Introduction

The term pedagogical content knowledge (PCK) was introduced by Lee Shulman in his presidential address to the American Educational Research Association (Shulman, 1986). Shulman argued that, for a long time, research on teaching and teacher education had undeservedly ignored questions dealing with the content of the lessons taught. Shulman presented a strong case for PCK as a specific form of knowledge for teaching which refers to the transformation of subject-matter knowledge in the context of facilitating student understanding. Teachers need this type of knowledge to structure the content of their lessons, to choose or develop specific representations or analogies, to understand and anticipate particular preconceptions or learning difficulties of their students, and so on. Shulman asserted that teachers had a unique way of looking at practice and his intrigue with the manner in which they did so encouraged an examination of teachers’ pedagogical thinking in ways that, it was anticipated, would reveal what teachers must know to best teach their content to their students.

Shulman’s introduction of PCK, that is, his call for attention to the knowledge that teachers use and need to teach specific content, connects with a well-established tradition in the European literature on teaching and teacher education. The German word *Fachdidaktik* is often used to refer to this tradition, which is more philosophical than empirical. *Fachdidaktik* may be translated as the pedagogy of subject matter.

In preparation programs for secondary teachers within this European tradition, a relatively large amount of time is usually reserved for coursework on *Fachdidaktik*. In this context, preservice teachers are required to address questions concerning the significance of the content for their students’ future, the structure and the exemplary value of the content, and the ways in which the content may be represented to make it interesting and comprehensible for students. However, the *Fachdidaktik* tradition has not provided detailed insights into the ways in which teachers transform subject-matter knowledge, and how they relate their transformations to student understanding during classroom communication in order to overcome student misconceptions, thus contributing to meaningful learning. Such issues lie at the heart of the concept of PCK, which explains why empirical research on PCK adds a new perspective to the *Fachdidaktik* tradition.

In the past 20 years, a plethora of publications studying and integrating PCK into teacher education have been published in the research literature. Publications have addressed various subject areas, including English, mathematics, science, physical education, and social studies (Grossman et al., 2005). Although researchers have thus began to push to find ways of examining what teachers know, still few concrete examples of PCK in subject areas have emerged. Hence, the construct itself has not yet positively impacted the valuing of teachers’ professional knowledge and practice.

Van Driel et al. (1998) highlighted this concern when they noted that although the research community embraced the notion of PCK, few topic-specific examples existed in the literature to illuminate this important aspect of teachers’ professional knowledge. Suggestions to account for this paucity of concrete examples include the tacit nature of teachers’ knowledge and the absence of a shared language or structure to adequately discuss that knowledge. Related to this is the problem that teachers are often unaware of the knowledge they possess, which is often contextualized and associated with particular students, events, and classrooms.

In this article, we begin with a brief review of the ways in which PCK has been conceptualized in the research literature, followed by an overview of research that has focused on the way PCK develops, and the factors influencing this development. Concluding this article, we discuss research on PCK in relation to the practice of teaching and teacher education.

Conceptualizing Pedagogical Content Knowledge

One of the preeminent issues in the research literature is the ongoing discussion on the nature of PCK: What is it, and how can it be represented? The key elements in Shulman’s original conception of PCK include knowledge of representations of subject matter, on the one hand, and understanding of specific learning difficulties and student conceptions, on the other. Shulman suggested that the more representations and strategies teachers have at their disposal within a certain subject domain, and the better they understand their students’ learning processes in the same domain, the more effectively can they teach in that domain.
In a later article, Shulman (1987) included PCK in what he called "the knowledge base for teaching." This knowledge base consisted of seven categories, three of which were content related (i.e., content knowledge, PCK, and curriculum knowledge). The other four categories referred to general pedagogy, learners and their characteristics, educational contexts, and educational purposes. In the subsequent years, many scholars have used Shulman's knowledge base for teaching as a starting point, and have conceptualized PCK in other ways. Although almost all scholars adopted the two key elements of PCK mentioned above (i.e., knowledge of comprehensible representations of subject matter and understanding of content-related learning difficulties), they have extended the concept by including other categories of knowledge in PCK from Shulman's knowledge base for teaching, such as knowledge of curriculum, or assessment.

In an often-cited paper, Magnusson et al. (1999) presented PCK as a separate domain of teacher knowledge which exists alongside other domains, such as pedagogical knowledge and beliefs. In their discussion of the nature of PCK, they presented a model in which PCK for science teaching consists of five aspects or components: (1) orientations toward teaching science, (2) knowledge of science curricula, (3) knowledge of students' understanding of science, (4) knowledge of assessment in science, and (5) knowledge of subject-specific and topic-specific strategies. Acknowledging that these components may interact in very complex ways, these authors claim that effective teachers need to develop expertise in all aspects of PCK, and with respect to all topics they teach. Orientations toward teaching science, in particular, have been identified as a critical component within this PCK model (Friedrichsen and Dana, 2005). Sources that shape teachers' orientations toward teaching science include: prior work experiences, professional development choices, beliefs about students and about learning, as well as time constraints.

Several scholars have addressed problems associated with investigating PCK in terms of specific components or categories. This may lead to a segmented and simplistic representation of teachers' knowledge. To acknowledge its constantly evolving nature, Cochran et al. (1993) preferred to speak of pedagogical content knowing (PCKg). Similarly, Mason (1999) emphasized the dynamic nature of PCK in research and teaching, respectively. Rather than representing PCK as a fixed or static body of knowledge, Mason perceived PCK as an ability to combine content knowledge of a discipline with the teaching of that discipline. Adding to this, Hashweh (2005) proposed to consider PCK as a collection or repertoire of pedagogical constructions, which teachers acquire when repeatedly teaching a certain topic.

Loughran and colleagues argued that researchers often fail to acknowledge the complex relationships and interactions existing within a teacher's personal professional knowledge base (Loughran et al., 2001, 2004). Attempting to portray PCK in a way that is valid and useful from a teacher's point of view, these authors constructed a series of resource folios for various (science) topics consisting of a content representation (CoRe) in combination with the so-called pedagogical and professional-experience repertoires (PaP-eRs). For example, a resource folio for the topic of force includes a CoRe and PaP-eRs about teaching and learning this topic. A CoRe is structured around questions related to some of the elements of Shulman's knowledge base, in particular, knowledge of the main content ideas associated with a specific topic, teaching procedures and purposes, and knowledge about students' thinking.

Each CoRe is connected to a collection of PaP-eRs, which illustrate aspects of PCK in action of the topic under consideration. PaP-eRs are short narratives based on teachers' accounts of teaching a specific topic and are intended to make explicit teachers' pedagogical reasoning, that is, the thinking and actions of a capable teacher in teaching a specific aspect of the content. PaP-eRs include a variety of narrative representations, for example: a dialog between two teachers exploring their approach to the teaching of particular content and student responses to it; a teacher's annotated curriculum document, or a student's perspective of a teaching/learning situation. The function of PaP-eRs is to elaborate and give insight into the various interacting elements that comprise a teacher's PCK.

To conclude this section, it is clear that PCK has attracted considerable attention in the research literature, but there is no universally accepted conceptualization of PCK. The general fuzziness around the concept of PCK has meant that that which is searched for, and that which is uncovered is variable indeed. In fact, the literature on PCK reveals several dilemmas:

- Since various scholars have included different elements within their conceptualization, it is unclear whether PCK should be seen as knowledge which is very specific for each topic that teachers teach, or one should think in terms of general or subject-specific PCK? The former implies that teachers need specific PCK for each particular topic they teach, whereas the latter suggests that there are ideas, for example, about teaching strategies, which are useful across topics within a subject area (e.g., algebra, or even mathematics).
- Given the discussion about the complex, dynamic, and holistic nature of PCK, there are obvious challenges for researchers investigating PCK in analytical, empirical studies, to avoid breaking down PCK into segmented and static entities, resulting in a simplistic and hence misleading picture of teachers' knowledge.
- Related to the previous issue is the problem of how research into PCK can become more relevant for the
practice of teaching and teacher education, so that PCK becomes an important concept, not only for researchers, but also for teachers and educators.

**The Development of PCK**

Marks (1990) perceived the development of PCK as an integrative process revolving round the interpretation of subject-matter knowledge and the specification of general pedagogical knowledge. Since this process is rooted in classroom practice, the implication is that preservice or beginning teachers usually have little or no PCK at their disposal. Magnusson et al. (1999) argued that development of PCK is a complex and nonlinear process. These authors stated that a teacher education program can never completely address all the components of PCK that a teacher needs. Research reported by Van Driel et al. (1998) concluded that while subject-matter knowledge is prerequisite, the major source of a teacher's PCK is teaching experience. Hence, the development of PCK should also be an important element of the continuing education of teachers.

How PCK develops is discussed in the following section. This discussion is organized according to the following themes relevant to PCK development: (1) the role of subject-matter knowledge, (2) teaching experience, (3) a focus on student learning, and (4) the design of teacher education.

**The Role of Subject-Matter Knowledge**

Several authors have pointed at the problematic nature of preservice teachers' content knowledge, both substantive and syntactical, when they enter teacher education (e.g., Halim and Meerah, 2002). When their subject-matter knowledge is very limited and contains many misconceptions, preservice secondary teachers hardly develop PCK during their teacher education program. Working with beginning elementary science teachers, Appleton (2003) tried to compensate for these teachers' lack of content knowledge and PCK by providing them with what he called activities that work that included, for instance, hands-on activities intended to raise interest among young children around particular science content. Using these activities apparently helped these teachers to start teaching science with some success, and consequently stimulated the beginning of the development of their PCK.

From studies on experienced teachers, however, it appears that a strong and well-integrated subject-matter knowledge does not guarantee the smooth development of an individual's PCK. In particular, when teaching unfamiliar topics, it appears that experienced teachers drew from their general pedagogical knowledge, which can constitute a supporting framework for the development of their PCK (Hashweh, 1987).

**Teaching Experience**

Preservice teachers' lack of teaching experience explains why they usually express little to no PCK. Added to this, the concerns of many preservice teachers related to self-confidence and an ability to teach may also, at least initially, hinder the development of their PCK. This means until a teacher has gained sufficient confidence and experience and mastered basic classroom skills, that the development of PCK as a readily accessible and useful translation of subject-matter knowledge into classroom practice may be delayed. However, while teaching experience may promote the development of PCK, the provision of structured opportunities for reflection on the relationship between subject-matter knowledge and classroom practice is also important for facilitating the development of preservice teachers' PCK. Without such opportunities PCK development is at best, haphazard and at worst, barely apparent.

The role of teaching experience was highlighted in a longitudinal study of 10 years of one elementary science teacher (Mulholland and Wallace, 2005). These authors found that all the various knowledge bases that comprise PCK grew over time, although in different ways. In particular, general teaching knowledge bases and interactive knowledge bases, such as knowledge about learners, developed substantially, whereas subject knowledge bases remained relatively stable. Moreover, this study illustrated the development of PCK as a complex pattern of interactions between these various components, which is situated in the teacher's classroom. In this particular study, new curriculum materials appeared to be an important source for this development.

**A Focus on Student Learning**

Central to the notion of PCK is the idea that instruction can only be effective if it is attuned to the ways in which students learn specific content. Preservice teachers usually have limited ability to relate students' prior knowledge to instruction and to adequately anticipate student conceptions. Consequently, it has appeared to be important to provide preservice elementary teachers with opportunities to observe student learning in practice and, in connection to this, to study the research literature (e.g., on misconceptions regarding specific topics). Applying these ideas, Zemba-Saul et al. (2002) found that preservice teachers were able to focus on student learning, while maintaining a strong subject-matter emphasis, thus contributing to the development of their PCK. Similarly, De Jong and Van Driel used a workshop format in which preservice teachers were asked to prepare and teach a
series of lessons on an important theme from the chemistry curriculum. As a result, these preservice teachers demonstrated a growing awareness of specific instructional strategies in relation to a better understanding of student thinking about the topic of their lesson series. Reflecting on and discussing teaching experiences appeared to be crucial for this development (De Jong et al., 2003; Van Driel et al., 2002).

The Design of Teacher Education

Various studies have been conducted on ways of structuring and organizing preservice teacher education programs to promote the development of PCK (De Jong et al., 2005; Loughran et al., 2006; Zemball-Saul et al., 1999). However, the reported impact of such programs on the development of preservice teachers’ PCK is varied. It would appear that the preservice teachers experience difficulty merging subject-matter courses and education courses that are not integrated by design. In programs that were not deliberately structured to help promote integration of different types of knowledge, preservice teachers appeared to retain separate views of subject matter and pedagogy as opposed to the integrated knowledge base advocated by PCK. In the context of such nonintegrated programs, it has been demonstrated that knowledge development appears most strongly influenced by individual and contextual factors, resulting, among other outcomes, in the adoption by preservice teachers of conventional instructional strategies, stressing procedures instead of student understanding.

Some significant gains in the growth of PCK through short-term, intensive, skill-oriented workshops or via specific activities have been reported. Justi and Van Driel (2005) incorporated the design of a lesson series in an action research project that was a requirement for preservice secondary teachers as part of their teacher education program. It was found that, in particular, reflective activities (such as writing reports and sharing experiences in collective meetings) stimulated the development of subject-matter knowledge and PCK of these preservice teachers. Sperandeo-Minea et al. (2005), working with a group of 28 preservice teachers of physics, found similar results, concluding that the development of PCK is a complex process which is connected with deepening of subject-matter knowledge and improved awareness of pedagogical issues. Loughran et al. (2006) employed a modified version of their aforementioned CoRe and PaP-eRs framework in a preservice science teacher education program, whereby preservice teachers developed their own CoRes and PaP-eRs based on their learning about PCK at university and from their experiences of teaching in schools. In this case, the structured framework together with ongoing opportunities for reflection about the process of their knowledge development supported deeper subject-matter understandings of these preservice teachers and a growing awareness of the value of PCK for teaching.

Conclusion

We conclude that research on the development of PCK presents an ambiguous picture. Obviously, teaching experience and subject-matter knowledge are important, but contextual and personal factors apparently may lead to quite different processes of knowledge development. The development of PCK is perhaps then best viewed as a complex interplay between knowledge of subject matter, teaching and learning, and context, and the way in which teachers combine and use this knowledge to express their expertise. In the context of preservice teacher education, PCK can be promoted by addressing both preservice teachers’ subject-matter knowledge and their educational beliefs, in combination with providing them with opportunities to gain teaching experience, and in particular, to reflect on these experiences. Specific workshops may serve as an intermediate measure, helping to initialize and frame subsequent teaching experiences.

At the level of specific topics, however, there is little research to inform us about the ways in which teachers transform subject-matter knowledge and how they relate their transformations to student understanding. Neither has there been specific input for teacher education in this respect. Instead, most recommendations regarding PCK development for preservice and in-service teacher education are of a rather general nature.

In our view, PCK implies a transformation of subject-matter knowledge so that it can be used effectively and flexibly in the communication process between teachers and learners during classroom practice. From this perspective, the main aim in studying teachers’ PCK is to understand how and why teachers teach a certain topic the way they do and, in particular, how their teaching approach is related to, or focused on, student learning. Achieving such an understanding is vital to the development of effective preservice and in-service programs.

However, much of the research on PCK so far has not served this purpose very well. This can be explained partly by the tacit nature of teachers’ personal professional knowledge, which has urged scholars to develop instruments and procedures that help to make this knowledge explicit and measure PCK in a valid manner, rather than exploring what the construct might offer to the practice of teaching and teacher education. In addition, it must be noted that PCK is quite sensitive to personal characteristics of teachers and their working contexts. Several studies (e.g., Henze, 2006) have reported substantial differences between the PCK of experienced teachers around the same topic area, even when their
subject-matter knowledge is similar and when they teach the same curriculum. These differences appear to stem from a range of factors including different orientations toward teaching, different purposes and practices.

Nevertheless, it seems possible to capture and portray PCK in such a way that key notions of teaching and learning a specific topic are made explicit (Van Driel et al., 1998). In addition, discussing and sharing such key notions among teachers may contribute to the establishment of a collective PCK, that is, a shared or common form of teachers' professional practical knowledge about teaching certain subject matter. At the same time, there should, of course, be room for individual teachers to adapt or complement this shared knowledge to their own situations (cf. the above-mentioned resource folios of Loughran and colleagues).

By introducing the construct of PCK, examining, analyzing, and modeling it in preservice teacher education practice (both at university and in school-based practice), it is more likely that teaching will be seen as a specialized and sophisticated practice. In this way, PCK may emerge as a way of thinking about teaching subject matter that encourages learning about teaching that goes beyond the acquisition of instructional strategies and techniques to include an understanding of how learners develop an insight in specific school subjects.

See also: A Pedagogy of Teacher Education; Contemporary Approaches to Teacher Professional Development; Experienced Teachers' Craft Knowledge; Science Teacher Education; Taking Prospective Teachers' Beliefs into Account in Teacher Education; Teacher Education and the Educational Foundations Knowledge Base.

Bibliography


Further Reading


