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Exemplary high school mathematics teachers' reflections on teaching: A situated cognition perspective on content knowledge

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ABSTRACT

This study explored mathematical knowledge needed for teaching by seeking perspectives of exemplary high school mathematics teachers. Participants were 11 teachers in one region of the United States who had been recognized for their excellent teaching through standardized programs. In individual interviews, participants reflected on their teaching with consideration of the mathematical knowledge used. Interview questions about abstract mathematical knowledge were developed from a cognitive perspective, but these did not capture teachers' understandings. Instead, grounded analysis of teachers' reflections and a situated cognition perspective illuminated teachers' rich ways of knowing and using mathematics. This work illustrates how a change in research perspective can give insight into the affordances, rather than deficits, of teachers' mathematical knowledge.

1. Introduction

In many Western countries, the content preparation for teaching high school mathematics is comprised mostly or solely of the completion of an undergraduate degree in mathematics, yet it is unclear whether and how the knowledge that teachers develop during this preparation leads to high-quality mathematics instruction (Goulding, Hatch, & Rodd, 2003; Stacey, 2008; Zazkis & Leikin, 2010). To sufficiently prepare novices for high school mathematics teaching, it is important to better understand the mathematical knowledge that teaching requires. One approach to understanding this knowledge is to explore the mathematical knowledge used by expert teachers, but many questions remain about the mathematical knowledge expert teachers use and how this knowledge is used, particularly at the high school level (Petrou & Goulding, 2011; Stacey, 2008).

Mathematical knowledge needed for teaching has been a prominent topic in recent research, and several theoretical frameworks have been built by relying on researchers' expertise in interpreting teachers' knowledge (e.g., Ball, Thames, & Phelps, 2008; Ma, 1999; Rowland, 2007; Silverman & Thompson, 2008). However, some researchers caution that an understanding of teachers' mathematical knowledge built solely from a researcher's outside perspective may lead to deficit views of teachers' mathematical knowledge (e.g., Oslund, 2012; Simon & Tzur, 1999), and several scholars have noted that

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more research on teachers' perspectives would provide a useful and alternative viewpoint (e.g., Asikainen, Pehkonen, & Hirvonen, 2013; Clemente & Ramírez, 2008; Kajander, 2010). Yet research that seeks to understand mathematical knowledge from the point of view of expert teachers is limited.

To contribute in this area, this study was designed to understand exemplary teachers' perspectives on the mathematical content knowledge used in their teaching. We sought teachers' perspectives on both what content knowledge was used in teaching and how it was used. We found that our direct questions about content knowledge did not capture teachers' understandings. Instead, participants' reflections on their teaching illustrated rich ways of knowing and using mathematics. In this paper, we use a situated cognition perspective to illuminate mathematics-specific attunements that teachers expressed in their reflections. The situated cognition perspective helped to deepen our understanding of teachers' mathematical knowledge, and we suggest that challenging implicit research assumptions may give insight into affordances rather than deficits of teachers' mathematical knowledge.

2. Background

In recent decades, content knowledge for teaching has been explored from a variety of perspectives, including cognitive perspectives and situated cognition perspectives. In mathematics education, cognitive perspectives have pervaded research on teacher knowledge, particularly in the United States (Bednarz & Proulx, 2009; Depaepe, Verschaffel, & Kelchtermans, 2013; Sfard, 1998), but situated cognition perspectives are gaining momentum and offer different insights into teachers' understandings.

2.1. Cognitive perspective on knowledge

Researchers using cognitive perspectives view knowledge as abstract, able to be explicated, and transferrable (Ernest, 1998). A major goal of cognitive research is to codify and describe knowledge using taxonomies or schematic representations (Greeno & The Middle School Mathematics Through Applications Project Group [MMAP], 1998), and methods such as written assessments and task-based interviews are often used to explicate knowledge.

As a prominent example in the realm of mathematics teacher education, Ball and colleagues (e.g., Ball & Bass, 2002; Ball et al., 2008) developed a framework of *mathematical knowledge for teaching*, which includes both *content knowledge*—knowledge of the subject to be taught—and *pedagogical content knowledge* (PCK)—including knowledge of teaching the content, knowledge of how students learn the content, and knowledge of the curriculum (Ball et al., 2008). To study this knowledge, Ball and colleagues developed written assessments of mathematical knowledge for teaching, and they used results from these assessments to explore relationships between teacher knowledge and measures of instructional quality (Hill, Rowan, & Ball, 2005; Hill et al., 2008). Researchers in Germany have also used written assessments to identify the specific mathematical knowledge that impacts instruction (Baumert et al., 2010). Many other researchers working from a cognitive perspective have used task-based interviews to identify strengths and weaknesses in teachers' mathematical knowledge and tied this knowledge to teachers' pedagogical actions (e.g., Chinnappan & Lawson, 2005; Even, 1993; Lloyd & Wilson, 1998; Ma, 1999; Sánchez & Llinares, 2003).

Recently, some researchers working from a cognitive perspective have explored teachers' views on mathematical knowledge for teaching, but results from these studies are limited. For instance, through interviews with secondary mathematics teachers in Finland, Asikainen et al. (2013) found that teachers valued many types of knowledge emphasized by researchers, but that teachers "may lack the concepts needed to discuss teacher knowledge, even if they are expert in demonstrating effective teaching" (p. 88). In another study, Zazkis and Leikin (2010) interviewed high school teachers about how they used advanced (university-level) mathematical knowledge in their teaching. Although teachers described general ways their knowledge was used, they did not provide many specific examples.

At this point, it is useful to consider the implicit assumptions involved in taking a cognitive perspective on the mathematical knowledge needed for teaching: Mathematics teachers have a body of relevant mathematical knowledge that can be assessed, explicated, and abstracted outside of context and applied in tasks of teaching. This assumption can be used to explain exemplary teaching episodes, in which abstract mathematical knowledge is assumed to be an important resource for teachers' pedagogical choices, and less effective teaching episodes, in which teachers may be assumed to lack abstract mathematical knowledge needed to make more appropriate chocies. A cognitive perspective can also be used to justify the requirement that prospective mathematics teachers complete a large number of advanced mathematics courses that do not concern the teaching of mathematics. Although these courses do not directly inform prospective teachers on how they should teach, they do provide decontextualized mathematical resources that can later be applied in pedagogical situations.

2.2. Situated cognition perspective on knowledge

A second view of expert knowledge for teaching is aligned with *situated cognition*, which is built on the assumption that knowledge is situated in contextual environments where it is used (Greeno, 1991). Hence, researching knowledge involves understanding the activity in which knowledge is applied (Brown, Collins, & Duguid, 1989) and how knowledge is expressed in meaningful environments (Ernest, 1998; Frade & Da Rocha Falcão, 2008). With this perspective, Greeno and MMAP (1998) described learning as developing *attunements* to aspects of an environment. Attunements include both "well-coordinated