Teacher Efficacy as an Affective Affiliate of Pedagogical Content Knowledge

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Abstract: Whether This paper argues that teacher efficacy is an affective affiliate of pedagogical content knowledge (PCK) based on empirical data of a study on the nature and construct of PCK. This study was a collective case study utilizing qualitative research methods. The participants of the study were three high school science teachers in the U.S. Data was collected from multiple sources such as classroom observation, interviews, teachers' written reflection, students' work samples, and researchers' field notes. Data was analyzed using the "In-depth Analysis of Explicit PCK" developed by the author. Data analysis indicated that teacher efficacy played a critical role in developing PCK by facilitating the movement from PCK to the enactment of PCK.

Key words: teacher efficacy, pedagogical content knowledge, in-depth analysis of explicit PCK

I. Introduction

The research reported here was conducted as part of a larger study (Park, 2005) which sought to gain a better understanding of the nature and construct of PCK. In the larger study (Park & Oliver, in press), a model of PCK called the "pentagon model" (see Fig. 1) was first established through a comprehensive literature review, the model was then tested against empirical data such as observations, interviews, teacher written reflections, etc., and finally it was refined based on the findings. However, as the data was analyzed to test the pentagon model in which PCK was defined as the integration of five components, an affective component which was unaccountable by the model repeatedly appeared to play a critical role in shaping teachers' PCK. Thus, the same data was analyzed from a different angle in order to identify this component. As a result it is concluded that the label that best fit is teacher efficacy. What follows is the theoretical background of this study.

II. Theoretical Background

1. Conceptions of Pedagogical Content Knowledge

There is no agreed-upon definition of PCK, and the inconsistency of the definitions is explained by the research agendas from which they arise. There are many definitions, each pointing to a different quality, characteristic, context, attribute, behavior, etc. It is the high level of specificity of PCK with respect to students' characteristics, subject matter, contexts, and pedagogy (Cochran, DeRuiter, & King, 1993) that makes defining PCK more challenging. Consequently, PCK is seldom clearly defined or used explicitly as a conceptual tool in the field of science education.

The term, PCK, originated with Shulman's 1985 presidential address to the American Educational Research Association. Shulman (1986) defined PCK as a particular form of content knowledge that "goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" [emphasis in original] (p. 9). PCK is "a particular form of content knowledge that embodies the aspects of content most germane to its teachability" (Shulman, 1986, p. 9). The key components of PCK include understanding of the ways of representing subject matter that make it comprehensible to others on the one hand, and understanding of specific learning difficulties and student conceptions on the other hand (Shulman, 1986).

Since the inception of PCK, a growing number of scholars have worked on the concept (e.g., Cochran *et al.*, 1993; Geddis, Onslow, Beynon, & Oesch, 1993;

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Grossman, 1990; Hashweh, 2005; Loughran, Mulhall, & Berry, 2004; Marks, 1990; Magnusson, Krajcik, & Borko, 1999; Van Driel, Verloop, & De Vos, 1998; Wilson, Shulman, & Richert, 1987). One of the common ways for the researchers to identify PCK has been to modify Shulman's (1986, 1987) definition. For example, in a case study investigating pre-service teachers' PCK, Geddis and colleagues (1993) defined PCK as knowledge that plays a role in transforming subject matter into forms that are more accessible to students. Magnusson and colleagues (1999) perceived PCK as teacher understanding of how to help students understand specific subject matter. Taken together, it is transformation of subject matter knowledge for the purposes of teaching that is at the heart of the definition of PCK, though the definition of PCK varies according to different scholars. Along this line, in this study, PCK is defined as teachers' understanding of and their enactment of how to help a diverse group of students understand specific subject matter using multiple instructional strategies, representations, and assessments in a given context. By this definition, PCK consists of two dimensions: understanding and enactment.

Table 1
Components of Pedagogical Content Knowledge from Different Conceptualizations (Park & Oliver, in press)

Scholars	Knowledge of								
	Purposes for Teaching a Subject Matter	**Student Under-standing**	Curriculum	**Instructional Strategies and Represen-tations**	Media	Assessment	Subject Matter	Context	Pedagogy
Shulman (1987)	D	O	D	O			D	D	D
Tamir (1988)		O	O	O		O	D		D
Grossman (1990)	O	O	O	O			D		
Marks (1990)		O		O	O		O		
Smith & Neale (1989)	O	O		O			D		
Cochran, DeRuiter, & King (1993)		O		N			O	O	O
Geddis, Onslow, Beynon, & Oesch (1993)		O	O	O					
Fernandez-Balboa & Stiehl (1995)	O	O		O			O	O	
Magnusson, Krajcik, & Borko (1999)	O	O	O	O		O			
Morine-Dershimer & Kent (1999)	O	O	O	N		O	O	O	O
Hasweh (2005)	O	O	O	O		O	O	O	O
Loughran, et. al. (2006)	O	O		O			O	O	O

D: Author placed this subcategory outside of PCK as a distinct knowledge base for teaching
N: Author did not discuss this subcategory explicitly (Equivalent to blank but used for emphasis)
O: Author included this subcategory as a component of PCK

Another common way of conceptualizing PCK is to identify the components constituting PCK and view PCK as an integration of those components. Table 1 summarizes the conceptualizations of PCK of various scholars.

As shown in Table 1, researchers have elaborated and expanded on Shulman's (1986, 1987) concept mainly by identifying the constituent components based on their beliefs or the findings from empirical studies. Among scholars, differences occur with respect to the components they integrate in PCK, and to specific labels or descriptions of these components. However, most scholars agree on Shulman's (1986) two key components of PCK: (a) knowledge of instructional strategies incorporating representations of subject matter and understanding of specific learning difficulties and (b) student conceptions with respect to that subject matter (see Table 1).

2. Components of Pedagogical Content Knowledge for Science Teaching

In addition to the working definition of PCK described earlier, it is also operationally defined as consisting of five components for the purpose of this study. The five components are as follows: (a) orientations to science teaching, (b) knowledge of students' understanding in science, (c) knowledge of science curriculum, (d) knowledge of instructional strategies and representations for teaching science, and (e) knowledge of assessments of science learning. Fig. 1 depicts these components and the relationships among them. Although these components are not mutually exclusive, it is conceptually useful to regard them as distinct components.

In order to emphasize the interrelatedness and integration among the components, the components were presented in a pentagonal form with PCK at the center. This placement implies that the development of one component may simultaneously encourage the development of others, and ultimately enhance PCK. However, PCK that comprises effective teaching requires the integration of all the components in highly complex ways. It is only when teachers are able to integrate all the components of PCK and apply them at the right time for the right students in

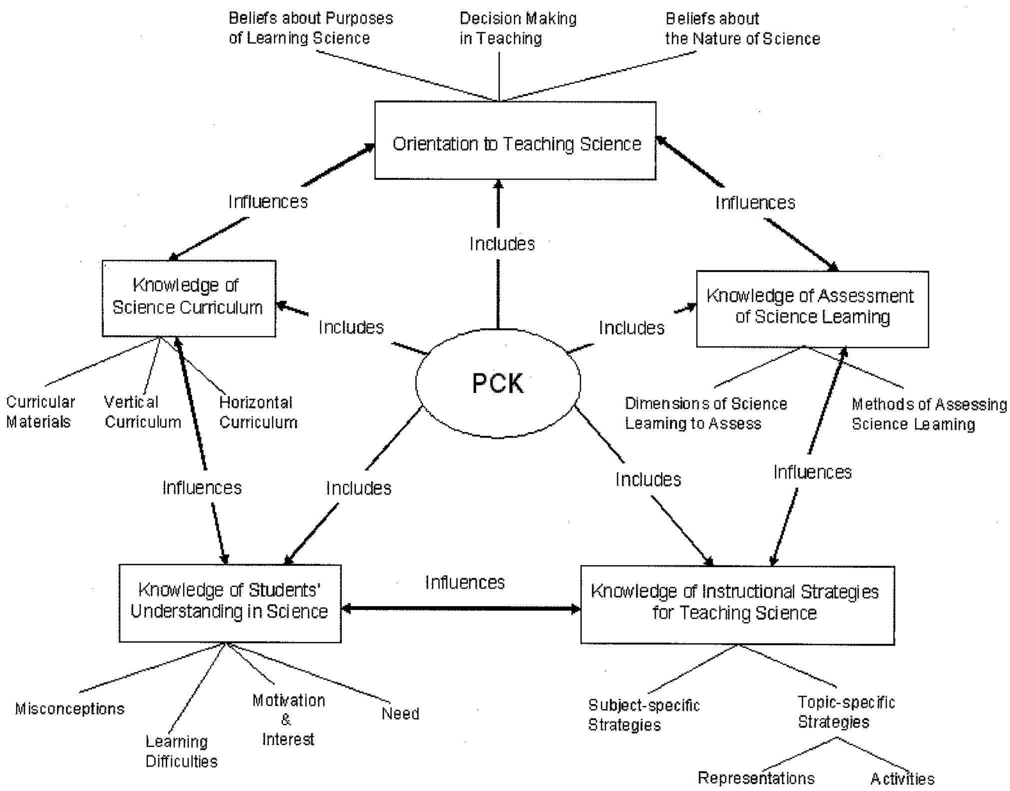

Fig. 1 *Pentagon model of pedagogical content knowledge for science teaching*

the right context that effective teaching will occur (Fernandez-Balboa & Stiehl, 1995). Thus, lack of coherence among components can be problematic in developing PCK and increased knowledge of a single component may not be sufficient to stimulate change in practice. What follows is the description of each of the five components of PCK.

Orientations to teaching science. This component refers to teachers' beliefs about the purposes and goals for teaching science at different grade levels (Grossman, 1990). The significance of this component is that these beliefs serve as a concept map that guides instructional decisions about daily objectives, student assignments, the use of particular curricular materials and instructional strategies, and assessment of student learning (Borko & Putnam, 1996). The transformation of knowledge from other knowledge domains into PCK is not a straightforward matter related primarily to simple possession of that other knowledge. Rather, PCK includes an intentional act in which teachers chose to reconstruct their understanding to fit a situation. Therefore, PCK is influenced by teachers' beliefs about the purpose for teaching a subject at a particular grade level, which are largely shaped by their understanding about the nature of knowledge.

Knowledge of students' understanding in science. This component includes knowledge of students' misconceptions of particular topics, learning difficulties, motivation, and understanding of diversity in ability, learning style, interest, developmental level, and need.

Knowledge of science curriculum. This component refers to teachers' knowledge concerning the curriculum materials available for teaching particular subject matter as well as about both the horizontal and vertical curricula for a subject (Grossman, 1990). Knowledge about the horizontal curricula is demonstrated by teachers' knowledge of the goals and objectives for students in the subject they are teaching as well as the articulation of those guidelines across topics addressed during the school year. On the other hand, knowledge about what students have learned in previous years and what they are expected to learn in later years is included in teachers' knowledge about the vertical curriculum.

Knowledge of instructional strategies and representations for teaching science. This component consists of two categories: subject-specific strategies and topic-specific strategies (Magnusson et al., 1999). Subject-specific strategies are general approaches to instruction that are consistent with the goals of science teaching in teachers' minds such as learning cycles, conceptual change strategies, and inquiry-oriented instruction. Topic-specific strategies refer to specific strategies that apply to teaching particular topics within a domain of science.

Knowledge of assessment of science learning. This component is comprised of knowledge of the dimensions of science learning important to assess, and knowledge of the methods by which that learning can be assessed (Tamir, 1988). This component includes knowledge of specific instruments, approaches, or activities.

2. Teacher Efficacy and Teacher Knowledge

Teacher efficacy is commonly described as a type of self efficacy (Bandura, 1977) pertaining to teaching and which refers to teachers' beliefs in their ability to affect student learning (Ross, 1994; Tournaki & Podell, 2005). Much research has shown that teacher efficacy is positively related to student achievement and motivation (e.g., McLaughlin & Marsh, 1978; Ross, 1994), teacher implementation of educational innovations (e.g., Cousins & Walker, 2000), and classroom management skills (e.g., Woolforlk, Rosoff, & Hoy, 1990). In this respect, teacher efficacy has been regarded as a key indicator of effective teaching and successful student learning.

Raudenbush and colleagues (1992) raised an important question about the relationship between teacher efficacy and teacher knowledge necessary to be effective. They argued that neither efficacy nor knowledge alone can generate effective teaching. Rather they highlighted that the role of efficacy as a mediator between knowledge and action. In other words, high efficacy provides the impetus for teachers to utilize their knowledge and skills to be effective. Along this argument, some researchers have investigated to what extent teacher efficacy is related to teacher knowledge. As a result, it has been shown that teacher efficacy is highly correlated to teachers' educational levels (e.g., Hoy & Woolfolk, 1993), courses taken (e.g., Enochs, Scharmann, & Riggs, 1995), specific learning experiences (e.g., Minke, Bear, Deemer, Griffin, 1996), and the level of demonstrated knowledge assessed by paper and pencil tests or supervisor ratings (e.g., Emmer & Hickman, 1991).

However, these studies heavily relied on correlation analysis which indicates that a relationship exists between efficacy and knowledge. Thus, it is difficult to understand the process by which efficacy and knowledge interact. In this regard, the significance of this present study can be explained. This study inductively arrives at the understanding of how teacher efficacy mediates the movement from teacher PCK to its enactment. This understanding is made through a detailed description of how the relationship between PCK and teacher efficacy manifests in teaching practices.

Finally, this study argues that teacher efficacy is an affective affiliate of PCK. Teacher efficacy is typically considered as a comparable component of belief, not knowledge. However, Kagan (1992) viewed beliefs as a form of knowledge referring to beliefs as a "particularly provocative form of personal knowledge" (p. 65). She further argued that most of a teacher's professional knowledge can be regarded more accurately as belief. Moreover, it is argued that teachers' beliefs play a major role in defining teaching tasks and organizing the knowledge relevant to those tasks (Nespor, 1987; Pajares, 1992). The contexts and environment within which teachers work and the problems they encounter are often ill-defined and deeply entangled (Nespor, 1987; Richardson, 1999). In order to solve those ill-defined problems, teachers need to go beyond the information contained in the problem instruction, use background knowledge, and make assumptions or decisions (Nespor, 1987). In other words, teachers have to reexamine the knowledge, which they already have, from many different perspectives. Thus, it follows that this more "affective" or provocative form of knowledge is playing an important role in the reexamination.

In this regard, it can be said that teacher efficacy plays a critical role in defining problems and determining teaching strategies to solve the problems, therefore leading to the reorganization of knowledge. Taken together, teacher efficacy can be viewed as a component of teachers' knowledge; a teacher's knowledge of self in terms of his or her own capability in teaching a particular subject matter

Ⅲ. Methods

1. Research Design

This study was a collective case study (Stake, 2000). The participants for this study were three experienced high school chemistry teachers. All three teachers worked in the same high school in northeast Georgia of U.S. All of them are female and Caucasian. Table 2 presents background information about the participants. For confidentiality, all were given pseudonyms.

2. Data Collection

As Kagan (1990) argued, the complexity of teachers' knowledge cannot be captured by a single instrument. Particularly, assessment of PCK requires a combination of approaches that can collect information about what teachers know, what they believe, what they do, and the reasons for their actions (Baxter & Lederman, 1999). In this regard, the researcher collected data from multiple sources including classroom observations, semi-structured interviews, lesson plans, teachers' written reflections, students' work samples, and field notes.

Table 2

Background Information of Participants

	Amy	Lucy	Jane
Education	B.S/M.Ed	B.S/B.Ed/M.Ed	B.ed/M.Ed/Specialist
Science background	Physics & Chemistry	Physics & Chemistry	Biology & Chemistry
Teaching years	21 years	11 years	8 years
Teaching subjects	Honors chemistry College preparatory chemistry	Advanced placement chemistry Gifted chemistry	Honors chemistry College preparatory chemistry

PCK concerns the teaching of particular topics and guides the teachers' actions in the classroom when delivering subject matter (Clermont, Krajcik, & Borko, 1993; Smith & Neale, 1989; Van Driel *et al.,* 1998). Accordingly, the translation of teachers' knowledge into classroom practice is clearly a critical aspect of PCK. Parallel to this concern, PCK was defined in this study as a construct consisting of both understanding and enactment. In this regard, the researcher observed three subject matter units for each teacher using a non-participant observation method. For each unit, at least four class periods were observed.

Since it is impossible to observe everything researchers want to know, interviews can provide access to the context of teachers' action (Seidman, 1998) and what they know. Thus, interviews were also conducted in combination with classroom observations in a semi-structured way. All interviews and observations were audiotaped and transcribed verbatim. The teachers were also asked to write reflections on their teaching. Field notes were recorded by the researcher during and right after each classroom observation, and a reflective journal was kept throughout the research process.

3. Data Analysis

In order to promote the capture of the construct of PCK, the data was analyzed through the in-depth analysis of explicit PCK in which teaching segments that revealed PCK explicitly were examined in depth (see Appendix for an example). The researcher first identified teaching segments of explicit PCK from the observation data according to the working definition of PCK and the pentagon model. As such, explicit PCK was recorded as occurring when observations of instructional enactments with a specific group of learners and dealing with specific subject matter content involved multiple instructional strategies, representations, assessments, etc.

Once a teaching segment containing explicit PCK was identified, the researcher made a detailed description of the segment in three aspects: (1) what the teacher did, (2) why the teacher did what she did, and (3) what the teacher knew. This description was grounded in observation, but supplemented by interviews, written reflections, student work, and field notes that were connected with the teaching segment being examined. A university professor who has expertise in both science education and teacher knowledge reviewed the descriptions and any incongruities were discussed and negotiated until a consensus was reached.

IV. Finding

An in-depth analysis of explicit PCK demonstrated by the three participants revealed an ancillary aspect of PCK that could not be accounted for by the five components of the pentagon model. However, after consistently finding this affective affiliate in 15 of 20 examples of explicit PCK drawn from the multiple data sources, the label that best fit seemed to be teacher efficacy (see Table 3).

Further characterization of this affect, confirmed its best descriptor was a highly subject specific version of teacher efficacy in that it was related to teacher beliefs about their ability to enact effective teaching methods for specific teaching goals and was very specific to classroom situations/activities. For example, Jane's statement below gives a glimpse of what teacher efficacy is:

> My plan book is more of yeah, I'll read some new materials, get some ideas, but for the most part I feel like I know how I'm going to teach it, how I'm going to guide them to get it. (Jane, Post observation interview 1)

This statement implies that Jane believed in her ability to have students reach understanding.

Table 3

Results of In-Depth Analysis of Explicit PCK (N=20; Lucy-8, Amy-8, Jane-4)

Orientations to science teaching	Knowledge of science curriculum	Knowledge of students' understanding in science	Knowledge of assessment of science learning	Knowledge of instructional strategies and representations	Other components (Teacher Efficacy)
19	8	19	6	18	15

Although 15 cases of explicit PCK across the three teachers showed that teacher efficacy is an affective component of PCK, Lucy's story was chosen in order to portray the process by which teacher efficacy influences PCK (see Appendix for an example from Amy). This is because Lucy's story is a representative example of what emerged from the data of the three teachers. The story was verified through triangulation of multiple data sources such as observation, interviews, written reflections, and field notes across the three teachers.

In an interview conducted before a class about the properties of elements and compounds, Lucy described how she would lead the class to challenge students' misconceptions associated with the topic. She said,

> I have some misconceptions that usually occur. There are some [misconceptions] that I think will happen [in today's class]. So I'll listen for them and if they seem to have it, but I'm not quite sure, I will ask a question that if they have the misconception that will trip them up. And I'll try to get them to think about it from a different angle so that they can correct their own misconception. I'm quite skilled in that. I'll get them correct the misconceptions. (Lucy, Pre observation interview 2)

During the class, this perceived confidence often urged Lucy to tackle students' misconceptions and encounter any possible challenges. When a student asked whether copper carbonate is conductive or not, she sensed that some students might hold the misconception that when an ionic compound contains a metal, it has all the properties of a metal. This was one of the common students' misconceptions she had discovered. Thus, she asked a series of questions such as whether rust would have any properties of a metal because iron was a part of the compound. In order to push students to assess whether they hold the misconception that ionic compounds never conduct electricity, Lucy initiated a discussion about conductivity, asking why iron (III) oxide did not conduct electricity as a solid compound in the past lab. Then the following discussion occurred:

S1: Ionic compounds don't conduct electricity.
Lucy: Ionic compounds don't conduct electricity and iron (III) oxide is an ionic compound, so it doesn't conduct electricity. Is this what you meant? [Yes] Okay, Are ionic compounds dissolved in water?
S2: Ionic compounds are very soluble in water because water is polar.
Lucy: What happens when an ionic compound is dissolved in water?
S2: The ions in the compound are separated.
Lucy: Then?
S2: Oh! They can conduct electricity! So, it depends!
S4: An ionic compound is going to conduct electricity when it is dissolved in water, but not as a solid. (Lucy, Observation 2)

This selection of discussion portrayed how Lucy's PCK for teaching the topic was demonstrated through her teaching. Lucy integrated her subject matter knowledge and knowledge of student understanding and applied them to the students through the instructional strategy of questioning. In her written reflection on this lab, Lucy described how she could affect students' understanding of the concepts:

> Listening carefully to justification of lab designs and data analysis and careful questioning allowed me to detect and immediately correct any misconceptions that students may have developed. (Lucy, Written reflection)

This successful experience fostered her teacher efficacy, which was evident in the interview with her after the post lab. She put it in this way:

> I got a lot of evidence I supported the kids getting correct concepts. I tried to go with them in their thinking and show them where they might have gotten off. Did it change their mind about one part of how they were thinking? Yes, I was able to correct their misconceptions. (Lucy, Post observation interview 2)

From this statement, it appeared that teacher efficacy was strengthened through successful teaching experience. Research has shown that higher teacher efficacy encourages the establishment of higher professional goals and manifests as a willingness to try new teaching strategies (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Guskey, 1988). These characteristics can subsequently lead to greater success in the classroom, which in turn stimulates higher teacher efficacy (Ross, 1995). This study cannot provide evidence that teacher efficacy affects actual teaching practices, because it is beyond the scope of this research. However, based on the previous research (e.g., Berman, *et al.,* 1977; Guskey, 1988; Stein & Wang, 1988), it can be expected that Lucy's enhanced teacher efficacy might facilitate her acquiring and implementing new teaching strategies, which might foster her PCK and effectiveness, thereby increasing her perception of success, suggesting that teacher efficacy is linked to PCK.

However, teacher efficacy appeared to be domain specific. While Lucy manifested high level of teacher efficacy in getting students correctly directed toward a valid understanding of the concepts, she felt that she was less efficacious for having the students take notes to record what they learned. She confessed,

> I often have hard time to have the kids take the notes. I don't have the skills needed to train them that way. I know they need to learn how to study to succeed in college. But I don't think I am good at doing that. (Lucy, Pre observation interview 3)

This statement suggests that Lucy's teacher efficacy in challenging misconceptions did not transfer to her belief in her ability to make students effective note takers. In other words, teacher efficacy is a specific rather than a generalized expectancy.

In a study that examined within-teacher variation in teacher efficacy, Ross and his colleagues (1996) found that teachers feel efficacious when teaching particular subject matter to certain students in specific settings, and they can be expected to feel more or less efficacious under different circumstances. This characteristic of teacher efficacy is compatible with the context and topic specific nature of PCK (Van Driel et al., 1998). Overall, teacher efficacy appears to be one of the components of PCK.

V. Discussion

This study was conceptually grounded in the pentagon model, which represents five components of PCK for science teaching; however, as a result of this empirical research, one new affective component of PCK, teacher efficacy, emerged. Teacher efficacy played a critical role in defining problems and determining teaching strategies to solve the problems, therefore leading to the reorganization of knowledge as shown in Lucy's example.

The notion of teacher efficacy is drawn from the concept of self-efficacy that evolved from Bandura's (1986) social cognitive theory. One main idea of this social cognitive theory is that individuals' perceptions of themselves mediate their behaviors. Thus, individuals pursue activities and situations in which they feel competent and avoid situations in which they doubt their capability to perform successfully (Bandura, 1997; Pajares, 1992). Along this line, when teachers believe their capability to execute their PCK effectively, the PCK will be more likely to be enacted in actual classrooms.

In this study, PCK was defined as a construct consisting of two dimensions: understanding and enactment. Teacher efficacy served as a conduit to connect those two dimensions. Increased teacher efficacy had the result of providing encouragement for teachers to enact their understanding. When the enactment was successfully performed, teacher efficacy was in turn increased. The increased teacher efficacy renders the teachers ready to learn relative to any of the components of PCK, whereby their understanding is expanded (Stein & Wang, 1988). In brief, teacher efficacy is considered as a promoter of a teacher's movement from understanding to action and vice versa (Gibson & Dembo, 1984; Raudenbush, Rowan, & Cheong, 1992; Woolfolk *et al.,* 1990). Through this argument, the conclusion was reached that teacher efficacy is linked with PCK.

VI. Implications

That teacher efficacy appeared to be a critical component of PCK provides several implications for future research and teacher education. Considered as a component of the whole, this affective feature combines with the previous cognitive features to describe a fuller understanding of teachers and teaching. Although teaching is largely conceived of as a cognitive activity, affective aspects must also be recognized as an integral part of teaching because teaching involves humans who always have opinions about and affinities toward life experiences. In consequence, teachers' instructional decisions are inextricably influenced by their affective characteristics. Even though this study, with regard to teacher efficacy, is exploratory and limited to simply identifying teacher efficacy as a component of PCK, future studies need to explicate how teacher efficacy is interrelated with the other components and integrated into PCK. In addition, teacher educators should take into consideration teachers' affective domains as well as their cognitive domains in building teacher education programs.

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Appendix

Example of the In-Depth Analysis of Explicit PCK

Amy; Honors Chemistry; Mendeleev manor unit - Zn lab

<table>
<tr><td colspan="6">Analysis</td><td>Data Sources</td></tr>
<tr><td colspan="6">What does the teacher do?</td><td rowspan="2">Observation,
Pre-/post-observation interview,</td></tr>
<tr><td colspan="6">Students were asked to figure out how to chemically separate the Cu covering of a post 1982 penny from the inner zinc core by using 15.0 mL of 6M HCl or 15.0 mL of 6M NaOH or Mg or Al. This activity included a 2 part reaction which involved recovering the copper shell which does not react with HCl and then finding a way to get the zinc (which reacts with the HCl) back from the zinc chloride. In this lab, Amy created an excess of HCl but did not tell the students. Only one group realized that HCl ws in excess and developed their labs. Amy had the groups to go last in PowerPoint presentation. Before students' presentation, she gave students 10 minutes to write a paragraph to explain why the zinc chloride solution was acidic, identify what might make it acidic, and to determine how the presence of this substance would have affected the rest of the lab.</td></tr>
<tr><td colspan="6">What does the teacher know?</td><td rowspan="3">Observation,
Pre-/post-observation interview,
Written reflection</td></tr>
<tr><td>Orientation to S/T</td><td>K of SC</td><td>K of SU (K of S)</td><td>K of As</td><td>K of IS/R</td><td>Etc</td></tr>
<tr><td>O</td><td></td><td>O</td><td></td><td>O</td><td>Teacher efficacy</td></tr>
<tr><td colspan="6">Why does the teacher do what she does?</td><td rowspan="2">Pre-/post-observation interview,
Interview #1,
Written reflection</td></tr>
<tr><td colspan="6">1. "In the zinc lab, we created an excess of HCl but did not tell the students. Only one group realized the significance of this and in the power point presentations, they impressed their peers and really drilled home the point of how an excess reactant can affect their final results. In previous years, I have had students discover this in the post lab discussion but I have modified it this year by having students present their lab strengths and work via PowerPoint presentations. Using this approach allowed students to evaluate and see what their peers had developed and was much more effective than me just summarizing the major points." (Written reflection) (K of IS/R) (K of SU) a

2. The reasons why Amy had students write a paragraph: "I wanted all students to have a chance to realize on their own how an excess reactant can affect a lab. This also gave me a chance to see how students could adapt to a new idea in a short amount of time which would help me to see if they could think scientifically. Plus, they would have one more chance to be successful! And I knew I could challenge them to discover it on their own." (Written reflection) (K of IS/R) (Teacher efficacy)

3. reasons why Amy had students write a paragraph: "I wanted all students to have a chance to realize on their own how an excess reactant can affect a lab. This also gave me a chance to see how students could adapt to a new idea in a short amount of time which would help me to see if they could think scientifically. Plus, they would have one more chance to be successful! And I knew I could challenge them to discover it on their own." (Written reflection) (K of IS/R) (Teacher efficacy)</td></tr>
</table>

Why does the teacher do what she does?	
4. "Although I developed the idea of the HCl paragraph on the spur of the moment when I realized how few students understood that the HCl was still in the beaker, it provided a powerful chance for students to be led to discover the pitfalls of having excess HCl." (Written reflection) (K of IS/R) (K of SU) 5. "I will keep the HCl paragraph because that proved truly powerful." (Post-observation interview) (K of IS/R) 6. "Students took different paths in their isolation of materials and we had wonderful post lab discussions where I was able to brag about their independent scientific ideas and reasoning." (Written reflection) (Teacher efficacy) 7. "They [students in a lab group] were saying zinc was soluble in hydrochloric acid. Well, zinc isn't soluble in hydrochloric; it reacts with hydrochloric acid. So what I'm doing for this time is each class I'm writing down any time I make a point in the class because these are the major points I'm seeing that maybe some of them missed. These are the major points that I want to emphasis in the post lab. I'll give the students a chance to pick up on it, and they have been. And then if they don't, then I'll bring it in." (Post-observation interview) (K of SU)	Pre-/post-observation interview, Interview #1, Written reflection

Abbreviations:
Orientation to ST: Orientation to science teaching;
K of As: Knowledge of assessment;
K of SC: Knowledge of science curriculum;
K of SU: Knowledge of student understanding;
K of IS/R: Knowledge of instructional strategies and representations