CHAPTER 2
REVIEW OF THE LITERATURE

In this chapter, related educational theories and research conducted in the past are described to provide a framework of what is known about a topic from previous research. The topics of the literature review are as follows:

1. Basic information on science education of Malaysia and Thailand
2. Pedagogical Content Knowledge (PCK)
3. Orientations to Teaching Science
4. Related Studies

1. Basic Information on Science Education of Malaysia and Thailand

Basic information on science education for the two countries participating in this study is composed of: 1) Instruction for Science in primary and lower secondary grades and 2) Teacher and teacher education. All information is from TIMSS 2011 Encyclopedia: Educational Policy and Curriculum in Mathematics and Science (Martin, M.O. et.al. 2012).

1) Instruction for Science in Primary and Lower Secondary Grades

In Malaysia

In Grades 1–3, students study science for three 30-minute periods per week, and in Grades 4–6, they study the subject for five 30-minute periods per week. At the lower secondary level, five 40-minute periods per week are devoted to science instruction.

- Instructional Materials, Equipment, and Laboratories: Schools are given autonomy to determine teaching approaches and strategies. The curriculum specifications for both science and mathematics, however, do provide suggested teaching and learning activities to help teachers plan and implement more effective instruction. Science lessons at the primary level are carried out in science classrooms, while proper laboratories are provided in secondary schools. The ministry provides annual grants to schools (on the basis of enrollment) for the purchase of equipment, chemicals, teaching aids, and materials needed for science, which schools then purchase directly. The ministry also regularly supplies any necessary general resources.

- Use of Technology: Technology is integrated into science teaching and learning to enable students to explore and develop their understanding of scientific concepts. Technology tools such as calculators, computers, educational software, and the Internet are used for independent or group work.

Communication, collaboration, problem solving and decision-making are some of the skills required in the 21st century. Online collaborative platforms enable information sharing as well as collaboration on group projects among students of different schools, communities, and cultures, both within Malaysia and in other countries. For example, Oracle's ThinkQuest is a collaborative platform in which students can work on group projects in science and mathematics, and where completed projects can be shared online. Students also use social platforms such as Facebook, Yahoo Groups, and Google to communicate and collaborate on science and mathematics topics. In addition, instructional materials developed by teachers and shared on YouTube, SlideShare, and other platforms have been used in the classroom.

EduwebTV, a platform managed by the Ministry of Education, also is available to teachers for downloading videos related to the curriculum, news, and instructional materials, as well as for uploading their own materials for sharing. Virtual Learning Environments (VLE) is a learning management system that also can be used to deliver instructional materials to students for individualized learning. For example, VLE can be used to deliver SharableContent Object Reference (SCORM) e-learning materials online, including assignments that teachers can score and record within the system.

In Malaysian education, there is a focus on user-generated content, which means that teachers develop customizable content suited to their students' learning needs. The Ministry of Education trains information technology coordinators and library media specialists (ICT lead users) to develop content, using software such as Microsoft PowerPoint and Movie Maker, which can be shared on EduwebTV or other collaborative platforms. ICT lead users then train teachers in their schools to develop and share content. Teacher Communities of Practice (COP) use online collaborative platforms to share ideas, best practices, instructional materials, and lesson plans, in order to enable other practitioners to learn from one another and to improve their teaching.

- Grade at Which Specialist Teachers for Science are Introduced: Specialist teachers in science teach these subjects at the primary, lower secondary, and upper secondary levels.

In Thailand

Learning media serve as support tools in the learning process, enabling students to efficiently acquire knowledge, skills, processes, and characteristics as prescribed in the curriculum standards. Learning tools come in various forms, sources, and channels; they may include print media, in- and out-of-school learning resources, resource persons, and science laboratories.

- Use of Technology: The *Basic Education Core Curriculum B.E. 2551* suggests the use of electronic media for teaching and learning in science education. These include computer-assisted instruction, software, the Internet, e-books, graphing calculators, and radio and television programs. It is recommended that the provision and application of learning media correspond to the curriculum and learning objectives. In addition, the design and coordination of learning activities should use material that is accurate, up-to-date, appropriate, and suitable to the developmental levels and learning processes of students.

- Grade at Which Specialist Teachers for Science are Introduced : Presently, Thailand's education policy does not require teachers to have educational degrees corresponding to the subjects they teach. However, at the lower secondary level, schools are required to have teachers accredited in mathematics and science. At the moment, the Teacher's Council of Thailand is moving toward reforming regulations on teaching licenses, stipulating that teachers must hold subject-based licenses, and that secondary teachers may only be permitted to teach those subjects related to their academic majors. The planned reform will take effect in 2013.

2) Teacher Education Specific to Mathematics and Science

In Malaysia: Teacher education institutions and public universities are responsible for teacher education, under the purview of the Ministry of Higher Education. Currently, Malaysia has 27 teacher education institutes and an English Language Teaching Center. The ministry uses stringent admission criteria to ensure that only qualified candidates enter the profession. Education program candidates are chosen through the Malaysian Teachers Selection Test, individual and group interviews, and a written English test.

In Thailand, the second report of the Office of the Higher Education Commission (OHEC), *Long Range Plan on Higher Education (2008–2022),* claims that the quality of secondary students who pursue higher education has regressed as a result of teacher quality. OHEC has decided that new conditions must be established to attract talented applicants into the teaching profession. For example, proper training will be provided to graduates of majors other than education who wish to enter the teaching profession. OHEC has therefore increased its efforts to review the production and development of teachers for schools and vocational colleges and has launched the New Breed of Teacher Production and Development program. Currently, the following measures are taking place:

- Adjusting the processes of teacher education, recruitment, remuneration, and welfare to attract quality personnel who are interested in the teaching profession (e.g., by providing scholarships and civil-service-job placement guarantees);

- Supporting research at higher education institutes on issues regarding the teaching profession, as well as establishing a system of guarantees to ensure the quality of teachers and teacher education institutes;

- Planning teacher education, development, and deployment systematically, and coincident with need; Supporting graduates of non-education majors who are interested in becoming teachers to realize their potential as teachers, and allowing local community member involvement in teaching and learning development; and

- Developing an education system for teachers at the higher-education level, enabling the linkage of teaching ability, knowledge transfer, and management with professional development experience.

Thailand has a program for educating professional teachers: a five-year bachelor's degree program. Details are as follows:

- Five-year bachelor's degree program—This program is for basic education teachers (Grades 1–12) and comprises four years of coursework and one year of internship in an educational institution. The scope of the program includes teaching, research in classroom settings, curriculum development in schools, learner development activities, school service, and community education and services. A teaching license is conferred upon graduation.

2. Pedagogical Content Knowledge (PCK)

What is pedagogical content knowledge?

Shulman (1986 : 9) defined pedagogical content knowledge (PCK) as the ways to present subject content that make it accessible to others. It can be illustrations, examples, demonstrations or analogies. In other words, it is knowledge of how to teach specific content in specific context- a form of knowledge in action. Grossman (1990 : 8-9) identified four major components of PCK as: (a) knowledge and beliefs about the purposes of teaching a subject at different grade levels, (b) knowledge of students' understanding, conceptions and misconceptions of particular topics in a subject matter, (c) knowledge of curriculum materials available for teaching particular subject matter as well as knowledge about both the horizontal and vertical curricula for a subject and (d) knowledge of instructional strategies and representations for teaching particular topics.

Magnusson et.al. (1999 : 96) perceived PCK in a different aspect by describing PCK as the transformation of various kinds of teacher's knowledge including subject matter knowledge, pedagogical knowledge and the knowledge of context. They proposed that we can interpret teacher PCK as a model of teacher thinking. There is a continuum of teacher thinking model. For one side, PCK does not exist as a domain of knowledge. Teaching depends on the presentation of content to students in some context using an appropriate form of instruction. The task of the teacher is to selectively draw upon the independent knowledge bases of subject matter, pedagogy, and context and integrate them as needed to create effective learning opportunities. An expert teacher, then, is one who has well-organized individual knowledge bases that are easily accessed and can be flexibly drawn upon during the act of teaching. The Integrative model also closely follows traditional patterns of pre-service teacher preparation with temporal and spatial separation of subject matter, pedagogical, and contextual issues. A potential danger in this model is that teachers may never see the importance of knowledge integration and continue to emphasize the importance of content over pedagogy, resulting in transmission modes of teaching with little regard for content structure, classroom audience, or contextual factors.

The other model, The Transformative model, recognizes the value of a synthesized knowledge base for teaching. PCK that helps students understand specific concepts is the only knowledge used in classroom instruction. While knowledge bases containing subject matter, pedagogy, and contest exist, they are latent resources in and of themselves and are only useful when transformed into PCK. Teachers can justify their instructional decisions within the domain of PCK; the teasing apart of teaching knowledge into its related forms is best left to researchers and theoreticians. An expert teacher, then, has well formed PCK for all the topics commonly taught. All teaching knowledge is contextually bound, potentially making transfer or drawing generalizations across teaching episodes difficult. The danger in this position is that it ignores context as it objectifies teaching knowledge, potentially implying that correct teaching practices exist for given topics to specific audiences. The classroom becomes the primary location of teacher knowledge, calling into question the value of decontextualized declarative and procedural knowledge and teacher preparation as it currently exists.

Assessment of PCK

To study pedagogical content knowledge, researchers and teacher educators have developed techniques, such as paper and pencil tests (in particular, multiple-choice exams), concept maps, pictorial representations, interviews and multi-method evaluations. These techniques have been used to pursue goals such as teacher evaluation, staff development, and program development. Baxter and Lederman (1999 : 147-161) have organized the studies by the technique used to assess pedagogical content knowledge. The studies fall into three groups: (a) convergent and inferential techniques, (b) concept mapping, card sorts, and pictorial representations, and (c) multi-method evaluations. The details of each group are as follow:

1. Convergent and inferential techniques include Likert-type self-report scales, multiple-choice items and short answer formats. What is common to all of these formats is that they use predetermined verbal descriptions of desired teacher knowledge as the criteria for comparing verbal answers of pre- and in-service teachers.

2. Concept mapping has been used by cognitive researchers to measure knowledge structures as represented by key terms and the relationships among those terms. Typically, researchers ask their subjects to generate words and phrases about a particular label or concept. The subjects are then asked to group the words in ways that make sense to them and explain their groups. Often the subjects are asked to draw pictures or maps that illustrate the key terms and relationships among them. An important assumption underlying this research is that concept maps reflect the organization of information as it resides in long term memory.

Card sort tasks were used extensively by Shulman and his students within the Knowledge Growth in Teaching Program. In a card sort task a set of “cards” are provided by the researcher with each card containing a particular concept, idea,principle, etc. The teacher is then asked to place the cards in an arrangement that best illustrates the relationship among the “items” contained on the cards. In effect, this approach is an alternative to concept mapping because the topics are provided by the researcher and there is more flexibility in terms of final format.

3. Most studies of pedagogical content knowledge employ multiple methods. In general, these studies use a variety of techniques such as interviews, concept maps, and video-prompted recall, to collect data. Next, the researchers triangulate the data from these multiple sources. Finally, the researchers infer a general profile of the teachers’ pedagogical content knowledge. As the construct of PCK was developed, refined, and examined in the research literature, it also acted as a stimulus for the development and evaluation of teacher preparation programs.

In this study, the multiple methods will be applied to the data collecting process. The participants will respond to the Teacher Orientation to Teach Science TOTS questionnaire developed in this study. The questionnaire will be constructed to assess orientation to teach science which is one of the important components of the pedagogical content knowledge and play an important role in how science instruction will be organized in classrooms. In addition to the questionnaire response, classroom observation and teacher's interview will be conducted and analyzed. All data will be triangulated to create a general profile of the teachers' pedagogical knowledge.

3. Orientations to Teaching Science

Magnusson et.al. (1999 : 97) conceptualized pedagogical content knowledge for science teaching as consisting of five components: (a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students' understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science.
These components are shown in Figure 1.

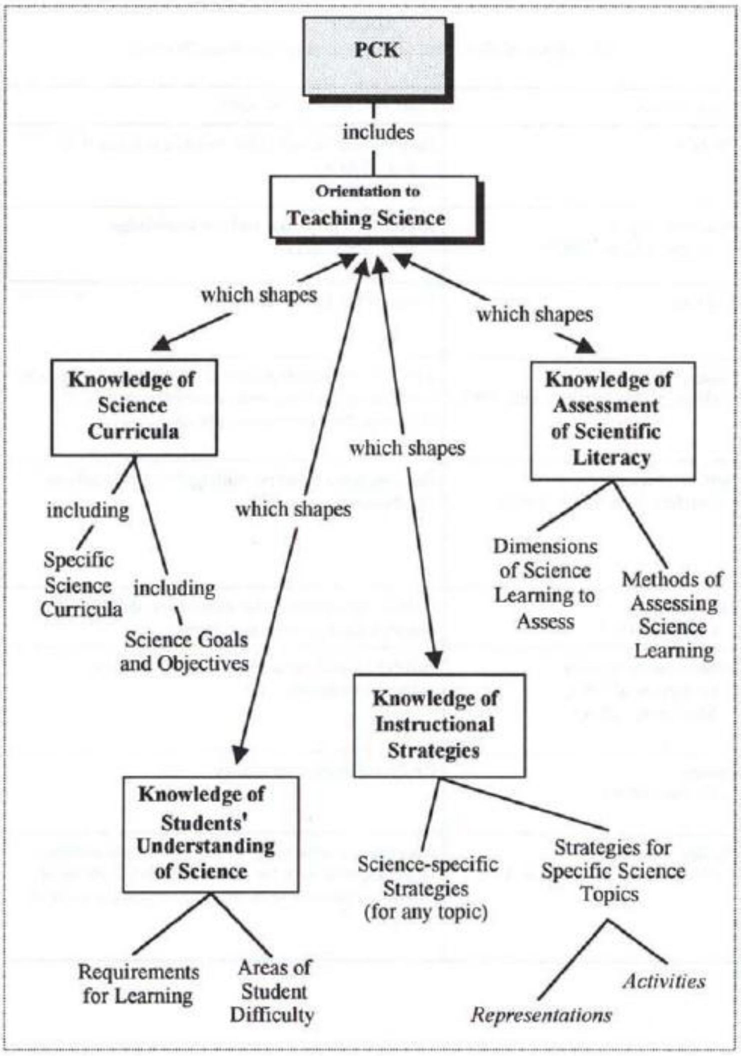

Figure 1 Components of pedagogical content knowledge in science teaching

(Magnusson et.al.,1999 : 99)

The orientations are generally organized according to the objectives of the instruction from only process or content to the instructions that focus on inquiry-based learning. Magnusson et.al. (1999 : 97) described each orientation with respect to two elements that are useful in defining and differentiating them: the goals of teaching science, and the typical characteristics of the instruction, which are presented in the following table 1.

Table 1 The Goals of Different Orientations to Teaching Science (Magnusson et.al., 1999:100)

ORIENTATION	GOAL OF TEACHING SCIENCE
Process	Help students develop the “science process skills.”
Academic Rigor	Represent a particular body of knowledge
Didactic	Transmit the facts of science.
Conceptual Change	Facilitate the development of scientific knowledge by confronting students with contexts to explain that challenge their naive conceptions.
Activity-driven	Have students be active with materials; “hands-on” experiences.
Discovery	Provide opportunities for students on their own to discover targeted science concepts
Project-based Science	Involve students in investigating solutions to authentic problems.
Inquiry	Represent science as inquiry
Guided Inquiry	Constitute a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using the tools of science.

Table 2 The Nature of Instruction Associated with Different Orientations to Teaching Science (Magnusson et.al., 1999 : 101)

ORIENTATION	CHARACTERISTICS OF INSTRUCTION
Process	Teacher introduces students to the thinking processes employed by scientists to acquire new knowledge. Students engage in activities to develop thinking process and integrated thinking skills.
Academic Rigor	Students are challenged with difficult problems and activities. Laboratory work and demonstrations are used to verify science concepts by demonstrating the relationship between particular concepts and phenomena.
Didactic	The teacher presents information, generally through lecture or discussion, and questions directed to students are to hold them accountable for knowing the facts produced by science.
Conceptual Change	Students are pressed for their views about the world and consider the adequacy of alternative explanations. The teacher facilitates discussion and debate necessary to establish valid knowledge claims.
Activity-driven	Students participate in “hands-on” activities used for verification or discovery. The chosen activities may not be conceptually coherent if teachers do not understand the purpose of particular activities and as a consequence omit or inappropriately modify critical aspects of them.
Discovery	Student-centered. Students explore the natural world following their own interests and discover patterns of how the world works during their explorations.
Project-based Science	Project-centered. Teacher and student activity centers around a “driving” question that organizes concepts and principles and drives activities within a topic of study. Through investigation, students develop a series of artifacts (products) that reflect their emerging understandings.
Inquiry	Investigation-centered. The teacher supports students in defining and investigating problems, drawing conclusions, and assessing the validity of knowledge from their conclusions.

ORIENTATION	CHARACTERISTICS OF INSTRUCTION
Guided Inquiry	Learning community-centered. The teacher and students participate in defining and investigating problems, determining patterns, inventing and testing explanations, and evaluating the utility and validity of their data and the adequacy of their conclusions. The teacher scaffolds students' efforts to use the material and intellectual tools of science, toward their independent use of them.

Though many definitions of PCK are different in some aspects, there is a consensus among science educators that this knowledge is important for teachers. It determines what learning activities the teachers are going to use, teaching methods that the teachers are going to implement, and the assessment tools that the teachers are going to administer. In this study, the Teachers' orientations to teaching science, based on Magnusson's framework, will be explored in order to study teachers' beliefs on the goals of teaching science and characteristics of instruction that should be used.

Related Studies

Research studies which are related to this study focused on pre-service and in-service teachers' orientation to teaching science, teachers' belief, and teachers' conceptions of science teaching.

Talanquer, Novodvorsky and Tomanek (2010) identified and characterized the major factors that influence entering science teacher candidates' preferences for different types of instructional activities, and to analyze what these factors suggest about teacher candidates' orientations to teaching science. The study involved prospective teachers enrolled in the introductory science teaching course in an undergraduate science teacher preparation program. Our analysis was based on data collected using a teaching and learning beliefs questionnaire, together with structured interviews. Our results indicate that entering science teacher candidates have strong preferences for a few activity types. The most influential factors driving entering science teacher candidates' selections were the potential of the instructional activities to motivate students, be relevant to students' personal lives, result in transfer of skills to non-science situations, actively involve students in goal-directed learning, and implement curriculum that represents what students need to know. This set of influencing factors suggests that entering science teacher candidates' orientations towards teaching are likely driven by one or more of these three central teaching goals: (1) motivating students, (2) developing science process skills, and (3) engaging students in structured science activities. These goals, and the associated beliefs about students, teaching, and learning, can be expected to favor the development or enactment of three major orientations towards teaching in this population of future science teachers: motivating students, process, and activity-driven.

Park and Chen (2012) explored the nature of the integration of the five components of pedagogical content knowledge (PCK): (a) Orientations toward Teaching Science, (b) Knowledge of Student Understanding, (c) Knowledge of Instructional Strategies and Representations, (d) Knowledge of Science Curriculum, and (e) Knowledge of Assessment of Science Learning. Given the topic and context specificity of PCK, this investigation was conducted in the context of the photosynthesis and heredity instruction of four teachers who were working at the same high school with the same curricular materials. Data sources included classroom observations, semi-structured interviews, lesson plans, instructional materials, and students' work samples. Data were analyzed through three different approaches: (a) in depth analysis of explicit PCK, (b) enumerative approach, and (c) the constant comparative method. Data analysis indicated five salient features of the integration of the PCK components: (a) the integration of the components was idiosyncratic and topic-specific; (b) Knowledge of Student Understanding and Knowledge of Instructional Strategies and Representations were central in the integration; (c) Knowledge of Science Curriculum and Knowledge of Assessment of Science Learning had most limited connection with other components; (d) Knowledge of Assessment of Science Learning was more often connected with Knowledge of Student Understanding and Knowledge of Instructional Strategies and Representations than with the other components; and (e) Didactic Orientations toward Teaching Science directed Knowledge of Instructional Strategies and Representations inhibiting its connection with other components.

Avraamidou (2013) used a narrative inquiry approach focusing on the collection of personal stories in order to examine the participants' science teaching orientations and the kinds of experiences that influenced their development. The findings of the analysis illustrated that the participants perceived certain experiences they had during their university coursework as critical to shaping their orientations to science and science teaching: inquiry-based investigations, contemporary theoretical discussions, outdoors field study, friendly classroom environment and the characteristics of their instructors. These findings have implications for the design of teacher education courses that aim to engage prospective elementary teachers, especially females, in meaningful learning experiences and support them in developing science teaching orientations that are in line with reform recommendations.

Zangori and Forbes (2013) determined what the extent of the prospective primary teachers' (PPT) pedagogical content knowledge (PCK) is on “effect of human on environment” subject in grade 5 science and technology curriculum before and after “Teaching Practice” course. Within case study research methodology, the study sample consisted of 6 senior PPTs selected from 49 trainees who attended “Teaching Practice-II” course in spring semester of 2009-2010 schooling year in the programme of primary teacher education in Rize University. To collect data, lesson plans, observations, and semi-structured interviews were used. While the data obtained from lesson plans and observations were analyzed by means of rubrics developed, those from semi-structured interviews were analyzed using content analysis. It was found that the PPTs did not have sufficient idea of sub- components of the PCK, especially curriculum knowledge, and knowledge of students' learning difficulties. Nevertheless, it was determined that the PPTs had adequate idea of pedagogical knowledge in context of the PCK. However, it was drawn out that although they had sufficient theoretical knowledge about instructional methods, techniques, strategies, measurement and assessment. They encountered some problems in transferring the theoretical knowledge into practicum. In the light of the results, it is suggested that the PPTs should be given more opportunities for practicing complementary measurement-assessment techniques. Furthermore, it is recommended that the PPTs with their own lesson plans ought to be given more opportunities to transfer their PCK into related subject matter one.

Bahcivan (2014) studied the relationships among pre-service science teachers' teaching and learning conceptions, scientific epistemological beliefs and science teaching efficacy beliefs. 310 Turkish pre-service science teachers from different regions of the country participated in the study. Three different instruments were validated by confirmatory factor analyses. Structural equation modeling analyses revealed that participants' constructivist conceptions of teaching and learning promoted sophisticated science related epistemologies. Sophisticated epistemologies also contributed participants' science teaching efficacy beliefs.

Tatar (2015) used case study method to examines pre-service teachers' beliefs about the images of a science teacher and the science teaching. Besides, how their beliefs are affected from inquiry-based teaching is investigated. Pre-service teachers had learned science with inquiry and how they teach science with inquiry in the science laboratory. Data were collected through the drawings and semi-structured interviews. Results indicate that most participants had teacher-centered and conceptual belief about the images of a science teacher and the science teaching at the beginning of the study. However, they had student-centered belief at the end of the study. It was remarked that three pre- service teachers who held different beliefs about student/teacher roles and the teaching of science before the study, had some common beliefs after the inquiry-based science laboratory. Based on the results, it can be said that inquiry-based science teaching positively affects pre-service teachers' beliefs about the images of a science teacher and the science teaching.

Conclusion

Pedagogical Content Knowledge (PCK) is teacher's knowledge that is transferred from Subject Matter Knowledge, Pedagogical Knowledge and Contextual Knowledge. This kind of knowledge is composed of five components: (a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students' understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science. Study on orientations to teaching science will reflect teacher beliefs of the goal of science teaching and the instruction that is more likely consistent with their beliefs.