



The influence of preschool teachers' content knowledge and mathematical ability beliefs on their sensitivity to mathematics in children's play.

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HIGHLIGHTS

- We investigated preschool teacher's mathematical competencies.
- The competencies studied were professional knowledge, self-efficacy & self-concept.
- Teacher's math self-efficacy and self-concept were correlated.
- Content knowledge (CK) predicted teachers' sensitivity to mathematics.
- Self-efficacy mediated the relationship between CK and teachers' sensitivity.

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ABSTRACT

In countries with a social pedagogic tradition for early childhood education, mathematical learning typically takes place in play-based situations. Preschool teachers' ability to recognize mathematical content in children's play is therefore an important prerequisite for educational quality. The present study examines how this ability relates to other aspects of preschool teachers' professional competencies. Findings from regression analysis indicate that mathematical content knowledge (CK) predicts teachers' sensitivity to mathematical content. However, further analyses reveal that this association is mediated by preschool teachers' self-efficacy beliefs.

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1. Introduction

Learning in mathematics starts long before children enter school. Young children are capable of acquiring basic competencies in mathematics (Cross, Woods, & Schweingruber, 2009; Ginsburg, Lee, & Boyd, 2008) and these early mathematical fundamentals support later, more complex mathematical understanding in school (Clements, Sarama, & DiBiase, 2004; Cross et al., 2009; Duncan et al., 2007; Sylva et al., 2013). Consequently, early mathematical education has become an important objective of preschool

programs in many western countries (OECD, 2011). The positive effects of preschool programs for later mathematical achievement in school are documented in recent longitudinal studies (Anders, Grosse, Rossbach, Ebert, & Weinert, 2012; National Institute for Child Health and Human Development Early Child Care Research Network [NICHD ECCRN], 2005; Sammons et al., 2009; Sylva et al., 2013). These studies have also shown that the success of these programs depends on the quality of the pedagogical interactions between preschool teachers and children: Higher quality leading to higher learning gains for the children (Anders, Rossbach, et al., 2012; Melhuish et al., 2008; Sammons et al., 2009; Sylva et al., 2013). However, offering high quality mathematical education is a challenging task for preschool teachers and requires a number of competencies (Cross et al., 2009). The specific competencies required depend on the preschool setting and these settings can

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vary between countries. Countries such as Australia, Canada, Germany, Korea, Sweden, Norway and Poland emphasize a child-centered approach in their curriculums (OECD, 2011). In these countries early mathematical learning is typically play-based, embedded in life situations and building up on children's interests. Preschool teachers are therefore required to integrate early mathematical education in children's every day play activities (Ginsburg et al., 2008; McCray & Chen, 2012; McCray, 2008). Yet, in order to help young children engage in mathematics during play, preschool teachers need to be able to recognize the mathematical elements in children's play themselves (McCray & Chen, 2012). In a recent study McCray and Chen (2012) showed that preschool teachers' ability to recognize mathematical content in children's play activities predicted the quality of early mathematical learning situations and children's learning gains. This ability is thus considered an important aspect of preschool teachers' professional competencies, more specifically, of their pedagogical content knowledge (PCK) (McCray, 2008). However, we currently know very little about which other aspects of preschool teachers' professional competencies are important for preschool teachers' ability to recognize mathematical content in children's play.

There is evidence that mathematical content knowledge (CK) is an important prerequisite for preschool teachers' PCK (Shulman, 1986; Siraj-Blatchford, Sylva, Muttock, Gilden, & Bell, 2002). Recognizing mathematical content in play-based situations requires mathematical CK. Moreover, preschool teachers can only implement early mathematical learning, if they have a conceptual understanding of the mathematical content they are required to teach (Cross et al., 2009).

In addition to mathematical CK, preschool teachers' beliefs are considered important as they guide and motivate daily pedagogical interactions (Fives & Buehl, 2012). According to the social cognitive theory, beliefs about ability in particular predict human motivation and action (Bandura, 1986). With regard to teaching, preschool teachers' math-related ability beliefs might influence their motivation and effort to initiate early mathematical learning situations. For instance, preschool teachers might only seize mathematics in play-based situations if they judge their mathematical ability to be sufficient for teaching early mathematics. In contrast, preschool teachers who consider their ability in mathematics to be low – regardless of their actual mathematical ability – might avoid mathematics and not recognize it in play-based situations. Therefore we assume that preschool teachers' mathematical ability beliefs play an important role for their sensitivity to mathematical content in play-based situations.

In this article we explore how preschool teachers' mathematical content knowledge (CK) and their mathematical ability beliefs are interrelated and how they affect preschool teachers' sensitivity to mathematics in play-based situations, as one aspect of their pedagogical content knowledge (PCK). In the following we outline the current state of research on preschool teachers' professional knowledge and ability beliefs. Finally, we introduce the theoretical framework for the study and formulate our research questions.

1.1. Preschool teachers' professional knowledge

Preschool teachers' professional knowledge is considered an important prerequisite for the quality of early childhood education (Lee, 2010; Siraj-Blatchford et al., 2002). Preschool teachers require an understanding of the concepts relevant to preschool education, of children's learning and development, and of effective pedagogy in order to initiate appropriate learning opportunities (McCray & Chen, 2012; Sylva et al., 2013). With regard to teaching early mathematics, two aspects of preschool teachers' professional knowledge are considered particularly important for the

educational quality: Their mathematical content knowledge (CK) and their math-related pedagogical content knowledge (PCK) (Cross et al., 2009; Lee, 2010; McCray & Chen, 2012). The concepts of CK and PCK draw on Shulman's (1986, 1987) framework for schoolteachers' professional knowledge and were also adapted to the context of preschool education (Siraj-Blatchford et al., 2002).

In his framework Shulman (1987) defines CK as the necessary subject matter knowledge base for teaching, whereas PCK refers to the "blending of content and pedagogy" (p. 8) into an understanding of how topics are best presented to learners. This suggests that mathematical CK is necessary for teaching mathematics, but mathematical CK alone does not guarantee high quality instruction. For instance, teachers require knowledge of basic mathematical concepts like addition and subtraction. However, mere mathematical CK of addition and subtraction does not guarantee that they can adequately explain these concepts to children. It is mathematical PCK of addition and subtraction that is required for effective mathematical instruction. Consequently, in the context of primary and secondary school education, mathematical PCK is considered a key prerequisite for high quality mathematical education (Ball, Lubienski, & Mewborn, 2001). Moreover, schoolteachers' mathematical PCK has been shown to be directly related to the instructional quality and students' learning gains (Baumert et al., 2010; Hill, Rowan, & Ball, 2005). For instance, results from the German COACTIV study revealed a substantial positive effect of teachers' PCK on instructional quality (Baumert et al., 2010). However, no direct effect on instructional quality was found for mathematical CK (Baumert et al., 2010). Similar results were obtained in a study by Hill et al. (2005) who showed that elementary teachers' PCK predicted students' learning gains during the first and third grade after controlling for key student and teacher level covariates.

Although these studies focus on elementary level schoolteachers, it is conceivable that similar mechanisms exist for preschool teachers' professional knowledge. Nevertheless, when transferring the concepts of CK and PCK to early mathematical education, one needs to take into account the particular characteristics of preschool education. There are currently two different approaches in the literature that conceptualize aspects of PCK relevant to preschool teachers. Lee (2010) proposes a concept of mathematical PCK that is very similar to the original definition of PCK by Shulman (1987). According to Lee (2010) preschool teachers need to know "how to teach or transfer knowledge to the target children" in an understandable manner (p. 29). Whereas Lee's (2010) concept might be suitable for preschool contexts which apply a teacher-directed approach that focuses on direct instruction, this might be less the case for child-centered approaches which emphasize play-based learning. Child-centered approaches are implemented in countries that inherited a social-pedagogy tradition (i.e. Australia, Canada, Germany, Korea, Sweden, Norway, Poland; see OECD, 2011). As this study is situated in Germany, we draw on McCray and Chen's (2012) concept of preschool teachers' mathematical PCK. According to McCray and Chen (2012), mathematical PCK represents preschool teachers' ability to help children "recognize, name, and experiment with the mathematics in their classroom environment" (McCray & Chen, 2012, p. 292). As early mathematical learning often takes place in children's play, teachers' ability to analyze children's play and recognize mathematical content suited for early mathematical education is an important aspect of their PCK (McCray, 2008). Based on this concept, McCray (2008) developed an interview that measures preschool teachers' ability to recognize mathematical content in a children's play scenario task. Using this instrument, McCray and Chen (2012) showed that preschool teachers' ability to recognize mathematics in children's play, as one aspect of their PCK, predicts process quality and children's learning gains.

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