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The relation between content-specific and general teacher knowledge and skills

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HIGHLIGHTS

- 171 teachers were tested on content-related and general knowledge and skills.
- CFA distinguished between levels of generalizability across teaching situations.
- Domain-specific, assessment-specific and one-dimensional cognitive models fit worse.
- Grades in the teaching exam were positively related to situation-specific skills.
- General cognitive abilities were positively related to knowledge and skills.

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ABSTRACT

The relation between teacher knowledge and skills and how these were influenced by teacher education was examined with 171 secondary mathematics teachers. Six paper-and-pencil and video tests were applied to assess content knowledge, pedagogical content knowledge and general pedagogical knowledge as well as diagnostic, teaching and classroom management skills. It was hypothesized that the relation between these six cognitive facets was best approximated by distinguishing between levels of generalizability across different mathematics teaching situations. The data strongly supported this model in confirmatory factor analyses. The data also revealed the hypothesized differential relations between teacher cognitions and teacher education.

1. Introduction

In-depth research on teacher cognition that includes a broad range of knowledge and skills facets and does not only focus on, for example, content knowledge (e.g., Baumert et al., 2010; Hill, Rowan & Ball, 2005) or classroom-management skills (Evertson & Weinstein, 2009) is still scarce. Most studies available focused either on content-specific *or* on general pedagogical facets, and within these again either on knowledge *or* on skills. This research gap exists although it is well known that teacher performance in the classroom is based on the integration of a range of cognitive resources in addition to beliefs, values and motivation (Schoenfeld, 2010). How precisely the different facets of teachers' knowledge and skills are related to each other is therefore not known because they have rarely been assessed in one study.

Furthermore, due to the challenges related to direct testing of teachers, self-reported data is still the most common approach in teacher research although their reliability flaws are widely known. A first aim of the present study was against this background to directly test different facets of teacher cognition and then using this data to clarify their relation to each other.

A second aim of the study was to examine effects of different types of teacher education on the cognitive structure identified. In Germany where the present study took place, mathematics teachers

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achieve their credentials through two different pathways. Those with preparation as "upper- and lower-secondary teachers" (includes typically teaching in grades 5 through 12) tend to have stronger mathematical preparation in high school, spend more time studying advanced mathematics in college and have more experience in mathematics classrooms as part of their preparation compared to those prepared as "lower-secondary teachers" only (includes typically teaching in grades 5 through 9). Such differences in training may result in different relationships between knowledge and skills. In distinguishing between different groups of teachers, the study will therefore not only provide insight into the structure of teacher cognition but also into potential effects of teacher education. The more information about the structure of teacher cognition is available and how it is related to teacher education, the better initial teacher education and professional development activities can be developed tailored to teachers' needs.

2. Conceptual framework

Blömeke, Gustafsson and Shavelson (2015) integrated research on teacher expertise into teacher knowledge frameworks and distinguished between teacher knowledge as rather stable cognitive resources generalizable across different mathematics teachingsituations on the one hand and cognitive skills which are more related to very specific classroom situations and, thus, more variable on the other hand. This integrated framework served as a point of reference for the present study.

2.1. Facets of teacher knowledge

Research on teacher knowledge and how it is structured has become an important research field during the past 10 years, in particular with respect to mathematics teachers (e.g., Hill, Rowan, & Ball, 2005). Inspired by Shulman's (1987) conceptualization, Schoenfeld and Kilpatrick (2008) developed a framework that distinguished between two facets of content-specific knowledge, namely *mathematics content knowledge* (MCK) and *mathematics pedagogical content knowledge* (MPCK). MCK includes fundamental mathematical definitions, concepts, algorithms, and procedures whereas MPCK includes knowledge about how to teach these mathematical concepts and procedures to students.

One of the earliest large-scale teacher assessments – the international "Teacher Education and Development Study: Learning to Teach Mathematics" (TEDS-M) – used this framework (Tatto et al., 2008) and assessed MCK and MPCK of secondary mathematics teachers from 16 countries directly with paper-and-pencil tests using mainly multiple-choice items. MCK covered from a higher level the mathematical content of the grades the teachers would teach. MPCK covered the conveyance of mathematical concepts and methods. On the basis of Anderson and Krathwohl's (2001) framework of cognitive processes, TEDS-M items assessed knowing and remembering MCK and MPCK as well as understanding and applying MCK and MPCK (Döhrmann, Kaiser, & Blömeke, 2012). Higher-order cognitive processes such as creating and generating MCK and MPCK strategies were only rarely covered by the TEDS-M items. Döhrmann et al. (2012) characterized the tests therefore as one that assessed predominantly declarative knowledge. Results from TEDS-M pointed to medium or strong relations between MCK and MPCK in all countries but one (Pearson's $r = 0.37–0.70$; Blömeke, Kaiser & Lehmann, 2010).

Shulman (1987) had also conceptualized a general facet of teacher knowledge, namely *general pedagogical knowledge* (GPK), defined as "broad principles and strategies for classroom management and organization that transcend subject matter" (p. 8). Germany, Taiwan and the U.S. developed a corresponding paper-and-pencil test with mostly open-ended items and brief written classroom scenarios in the context of TEDS-M (Blömeke, Kaiser & Lehmann, 2010). The test covered the same cognitive processes as the main study but included also items and scenarios covering Anderson and Krathwohl's (2001) highest level of creating and generating instructional strategies. Blömeke, Kaiser & Lehmann (2010) characterized the test therefore as one that assessed declarative but also procedural knowledge. Results pointed to low to medium relations between GPK and MPCK or MCK ($r = 0.14–0.30$ or $0.11–0.29$).

2.2. Facets of cognitive skills

The body of studies examining teachers' cognitive skills has recently grown, in particular their skills to *perceive*, *interpret* and to make *decisions* with respect to general *classroom management* (*P-I-D CM*; Gold, Förster, & Holodynski, 2013; Stürmer, Könings, & Seidel, 2012) but also with respect to teachers' skills to *perceive*, *interpret* and to make *decisions* about *mathematics instruction* (*P-I-D math*). Mathematics instruction is to our knowledge the only content domain where this has been examined systematically. Kersting (2008) showed that mathematics teachers' skills of perceiving mathematics instruction were significantly positively correlated with their MCK. Sherin, Jacobs, and Philipp (2011) showed that perceiving mathematics instruction in turn predicted these teachers' performance in the classroom (see also Star & Strickland, 2008).

Drawing on expertise research, Krauss and Brunner (2011) distinguished another skill facet from those pointed out above, and this was mathematics teachers' *diagnostic* skills to identify student errors in *mathematics* (MDiagnose). Their data revealed that mastery of this skill facet could be identified through a speed component because the time teachers needed to diagnose students' mathematical errors differed significantly. This result reflects that experts can make rapid judgments based on a rich knowledge and skills base because they dispose of more cognitive chunks than novices (Clark & Lampert, 1986). Mentally grouping classroom situations overcomes the limits of short-term memory so that, with extended experience, experts can retrieve information more quickly and from a broader repertoire of critical incidents than novices. Expert teachers have therefore an idea about problems already prior to a lesson, for example about typical student errors and on which parts of a student solution to focus (Bromme, 1992). This skill facet is therefore more independent from specific classroom situation and can be regarded as rather generalizable. According to Krauss and Brunner (2011), this skill is significantly related to MCK.

2.3. Research gaps with respect to teacher knowledge and skills

Although a number of studies on the different facets of teacher knowledge or skills exist, it is widely unknown how general pedagogical and content-specific skills are related to each other and how these in turn are related to general pedagogical and content-specific knowledge facets because the facets are rarely examined within one study. The gap between general and content-specific research may partly go back to expertise research itself. Already De Groot (1946/1978) had defined expertise as a domain-specific construct. Later research confirmed that experts have difficulties to transfer their knowledge and skills from one domain to another (Glaser & Chi, 1988; Van Overschelde, Rawson, Dunlosky, & Hunt, 2005). However, the demands teachers are confronted with in a classroom require to combine a content-specific perspective on learning and instruction with a general pedagogical perspective on classroom management (Fauth, Decristan, Rieser, Klieme, & Büttner, 2014). The definition of a "domain" may therefore be different in the case of teachers than else in expertise research.