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The nature and development of interaction among components of pedagogical content knowledge in practicum

Sevgi Aydin [a, *], Betul Demirdogen [b], Fatma Nur Akin [c], Esen Uzuntiryaki-Kondakci [c], Aysegul Tarkin [a]

[a] Yuzuncu Yil University, College of Education, Secondary Science and Mathematics Education (SSME) Dept., 65080, Van, Turkey
[b] Bulent Ecevit University, Eregli College of Education, Department of Science Education, SSME, 67300, Zonguldak, Turkey
[c] Middle East Technical University, College of Education, SSME, 06800, Ankara, Turkey

HIGHLIGHTS

- When necessary support is provided, preservice teachers are able to develop PCK.
- The development in the interplay among PCK components was idiosyncratic.
- PCK interaction can be nourished through mentoring in preservice teacher education.

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ABSTRACT

This secondary analysis study focused on how interactions among preservice teachers' pedagogical content knowledge (PCK) components developed throughout a 14-week CoRe-based mentoring-enriched practicum course, and the nature of those interactions. Data were collected from three preservice teachers, information-rich cases, by the use of content representation (CoRe) and semi-structured interviews. Content analysis and the constant comparative method were employed in the data analysis. Results revealed that the development of integrations was idiosyncratic. Additionally, PCK integration moved from fragmented to a more integrated and coherent one by the end of the semester. Implications for science teacher education and research are discussed.

1. Introduction

Over the years, there has been considerable debate among those in the field of science education about the criteria for being a qualified teacher. One of the criteria, pedagogical content knowledge (PCK), was introduced to the science education community by Lee Shulman (1986, 1987). PCK was conceptualized as "an understanding of how particular topics, problems, or issues are organized, presented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). Since then, science educators have directed increased attention to the role of PCK in science teaching and to the contexts for PCK development (Nilsson & Loughran, 2012). Concurrently, researchers have reported that novice teachers need support and guidance for their professional and PCK development in the first few years of their careers, due to the complex nature of the teaching profession (Wildman, Niles, Magliaro, & McLaughlin, 1989). Therefore, the quality of preservice teacher education gains importance in ensuring that individuals enter the teaching profession with more classroom experience and deeper knowledge.

Teachers should have a firm understanding of all PCK components (e.g., knowledge of learner and instructional strategies). More importantly, according to the scholars, in order to effectively plan and enact instruction for a certain group of students in a specific context, teachers must be able to integrate those components into PCK in a coherent way (Loughran, Berry, & Mulhall, 2006; van Driel, De Jong, & Verloop, 2002). This interplay is important for PCK development; the components interact with each other in highly complex ways (Park & Oliver, 2008). Although interplay is vital for PCK development, researchers have focused more on how various opportunities (e.g., explicit PCK use, teaching experience, and teacher certification programs focusing on some PCK components

* Corresponding author. Tel.: +90 4322251751; fax: +90 4322251368.
E-mail addresses: sevgi.aydin45@hotmail.com, sevgiaydin@yyu.edu.tr (S. Aydin).

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such as knowledge of learner and instructional strategy) provided in preservice teacher education courses support the development of PCK components separately (De Jong & van Driel, 2004; Hanuscin, 2013; Hume & Berry, 2011). The literature lacks research on how teacher education courses stimulate the development of preservice teachers' ability to integrate PCK components. Surprisingly, careful and deliberate consideration of how these components integrate with each other to structure PCK has been an unexplored issue for science teacher educators until recently (Aydin & Boz, 2013; Kaya, 2009; Padilla, Ponce-de-Leon, Rembado, & Garritz, 2008; Padilla & van Driel, 2011; Park & Chen, 2012; Park & Oliver, 2008), considering the long history of PCK since 1986. Those studies solely explored the nature of the interaction among PCK components in the instruction of experienced teachers. Other researchers have investigated interaction among PCK components; however, they have only focused on one or two components, exploring how two specific components are related (e.g., Cohen & Yarden, 2009; Veal & Kubasko, 2003), or how the development of one component affects the whole of PCK and one's teaching practice (e.g., Kamen, 1996; Matese, 2005). Still, the way that the interaction among all PCK components develops has not been fully resolved. Moreover, research shows that preservice teachers have fragmented PCK (Lee, Brown, Luft, & Roehrig, 2007) and the literature highlights the importance of support to enable them to integrate PCK components (Aydin & Boz, 2013; Kaya, 2009; Park & Chen, 2012). Therefore, further research is needed regarding the nature and development of the interaction among preservice teachers' PCK components, and regarding how various contexts stimulate the interaction of PCK components. Accordingly, this study aimed to investigate the development of interaction among all PCK components of preservice teachers during a practicum course. In the following section, we present related literature on PCK and the interplay among PCK components.

2. Literature review

2.1. Pedagogical content knowledge

Shulman (1986) defined PCK as specialized knowledge differentiating the teacher from the content specialist. The current study employed the widely used PCK model proposed by Magnusson, Krajcik, and Borko (1999) because it represents a broader view of PCK than the original conceptualization. According to Magnusson et al. (1999), PCK is the "*transformation* of several types of knowledge (including subject matter knowledge)" such that "it represents a unique domain of teacher knowledge" (p. 95, italics in original). This model conceptualizes PCK as consisting of five connected components: science teaching orientation, knowledge of curricula, knowledge of learner, knowledge of instructional strategies, and knowledge of assessment. Science teaching orientation refers to teachers' knowledge and beliefs about the goals and purposes of teaching science at a specific grade level. Knowledge of curriculum involves an understanding of both curriculum goals and curricular materials. As part of their knowledge of learner, teachers should be aware of students' difficulties in learning specific topics, and of misconceptions related to those topics. Knowledge of instructional strategy involves science-specific strategies (such as the learning cycle) and strategies for specific science topics (e.g., illustrations and analogies). The assessment component of PCK requires an understanding of how to assess student performance (e.g., through portfolios or written tests) and what to assess (e.g., science process skills). Although Magnusson et al.'s PCK model was proposed for use in science education (e.g., chemistry and biology), the literature provides examples of the applicability of this model to other topics (i.e., nature of science, Faikhamta, 2013) and other curriculum areas (e.g., mathematics, Lannin et al., 2013). PCK is an accepted theoretical framework that leads us to better understand teachers' knowledge of teaching (Abell, 2008), thus, this model served as both the conceptual and analytic framework for this study.

2.2. Research on interplay among PCK components

Of the various efforts to delineate PCK, few considered how the components interact during teaching (Cochran, King, & DeRuiter, 1991; Fernández-Balboa & Stiehl, 1995; Grossman, 1990; Magnusson et al., 1999). The first scholar to consider the interaction among knowledge components was Grossman (1990), who stated that "… these components are less distinct in practice than in theory" (p. 9). Then, Cochran et al. (1991) argued that PCK components cannot be considered as separate knowledge bases because these components are so integrated and interrelated. Adopting the idea of interplay, Fernández-Balboa and Stiehl (1995) argued that "… it is not the separate existence, but rather the intersection and rightful integration of all these PCK components that comprises good teaching" (p. 294). According to Magnusson et al. (1999), there is a reciprocal shaping interaction between science teaching orientation and the other PCK components. This shaping effect was empirically supported by other researchers (Padilla et al., 2008).

One of the first attempts to investigate the interaction of PCK components (Henze, van Driel, & Verloop, 2008) focused on how two different types of teachers' orientation (type A PCK vs. type B PCK), knowledge of learner, assessment, and instructional strategy were integrated while teaching the "Models of the Solar System and the Universe" curriculum. Type A PCK teachers were mainly oriented toward the teaching of science content, whereas Type B PCK teachers were more oriented toward teaching how science works. Henze et al. (2008) drew maps to visualize the interplay among PCK components. In Type A PCK, the teachers' knowledge of instructional strategies was consistent with their orientation. There were one-directional interactions between knowledge of instructional strategy, assessment, and learner. For example, teachers used multimedia such as films and videos, and concrete models (instructional strategy) to teach concepts by considering student difficulties (knowledge of learner). Also, the information these teachers assessed (knowledge of assessment) was consistent with what they taught (knowledge of instructional strategy). Lastly, the teachers' knowledge of learner was enhanced by the interpretation of students' responses in written tests (knowledge of assessment). Type B PCK teachers had some additional interplay. Their knowledge of learner was related to their knowledge of instructional strategy. Moreover, those teachers' knowledge of assessment was enhanced by an increase in their knowledge of learner. Similarly, Park and Oliver (2008) found that the development of teachers' knowledge of learner, especially in the area of misconceptions, shapes teachers' knowledge of instructional strategy and assessment.

Kaya (2009) brought a quantitative approach to PCK research and explored the intra-relationships between preservice science teachers' PCK components within the topic of ozone layer depletion. Kaya (2009) created a rubric and scored 25 preservice teachers' PCK components as appropriate (3.5 pts.), plausible (1 pt.), and naïve (0 pts.). The Pearson product–moment correlation coefficients indicated that the intra-relationships among the components were generally moderate. However, the relationships between knowledge of assessment and other components were low. Likewise, Padilla and van Driel (2011) analyzed the