SELF-EFFICACY AS AFFECTIVE DOMAIN OF PEDAGOGY CONTENT KNOWLEDGE (PCK) : THE IMPLICATIONS FOR PRE-SERVICE AND IN-SERVICE TEACHERS IN SCIECE TEACHING

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Abstract

The studies on Pedagogy Content Knowledge (PCK) since it was proposed by Schulman in 1986 have provided coverage of diverse components. The components of PCK can be classified into several categories : PCK declarative - PCK procedural, PCK on action - PCK in action, etc. Most of the PCK components refers to cognitive knowledge required of the teachers in science teaching. In depth study on the performance of the teachers find self-efficacy as a PCK component that are in the teachers' affective domain. Self-efficacy mediates between the teachers' knowledge of instructional strategies of science teaching and students' understanding of science knowledge. The relationship between self-efficacy and cognitive knowledge of PCK shows the relationship is mutually beneficial. Teachers' self-efficacy beliefs will affect the implementation of the PCK through the teaching in class, and vice versa. The relationship properties of PCK-self efficacy can be referenced in the framework of training for pre-service and in-service teachers in science teaching.

1. Introduction

It is understood the progress of science education is largely determined by the quality level of professionalism of teachers and education management from level policy makers to school institutions. The teacher is the central figure of science teaching at the smallest unit of the class. Then, to understand the importance of continuing education / training should be given to pre-service and in-service teachers in science teaching in the classroom will be qualified. The quality of science teaching will provide an increase of students' science achievement. It is consistent with studies that have been done that the first step taken in order to improve the quality of science teaching must be understood from the values and beliefs of the people who take an active role in this process; it is the teacher (Carter and Norwood, 1997). Brousseau, Book and Byers (1988) showed that self-efficacy and ideas acquired over time education / training for pre-service and in-service teacher in the educational institution / teacher training is a big part of the values and the beliefs. Self-efficacy beliefs are reflected in classroom activities have an important effect to provide the quality of science learning (Tobin, Tipin and Gallard, 1994).

In other hand, to implementation of science learning, required capabilities related to the content of science materials and the science learning. This approach is known as a PCK (Pedagogy Content Knowledge) approach. Schulman (1986) provides a basis thinking for teaching science; it is not enough just to understand the content of science material (knowing science) but also how to teach. Science teachers must have a knowledge of science learners, curriculum, instructional strategies, assessment so as to perform the transformation of science knowledge.

Duschl (1983) showed that the professional experience (included the implementation of PCK) and personal features (included an efficacy) teachers have a significant effect on the teaching and learning of science in the classroom. Self-efficacy beliefs and Pedagogy Content Knowledge (PCK) affect teaching qualification and sustainability of pre-service and in-service teachers, so that the bilateral interaction of self-efficacy and PCK needs to be studied in order to be a guide in regulating the process of education / training teachers.

Based on a literature review, this paper aims to describe the relationship of PCK with self-efficacy and implications for pre-service and in-service teachers in the science teaching.

2. Methodology

Description of the article is done through a systematic review of the 35 articles of Pedagogy Content Knowledge (PCK) and 32 articles of self-efficacy beliefs well done conceptually and empirically. The analysis was performed every element or component to see the relation between PCK with self-efficacy in the context of science teaching.

3. Self-Efficacy

Self-efficacy is one of the important concepts that are based on the theoretical framework of social cognition Bandura (1988). Self-efficacy, which is defined as the conviction of an individual to meet the expected behavior in achieving the goal successfully. This concept is usually also known as "the perception of self-efficacy", "self-efficacy beliefs" or "considerations of self-efficacy" (Emmer and Hickman, 1991; Pajares, 1996; Wolfolk-Hoy and Hoy, 1998; Saracalolu and Yenice 2009).

Self-efficacy describes thoughts about the ability of the individual and the positive or negative assessment of him. In other words, compared to the function of individual skills, self-efficacy is the result of an individual assessment of performance using the skills they have. According to Bandura (1988), self-efficacy means the belief is in one's ability to deal with different situations and performance certain tasks required to produce a given achievement and confidence depends on the individual's beliefs about ability. This belief is also necessary to regulate certain behaviors and realize the behavior to achieve certain goals.

According to Bandura, self-efficacy beliefs can be analyzed in two dimensions as : "personal self-efficacy" and "outcomes expetancy". Personal self-efficacy is the assessment of the values and beliefs of the individual in terms of personal competence that affect the responsibilities assigned. Outcome expectancy is an assessment of an individual's belief in a performance that will be realized in a particular task. Gibson and Dembo (1984) showed that personal self-efficacy and outcome expectancy is different and if people believe that they can not perform certain activities, they do not perform the required behavior or they would not be urged to do the behavior.

Self-efficacy beliefs helps people in estimating how much effort they will exert against a difficult situation, how long they will muster the effort in the face of adversity and how they will

pull themselves together (Bandura, 1977; Pajares 2002). Therefore, according to Bandura (1988) the trust is a factor that is as important as the skills, abilities and knowledge in determining their achievement and behavior. A high level of self-efficacy beliefs carries higher purpose and consistency in individual decisions; provide a high level of cognitive processes and motivation (Locke and Latham, 1990).

Bandura (1997) emphasizes that self-efficacy beliefs rely on four sources are interrelated and this belief occupies an important place in human life. Bandura summarizes these resources as follows :

- Mastery experiences (work accomplished and achieved goals) : It is directly related to the individual's own experience, the success of an individual is success indicator in the future.
- Vicarious experiences (thoughts of others) : The number of expected results from the experience of others. Observations achievements of others impact on the individual's own expectations of success.
- Verbal persuasion (external support) : Expression and advice from others to the realization of success to encourage changes in individual behavior and can contribute to changes in self-efficacy.
- Motivation processes (emotional state) : Welfare or physical and mental health affects their potential for expected behavior.

4. Science Teaching Self-Efficacy

Research on the efficacy of education has defined this construct as a major influence on teachers' expectations (theirself and students), the practice of teachers is in the classroom and ultimately, student achievement (Gibson & Dembo, 1985; Huitt, 2000; Tschannen-Moran & Hoy, 2001). According Savran and Cakiroglu (2001), in terms of the self-efficacy dimensions, personal self-efficacy represented in beliefs and assessment of teachers in terms of behavior necessary for effective teaching; whereas outcome expectation that the second dimension is represented on trust and assessment of teachers to improve student achievement in science teaching methods are effective.

Proctor (1984) has developed a process model of teaching / learning stressed the importance of expectations (efficacy) teacher in order to student learning. This model explains variable or school and classroom factor considered under the influence of educators / teachers (Figure 1).

Figure 1. A school-based models for teacher expectations

Ashton (1990) stated efficacy as an important element of teacher education and professional development of science teachers. Perhaps it is not surprising, because one of the strongest antecedents of self-efficacy is teaching experience (Hebert, Lee, & Williamson, 1998; Tschannen-Moran & Hoy, 2007).

Prospective and novice teachers, veteran teachers who lack of mastery experience, usually had to rely more on other factors, such as the available teaching resources and internal support (Bandura [1977] termed "verbal persuasion"). However, with the number of experience, perceived self-efficacy is often increased (Brand & Wilkins, 2007; Sodak & Podell, 1997). In addition, prospective teachers feel instructional development strategy of active (rather than

passive) to be more important to improve personal teaching efficacy (Mosley, Huss, and Utley, 2010).

Many researchers have conducted a study to measure the self-efficacy of teachers that influence the behavior and attitudes of teachers and student achievement (Gibson and Dembo, 1984; Riggs and Enochs, 1990; Woolfolk, Rosoff and Hoy, 1998; Soodak and Podel, 1993; Guskey and Passaro , 1994; Cannon and Scharmann, 1996). A review of the literature indicates that perceptions of teachers' self-efficacy has been analyzed in terms of student achievement (Tschannen-Moran and Hoy, 2001), classroom management and time management strategies (Gibson and Dembo, 1984).

Analysis to the study of teachers' self-efficacy in science teaching can be obtained 8 dimensions, namely a sense of personal accomplishment, positive expectations for student behavior and achievement, personal responbility for student learning, strategies for achieving objectives, positive affect, sense of control, a sense of common teacher / student goals and democratic decision making (Table 1).

Table 1. Dimensions of teacher efficacy

According Czerniak (1990), teachers with high levels of self-efficacy adopt investigation and strategies of science teaching in student-centered; while teachers with lower levels of self-efficacy generally adopt a strategy science teaching in teacher-centered.

5. Pedagogical Content Knowledge (PCK)

Schulman (1986) introduced the concept of PCK that illustrate the unique integration of content knowledge of teachers in general pedagogical knowledge. PCK states, subject matter knowledge and general pedagogical strategies are not mutually exclusive. Both represent the construct of teacher knowledge, because both are accessed simultaneously when teachers interpret and present the subject in a way that is accessible learners. In PCK categorization covered, topics most commonly taught in the 'subject area', forms the most benefit from the representation of ideas, analogies 'powerful', illustrations, examples, explanations, and demonstrations. In other words, the ways of representing and formulating the subject matter which makes it understandable to others. PCK also includes an understanding of what makes learning easy or difficult of a particular concept : conceptions and preconceptions of students of various ages and backgrounds who bring them to learn.

Schulman (1986) developed a new framework for teacher education and the trend which replaces the dichotomous view of teacher education is based on the separation of content knowledge and general pedagogical knowledge. Therefore, teacher education programs should also consider the PCK by combining pedagogical content knowledge and general knowledge in stages to prepare a more effective teacher. A large amount of knowledge about the concept of PCK has been developed (eg, Grossman, 1990; Hashweh, 2005; Magnusson, Krajcik & Borko, 1999; Marks, 1990; Park & Oliver, 2008). As a result, there is no agreement on the concept of PCK. Attempts were made to clarify the substance, a series of review of the literature that has been published since the late of 1990s and has summarized the kinds of PCK concept (eg van Driel, Verloop & de Vos, 1998; Abell 2008; Gess-Newsome, 1999; Lee & Luft, 2008). For example, van Driel et al. (1998) found PCK is usually understood as knowledge of the specific topics that include various components of knowledge. However, different researchers vary for

components used in the concept of PCK. However, the authors conclude that there is consensus on two important knowledge components: (1) knowledge of learning and students' conceptions and (2) knowledge representation and instructional strategies.

PCK implies two types of knowledge : declarative knowledge and procedural knowledge (Heller, Daehler, Shinohara & Kaskowitz, 2004). PCK declarative or knowing that (Ryle, 1971) have also been described in terms of PCK-on-action (Park & Oliver, 2008), the theoretical formal of PCK (Fenstermacher, 1994), or PCK proportional (Knight, 2002). Declarative PCK is factual knowledge that can easily be expressed in a sentence or indicative proposition (Anderson, 1981; Polanyi, 1958). It includes the proposition, correlation, rules, and theoretical knowledge of ideas and principles as well as a focus on logical and meaningful decision making (Knight, 2002). Thus, PCK declarative include, for example, specific factual knowledge preconceptions and misconceptions students. PCK procedural or knowing how well described in terms of knowledge of expertise / skills (van Driel et al., 1998), PCK-in-action (Park & Oliver, 2008), skills (Tamir, 1988), or practical knowledge (Fenstermacher, 1994). PCK procedural, therefore, describes the automatic skills and routine actions taken in execution of tasks (Polanyi, 1958). Thus, procedural PCK includes teacher during the lesson, for example, if a teacher is able to react appropriately to the questions and the students' mistakes. Contrary to declarative knowledge, procedural knowledge is the ability to do something, which is why it is difficult to be articulated. It relates to the tacit knowledge that is difficult to be transferred to another person by rewriting or verbalization (Polanyi, 1958; Stillings, Weisler, Chase, Feinstein, Garfield & Rissland, 1995).

According Schemelzing (2012) PCK concept can be described by three cognitive dimensions: (1) the components, (2) type, and (3) the topic (compare also Jüttner & Neuhaus, 2012). Component involves knowledge of student learning, conception and knowledge representation and strategy (van. Driel et al, 1998); Type distinguish between PCK declarative and PCK procedural : the knowledge of what to do and the ability to do so (Baumert et al, 2004). Additionally, PCK includes a teacher's ability to adapt to related topics and issues with diverse interests and abilities of learning groups and the ability to present topics related to instruction (Schulman, 1986). In this view, the PCK refers in particular topics, concepts, problems, and issues.

6. Self-Efficacy as PCK Affective Domain

Park and Oliver (2008) have studied empirically components PCK to teach science. As a result of the empirical research obtained one of the new components affective PCK, namely the emergence of teacher efficacy. Teacher efficacy refers to confidence teachers in their ability to affect the student outcome (Tournaki and Podell 2005), it is usually considered as a component that is proportional to the belief, not the knowledge. However, Kagan (1992) defines, this belief as a provocative form of personal knowledge and concluded that belief is a form of knowledge. Furthermore, Kagan stated that most of the professional knowledge teacher can be considered more accurate as a confidence. Nespor (1987) emphasized the role of confidence teacher in determining tasks teaching and organize knowledge relevant to tasks. In order to overcome the various problems often faced (Richardson 1996), teachers need to go beyond the information contained in instruction issue, re-check knowledge they already have from various perspectives, and make assumptions or decision (Nespor 1987). In this process, efficacy is a form of knowledge that is more "affective" or provocative has played important role.

Additionally,PCK conceptually defined as the two dimensions : understanding construction which consists of and enactment. Efficacy teachers act as a bridge to connect two these dimensions. Increased of efficacy teachers in teaching gives a boost for teachers to enforce their understanding. When enactment it successfully performed, teacher efficacy in turn increased. Improved teacher efficacy create teachers ready to learn relative to one of PCK component, so that their understanding be extended (Stein and Wang 1988).

Affective component, teacher efficacy, can be associated most closely with success teacher in determining teaching strategies to solve the problem, because it leads to reorganization teacher knowledge. Taken together, it is reasonable to look at teacher efficacy as component knowledge teachers. The emergence of teacher efficacy component cause modification of PCK heuristic model evolutionary as shown in Figure 2. In this model, the concept of PCK represent not only comprehension teacher about how to teach subject matter effectively, but also attributed their knowledge of self-efficacy.

Figure. 2 Hexagon models of pedagogical content knowledge for science teaching

7. Implications relations PCK-Self-Efficacy of Teaching Science

Hexagon model of PCK (Fig.2) shows role the teacher efficacy as a bridge that connects the knowledge of instructional strategies of science teaching to students' understanding of science knowledge. In line, Bandura theory showed that an increase of knowledge (PCK, students' learning-conception with strategies) teachers will lead to an increase in self-efficacy beliefs, otherwise the potential for increased self-efficacy of teachers in the classroom will increase the likelihood that the science teaching is doing will based on knowledge of pedagogy and content. Sahin, Aktürk, and Schmidt (2009) saw a positive relationship between knowledge of PCK pre-service teachers' self-efficacy beliefs about their ability to teach in the classroom.

Allinder (1994) found that teachers with high teaching efficacy beliefs have a tendency to apply a variety of methods in their teaching instruction. In addition, the higher the self-efficacy of teachers teach, they are more confident in giving instruction. Allinder (1994), Woolfolk and Hoy (1990) showed that there was a significant negative correlation between self-efficacy teaching and ideological control of students. Teachers who have taught high efficacy has a more humanistic perspective in controlling the students while teachers with low teaching efficacy has strict control over the students. Similar results were confirmed by Enochs, Sharman and Riggs (1995).

One of the most common method be used in teaching science is discovery, inquiry and laboratory work. These methods are used extensively to develop learning conceptual students, understanding of science and provide the environment appropriate for development process of thinking skills and problem solving skills (Garnet,Garnet & Hackling, 1995). Through discovery, inquiry and laboratory work information, skills, and attitudes desirable for implanted on students most of the determined by the information, skills and attitudes of teachers in related field (Hofstein & Mamlok-Naaman, 2007). In this case, in addition to perception of science teachers, their self-efficacy for teaching science in their perception of self-efficacy in order to practice of discovery, inquiry and laboratory work are very important.

The proposed strategies that can be built in improving self-efficacy beliefs student teachers and teachers in pedagogy framework content knowledge (PCK) is through modeling, sharing story self-efficacy, constructive feedback in microteaching activities and effective use of

lesson study (Figure.3). Because of the student teachers and teachers training have an important impact on their self-efficacy beliefs, self-efficacy beliefs student teachers and teachers receive training should be monitored regularly by educators and activities designed to increase self-efficacy they should be intensified in teacher training programs (Azar, 2010).

Figure 3: Conceptual diagram of the connection between PCK strategy and science teaching self-efficacy

References

Abell, S. K. (2008). Twenty years later: Does pedagogical content knowledge remain a useful idea? *International Journal of Science Education*, 30, 1405–1416.

Allinder, R. M. (1994). The relation between efficacy and the instructional practices of special education teachers and consultants, *Teacher Education and Special Education, 17,* 86-95.

Ashton, P. (1990). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of Teacher Education,* 35, 28-32.

Azar, A. (2010). In-service and pre-service secondary science teachers'self-efficacy beliefs about science teaching. *Educational Research and Reviews* Vol. 5(4), 175-188.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura A (1988). Perceived self-efficacy: Exercise of control through self-belief. In JP Dauwalder, M Perrez, V Hobi (Eds) Annual series of European research in behavior therapy. Amsterdam/Lisse, Netherlands 2:27-59.

Bandura A (1997). Self- efficacy: The exercise of control. New York : Freeman.

Brand, B. R., & Wilkins, J. L. M. (2007). Using self-efficacy as a construct for evaluating science and mathematics methods courses. *Journal of Science Teacher Education, 18,*297-317.

Baumert, J., Blum, W. & Neubrand, M. (2004). Drawing the lessons from PISA 2000. Zeitschrift für Erziehungswissenschaft, Beiheft, 3, 143–157.

Brousseau BA, Book C, Byers JL (1988). Teacher beliefs and the cultures of teaching. *J. Teacher Educ.* 39(6): 33-39.

Cannon JR, Scharmann LC (1996). Influence of a cooperative early field experience on pre-service elementary teachers' science selfefficacy. *Science Education*. 80: 419-436.

Carter G, Norwood KS (1997). The relationship between teacher and student beliefs about Mathematics. *School Science and Mathematics* 97(2): 62-67.

Cochran, K. F., King, R. A. & De Ruiter, J. A. (1993). Pedagogical content knowing: An integrative model for teacher preparation. *Journal of Teacher Education,* 44, 263–272

Czerniak CM (1990). A study of self-efficacy anxiety and science knowledge in pre-service elementary teachers. Paper presented at the Meeting of the National Association for Research in Science Teaching, Atlanta GA.

Duschl RA (1983). The elementary level science methods course : breeding ground of apprehension toward science: a case study. *J. Res. Sci. Teaching* 20(8): 745-754.

Emmer E, Hickman J (1991). Teacher decision making as a function of efficacy attribution and reasoned action. Paper presented at the Annual Meeting of the American Educational Research Association, Boston MA.

Enochs, L. G., Scharman, L. C., & Riggs, I. M. (1995). The relation of pupil control to pre-service elementary science teacher self-efficacy and outcome expectancy. *Science Teacher Education, 79,* 63-75

Fenstermacher, G. D. (1994). The knower and the known: The nature of knowledge in research on teaching. In L. Darling-Hammond (Ed.), Review of research in education (20th ed., pp. 3–56). Washington, DC: American Educational Research Association.

Fernandez-Balboa, J.-M. & Stiehl, J. (1995). The generic nature of pedagogical content knowledge among college professors. *Teaching and Teacher Education*, 11, 293–306.

Garnett, P.J., Garnett, P.J., & Hackling, M. W. (1995). Refocusing the chemistry lab: A case for laboratory-based investigations. *Australian Science Teacher Journal, 41(2)*, 26-32.

Geddis, A. N. (1993). Transforming subject-matter knowledge: The role of pedagogical content knowledge in learning to reflect on teaching. *International Journal of Science Education*, 15, 673–683.

Gess-Newsome, J. (1999). Pedagogical content knowledge: An introduction and orientation. In J. Gess-Newsome & N. G. Lederman (Eds.), Examining pedagogical content knowledge (pp. 3–17). Dordrecht: Kluwer Academic

Gibson, S., & Dembo, M. H. (1985). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582.

Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. New York: Teachers College Press.

Guskey TR, Passaro PD (1994). Teacher efficacy: A study constructs dimensions. American Educational Research J. 31: 627-643.

Hashweh, M. (2005). Teacher pedagogical constructions: A reconfiguration of PCK. *Teachers and Teaching : Theory and Practice*, 11, 237–292

Hebert, E., Lee, A., & Williamson, L. (1998). Teachers' and teacher education students' sense of efficacy: Quantitative and qualitative comparisons. *Journal of Research and Development in Education, 31*(4), 14-225.

Heller, J. L., Daehler, K. R., Shinohara, M., & Kaskowitz, S. R. (2004). Fostering pedagogical content knowledge about electric circuits through case-based professional development. Paper presented at the NARST Annual Meeting, Vancouver. Retrieved from http://www.wested.org/understandingscience/downloads/ppr_fostped.pdf.

Hofstein, A., & Mamlok-Naaman, R. (2007). The laboratory in science education: The state of the art. *Chemistry Education: Research and Practice in Europe*, *8*(2), 105-108.

Huitt, W. (2000). Teacher efficacy. *Educational Psychology Interactive.* Valdosta, GA: Valdosta State University.

Jüttner, M. & Neuhaus, B. J. (2012). Development of items for a pedagogical content knowledge-test based on empirical analysis of students' errors. *International Journal of Science Education*, 34, (7), 1125–1143.

Kagan, D. M. (1990). Ways of evaluating teacher cognition: Inferences concerning the Goldilocks Principle. *Review of Educational Research, 60*(3), 419–469.

Knight, P. (2002). A systemic approach to professional development: Learning as practice. Teaching and Teacher Education, 18, 229–241.

Lee, E. & Luft, J. A. (2008). Experienced secondary science teachers' representation of pedagogical content knowledge. *International Journal of Science Education,* 30, 1343–1363.

Locke EA, Latham GP (1990). A theory of goal setting and task performance. Englewood cliffs NJ: Prentice Hall.

Loughran, J., Berry, A. & Mulhall, P. (2006). Understanding and developing science teachers' pedagogical content knowledge. Rotterdam: Sense

Magnusson, S., Krajcik, J. & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge. In J. Gess-Newsome & N. G. Lederman (Eds.), Examining pedagogical content knowledge (pp. 95–132). Dordrecht: Kluwer Academic

Marks, R. (1990). Pedagogical content knowledge: From a mathematical case to a modified conception. Journal of Teacher Education, 41, 3–11.

Moseley, C., Huss, J., & Utley, J. (2010). Assessing K-12 teachers' personal environmental education teaching efficacy and outcome expectancy. *Applied Environmental Education & Communication, 9*(1), 5-17.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317–328.

Pajares F (1996). Self-Efficacy beliefs in achievement settings. *Review of Educational Research.* 66: 543-578.

Pajares F (2002). Overview of Social Cognitive Theory and of Self-Efficacy Retrived January 11 2004 from http://wwwemoryedu/EDUCATION/mfp/effhtml

Park, S. & Oliver, S. J. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, 38, 261–284.

Polanyi, M. (1958). Personal knowledge. Chicago: University of Chicago Press.

Proctor, C. (1984). Teacher expectations: A model for school improvement. *The Elementary School Journal,* 469-481.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education* (2nd ed., pp. 102–119). New York: Macmillan.

Ryle, G. (1971). 'Knowing how and knowing that' (Proceedings of the Aristotelian Society, 1946). In G. Ryle (Ed.), Collected papers. Volume II: Collected essays, 1929–1968 (pp. 212–225). London: Hutchinson & Co.

Riggs L, Enochs L (1990). Toward the development of an elementary education teachers' science teaching efficacy belief instrument Science Education. 74: 625-637.

Rohaan, E. J., Taconis, R. & Jochems, W. M. G. (2009). Measuring teachers' pedagogical content knowledge in primary biology education. Research in Science and Technological Education, 27, 327–338.

Sahin, I., Akturk, A., & Schmidt, D. (2009). Relationship of preservice teachers'technological pedagogical content knowledge with their vocational self-efficacy beliefs. In C. D. Maddux (Ed.), *Research Highlights in Technology and Teacher Education 2009,* (pp. 293–301). Chesapeake, VA: AACE

Savran A, Çakıroglu J (2001). Pre-service biology teachers' perceived efficacy beliefs in teaching biology. *J. Educ*. *Faculty* of University of Hacettepe 21:105-112.

Saracoglu AS, Yenice N (2009).Investigating the self efficacy beliefs of science and elementary teachers with respect to some variables. *J. Theory Practice Educ*. 5(2):244-260.

Schmelzing, S., Wüsten, S, Sandmann, A. & Neuhaus, B. (2010a). Measuring declarative and reflective components of biology teachers' pedagogical content knowledge. In: M.F. Taşar & G. Çakmakcı (Eds.). Contemporary science education research: preservice and inservice teacher education. Ankara, Turkey: Pegem Akademi, pp. 71–77

Schmidt, W. H., Tatto, M. T., Bankov, K., Blömeke, S., Cedillo, T., Cogan, L., Schwille, J. et al. (2007). The preparation gap: Teacher education for middle school mathematics in six countries. MT21 report. East Lansing: Michigan State University.

Schulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Smith, D. C. & Neale, D. C. (1989). The construction of subject matter knowledge in primary science teaching. *Teaching and Teacher Education*, 5, 1–20.

Sodak, L. C., & Podell, D. M. (1997). Efficacy and experience: Perceptions of efficacy among preservice and practicing teachers. *Journal of Research and Development in Education, 30*(4), 214-221.

Stein, M. K., & Wang, M. C. (1988). Teacher development and school improvement: The process of teacher change. *Teaching and Teacher Education, 4*, 171–187.

Stillings, N., Weisler, S. E., Chase, C. H., Feinstein, M. H., Garfield, J. L. & Rissland, E. L. (1995). Cognitive science: An introduction. Cambridge: MIT.

Tamir, P. (1988). Subject matter and related pedagogical knowledge in teacher education. *Teaching and Teacher Education: an Internal Journal of Research and Studies*, 4, 99–110.

Tobin K, Tippin DJ, Gallard AJ (1994). Research on instructional strategies for teaching science. In DL Gabel (Ed). Handbook of research on science teaching and learning. New York : National Science Teachers Association.

Tournaki, N., & Podell, D. M. (2005). The impact of student characteristics and teacher efficacy on teachers' predictions of student success. *Teaching and Teacher Education, 21*, 299–314.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805.

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23*(6), 944-956.

van Driel, J. H., Verloop, N. & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. Journal of Research in Science Teaching, 35, (6), 673–695.

Woolfolk, A. E., & Hoy, W. K. (1990). Prospective teachers' sense of efficacy and beliefs about control. *Journal of Educational Psychology, 82,* 81- 91.

Woolfolk AE, Rosoff B, Hoy WK (1998). Teachers' sense of efficacy and their beliefs about managing students. *Teaching and Teacher Education* 6(2):137-148.

Table 1. Dimensions of teacher efficacy

DIMENSIONS OF TEACHER EFFICACY	
1. A sense of personal accomplishment	The teacher must view the work as meaningful and important.
2. Positive expectations for student behavior and achievement	The teacher must expect students to progress.
3. Personal responsibility for student learning	Involves students in making decisions regarding goals and strategies.
4. Strategies for achieving objectives	Must plan for student learning, set goals for themselves, and identify strategies to achieve Them.
5. Positive affect	Feels good about teaching, about the self and students.
6. Sense of control	Believes (s) he can influence student learning.
7. Sense of common teacher/ student goals	Develops a joint venture with students to accomplish goals.
8. Democratic decision making	Involves students in making decisions regarding goals and strategies.

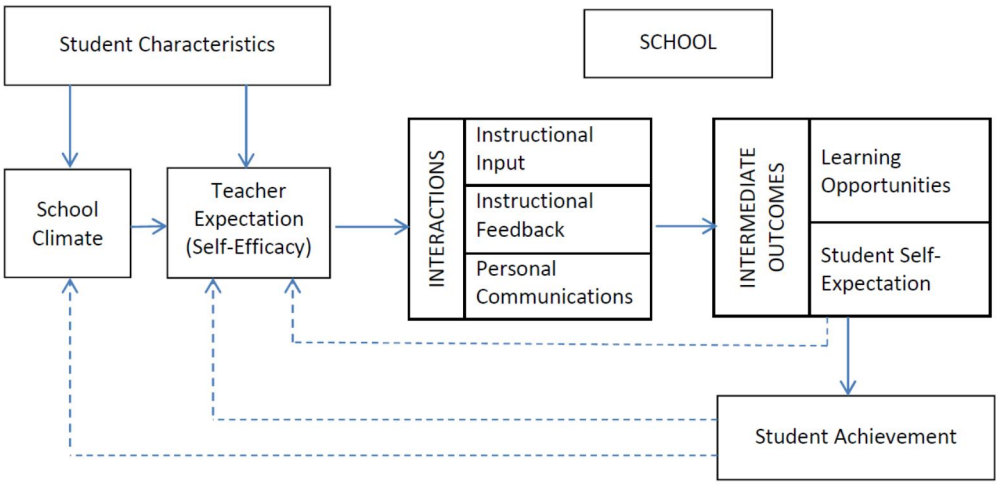

Figure 1. A school-based models for teacher expectations (adapted from Proctor, 1984)

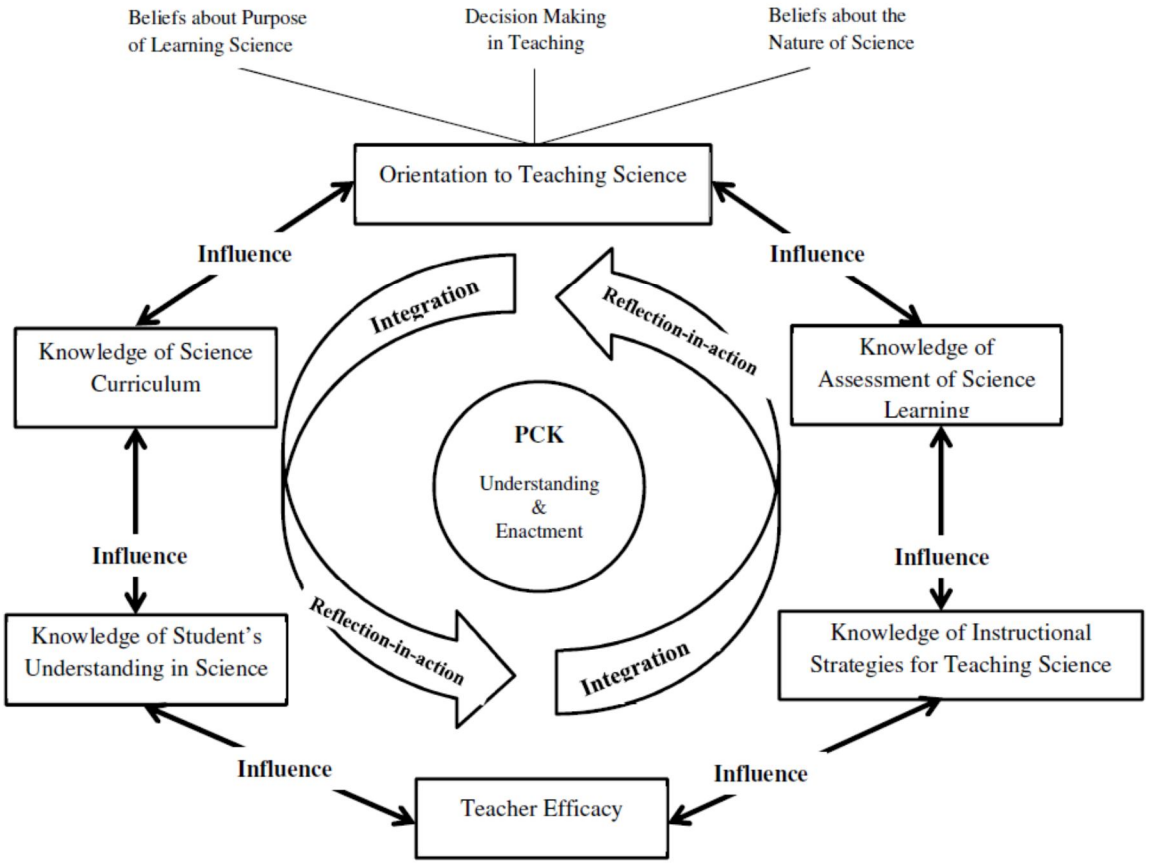

Figure. 2 Hexagon models of pedagogical content knowledge for science teaching (adapted from Park and Oliver, 2008)

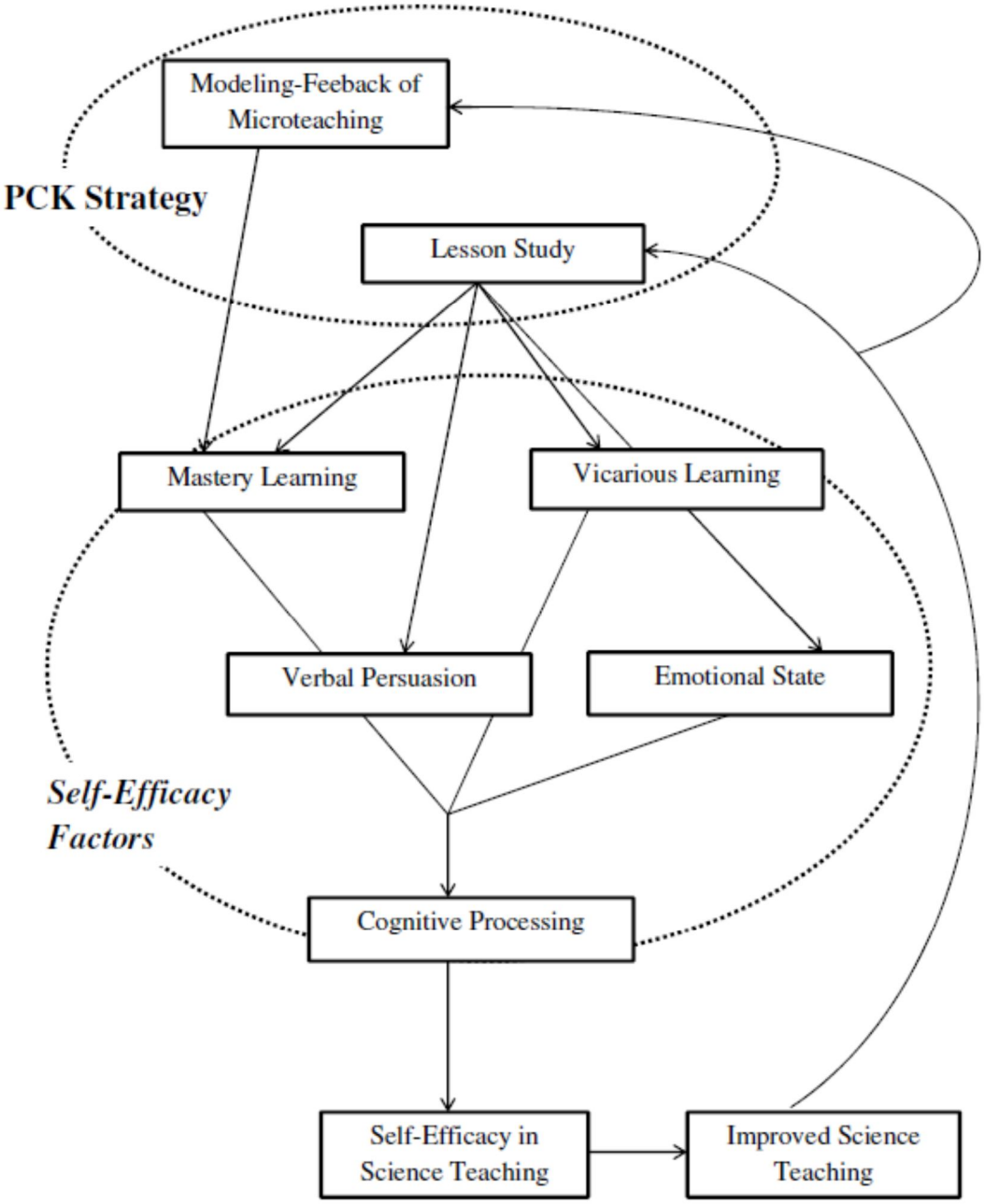

Figure 3: Conceptual diagram of the connection between PCK strategy and science teaching self-efficacy