Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Improving Thai Science Teachers' TPACK through an Innovative Continuing Professional Development Program

Improving Thai Science Teachers' TPACK through an Innovative Continuing Professional Development Program

Chatmaneerungcharoen, S.

Department of General Science, Faculty of Education Phuket Rajabhat University

*Corresponding author's e-mail address: drsiriwankief@pkru.ac.th

Abstract. This study focuses on teaching and learning development in science through collaboration between science cooperative teachers and researchers. At the main goal was the ambition to integrate coaching strategy into internship course—with teaching practice, aligned with professional development on teacher's technological pedagogical content knowledge (TPACK). The phase where the collaboration moves from initial establishment towards a stable practice is investigated. The study aims to identifying the character of professional program with specific questions are "How does professional development program was identified as actions and arrangements impacting the development of teacher's TPACK and their emerging practice?" and "How does the teachers' TPACK change?" Therefore, the study focuses on developing 40 Cooperative Science teachers who were science cooperative teachers that participated in this study for 1 year. Data sources throughout the research project consisted of teacher refection, classroom observations, Semi-structure interviews, Situation interview, questionnaires and document analysis. Interpretivist framework was used to analyze the data.Research findings indicate that STEM Education Professional Development Model: STEMed- PD which was developed on the frameworks of coaching and mentoring, lesson study, after action reflection and professional development community can enhance the cooperative science teachers' understanding and practice on STEM lessons. These teachers conducted their classrooms with integrated science concept to other subject concepts. The lesson's learning objectives are related to the 21st century skills that encouraged students to apply their knowledge into their daily life. Different from the beginning, the teachers understand only the meaning of STEM Education but they do not know how to integrate STEM into their science classrooms and they thought STEM lesson should be taught through Science Camp, not in normal classroom. For 1 year of STEMed-PD progression, both Science cooperative teachers and their student teachers have shown their development of STEM understanding and practice in aspects of STEM definition, STEM background, learning goals based on STEM and the 21st century skills, STEM lesson plan development, classroom practice with STEM lesson, connecting STEM lesson into student's daily life, and evaluation and assessment of STEM classroom. The development of teachers' understanding and practice is presented in their lesson plans that are produced during STEMed-PD. Moreover, the study also indicates the importance of co-working between cooperative science teachers and university supervisors in lesson preparation through coaching and mentoring. Implication for further research, science educators should focus on teacher self-efficiency and teacher's background in technology knowledge which are factors to support or obstruct science teachers to develop their STEM practices.

1. Background

Building individuals with adequate knowledge and understanding of science and technology has become one of the main goals of national education. Current national documents are called for changes in K-12 science, technology, engineering, and mathematics (STEM) education to increase STEM literacy for preparing the 21st Thai citizenship. Will this happen without teachers? The answer is NO. Therefore, science teachers should have appropriated knowledge. Technological Pedagogical Content Knowledge or TPACK framework [7] has emerged as a professional development framework to describe required science teachers' knowledge for the 21st century science classroom. Emerging 21st century era, science teachers should conceptualize TPACK that is referred to a specific category of knowledge for teaching science. TPACK is a conceptualized blend of technological knowledge, content knowledge and pedagogical knowledge to design Information and Communication Technological lessons in science concept. Teachers' knowledge influences what they know, what they think, and how they act in the classroom. TPACK was extended from [13] who defines the knowledge of teaching a subject matter as pedagogical content knowledge (PCK): the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, adapted to the diverse interests and abilities of learners, and presented for instruction. In emerging of the 21st century, people are taught to be familiar with technology because of the world communication and information access. Given this change, education must shift to incorporate computer based, electronic technologies integrating learning with these technologies within the subject area. Now the knowledge benchmark that teachers need in order to teach their subject matter with technology is more than just PCK, it needs the development of "Technology Pedagogical Content Knowledge (TPACK)" [6, 9]. From the National Research Council "The relationship between Science and Technology is so close that any presentation of science without developing an understanding of technology would portray and inaccurate picture of science" [8]. Similarly, the International Society for Technology in Education developed new technology standards for students and teachers that specifically confront teachers with integrating technology throughout education. These standards direct that electronic technologies become "an integral component or tool for learning of academic subject area" [5]. Therefore, the process of teacher education should focus to prepare the student teacher to have the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies.

According to educational reform, teachers still have difficulties in implementing constructivist-based teaching and learning approaches. These approaches are seen to be radically new for the majority of science teachers and they are suspicious of their effectiveness [10]. Particularly, there are numbers of studies that document the problems in-service elementary science teaching. Thai elementary school teachers often do not have enough pedagogical content knowledge necessary to create a constructivist classroom. Most importantly, they lack an understanding about how to represent science content in ways that are personally meaningful and potentially accessible to students [11, 18] of pre-service teacher education [14], as it provides student teachers with essential bridge between theory and practice and the opportunity to define and refine their teaching skills. Similarly, the current literature supports the important of teacher practice, identifies student teaching as the most helpful part of professional education and comprises the first steps of a personal journey of becoming a teacher [15, 16, 17]. In school-based pre-service teacher education, mentoring refers to the supervision of a student teacher by an experienced teacher during the teaching practice. Student Teachers are assigned to teacher (Cooperative teachers) to be supervised throughout the practicum. Additionally, students are supervised by a university supervisor who occasionally visits the school. The university supervisor and the cooperating teacher serve as mentors to the student teachers, as both of them interact with the protégé and help him or her again the necessary professional knowledge and skills [4]. Cooperating science teachers are selected with care and with the knowledge that their experience will provide a nurturing environment for the science teacher education student. It is primary importance that the

IOP Conf. Series: Journal of Physics: Conf. Series **1340** (2019) 012017 doi:10.1088/1742-6596/1340/1/012017

clinical experience be a positive experience for student teacher. Therefore, the cooperating science teachers should carry with appropriate TPACK and supervisory skills.

Thus, effective professional development opportunities are important for helping science teachers to improve their TPACK.

Purpose of study

1. To develop science teachers' TPACK for integrating ICT into classroom.
2. To create professional development program to develop TPACK which move teachers' practices to more integrated way.

Research Questions

1. How do teachers develop their Technological Pedagogical Content Knowledge (TPACK)?
2. What is the relationship of TPACK development with the in-class use of new technologies such as the teachers' ICT integration and the emphasis on STEM education?

2. Method

2.1. Research Methodology

This study employs a phenomenological, interpretive multiple-case study design to develop science teachers' TPACK which promotes teachers to integrate STEM in their classes. The data analysis focused on assessing how science teachers develop their technological pedagogical content knowledge through Co-TPACK PD and STEMed PD. A multiple- case study design provides rich descriptions and interpretations of teachers' experiences relating to ICT and STEM integration. This study was conducted for 3 years.

2.2. Participants and Setting

Participants and The research participants were 40 science cooperative teachers and40 student teachers in major of General Science, Faculty of Education at Phuket Rajabhat University. This purposive sampling method is based on the criteria that the researcher would like to learn and find the answer for research questions. Forty science cooperative teachers indicated their willingness to participate in the study. In the end three criteria were used for choosing the participants and they were as follows:

2.1.1 Teachers who were teaching Science subject in the elementary and high school levels in school located in Phuket Province. They were cooperative teachers who worked with student teachers in 2015-2017 academic year.

2.1.2 The teachers were teaching Science in both semesters and could participate in long term professional development program. They showed a willingness to contribute to the profession by being open to classroom observations by the researcher, participate in follow-up interviews and be able to attend meeting of the TPACK PD for 2 years and STEMed PD for 1 year.

Research Instruments

In order to study the development of Thai science cooperating teachers' understanding of TPACK and practice through CO-TPACK PD and STEMed PD, multiple data sources have been used during the research process. Utilizing grounded theory in this research, the researcher used data from multi-sources to maximize flexibility and to help generate theory. Using data from a variety of resources or using more than one method has provided a fuller understanding of this study for the researcher. In interpretive case study, classroom observation, individual interview, questionnaire, inquiry-based lesson plan, written reflection, and group discussion are preferred to assess all teachers' TPACK with their thinking, actions, and reasons in the specific context and setting. In this research, classroom observation, interview, questionnaire, case study, card sort and documents were used as research methods to provide opportunities for participants and the researcher to generate an understanding for a particular situation. Research participants present their TPACK through writing lesson plans, teaching journals, meeting, card sorting, and answering or discussing topics in the interview process. An understanding of their TPACK was transcribed and explained by the researcher who has used the inductive approach to generate theory

Data Analysis

The researcher analyzed documents and underlying knowledge of participants in speaking and writing. Data from multiple sources such as teachers' journals and interviews; field notes and videotapes from observations and card sorting were analyzed by the process of open coding to get the transcripts from the first interview, observation, reflection and card sorting, developing initial categories of the participant's technological pedagogical content knowledge and their practice. In developing categories, the researcher used a constant comparative method of analyzing multiple sources of data served to triangulate the data in order to increase trustworthiness of the research findings and assertions made.

3. Result and Discussion

3.1. Science Teacher Program Innovation (STPI)

This study reports the finding of research on TPACK enhancement program effectiveness. TPACK PD and STEMed PD were parts of a large-scale Thai science cooperative teacher's professional development intended to improve in-service science teachers who work as cooperative teachers at elementary and junior high schools. The program consisted of a preparation stage, implementation stage, feedback exchange; and revising stage (Figure 1)

Figure 1. Professional Development Framework

The STPI program consisted of inquiry activities, teaching strategies (Explicit-Reflective and Content based approach) (Figure 2)

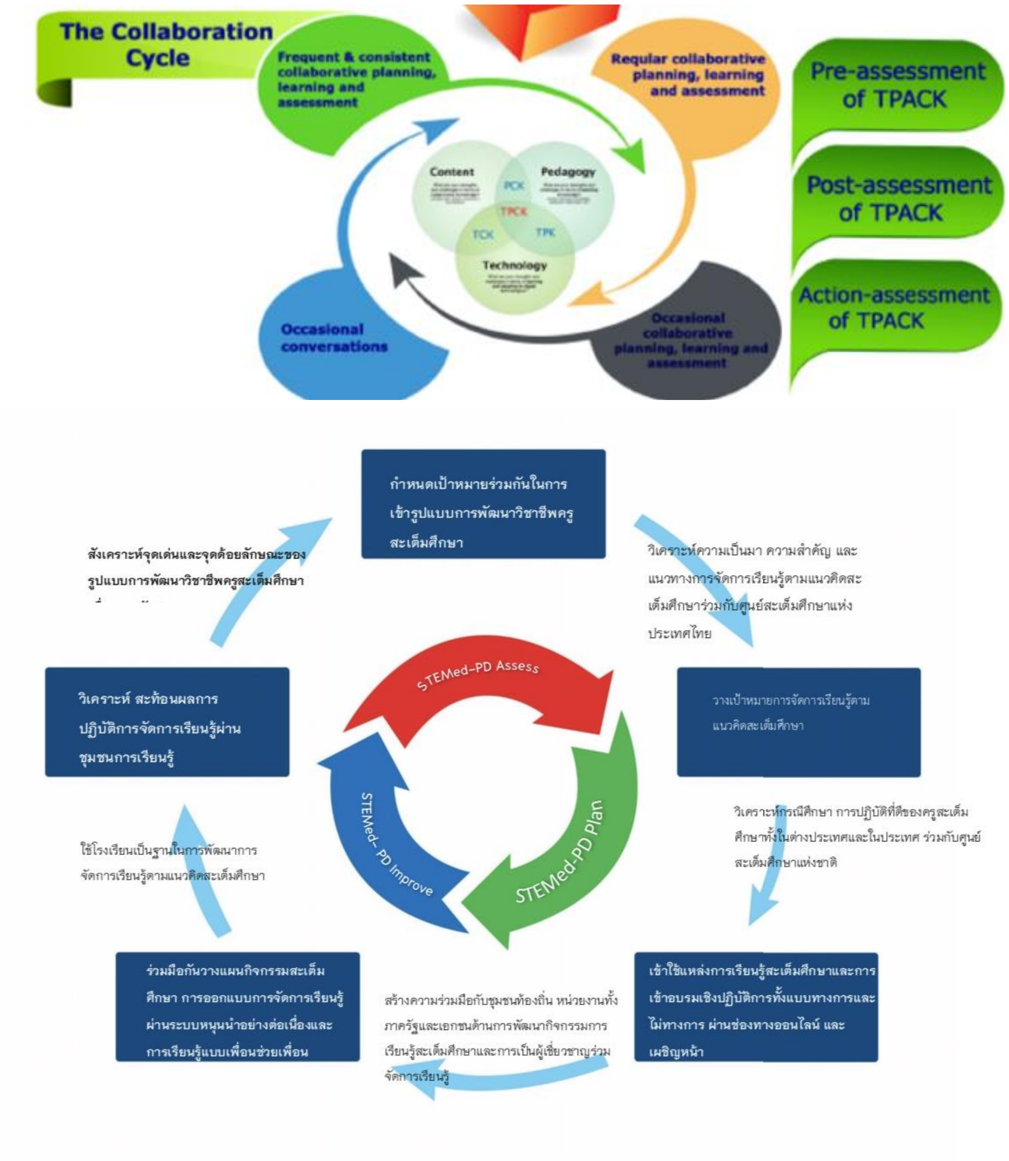

Figure 2. Continually Professional Development (Co-TPACK and STEMed PDs)

Co-TPACK 1 I: Integrating Technology in the Pre-service Science Teacher Preparation Program (Semester of 2016 Academic Year)

40 pre-service science teachers were attending Science Education course integrating ICT for one semester induration and emphasized learning through hands-on design of ICT lesson plans. The course was aimed at preparing pre-service science teachers to design student-cantered ICT-integrating science lessons that support the 21st century in Thai students. The pre-service science teachers' course was conducted 4 months (3 hours/lesson). The first two months were interactive lectures and workshops on Thai National Science Curriculum, science teaching methods, measurement and evaluation in science classroom. The last two months were about technological training, ICT lesson design in concepts of science, and microteaching lesson study. The specific technology section used science problem-based activities to guild the pre-service science teachers in learning about educational technologies, pedagogical considerations with these technologies and teaching/learning with these technologies. The first stage of the program, the student teachers explored a variety of science concepts integrating technologies that could be considered in the curriculum. Microteaching lesson study section focused

IOP Conf. Series: Journal of Physics: Conf. Series **1340** (2019) 012017 doi:10.1088/1742-6596/1340/1/012017

the pre-service science teachers gaining teaching experience, reflective skill on lesson plan development fours instructional methods: demonstrations, hands on/ laboratories, inductive and deductive activities. The pre-service science teachers were assigned to develop a science lesson for each model that has to integrate with technology. The pre-service science teachers teach (videotaping the instruction and upload on Facebook group by YouTube link) their lessons to their peers, and reflect (assessing and revision though written reflective journal and group discussion). The microteaching lesson study is recorded by videotapes to recall the teaching and debriefs of the lessons by their peer, instructor and ICT experts. The remaining 6 months of the program focused specifically on providing extended ICT workshops and professional classroom observations. Prior to be the student teachers starting their fulltime practicum at the school sites, the three student teachers were assigned to work with their cooperative teachers to design their sequence of lessons for an integration of technology.

Co-TPACK II: Pre-service science teachers' Practicum (Semester of 2017 Academic Year)

During fulltime student teaching, the pre-service science teachers were expected to adjust their lesson plans under the supervision of supervisor (researcher) and cooperative teachers. The technology integration theme highlighted in the shaded areas provided the explicit preparation of the pre-service science teachers' development of knowledge needed for development of TPACK. During teaching practicum, the pre-service science teachers were observed, all assignments were collected and analyzed, and the case studies were interviewed extensively over the various parts of the program. After each lesson, the pre-service teachers prepared written reflections that considered revised plans for succeeding lessons. They were assigned to reflect on their understanding of science concepts, instructional methods, learning and teaching assessment, the success of the integration of technology in the lesson and recommendations for the changes, and their teaching while integrating technology in teaching science.

Co-TPACK III: Cooperative science teachers' development of TPACK (Semester of 2017 Academic Year)

Data from teachers' journals and interviews, field notes and videotapes from classroom observations, videotaped transcriptions from group discussions, semi- structured interviews, and card sorting when using the CO-TPACK PD will be transcribed and developed to core categories of developing technological pedagogical content knowledge In the data analysis methods, the researcher attempted to find out patterns of growth or development by comparing the pre-service science teachers' understandings and practices of TPACK through CO-TPACK PD, The participants gained technological content knowledge in the use of both Weblogs and Facebook for sharing knowledge and experiences. The case studies are more confident of their TPACK perceptions. The finding presents that the pre-service science teachers tend to give more considerations to integrate technology into their lessons in three aspects (resource, teaching material, and student assignment). Through CO-TPACK PD and guided supervision within the school site enhances the student teachers development of TPACK based on educational theories and knowledge. This includes providing an effective way to convey the use of the technology to enhance student learning such as YouTube, Anusura, Dreamweaver, and Flash. By experiencing these different multimedia applications, they realized that they could represent many concepts to their students through technology. In an opposite way, students can learn science by creating project-based learning.

Sharing, reflecting, and discussing during co-planning, co-teaching, and co-evaluating of CO-TPACK PD were key activities in the CO-TPACK PD that enhanced Cooperative teachers' TPACK development. Through participating in the CO-TPACK PD, Cooperative teachers' understanding about student-cantered learning became clear. In their broadened ideas, student prior knowledge, and participating in hands-on activities were key aspects of student-cantered teaching. Three Cooperating teachers also had a chance to clarify his understanding of how to integrate knowledge bases for teaching particular content. These cooperative teachers reflected on their own teaching skills that

IOP Conf. Series: Journal of Physics: Conf. Series **1340** (2019) 012017 doi:10.1088/1742-6596/1340/1/012017

helped them become aware of the importance of each knowledge base for teaching and its integration. In their second lesson plan, learning goals and purposes, learning activities sequence, instruction media, and assessment methods, had more detail and were more interrelated. They appeared focused more on teaching science by inquiry approach and enhanced students to learn science by integrated learning, PBL, or experimental learning as dimensions of student learning. They changed to use a variety of assessment methods such as asking questions of students, observing their behaviour, creating mind mapping and interaction with them. These student-student and student-teacher interactions appeared in their microteaching activity and their supervising to their student teachers. Three Cooperating teachers showed the CO-TPACK team can help their TPACK development and supervising skill because the CO-TPACK PD (during internship placement) contained a friendly and comfortable environment, interesting teaching and learning activities, and various types of assessment methods. The results of study suggest several aspects need to be addressed for science teacher education (pre-service and in-service science education) to be successful in integrating TPACK in their teaching of science, particularly in a classroom similar to the case study teachers'. First, the science teacher needs to hold the goals and purposes that focus on student learning with respect to science knowledge, science process skills, and scientific attitude. When the cooperating science teachers can teach science along with the reform-based science teaching, the student teachers will be trained to teach science as the same way of their cooperating science teachers. Second, strong pedagogical knowledge would make it easier for the science teacher to teach science through inquiry-based teaching and learning.

After 2 years with Co-TPACK, these teachers still continually worked with STEM project. Because the national proliferation of models of STEM that exist and the associated lack of practical advice creates confusion about how to integrate STEM in their classroom. Therefore, another 1 year of STEM professional development program was conducted in three stages: STEMed Plan; STEMed Assess; and STEMed Improve. The goal of STEM professional development is to increase student learning of science and mathematics by suing an engineering design-based approach for integrated STEM instruction to guide professional development and curricular design.

4. Conclusion

The study reported in this research is aimed at identifying how a Co-TPACK PD impacts on the development of cooperative science teachers' TPACK, and how does the Co-TPACK PD look like. The results focused on the teachers 'development of TPACK before and after they engaged in the Co-TPACK PD. As the CO-TPACK PD progressed during internship placement, Cooperative science teachers' TPACK knowledge base gradually broadened through learning activities in the CO-TPACK PD. Majority of cooperative science teachers have grown in their TPACK. Cooperating teachers were provided with many opportunities to broaden their understandings and practices about science concepts, pedagogy, assessment, technology integrated teaching and the nature of science. They had a chance to express their initial understandings and compare these understandings to constructivist understandings of teaching and learning science, proposed in the Basic Education Curriculum, and the Science Curriculum Framework. The Cooperating teachers were provided interesting ideas from the CO-TPACK members through sharing, reflecting, and discussion during their co-planning, co-teaching, and co-evaluating. Through these activities, three Cooperating teachers' understanding and practices of TPACK supporting teaching and learning science based on constructivism shifted to more constructivist understandings specifically, in the nature of scientific knowledge including the teacher 's supervising skill which was increased. The three stages of Co-TPACK PD provide guidelines for designing professional learning contexts for teacher development of TPACK knowledge. This study presents that effective professional development program that can help teachers developing their knowledge have the following these features:

1. Based on science teacher needs
2. Active engagements of science teachers, student teachers, and university supervisors.

3. Enhancement of technology knowledge into pedagogical content knowledge.
4. Ensuring science teacher's collaboration with other.
5. Provision opportunities for science teacher reflection and giving feedback throughout the professional development
6. Provision of experts and local supporters.
7. Along with STEM lesson plans were implemented, overall, these teachers reflected that their students enjoy the new activities which were the new way to represent science concepts or the new way of doing science through an integration of STEM unit.

5. Research Implication

According to the results of this study, the Co-TPACK PD and STEMed PD are productive in affecting changes of the teachers' TPACK in the classroom. The crucial components underlining these PDs that are likely to have an impact on the development of the science teachers might be: establishing common goals among program members, empowering teachers' leadership of the professional development program, providing opportunities for teachers to learn in their actual classrooms, giving time and support for teachers to plan, implement, observe, and reflect on their lessons, providing chances for teachers to learn through other teachers who are colleagues, having long-term assistance for continuous learning and practical change, and most importantly building and sustaining a trusting and respectful atmosphere among the teachers and the researcher. For readers and researchers who are interested in doing similar studies, it is important to remember that this study was conducted with a group of science teachers who taught at the elementary level or high school level. The findings from this study were not intended to generalize to all science teachers. Nevertheless, the description of how the Co-TPACK PD approach to professional development was implemented and the context surrounding the use of this approach may be useful to others who decide to use this as model for teacher professional development in their own context.

6. Acknowledgeable

My success would not be happened if I did not have helps from the National Research Council of Thailand and Phuket Rajabhat University for providing me the scholarship. Furthermore, this research would not have been completed without the support from the group of experts, research participants, and school administrators. I would like to thank all of the English editors and especially my husband, Robert Kief, for his patience and devotion in proof reading my writing.

References

[1] Beetham H and Sharpe R 2013 Rethinking pedagogy for a digital age: Designing for 21st century learning (New York: Routledge)
[2] Charmaz K 2003 Grounded theory In: J. A. Smith Qualitative Psychology: A Practical Guide to Research Methods (London, Sage)
[3] Chatmaneerungcharoen S 2008 The Elementary Science Teachers' Pedagogical Content Knowledge and Practices of Schools under the Bangkok Metropolitan Administration **KKU Research Journal 14** pp 1132–1142
[4] Healy C C and Welchert A J 1990 Mentoring relations: A definition to advance research and practice **Educational Researcher** pp 17–21
[5] International Society for Technology in Education 2000 National Educational Technology Standards for Teachers (U.S and Canada: Intel)
[6] Koehler M and Mishra P 2006 Technological Pedagogical Content Knowledge: A new framework for teacher knowledge **Teachers College Record 108** pp 1017–1054
[7] Koehler M and Mishra P 2009 What is technological pedagogical content knowledge (TPACK)? **Contemporary issues in technology and teacher education 9** pp 60–70
[8] National Research Council 1996 The National Science Education Standards (Washington, DC: Brooking Institution)

[9] Niess M L 2007 Mathematics teachers developing technological pedagogical content knowledge (TPCK) Paper presented at IMICT 2007 (Boston, MA)
[10] Office of the Education Council (OEC) 2004 Education in Thailand 2004 (Bangkok: Amarin Printing)
[11] Office of the National Education Commission (ONEC) 2001 The Research Report for Comparing of Educational Reform to Know in Thai Science Education Reform (Bangkok: ONEC)
[12] Office of the Rajabhat Institutes Council 2002 Quarterly report on World Bank project -The secondary education quality improvement (project IBRD Loan 4052 TH Bangkok: Author)
[13] Shulman L 1986 "Those who understand: Knowledge Growth in Teaching" **Educational Researcher, 15** pp 4–14
[14] Tanruther E M 1994 What does it mean to be a supervisory teacher? **College Journal** 167–171
[15] Thibeault J 2004 The relationship between student teachers and cooperating teachers as a foundation for the development of reflective thinking: An exploratory study based on student teachers' perceptions. Unpublished doctoral dissertation (McGill University, Montreal, Canada)
[16] Walkington J 2005 Becoming a teacher: encouraging development of teacher identity through reflective practice **Asia-Pacific Journal of Teacher Education 33** pp 53–64
[17] Williams C C 2001 Student teacher perceptions of university supervisor performance. Unpublished dissertation, Tennessee State University
[18] Yutakom N and Chero P 1999 Reporting of In-service Science Teacher Professional Development in Accordance with the National Education Act of B.E. (Bangkok: IPST)