	0	0	0	0	0	0	0	1	0	1	0	0	
4. Needs assessment of the 4 <sup>th</sup> year pre-service science teacher															
4.1 in 2004	0	0	1	0	1	1	0	0	0	1	0	1	0	0	
4.2 in 2005	0	0	1	0	1	1	1	0	0	1	0	1	0	0	
4.3 in 2006	0	1	1	1	1	1	1	0	0	1	0	1	0	0	
<b>Total</b>	<b>2</b>	<b>9</b>	<b>4</b>	<b>6</b>	<b>1</b>	<b>1</b>	<b>9</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>2</b>	<b>11</b>	<b>2</b>	<b>2</b>	
Note: Meaning:	1 present in the data						0 not present in the data								

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