



# Exploration of secondary science prospective teachers' development of PCK during a school-based practicum

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## Abstract

Considering the amount of time prospective teachers spent in practicum during teacher education programs, it is important to understand how they develop their knowledge of teaching and learning in this setting and further inform how teacher educators can design adequate support. The objective of this study is to investigate a group of secondary prospective science teachers' knowledge development as described by the pedagogical content knowledge (PCK) framework when they attended practicum associated with a block of teacher education courses. With qualitative approaches, we analyzed prospective teachers' interviews to probe their learning experiences. Results show that prospective teachers' development of PCK is idiosyncratic, and they implemented different strategies to learn in the practicum when they are in the same practicum classes. Implications of designing practicum experiences to support prospective teacher learning are discussed.

**Keywords:** Prospective Science Teachers; Practicum; PCK; Teacher Preparation

Pedagogical content knowledge (PCK) is a framework that has been widely adopted to understand teacher knowledge since Shulman put it forward in the 1980s. Shulman described PCK development as a process of transforming the subject matter knowledge for the purpose of pedagogical use (Shulman 1986, 1987). Research indicates that teachers need to be exposed to some sort of practical experience to develop their PCK (Barnett & Friedrichsen, 2015; Beyer & Davis, 2012; Van Driel, de Jong & Verloop, 2002). A bulk of studies have documented that teachers developed their PCK through teaching practices (Gess-Newsome, 2015; Harris & Hofer, 2011), but the question of how prospective science teachers (PSTs) who have limited practical experiences develop their PCK has not been adequately researched. The objective of this research is to investigate how PSTs build their knowledge as described by the PCK framework while they participate in the classroom activities associated with their practicum in a block of school-based science teacher education courses.

## Conceptual Framework

Shulman and his colleagues defined PCK as an amalgam of teachers' subject matter content knowledge, pedagogical knowledge, and knowledge of the context (Shulman, 1986, 1987; Grossman, 1990). Magnusson, Krajcik, and Borko (1999) put forward a pentagon-shaped PCK model, which contains five components: orientations towards science teaching (ORNT), knowledge of science curriculum (KSC), knowledge of assessment for science (KAS), knowledge of student understandings (KSU), and knowledge of science instructional strategies (KIS). These labels for the components offer a broader view of the original conceptualization (Abell, 2007). Building on the previous models, Park (2005) developed a hexagon PCK model by adding an affective dimension of PCK to the pentagon model, teacher efficacy, which she described as teachers' beliefs about their ability to perform teaching. We adopted this hexagon-shaped model in this paper to analyze the PSTs development of PCK.

Assessing PCK is a complex task. Researchers have inferred in-service teachers' PCK by observing their instruction (Nilsson & Vikstrom, 2015; Rozenszajn & Yarden, 2014). When working with prospective

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teachers, who have limited teaching experience, the interview becomes a common method (Wang & Oliver, unpublished work). Interviews provide researchers opportunities to probe what PSTs know, which is an effective way especially when instruction observation is not available. Other measures were also developed to measure PCK, such as questionnaires (Van Driel De Jong & Verloop, 2002).

### Research questions

This research attempts to gain an understanding of PSTs knowledge development as they participate in the practicum in their final year of the teacher education program. The hexagon PCK model (Park, 2005) is used to characterize prospective science teachers' PCK. However, it is necessary to state that in this study, the PCK framework is regarded as a conceptual framework and a tool to characterize PSTs knowledge. Because the PSTs have limited chances of teaching but observing and assisting their mentor teachers, their "proto-PCK" may not be the same as experienced teachers' PCK.

The research questions guide this study include:

- (1) How does PSTs knowledge for teaching develop when analyzed using a PCK framework?
- (2) What are the potential sources that contributed to PSTs development of PCK when they are in the practicum?
- (3) How do the PSTs PCK components develop and interplay with each other?

### Method

#### Participants and data collection

A group of prospective secondary science teachers (PSTs) enrolled in a block of secondary science methods, secondary science curriculum, and practicum in science teaching during a secondary science teacher education program. We recruited four PSTs through purposeful sampling (Patton, 2014). All four PSTs content background is biology. During the semester, PSTs spent three mornings a week (75-90 mins) in their mentor teachers' classrooms after a 75-minute class period with their university instructors each morning. All PSTs were placed in two classrooms, one middle school and one high school. They attended the first placement from week 1 to week 8 and transferred to the second in week 9. All four PSTs worked in groups of two. Gabby worked with Jane across the semester. Carlie and Cary were respectively in groups with the other two PSTs who did not participate in the study, but they exchanged their

placements in week 9. All names used are pseudonyms. While in their practicum classrooms, PSTs observed the mentor teachers' classes, assisted teaching as needed, taught once or twice, and were provided opportunities of participating in other activities, such as morning tutoring and sitting in teachers' co-planning meetings.

The major data source is PSTs interviews. Four semi-structured interviews were conducted with each participant across one semester. The first interview was carried out in the first two weeks, the objective of which was to probe PSTs' previous teaching experiences and orientations to science teaching. The second, third, and fourth interviews lasted about 60 minutes and were conducted in week 4, week 9, and week 13 of the semester. In each of those interviews, PSTs were asked to elaborate on what they had noticed while in their practicum classrooms and what they learned from observing and assisting their mentor teachers. All interviews were audio-recorded and transcribed verbatim. PSTs weekly journals and the researcher's non-participant observations serve as supplementary data sources.

#### Data analysis

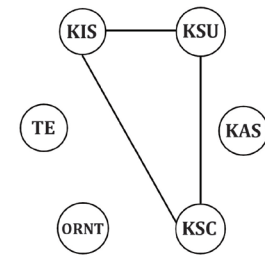
The interview transcripts were first segmented into PCK units. To qualify as a PCK unit, the following criteria need to be met: 1. Descriptions of what teachers/students were doing; 2. PSTs interpretation or evaluation of what and why the teacher/students did what they did. 3. PSTs comments on the behaviors of mentor teachers and/or students. If a PCK segment contains information that the PST also shared in their weekly journals, the relevant descriptions from the journal were also added to construct the PCK unit.

Each PCK segment was then coded using the six components of the hexagon PCK model (Table 1) to identify the PCK statements and observations reflected on by the PSTs.

The sources through which PSTs developed their PCK were also coded. If there is more than one source within a PCK segment, each source was marked separately. For example, in one PCK segment, the PST developed their understanding of KIS and KSU through interacting with students and observation of their mentor teachers. To represent this correlation, we marked 1 under "interacting with students" with KIS and another 1 with KSU. Then we marked 1 under "observation" with KIS and again another 1 with KSU (Table 2).

**Table 1.** PCK Components Based on Magnusson et al (1999) and Park (2005).

Components	Codes	Meaning of the components
Orientations toward science teaching	ORNT	Teachers' beliefs about the purpose of science teaching and learning.
Knowledge of science curriculum	KSC	Teachers' knowledge of curriculum materials both horizontally and vertically.
Knowledge of assessment for science	KAS	Teachers' knowledge of the important concepts needs to be assessed and how to deliver assessments.
Knowledge of student understandings	KSU	Teachers' knowledge of what students already know, their learning difficulties, and learning needs.
knowledge of science instructional strategies	KIS	Teacher's knowledge of strategies to represent science content, including subject-specific strategies and topic-specific strategies.
Teacher efficacy	TE	Teachers' beliefs about their ability to perform teaching.



**Figure 1.** An Example of PCK Components Interplay

**Table 2.** PCK Components and Learning Sources

PCK segment	PCK components	Sources	
		Interacting with students	Observation
Gabby, segment 1	KIS	1	1
	KSU	1	1

Finally, to portray the interplay of PCK components, a PCK map was constructed for each of the participants based on the components reflected from all their PCK segments (adapted from Park & Chen, 2012). After identifying the PCK components within each segment, if more than two components were recognized, one interplay was recorded between any of the components. For example, if KIS, KSU, and KSC were identified within one PCK segment, one connection was recorded between KIS and KSU, KIS and KSC, and KSU and KSC respectively (Figure 1).

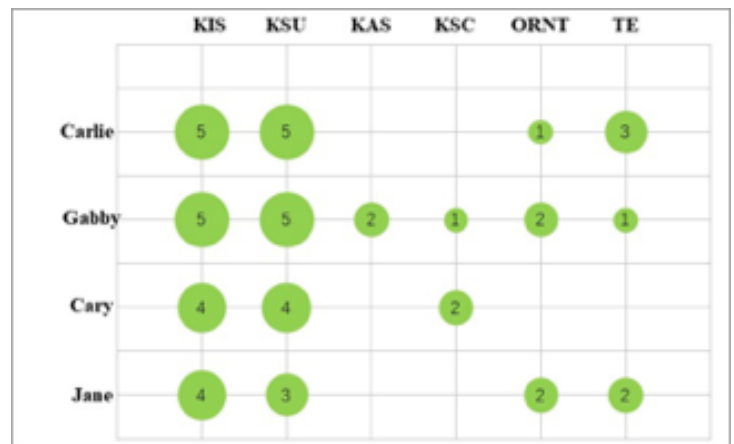
**Results and Discussion**

Four PSTs PCK were summarized in Table 3. The analysis results suggest four features of their PCK: (1) PSTs PCK development is idiosyncratic; (2) KIS and KSU are the two common components of PCK that PSTs developed and their connection is central for all connections; (3) KAS is the least PCK component that PSTs developed; (4) PSTs

**PCK development is idiosyncratic**

The four PSTs developed different aspects of PCK. Gabby developed the knowledge for teaching related to all six PCK components, Carlie and Jane exhibited knowledge connected to four PCK components and Cary developed knowledge related to three components (Figure 2).

Gabby and Jane worked together as a pair for their practicum placements, but they exhibited different knowledge related to PCK. Both developed PCK components of KIS, KSU, ORNT, and TE but Gabby also developed two more components, KAS and KSC, than Jane. In addition, even within the same PCK component they developed, Gabby and Jane focused on different aspects of the components. For example, they both developed KSU but Gabby focused on students' learning difficulties and



**Figure 2.** PSTs PCK components



**Table 3.** PSTs PCK Profiles

PSTs	Number of PCK segments	PCK components	Sources				PCK map
			IWS	POT	OBSV	PLE	
Carlie	6	KIS	4	2	1		
		KSU	4	2	1		
		ORNT	1	1			
		TE	3	2			
Gabby	7	KIS	3		4		
		KSU	4		3		
		KAS	2		1		
		KSC	1		1		
		ORNT			2		
		TE			1		
Cary	4	KIS	2		3		
		KSU	2		3		
		KSC	1		2		
Jane	5	KIS			4	2	
		KSU		1	2	1	
		ORNT			2	1	
		TE			2		
Note: Interaction with Students: IWS Observation: OBSV PSTs own teaching: POT Previous learning experiences: PLE						Interplay Strengths 1: 2: 3: 4:	



misconceptions, whereas Jane's knowledge was about what teachers could do to address students learning difficulties. For example, Gabby shared in the second interview that she realized students learning difficulties in understanding the question statement. She stated:

*"So I realized a lot of the problem is that students faced with these questions, is they don't know like an important part of the question to be able to answer the questions even if they are familiar with the knowledge or the content knowledge."* (Gabby, S3).

In this example, Gabby identified the specific learning difficulties students encountered as she interacted with them: they didn't understand "an important part of the question". This PCK unit was coded as knowledge of student understanding (KSU), as Gabby identified student learning difficulties. Jane came across a similar situation when students experienced learning difficulties:

*"While lecturing he (Mentor teacher) taught about concentration and diffusion. Some students had a hard time grasping this concept so Mr. Smith asked the students about their sweet tea recipes."* (Jane, S-2)

She then continued discussing how her mentor teacher used the sweet tea example to explain concentration. In this example, although Jane reflected her knowledge of student understanding, instead of focusing on students learning difficulties, she paid more attention to her mentor teacher's strategy of dealing with students' learning difficulties and the effects.

This idiosyncratic PCK development is also apparent in Carlie and Cary's PCK profiles, who worked with the same two mentor teachers at different times of the semester. Among the six components, they developed two common ones: KIS and KSU. One possible reason that may contribute to their different PCK development is that they switched their placements at week 9. After a half-semester of observation, they might be at very different places in their professional development.

The PSTs were provided limited directions regarding what to observe in the practicum. They made sense of what happened in the classes, so they developed different PCK components even when observing within the same context. This idiosyncratic development of teachers' PCK has also been documented by other

researchers (Loughran, Mulhall, & Berry, 2008; Park & Chen, 2012; Park & Oliver, 2008). This finding suggested that PSTs made sense of the same events and incidents in the same context in a variety of ways and subsequently developed different PCK components.

### **KIS and KSU components**

Despite the variations in PSTs PCK components, all of them developed KIS and KSU, which were exhibited within the highest number of PCK segments. Considering that the PSTs were observing in their mentor teachers' classes, it is not surprising that they focused on what strategies their mentor teachers used as well as on the status of what students were learning.

Furthermore, the connection frequencies between the two components are the highest compared to all other connections in their PCK maps. Carlie and Gabby's KIS and KSU connection frequencies are 4, Cary's is 3, and Jane's is 2. This implies that PSTs related their understanding of instructional strategies with students learning behaviors. In other words, the co-occurrence of KIS and KSU within one PCK segment means when PSTs made sense of their mentor teachers' instructional strategies, they also checked the effects of the strategies: student understanding.

Given that KIS and KSU are the two most common components of the PSTs PCK and the strong connections between these components, it seems clear that these two components are the central features of the PSTs knowledge for teaching. In other words, KIS and KSU guided what other components were included. As shown in Table 3, the only PCK component that PSTs developed but is not attached to KSU or KIS is Gabby's knowledge of teacher efficacy.

### **KAS is least developed component of PCK**

Knowledge of assessment of science learning is the component that PSTs developed least and therefore has the most limited connection to other components. KAS refers to teachers' knowledge of what are important issues to be assessed and knowledge of the appropriate approaches to use to assess students' learning (Park, 2005). The assessment approaches considered include both formative and summative assessments. Gabby is the only PST who developed this component. She exhibited an understanding of assessments regarding how teachers used formative assessments to guide subsequent instruction, the reasons behind students' low performances, and the way tests were delivered.

### **PSTs draw from different sources to build their PCK**

As shown in Table 3, the four PSTs drew from different sources to build their PCK. Carlie's major source for her PCK development is interaction with students. Gabby and Cary developed their PCK through both interactions with students and observation. Based on their PCK segments, the numbers of their learning instances from observation and interactions with students are similar. Most of Jane's learning happened from her observation of her mentor teachers. She is also the only PST who processed her learning by comparing what she observed with her own learning experiences and developed her knowledge by building on her own learning experiences as a student.

### **Conclusion and Implication**

This study examined four PSTs development of PCK. Although PSTs were placed in the same learning context, the outcomes and experiences of their learning are different. Their PCK development is idiosyncratic in nature and cultivated various learning aspects within the same component. They drew from different sources to build their knowledge and developed different components of PCK. These results suggest that prospective science teachers as learners have diverse learning strategies when they are prepared to be science teachers during practicum. This implies that when preparing science teachers, their existing knowledge and experiences need to be considered when designing learning opportunities. Future studies are needed regarding questions such as what some possible reasons contribute to PSTs' diverse development of PCK, and how we

provide learning supports to make sure teacher candidates can develop appropriate PCK before they start their teaching career. Results of this study also have implications for the design of practicum experiences within teacher education programs. PSTs development of PCK from different sources indicates that exposure to diverse learning experiences may benefit PSTs learning in the practicum. Therefore, the availability of different learning opportunities in the hosting schools is important to promote PSTs development of PCK, such as direct interactions with students through small group and whole group instruction, observation of mentor teacher modeling, as well as professional development opportunities.

Two limitations need to be considered when interpreting the conclusions. First, we inferred PSTs' PCK through their interviews. As described above, PCK can be reflected in teaching practices. But because our participants are prospective teachers who had limited teaching practices in the practicum, we had to infer their PCK through their descriptions of their learning. Another factor that was also a powerful shaping force in the PSTs development of PCK is that they attended the practicum three days each week instead of the whole week, therefore, were not able to observe the complete implementation of the curriculum. This incomplete observation of the whole teaching may influence their understanding of teaching and learning in the practicum classes.

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