

3. SECONDARY TEACHERS' KNOWLEDGE AND BELIEFS ABOUT SUBJECT MATTER AND THEIR IMPACT ON INSTRUCTION

Early in my experiences as a university instructor I had the responsibility for leading a micro-teaching course. As the prospective secondary math and science teachers taught 20 minute lessons to their peers emulating the instructional models they had been taught, I was struck by the wide range of developing presentation skills, lesson creativity, content knowledge, and conceptions of teaching that were revealed in the lessons. Of this group, one student in particular caught my attention. Where other students were satisfied teaching traditional lessons such as the parts of the cell or how to apply the Pythagorean Theorem, Sarah's lessons compared and contrasted wild and domestic animals or evaluated different arrangements of natural areas for the attraction of wildlife. Later that year I asked Sarah about the unique teaching topic choices she had made during the class. A bit defensively she explained:

You know, I'm a biology major. I took all the required course work for my degree, and did quite well. But no one has ever explained to me what it is that I am expected to *teach* about biology. In micro-teaching, I selected lessons that I had seen in workshops or that other instructors had taught. I wasn't trying to be unique. I just didn't know what else to do.

Sarah's answer has intrigued me since that day. What *do* teachers know about the content that they are expected to teach? What lessons about content instruction do they take away from their personal experiences, time in formal education, and induction into the teaching profession? How do teachers perceive their content and how do these perceptions impact the manner in which they organize and deliver instruction? This chapter will examine the research on the knowledge and beliefs about subject matter held by secondary teachers and how this knowledge impacts classroom practice and student understanding.

HISTORICAL CONCEPTIONS OF SUBJECT MATTER KNOWLEDGE

Research on teachers' content knowledge is not new. The earliest attempts at defining good teaching systematically explored the relationship between teacher knowledge and student achievement. Described as the presage-product era of research, relationships were sought between the number and type of courses that

teachers took, their grade point averages, their scores on various standardized tests and student learning (Druva & Anderson, 1983; Dunkin & Biddle, 1974). Despite weak correlations, the intuitive belief in the relationship between teacher knowledge and student achievement has persisted. More recent extensions of this research (Ferguson & Womack, 1993; Guyton & Farokhi, 1978) have been undertaken, matching preservice teachers' academic performance to their teaching performance. Grades in the students' major accounted for less than 1% of the variance in teaching performance while grades in education courses seemed to be strong predictors of successful teaching. Despite the contributions made by such research to our understanding of teaching, the narrow operational definition of subject matter knowledge, often limited to factual knowledge, and inadequate measures of this understanding provide potential explanations for the decline of this paradigm (Wilson, Shulman & Rickert, 1987).

Research on subject matter understanding was abandoned during much of the process-product era of research only to reemerge later. Information processing research, and studies inspired by the teacher-as-decision-maker movement, brought renewed interest in the nature and influence of teacher content knowledge. Assuming that teachers' thoughts, decisions, and judgements guided classroom actions, Shavelson and Stern (1981) created a model of pedagogical decision making from the extant research literature. Differences in teachers' beliefs and conceptions about their subject matter were directly linked to teachers' judgements about content and were noted as a primary factor influencing planning. Unique to this research was the systematic examination of teachers' beliefs and their impact on practice as opposed to the simple measurement of subject matter knowledge. Two of the six recommendations from their review call for additional research that focuses on the integration of teachers' subject matter understanding and classroom practice, and an examination of the structure of the subject matter that teachers portray to their students.

In 1986, Shulman refocused the attention of researchers again on the importance of teachers' subject matter understandings. In an attempt to define the knowledge bases held by teachers, three initial areas of expertise were delineated: subject matter knowledge, pedagogical knowledge, and curricular knowledge (1986a, p. 26). The definition of content knowledge was expanded in future articles (Shulman, 1986b, p. 9) subsuming subject matter knowledge and curricular knowledge, and adding the new sub-category—pedagogical content knowledge. In 1987, Shulman identified a minimum of seven knowledge bases needed for teaching: content knowledge, pedagogical knowledge, curricular knowledge, pedagogical content knowledge, knowledge of students, knowledge of context, and knowledge of educational goals. Shulman and his colleagues initiated a rich line of research, reframing the definition of subject matter understanding to include the "nature, form, organization, and content of teacher knowledge" (Grossman, Wilson & Shulman, 1989, pp. 25-26). This broadened definition of subject matter knowledge avoided many of the pitfalls of earlier definitions and reopened the possibility of finding links between the knowledge teachers possess, the instructional actions they employ, and the learning, attitudes, and beliefs of the students they teach.

National reform movements across a number of disciplines have recently pushed issues of content knowledge to the forefront of educational concerns. Where early attempts to define subject matter knowledge were based on easily quantifiable measures, new conceptualizations of the advocated outcomes of schooling were portrayed using a new vocabulary. Goals such as science and mathematical literacy for all students, integrated understandings of the unifying concepts within a discipline, and participation in the discourse that surrounds the creation and evaluation of new knowledge have replaced the more simplistic indicators of knowledge such as GPA, national test scores, and rates of course completion (American Association for the Advancement of Science, 1990; National Council of Teachers of Mathematics, 1989; National Research Council, 1996). These changes in intended student outcomes demanded a change in the knowledge expectations and classroom practices of their teachers. Reciting endless lists of vocabulary terms, applying disconnected and meaningless algorithms, and memorizing the names, dates and places associated with fragmented historical events were no longer considered acceptable instructional practice. To teach as advocated by the reforms, teachers must hold deep and highly structured content knowledge that can be accessed flexibly and efficiently for the purposes of instruction (Sternberg & Horvath, 1995; Talbert, McLaughlin & Rowan, 1993). Such knowledge will be essential in order to teach for understanding and to provide authentic learning opportunities for students (Newmann, 1993; Talbert, McLaughlin & Rowan, 1993). Teachers will need to understand the structure and nature of their discipline, have skill in selecting and translating essential content into meaningful learning activities, maintain fluency in the discourse of the community, and recognize and highlight the applications of the field to the lives of their students.

Conceptions of teachers' subject matter knowledge have increased in complexity and sophistication, and so has the research base that supports our understanding of teachers and teacher education. This chapter will review the literature on secondary teachers' subject matter knowledge and beliefs and its impact on teaching. Though the borders among the constructs used to frame teachers' knowledge are fuzzy and perhaps more clearly defined in research than in practice (see McEwan & Bull, 1991), this chapter is limited to teachers' subject matter knowledge rather than pedagogical or pedagogical content knowledge, which are described more fully in Chapters 1, 2, 4 and 5 (this volume).

SELECTION OF RESEARCH AND ORGANIZATION OF THE REVIEW

Determining the best way to organize the literature surrounding teachers' subject matter understandings is not a simple task. For the purpose of this review, the literature has been organized into five broad but overlapping categories of teacher knowledge: conceptual knowledge, subject matter structure, nature of the discipline, content-specific orientations to teaching, and contextual influences on curricular implementation. In all cases, research seeking to relate teachers' knowledge or beliefs to classroom practice are highlighted.

Elementary and secondary teachers are different. In a review of the characteristics of teacher candidates as they enter their first methods course, Brookhart and Freeman (1992) found that both groups held high levels of confidence in their general teaching abilities and valued the nurturing and interpersonal aspects of the teachers' role more than the academic aspects. They differed in their general orientation to teaching, with elementary candidates being more child-centered and secondary candidates more subject-centered. Prospective secondary teachers, having taken more concentrated content-specific course work, held fewer reservations about their subject matter knowledge than their elementary counterparts.

Since elementary and secondary teachers have a different relationship with the content they teach established by their university preparation and their expectations for teaching, this chapter will only focus on the knowledge and beliefs of the secondary teacher. As a content specialist, secondary teachers are the most likely individuals to hold the complex knowledge needed to implement the goals outlined by the national reforms. Since teacher knowledge changes with time and experience, the literature reviewed in each section will progress from novice to the more experienced teacher in order to reveal potential developmental trends across a teacher's career continuum. Finally, in keeping with the organization of the book and the content expertise of the author, this review will focus primarily on studies that have been conducted in the area of science, but will be informed by the research that exists in other disciplines, primarily mathematics, English, and social studies. The chapter concludes with a discussion of the sources of teacher subject matter knowledge and beliefs across a career and the concomitant impact of content-specific knowledge and beliefs on classroom practice. Implications for teacher education research and practice close the chapter.

TEACHERS' KNOWLEDGE OF AND BELIEFS ABOUT SUBJECT MATTER: A CATEGORICAL OVERVIEW

Defining, characterizing, and categorizing teachers' knowledge of subject matter and distinguishing it from closely intertwined beliefs and attitudes has been the topic of numerous articles. Yet, there is no agreement about the definitions of knowledge and beliefs, their relationships, or their relative influence on teaching (Alexander & Dochy, 1995). For example, in a review of a line of research on the knowledge of mathematics teachers, Peterson, Fennema and Carpenter (1991) noted:

We were struck both by the influences of teachers' knowledge on their thinking about instruction, learning, and assessment, as well as by the pervasive influence of teachers' beliefs about students' knowledge; by the way in which teachers' thinking was influenced both by their beliefs and by their knowledge; and by the interconnections that seem to exist between knowledge and beliefs in the teachers' minds. (pp. 60-61)

They follow with the question, "Where does knowledge end and belief begin?" That such a distinction is difficult to make has implications for any categorization of the knowledge bases held by teachers.

Knowledge is most often described as evidential, dynamic, emotionally-neutral, internally structured, and develops with age and experience (Alexander, Schallert & Hare, 1991; Gagne & Glasser, 1987; Hiebert & Carpenter, 1992). Conceptual knowledge, or knowledge that is rich in relationships, is used in problem solving situations (Post & Cramer, 1989). The amount, organization and accessibility of conceptual knowledge has been shown to distinguish experts from novices (Eraut, 1994; Shuell, 1986). Beliefs, in contrast, are described as both evidential and non-evidential, static, emotionally-bound, organized into systems, and develop episodically (Nespor, 1987; Pajares, 1992). Beliefs have both affective and evaluative functions, acting as information filters and impacting how knowledge is used, organized and retrieved. Beliefs are also powerful predictors of behavior, in some cases reinforcing actions that are consistent with beliefs and in other cases allowing for belief compartmentalization, allowing for inconsistent behaviors to occur in different contexts.

Though the semblance of a simple dichotomy is portrayed by the above use of contrasting terms, the lines between teacher knowledge and beliefs become easily blurred when one looks at classroom practice (Bullough & Baughman, 1997; Grossman, 1990). This creates a conundrum since making distinctions between aspects of teacher's knowledge and beliefs is heuristically convenient for the study of teaching, though flawed in the potential misrepresentation of the dynamic interplay between the constructs that we wish to describe (Carlsen, 1991a). For the purposes of this review, no specific attempts will be made to categorically distinguish between knowledge and beliefs, using instead categories based on the structure of the discipline or the implementation of teacher knowledge and beliefs into classroom practice. Operational definitions of the five categories used in this review are presented below.

Conceptual Knowledge

For the purposes of this review, *conceptual knowledge* is defined as the facts, concepts, principles, and procedures that are typically taught in secondary school classrooms. This knowledge is assumed to be interconnected in nature, impacted by related beliefs, socially constructed, and personally integrated, distinguishing it from knowledge that is strictly declarative in nature (Alexander et al., 1991). This distinction is important since early attempts at establishing relationships between teacher declarative knowledge and teaching were unsuccessful, and richly integrated conceptual knowledge matches most closely the types of student outcomes advocated in the national school reforms. Finally, the rich connections of conceptual knowledge allows for its use in problem solving situations. Since teaching is clearly an ill-structured problem solving context, the organization of and access to stored conceptual knowledge plays a vital role in the reaction of teachers to teaching

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