

1. PEDAGOGICAL CONTENT KNOWLEDGE: AN INTRODUCTION AND ORIENTATION

THE NATURE AND HISTORY OF PEDAGOGICAL CONTENT KNOWLEDGE

Human beings are inherently complex. We have history, background experiences, emotions, knowledge and goals. We make assumptions, recognize tradition, make sense of information, invoke beliefs, and take action. In some cases we recognize and can articulate the basis for our actions, in others we cannot, seeming to act on instinct.

To make sense of the teaching process and to understand the influence of teachers' knowledge on instruction, it is necessary to reduce the conceptual and contextual complexity of teaching: "scholars must necessarily narrow their scope, focus their view, and formulate a question far less complex than the form in which the world presents itself in practice" (Shulman 1986, p. 6). Knowledge, beliefs, attitudes and values, as well as a myriad of constructs are now used to help reduce, yet still communicate, this complexity. Unfortunately, such terms tend to be unclear and used inconsistently by researchers (Alexander, Schallert, & Hare, 1991).

The attempt to understand and reduce the complexity of teaching to enable its study has generated a variety of metaphors and models. Models of cognition are created from data interpretations, are proposed as conceptual tools to identify and discriminate among hypothesized constructs, and represent inferred relationships among constructs. For researchers, a fundamental task is to select, modify, or create a conceptual model from which to work. Good models, like good theories, organize knowledge in new ways, integrate previously disparate findings, suggest explanations, stimulate research, and reveal new relationships.

In 1986, a new model and set of hypothetical domains of teacher knowledge were offered by Lee Shulman. In reaction to the proliferation of generic educational research, Shulman argued that the study of "teachers' cognitive understanding of subject matter content and the relationships between such understanding and the instruction teachers provide for students" (1986a, p. 25) may be the "missing program" in educational research. He went on to differentiate and call for the study of three types of content understandings and their impact on classroom practice: subject matter knowledge, pedagogical knowledge, and curricular knowledge. Later model refinements renamed the constructs as subject matter knowledge, curricular knowledge, and pedagogical content knowledge (Shulman, 1986b). Of these, pedagogical content knowledge, the "subject matter *for teaching*" (1986b, p. 9, emphasis in original), has prompted considerable interest in both the arenas of research and practice. Shulman described pedagogical content knowledge (PCK) as

“the most useful forms of [content] representation..., the most powerful analogies, illustrations, examples, explanations, and demonstrations -- in a word, the ways of representing and formulating the subject that makes it comprehensible for others” (1986b, p 9).

Additional articles by Shulman and his colleagues provide evolving conceptions of the domains of teacher knowledge, the description of PCK, and its place within the constellation of knowledge categories for teaching. In 1987, PCK was listed by Shulman as one of seven knowledge bases for teaching, removing it as a subcategory and placing it on equal footing with content knowledge, general pedagogical knowledge, curricular knowledge, knowledge of learners, knowledge of educational contexts, and knowledge of the philosophical and historical aims of education. PCK was defined as:

that special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special form of professional understanding....Pedagogical content knowledge...identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue. (Shulman, 1987, p. 8)

Later work by Shulman and colleagues continued to explore PCK, sometimes subsuming it under content knowledge, but ultimately recognizing its role in the integration and transformation of other forms of knowledge (Wilson, Shulman, & Richert, 1987). The most comprehensive delineation of the knowledge bases for teaching and their interrelationships is found in Grossman (1990), where she defines “four general areas of teacher knowledge...as the cornerstones of the emerging work on professional knowledge for teaching: general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, and knowledge of context” (p. 5). Of the four knowledge bases, PCK was anticipated as having the greatest impact on teachers’ classroom actions.

In the 13 years since the publication of the *Third Handbook of Research on Teaching*, research into teachers’ understandings of subject matter knowledge within disciplines has proliferated. PCK is now a commonly accepted construct in the educational lexicon. Books and chapters have been dedicated to the exploration of teachers’ knowledge of subject matter in general (see Ball & McDiarmid, 1990; Brophy, 1991), and in specific disciplines (see Grossman, 1990). In addition, PCK has been used as a major organizing construct in reviews of the literature on teachers’ knowledge (see Borko & Putnam, 1995).

With a focus on science education, this book represents the first systematic attempt to synthesize the research on PCK and the model from which it was derived and trace its implications for research and practice. Specifically, this book addresses the following questions: What are current conceptions of PCK? What research exists to support PCK and the related constructs of teacher subject matter knowledge and pedagogical knowledge? How have researchers used both PCK and related constructs to develop lines of research on teacher thinking and learning? And, how

have visions of PCK been applied to teacher preparation program development and evaluation?

ORGANIZATION

Pedagogical Content Knowledge: The Construct and its Implications for Science Education is organized into three major sections: the literature, emerging lines of research in science teacher education, and the impacts of PCK on the development of science teacher education programs. Each section and its chapters are described below.

The Literature

Using subject matter knowledge, pedagogical knowledge, and PCK as primary divisions in the knowledge base for teaching, the first four chapters provide an overview of the research literature that exists within the field of science education and other disciplines. While science education remains a focus, research from mathematics, English, social studies, and reading are included where appropriate.

PCK is commonly believed to be a transformation of at least two constituent knowledge domains: general pedagogical knowledge and subject matter knowledge. Morine-Dersheimer and Kent (Chapter 2) open the literature review section with a careful examination of pedagogical knowledge and the presentation of their own model of its derivative components. They posit that the most important aspect of generic knowledge that impacts teaching is context-specific pedagogical knowledge. This knowledge is created through reflection, active processing and the integration of its two contributing components: general pedagogical knowledge and personal pedagogical knowledge. General pedagogical knowledge, gleaned from the research and scholarly literature on classroom organization and management, instructional models and strategies, and classroom communication and discourse, and typically presented in teacher preparation programs, is ultimately combined with personal pedagogical knowledge, which includes personal beliefs and perceptions about teaching. A critical and integrating aspect of pedagogical knowledge is teaching experience, where the subtleties of applying general pedagogical knowledge to classroom situations are learned. The result, context-specific pedagogical knowledge, assists in teacher decision making and contributes most directly to PCK.

In an examination of subject matter knowledge, Gess-Newsome (Chapter 3) concentrates on the instructional implications of secondary teachers' knowledge and beliefs. Synthesizing the literature in science, mathematics, social studies, and English, she suggests five overlapping categories of subject matter research: conceptual knowledge, subject matter structure, nature of the discipline, content-specific teaching orientations, and contextual influences on curricular implementation. Derived from an analysis of the research literature in science and other disciplines rather than from a philosophical position, these categories represent a

departure from the now traditional view of subject matter as falling into the three categories of content, syntactic and substantive structures (Grossman, 1990). Using teacher development as an analytical frame, three critical junctures in the preparation and development of teachers are identified: university content preparation, content-specific methods courses, and the induction period of teaching. Specific strategies and methods to increase the subject matter knowledge of teachers are described, as well as a consideration of theoretical issues surrounding subject matter knowledge research.

Both Chapters 2 and 3 use Shulman's model as a point of departure for further articulation of knowledge ascribed to each domain. The same is true for the review of PCK found in Chapter 4. Magnusson, Krajcik, and Borko argue for the uniqueness and importance of PCK within science education research and teacher preparation, taking a strong stance on the existence of PCK as a separate domain of knowledge that is iteratively fueled by its component parts: subject matter knowledge, pedagogical knowledge, and knowledge of context. Five aspects of PCK are identified and described: science curriculum, student understandings of specific science topics, assessment, instructional strategies for teaching science, and orientations toward science teaching. The value of PCK as a unique and identifiable construct is explored and a model of PCK development is forwarded.

The degree of overlap in construct articulation in the first three chapters requires mention. On the surface, both Chapters 2 and 4 include subcategories of instructional models and strategies, while Chapters 3 and 4 include teaching orientations. A careful analysis reveals a more substantial degree of overlapping of ideas and highlights the fuzzy borders between knowledge domains. This overlap demonstrates the difficulty of producing adequate definitions of complex concepts and of establishing clear, discrete, and manageable categories that avail themselves to examination. It also raises questions about this model of teacher knowledge itself. And, while the authors in this book recognize that assigning knowledge to categories is more easily accomplished in theory than practice, knowledge categorization itself has implications. Carlsen (Chapter 5) explores this issue when he claims that many researchers employ structuralist views of teacher knowledge -- where a knowledge domain is recognized and characterized in relation to other forms of knowledge and described independently from the individual. Carlsen challenges such views by contrasting them with views from a post-structural framework -- where knowledge is historically and politically situated, idiosyncratic, and embedded in a community as opposed to an individual. Within the post-structural framework, Carlsen examines the theoretical, political and historical background of PCK as it relates to the movement to professionalize teaching. While cautioning about the over reliance on structural models, Carlsen offers his own explication of the knowledge bases for teaching by adding subcategories that reflect recent developments in educational research, science education reform, and socio-cultural perspectives. Separately or juxtaposed, the chapters in this section offer contemporary views of PCK, expanding the conception from how it was originally proposed and providing evidence that a reexamination of the PCK model is perhaps warranted.

Emerging Lines of Research in Science Education

While arguments about the composition of and relationships among teachers' knowledge domains will continue, individuals and research teams have drawn upon the concept of PCK to design and conduct extensive research. The chapters in this section focus specifically on the use of PCK in science teacher education research and teaching. The section opens with an analysis of issues related to the assessment of PCK and concludes with descriptions of research conducted at the elementary and secondary levels.

Baxter and Lederman (Chapter 6) present a review of methods and techniques used for studying PCK and its related domain, subject matter knowledge. While acknowledging the difficulties of accessing teacher cognition, they identify three assessment categories: convergent and inferential measures; concept mapping, card sorts and pictorial representations; and multi-method evaluations with triangulation. Critiques of the assessments include incoming assumptions inherent in the measures, the accuracy of long term memory representation, the clarity or ambiguity of data analysis, and the strength of the assessment versus the intensity of labor in data collection and analysis. In addition to providing data for research, the authors observed that some assessments are useful as teacher development tools through their stimulation of thinking, reflection, and articulation of beliefs and knowledge. Implications of this review of PCK assessments has implications for the literature reported in the first section of this volume. Do all studies of PCK produce equally useful data? Can quantitative measures of PCK ever be effectively developed and interpreted? Baxter and Lederman conclude that, to be useful, measures of PCK must ultimately examine the interaction and consistency across teacher knowledge, belief and reasoned action.

Smith (Chapter 7) takes us on a personal and professional journey as a teacher and researcher of elementary science instruction. In her chapter, Smith explores teacher knowledge development and instructional strategies used to teach children content related to light and shadows. Four separate and interactive aspects of PCK are used in her analysis: illustrative content examples, curriculum and materials, children's naive ideas, and teaching strategies. Through the presentation of her own development as a teacher, researcher, and facilitator of teacher development, Smith reveals the critical dependence of PCK on accurate content understanding, the usefulness of PCK for teachers as they meet the challenges of teaching and changing their practice, and the recursive and reinforcing aspects of learning about content, teaching, and the teaching of content.

In Chapter 8, Lederman and Gess-Newsome trace their development as researchers in the examination of subject matter knowledge as it impacts teaching practice. Early studies revealed a mismatch between the superficial and fragmented subject matter knowledge held by beginning biology teachers and the deep and well-organized knowledge they needed for teaching. From the studies that followed, issues related to the development of subject matter knowledge, the ability of preservice teachers to implement instructional beliefs while struggling with classroom management, and the types of content understandings developed from

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