A critical review of Pedagogical Content Knowledge' components: nature, principle and trend

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[Abstract] This paper is a critical review of studies of pedagogical content knowledge. The components of pedagogical content knowledge that are identified in the existing literature were summarized and three relevant issues were discussed. These issues include (1) the generic and specific nature of PCK components, (2) the principle researchers rely on to clarify the components of PCK, and (3) the trend of clarifying PCK components.

Keywords: pedagogical content knowledge, components, definition

The term *pedagogical content knowledge* was introduced into the discourse of teacher education in Shulman's 1985 presidential address to the American Educational Research Association. It was defined as "a second kind of content knowledge" (Shulman, 1986, p. 9), "which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (Shulman, 1986, p. 9). It is "the particular form of content knowledge that embodies the aspects of content most germane to its teachability" (Shulman, 1986, p. 9).

Following the conception of the term, "a shift was about to take place in how teacher educators thought about the knowledge base of teaching" (Bullough, 2001, p. 655), and quite a lot of value has been attached to PCK.

Due to its significance, a bulk of studies on PCK emerged during the last twenty-five years. "What are the components of PCK" is one of the fundamental questions that researchers try to figure out. Although PCK is theoretically an integrated and coherent whole, the ingredients of which cannot be separated, it is of practical significance to clarify its components. A large volume of studies have been conducted, using the key concept of PCK. The knowledge elements that are explored as PCK components in these studies, however, often vary from one to another. The inconsistent use of PCK has been realized and deplored (Abell, 2008). Only if the components are distinctly clarified, researchers will have clear ideas of what they need to explore with teachers. A general description of PCK components has been made since the notion PCK was first introduced by Shulman (1986). Many more efforts were made later to clarify PCK components.

This paper reviews and discusses the clarifications of PCK components. The clarifications which are widely adopted and used in the relevant studies are reviewed first. Then some researchers' summaries of clarifications are described, followed by the summary of the author of the current paper. Three issues of the clarification of PCK components are discussed in the end.

1. Clarification of PCK components

1.1 Shulman's clarification

In Shulman's 1986 article, a general description of PCK components was made as follows:

> …the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others… Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (p. 9).

This clarification include three components: (1) knowledge of topics regularly taught in one's subject area, (2) knowledge of forms of representation of those ideas, and (3) knowledge of students' understanding of the topics.

Shulman (Gudmundsdottir & Shulman, 1987) expanded and specified his 1986 clarification in another paper co-authored with Gudmundsdottir. They divided PCK into three categories, which were (1) knowledge of the central topics, concepts, and areas of the subject matter that can be and are taught to students and knowledge of analogies, similes, examples and metaphors by which to explain the subject matter to students, which is influenced by content knowledge, (2) knowledge of the different ways topics can be taught, and the pros and cons of each approach, which is influenced by general pedagogical knowledge, and (3) knowledge of students' preconceptions or misconceptions about the topics they learn, and knowledge of the topics students find interesting, difficult or easy to learn, which is influenced by knowledge of students (Gudmundsdottir & Shulman, 1987).

Compared to 1986's clarification, the second category in 1987's clarification is new, which is about teaching approaches. The difference between these two clarifications also lies in that more sub-components are included in 1987's clarification. For example, the component of knowledge of students' understanding of the topics includes two sub-components—the conceptions and preconceptions of students—in 1986's clarification, while four sub-components—students' preconceptions, misconceptions, learning interests and learning difficulties—were included in 1987's clarification.

Though more components and sub-components are included in 1987, Shulman's clarification of PCK components is still relatively narrow. The subsequent researchers have further expanded PCK components and their sub-components. Some clarification of PCK components are reviewed in the following sections.

1.2 Grossman's clarification

Grossman's (1990) clarification of PCK components is a most widely referred one in the studies on PCK (e.g., Akkoç & Ye, 2010; Magnusson, Krajcik, & Borko, 1999). In her

clarification, the construct of PCK includes four central components: (1) conception of teaching purposes – knowledge and beliefs about the purposes for teaching a subject at different grade levels; (2) knowledge of students, including students' understanding, conceptions, and misconceptions of particular topics in a subject matter; (3) curricular knowledge, which includes knowledge of curriculum materials available for teaching particular subject matter and knowledge about both the horizontal and vertical curricula for a subject; as well as (4) knowledge of instructional strategies and representations for teaching particular topics. Compared with Shulman's (1987) clarification, knowledge of conceptions of purposes for teaching subject matter knowledge is added into Grossman's clarification PCK components. These components are demonstrated in Table 1.

Table 1Grossman's clarification of PCK components (1990, p. 5)

PEDAGOGICAL CONTENT KNOWLEDGE		
Conceptions of Purpose for Teaching Subject Matter		
Knowledge of Students Understanding	Curricular Knowledge	Knowledge of Instructional Strategies

1.3 Tamirs' clarification

Tamir's (1988) clarification of science PCK components also extends Shulman's 1987 clarification, including knowledge of evaluation, which is not included in Grossman's (1990).

Unlike other clarifications of PCK components, Tamir's emphasizes not only the declarative knowledge but also the procedural nature of PCK, which is named as skill in Table 2.

Table 2Tamir's description of science PCK components (1988, p. 100)

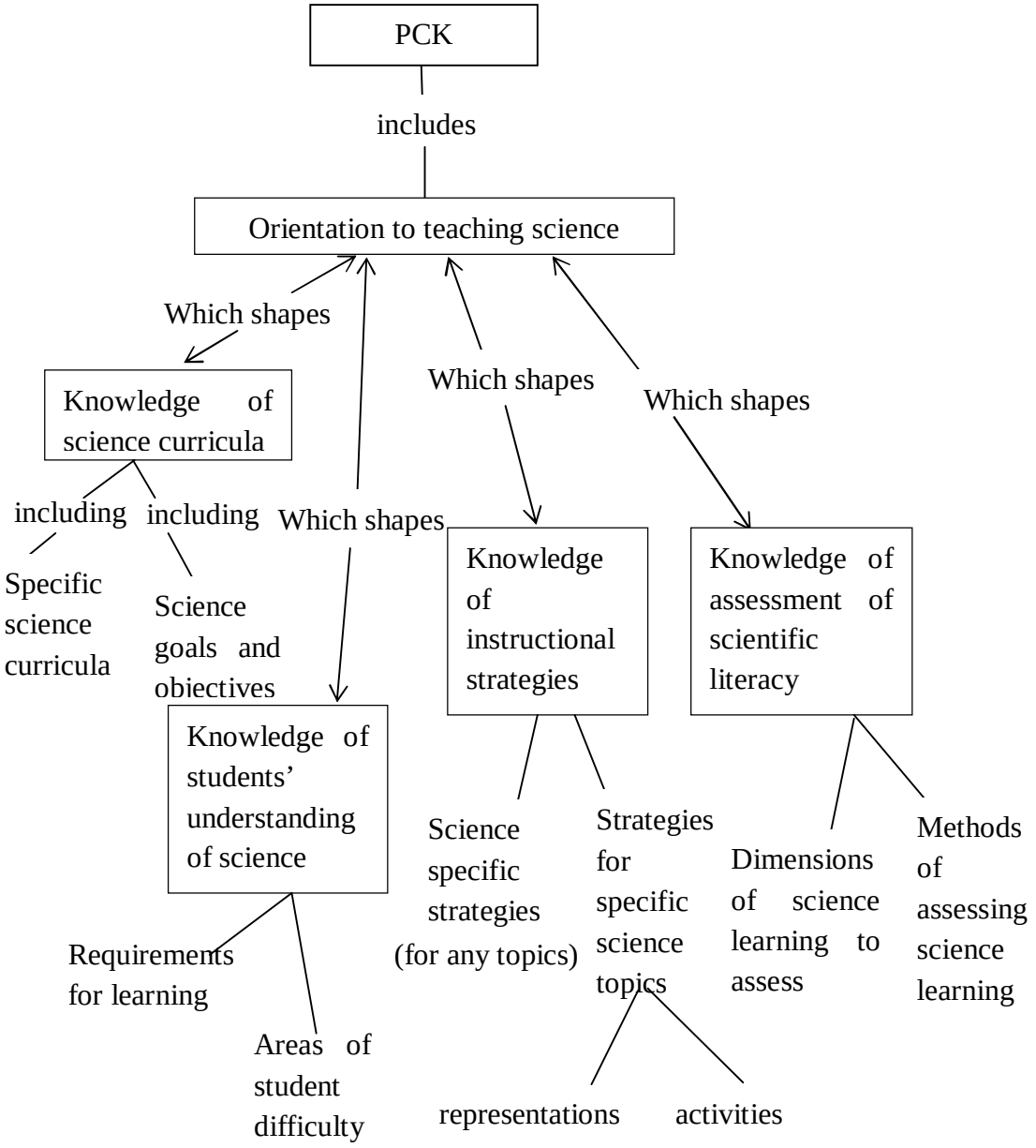
	Knowledge	Skill
Student	Specific common conceptions and misconceptions in a given topic	How to diagnose a student conceptual difficulty in a given topic
Curriculum	The pre-requisite concepts needed for understanding photosynthesis	How to design an inquiry oriented laboratory lesson
Instruction (teaching and management)	A laboratory lesson consists of three phases: pre-lab discussion, performance, and post-laboratory discussion.	How to teach students to use microscope
Evaluation	The nature and composition of the Practical Tests Assessment Inventory	How to evaluate manipulation laboratory skills

1.4 Magnusson et al.'s clarification

Based on Grossman's (1990) and Tamir's (1988), Magnusson et al. (1999) construct a PCK component model for science teaching, which contains both conception of teaching purposes and

knowledge of evaluation. One of the contributions of this model is that it further specifies the PCK components, which makes the framework clearer and more easily applied to the studies on PCK. Figure 1 diagrams Magnusson's PCK component model.

Figure 1Magnusson et al.'s PCK component model for science (1999, p. 99)

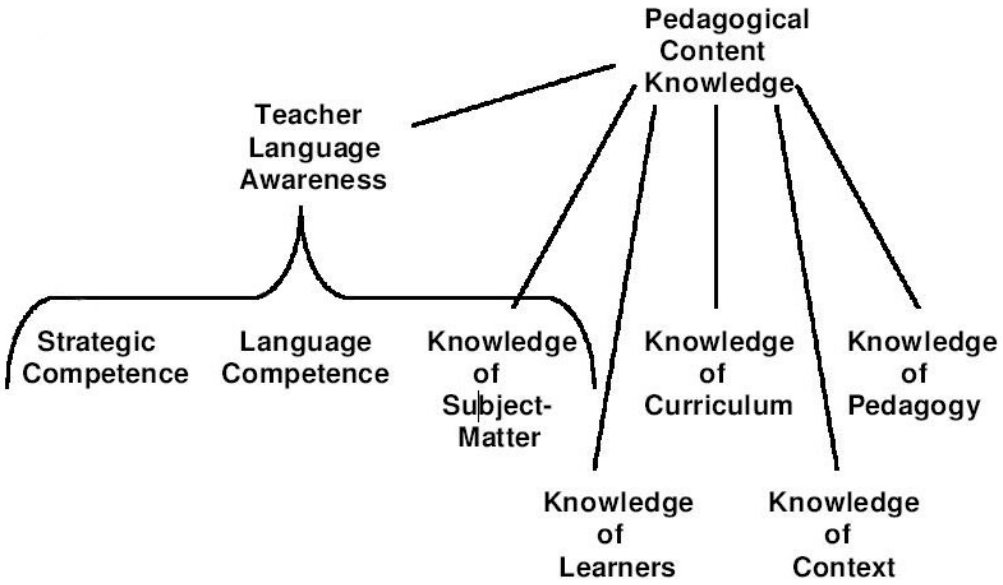


1.5 Andrews' clarification

Andrews (2001) argues that the PCK defined by other researchers is too generic to demonstrate the uniqueness of language teaching. He emphasizes Language itself in language teaching, because he supposes the uniqueness of language teaching lies in that "language is taught

through language" (p. 78). He therefore suggests that teacher language awareness, which includes strategic competence, language competence and knowledge of subject matter, should be included as a major language PCK component. Figure 2 diagrams his clarification of language PCK.

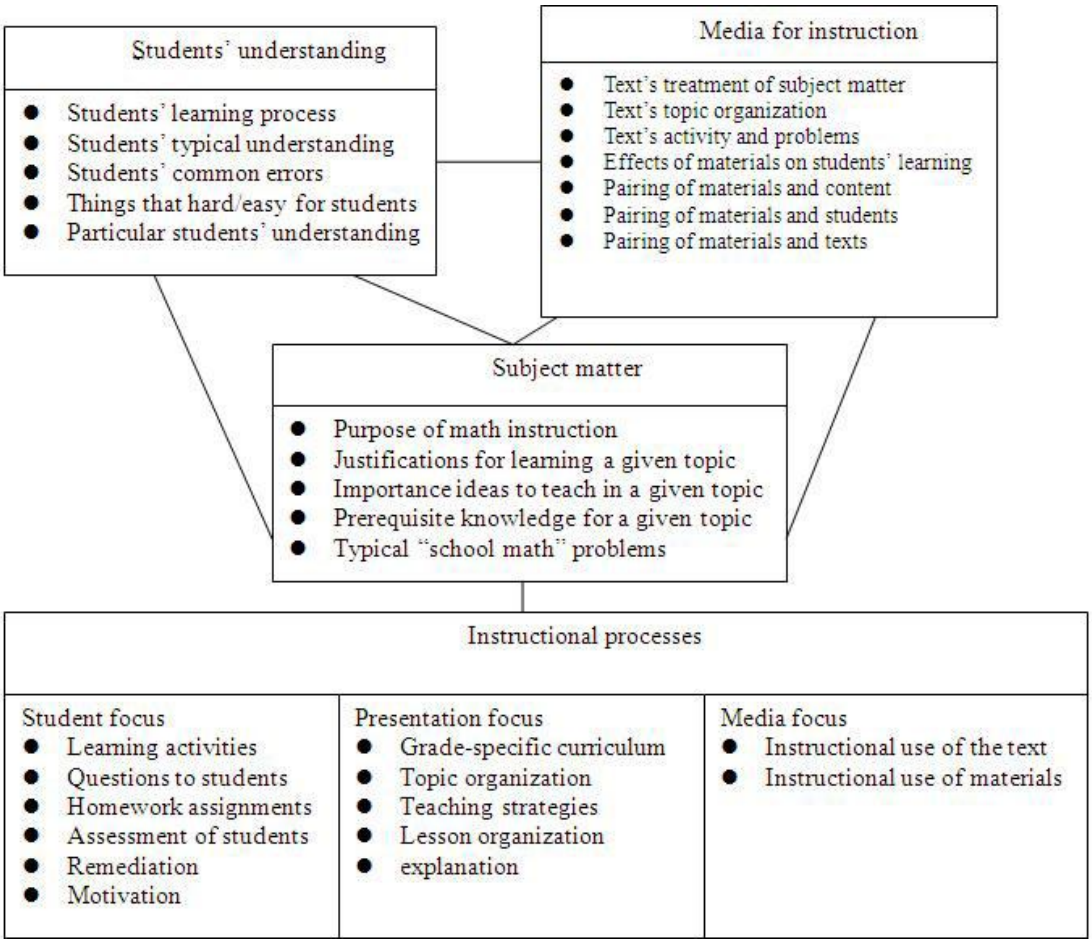
Figure 2Andrews' clarification of language PCK component (2001, p. 79)



1.6 Marks' clarification

Marks (1990) clarifies mathematics PCK components according to the findings of the study he conducted. The data collection method used in his study was interview. The interview was task-based, focusing on fifth-grade mathematics teaching, including planning a lesson, critiquing a classroom videotape, and diagnosing and remediating students' errors. The coding of the data began with a set of 12 secondary categories that were derived from related research and that classified teachers' knowledge in familiar terms. The portrait of PCK that emerges in this study is composed of four major areas: subject matter for instructional purposes, students' understanding of the subject matter, media for instruction in the subject matter, and instructional processes for the subject matter. Sub-components of each component were also identified. Figure 3 shows Marks's clarification of mathematics PCK components.

Figure 3Marks's PCK clarification of mathematics PCK components (1990, p. 5)



2. Summary of clarifications of PCK components

Besides the works that are reviewed above, there are many other clarifications of PCK components. Several attempts have been made to summarize them (e.g., S. Park & Oliver, 2008; van Driel, Verloop, & de Vos, 1998). The summaries by different researchers, however, are not consistent. For example, in van Driel et al.'s (1998)interpretation, Marks (1990) considers knowledge of curriculum and media as one PCK component, while in Park and Oliver's (2010) interpretation, Marks (1990) does not see curriculum as a PCK component. The summaries of PCK components are shown in Table 3 and Table 4.

	Knowledge of:						
Scholars	Subject matter	Representations and Strategies	Student Learning and Conceptions	General Pedagogy	Curriculum and Media	Context	Purposes
Shulman (1987)	[a]	PCK	PCK	[a]	[a]	[a]	[a]
Grossman (1990)	[a]	PCK	PCK	[a]	PCK	[a]	PCK
Marks (1990)	PCK	PCK	PCK	[b]	PCK	[b]	[b]
Cochran, et al. (1993)	PCKg	[b]	PCKg	PCKg	[b]	PCKg	[b]
Fernández-Balboa & Stiehl (1995)	PCK	PCK	PCK	[b]	[b]	PCK	PCK

[a]Distinct category in the knowledge base for teaching.
[b]Not discussed explicitly.

Table 3Van Driel et al.'s summary of components in different conceptualization of PCK (1998, p. 676)

Table 4Park and Oliver's summary of components in different conceptualization of PCK (2008, p. 265)

scholars	Knowledge of								
	Purposes for teaching a subject	Student understanding	Curriculum	Instructionalstrategiesandrepresentations	Media	Assessment	Subject matter	content	Peda-gogy
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 et al. (1993)		O		N			O	O	O
Geddis et al. (1993)		O	O	O					
Femandez-Balboa & Stiehl (1995)	O	O		O			O	O	
Magnasson et al. (1999)	O	O	O	O		O			
Hasweh (2005)	O	O	O	O		O	O	O	O
Loughran et al. (2009)	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 for emphasis); O author included this subcategory as a component of PCK.

The summaries in these two tables have three disadvantages. First, in van Driel et al.'s (1998) summary, two elements are sometimes treated as one PCK component, (i.e., representations and

strategies, student learning and conception, and curriculum and media). This makes the summary not clear enough. Secondly, both van Driel et al.'s (1998) and Park and Oliver (2008)'s summary do not include sub-components of each knowledge component. This makes the summary not specific enough. Thirdly, the general terms used in Table 3 and Table 4 may lead to misunderstandings of PCK components. For example, the knowledge component "curriculum" is put in the two tables. About this component, it is summarized in the two tables that Grossman (1990) includes it as a PCK component. According to these two tables, readers might think that "curriculum" refers to general knowledge of curriculum by mistake. However, in Grossman's (1990) conceptualization, it is the knowledge of curriculum in specific subject areas rather than the general knowledge of curriculum that is PCK component. Therefore, I re-summarize components in some commonly-referred-to conceptualization of pedagogical content knowledge in Table 5. In Table 5, one knowledge component takes one position. For example, unlike in Table 3 and Table 4, representations and strategies (replaced by "activities" in Table 5) in different conceptualization of PCK are analyzed respectively. What is more, the knowledge components that are somewhat general are specified into sub-components to make the summary more specific. For example, knowledge of curriculum in specific subject areas is specified as selection of content, teaching materials, and organization of content. Besides, to avoid misunderstandings, I distinguish general knowledge components from the amalgam of subject matter knowledge and other knowledge in knowledge base for teaching. For example, general knowledge of curriculum and knowledge of curriculum in specific subject areas are distinguished in Table 5.

Scholars / Components & sub-components		Shulman (1986)	Gudmundsdottir & Shulman (1987)	Grossman (1990)	Tamir (1998)	Magnusson et al. (1999)
Subject matter knowledge		a	a	a	a	a
General Pedagogical knowledge		b	a	a	a	a
General knowledge of curriculum		a	a	a	b	b
Knowledge of Context		b	a	a	b	a
Knowledge of students		b	a	a	b	a
Knowledge of instructional strategies for teaching the subject matter	Representations (analogies, similes, examples and metaphors)	PCK	PCK	PCK	PCK	PCK
	activities	b	b	b	PCK	PCK
Knowledge of curriculum in specific subject areas	Selection of	PCK	PCK	b	b	b
	Teaching materials	b	b	PCK	b	b
	organization of content	b	b	PCK	PCK	b

Knowledge of students' understanding of the subject matter	Students' conceptions of learning the subject matter	PCK	PCK	PCK	PCK	b
	Students' learning interest in the subject area	b	PCK	b	b	PCK
	Students' learning approaches	b	b	b	b	PCK
	Students' difficulties in learning the	PCK	PCK	b	b	PCK
Knowledge of the goals for teaching a subject		b	b	PCK	b	PCK
Knowledge of assessment of students' learning of the subject matter		b	b	b	PCK	PCK

Table 5Summary of components in different conceptualization of pedagogical content knowledge

a: Author placed this subcategory outside PCK as a distinct knowledge base for teaching;

b: Author did not discuss this subcategory explicitly.

3. Discussion

This section discusses three issues about PCK components based on researchers' clarifications that were reviewed above. These issues include (1) the generic and specific nature of PCK components, (2) the principle researchers rely on to clarify the components of PCK, and (3) the trend of clarifying PCK components.

3.1 The generic and specific nature of PCK components

"Are PCK components generic or specific?" This question concerns whether the components identified in one subject area are applicable in another. To answer this question, we need to compare the components that are identified in different subject areas to see if the researchers overlap their clarifications of one another.

The PCK components summarized in Table 5 were identified in several subject areas. Shulman's (Gudmundsdottir & Shulman, 1987; Shulman, 1986) discussion about PCK is general, without focusing on one specific subject area. Grossman's (1990) study of PCK focused on English literature teaching. Tamir's (1988) and Magnusson et al.'s (1999) focused on science teaching. As shown in Table 5, some are identified as PCK components in all the clarifications reviewed (e.g., representations); some are identified in most of the clarifications (e.g., Students' conceptions of learning the subject matter); some are identified in two clarifications that respectively focus on one subject area (e.g., Knowledge of the goals for teaching a subject, and organization of content). This indicates that the components identified in Table 5 are generic and they apply to different subject

areas.

What's more, Magnusson et al.'s (1999) clarification of PCK components is based on Grossman's (1990) and Tamir's (1988). All the four components in Grossman's (1990) clarification are accepted in Magnusson et al.'s (1999). The widespread use of Magnusson et al.'s (1999) PCK components model in the subject area of science implicates that PCK components for teaching English literature could be well applied in science teaching. Besides, Magnusson et al.'s (1999) clarification has been referred not only in the subject area of science (e.g., Hanuscin, Lee, & Akerson, 2011; Henze, van Driel, & Verloop, 2008; Jong, Driel, & Verloop, 2005; Käpylä, Heikkinen, & Asunta, 2009), but also in mathematics (e.g., Akkoç & Ye, 2010; Bukova-Güzel, Kula, Uğurel, & Özgür, 2010). This also indicates that the terminologies of PCK components are sometimes generic.

However, PCK components are not necessarily generic all the time. There might be two reasons why Magnusson's (1999) PCK component model for teaching science has been well applied to many studies of mathematics teacher knowledge. One is that Magnusson's PCK components are not specific enough to embody the characteristics of science subject matter, although some sub-components, such as requirements for learning and areas of student difficulty, have been identified in his model. When PCK components are thought up more deeply, elements that carry subject-specific features might emerge. Another possible reason is that the subject matter in the subject areas of science and mathematics has a lot in common. For example, the subject matter of these two subjects is organized in terms of concepts, and the concepts to be taught are undoubtedly the knowledge students need to master. However, the nature of subject like foreign language is quite different from science or mathematics. As some researchers (Macaro, 2003;Pachler, Evans, & Lawes, 2007) have realized, foreign language PCK is more complex than PCK of other subjects. According to them, one reason is that the subject matter to be taught in foreign language lessons is also the medium through which students learn the subject. What's more, a constant interference from another subject—the first language also makes foreign language PCK complex. Therefore, the focus on the instructional language in foreign language PCK might be much bigger than that in other subjects.

As Andrews (2001) argues, the components identified by other research are too generic to demonstrate the uniqueness of language teaching. He suggests teacher language awareness, which includes strategy competence, language competence, and subject matter knowledge, should be identified as language PCK. I do not accept Andrews' clarification of language PCK component, for according to Shulman's definition, all the PCK components should be combinations of subject matter knowledge and pedagogy or other knowledge components (More discussions are made in Section 3.2). However, his viewpointsare supported that language PCK component model needs to include some components that are specific to language teaching, and that the uniqueness of language teaching lies in that "language is taught through language". Therefore, the instructional language issuggested in the current paper as one of the EFL reading PCK.

3.2 The principle researchers rely on to clarify the components of PCK

According to the clarifications of PCK components reviewed in the section above, scholars have focused on different aspect of teacher knowledge. Even when claiming their model was built upon Grossman's (1990) and Tamir's (1988) work, Magnusson et al. (1999) only roughly adopted their PCK components in a general sense. The sub-components in their model, which represent the connotation of each component, are quite different from Grossman's (1990) and Tamir's (1988). Besides, the procedural nature of PCK that was focused on in Tamir's (1988) definition is not reflected in Magnusson et al.'s model.

However, no matter what elements are identified as PCK components, a principle is relied on by many researchers when the clarification is conducted. The principle is that all the components are combinations of subject matter knowledge and pedagogy or other knowledge components for teaching. This principle matches the core of Shulman's definitions: PCK is the transformation from subject matter knowledge to the knowledge with a pedagogical dimension which is understandable to the students. Therefore, neither subject matter knowledge nor knowledge of pedagogy itself is PCK.

Although the general terms like curricular knowledge, instructional strategies, and knowledge of students are used in Grossman's (1990) clarification of PCK components, the examples given to describe those terms indicate that they are actually confined to the elements that are closely related to subject matter knowledge. For example, while putting curricular knowledge in her PCK component model, Grossman restricts this component in the description to "knowledge of curriculum materials available for teaching particular subject matter, as well as knowledge about both the horizontal and vertical curricula for a subject" (Grossman, 1990, p. 8). These two elements are combinations of curricular knowledge and subject matter knowledge.

Some of the recent researchers (Magnusson et al., 1999; S. Park & Oliver, 2008) might have realized that the use of general terms might lead to misunderstanding of the definition of PCK. They are very careful about their expressions of PCK components, confining the general terms to a specific subject. For example, in the models of Magnusson et al. (1999) and Park & Oliver (2008), knowledge of science curriculum and knowledge of students' understanding of science are used instead of the general terms like knowledge of curriculum and knowledge of students that were used before. This makes it clear what are focused on in these components are the combination of science subject matter and curriculum knowledge and the combination of science subject matter and knowledge of students.

As researchers suggest there is no one right way to carve up the knowledge in the knowledge base for teaching (Magnusson et al., 1999), and that any classification of an item as PCK is simply "a matter of focus" (Marks, 1990). Therefore, no one clarification should be considered as the right one. However, when PCK components are being clarified, the basic principle—all the components are combinations of subject matter knowledge and pedagogy or other knowledge components for teaching—should be followed. Otherwise, the proposal of the term will lose its relevance.

3.3 The trend of clarifying PCK components

A trend of clarifying PCK components can be identified in the clarifications reviewed in Table 5, that is, the components become more and more comprehensive and specific. From Shulman's definitions to Grossman's or Tamir's and from these two definitions to Magnusson's, we see a trend of the focuses in the definition of PCK being broader. Compared to Shulman's definitions of PCK, a new component – conceptions of purpose for teaching subject matter – is included in Grossman's PCK component model, and another new component – knowledge of evaluation – is included in Tamir's. In the model of Magnusson et al., Grossman's and Tamir's are combined. Both purpose for teaching subject matter and assessment strategies are included. Those broader clarifications reflect that researchers' foci of PCK have become more comprehensive.

On the other hand, we also see a trend of the clarifications being more specific. PCK was described in paragraphs in Shulman's (Gudmundsdottir & Shulman, 1987; Shulman, 1986, 1987) definitions, in which the components were not clearly identified. In Grossman's (1990) and Tamir's (1988), four components are explicitly presented in each of the two clarifications. On the basis of these two definitions, Magnusson et al. (1999) even divided those components into more specific ones. The clearer clarifications of PCK components and their sub-components make the notion of PCK clearer and more easily to apply.

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