

## Pre-Primary School Teachers' Pedagogical Content Knowledge in Teaching Mathematics: A Review of Literature

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### Abstract

This paper reviews and analyzes the literature on pre-primary teachers' pedagogical content knowledge (PCK) in teaching mathematics at the pre-primary level. It examines the nature of mathematical content pre-primary teachers have to master and the strategies that are considered to be helpful to children to effectively learn the subject at the pre-primary level. The review showed that pre-primary mathematics plays a vital role in building a solid foundation for children's future learning. It has been shown that many pre-primary teachers lack the PCK in teaching mathematics at this level. Therefore, after reporting on the teacher competencies needed to improve teaching and learning of early years mathematics, some educational implications and recommendations for effective teaching and learning pre-primary mathematics are outlined.

Keywords pre-primary mathematics; pedagogical content knowledge; pre-primary teachers; teaching and learning

### Introduction

Mathematics plays an utmost role in helping learners develop necessary skills for lifelong learning and is an important tool for learners to develop higher-level thinking skills (Kusmanyono, 2014). It was highlighted that the majority of learners do not fail to understand mathematical concepts being taught when the high quality of mathematics education starts from pre-primary schools (Clements & Sarama, 2013). In the same regard, pre-primary teachers' quality in terms of teaching experience, mastery of the content, and skills of delivering it is among the most critical variables to improve learner's achievement (Darling-Hammond, 2000). Even though governments in the world recognize this level of education, it is not formalized and systematized in the entire education spectrum, which makes it hard to consider pre-primary as part of the formal

education and training system (Kitta, 2004). Formal pre-primary education cannot be discussed in the isolation from qualified teachers. The study conducted by Darling-Hammond and Sykes (2003), claimed that qualified teachers are those who possess both good pedagogical information and content understanding. Content knowledge is the knowledge of subject matter which teachers have to deeply understand to develop their learners' mindset during teaching and learning (Shulman, 1987), whereas pedagogical knowledge refers to teacher's required knowledge of applying effective methods of delivering the content, classroom management, and assessing learners (Koehler et al., 2013). The pedagogical content knowledge (PCK) was initially introduced by Shulman (1986) and was defined as the teacher's knowledge of how to break down the

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subject to make it more understandable to learners (Shulman, 1987).

According to McCray and Chen (2012), Pedagogical content knowledge is positively related to children's outcomes. However, in many countries, pre-primary school teachers were not considered even when there were special pieces of training regarding teaching pre-primary mathematics (Oppermann et al., 2016). Additionally, there were very few researches that focused on pre-primary teachers' PCK in teaching mathematics (Lee, 2010), and in the study conducted by Dağlı et al. (2019), it has been shown that in many different studies conducted on pre-primary mathematics subject, only two studies were conducted on teachers' PCK of mathematics. For instance, in the Rwandan educational system, there is no kind of study conducted on pre-primary school teachers' PCK. Therefore, this current study has a great significant contribution to pre-primary school teachers to be aware of what knowledge is necessary for them to help children to have a good conceptual understanding of mathematics by considering the special characteristics of teaching pre-primary grade (Dağlı et al., 2019).

### **Why Pre-primary education?**

Every child has the legal right to attend pre-primary education (Björklund, 2015). To him, Björklund (2015) defined pre-primary education as a practice positioned in the period between pre-school and primary education. In line with Haque et al. (2013)'s views, Pre-primary education is a smooth transition to primary education. Fitzsimmons et al. (2017) reiterate that pre-primary education was found to be very crucial for children as it develops essential skills and prepares them for their future academic endeavors. Moreover, Haque et al. (2013) argue that pre-primary education has a purpose to prepare children to avoid their

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poor performance in their primary education and other high levels of education. Therefore, pre-primary education was found to be a required area of intervention for the success of other levels of education (Haque et al., 2013).

### **Teachers with mathematics content in pre-primary school**

Studies on mathematical content areas designed for teaching pre-primary children have been conducted (Keller et al., 2001; Jang, 2013). The studies showed that pre-primary mathematics content consists of five areas such as 1) Numbers and operations, 2) Patterns, 3) Measurement, 4) Geometry and spatial sense, and 5) Data analysis. However, there is a consensus across all countries that the concepts of numbers and operations, geometry and pattern, data and probability, and measurement are the most important mathematics content areas for which pre-primary teachers have to master to meet their curricular goals (Oppermann et al., 2016). Pre-primary mathematics education was found to be a helpful content since it is through mathematics that children construct a solid base for school achievement. Numbers and operations come first when delivering the pre-primary mathematics content because they prepare a basis for children's prospect of educational achievements in mathematics (Yilmaz, 2017) and it was highlighted that teachers' understanding of the concepts of numbers and operations helps them create the foundation of young children's math understanding (Maclellan, 2012).

According to Graven (2016), the progress of numbers and operations begins at the pre-primary level where children are aware of numbers and pleasure for functioning with numbers when they count objects, add and take away small numbers. Further, learning to count enables children to develop the language of numbers and leads the children to

take a grasp on the meanings of songs they sang before starting school, makes the children know more numbers through counting, and it helps the children know how they can solve the different mathematical equations. However, it was found that teachers still have gaps in teaching numbers and operations (MacLellan, 2012). Thus, teachers need to possess a special kind of knowledge relevant to the level of pre-primary children and also to the mathematics content areas discussed here especially the area of numbers and operations as it helps children to easily understand other mathematics content areas.

### **The required pedagogy to teach mathematics in pre-primary education**

Studies underpinned different methods and techniques that pre-primary teachers have to apply to enhance children's understanding of mathematical concepts (Anders & Rossbach, 2015; Chin & Zakaria, 2015; Fitzsimmons et al., 2017). In pre-primary education, the learning of pre-primary children usually takes place in playing situations (Anders & Rossbach, 2015). This method of teaching was seen as basic to high-quality mathematics pedagogy in pre-primary education, as it makes children more interactive and motivated (Dağlı et al., 2019).

In their study, Fitzsimmons et al. (2017) explained that engaging children in important play help children to discover, create, and expand their learning and it supports children's emotional and physical development. It was also recommended that teaching and learning with the games approach in manipulative form, is one of the suitable strategies that help children at the pre-primary level because they require concrete materials that help learners to master the content (Chin & Zakaria, 2015). The effective way of teaching mathematics at the pre-primary level is to integrate mathematics with other subjects since it is in this way that teachers explain to the children the relevance

of mathematics (Jang, 2013). In line with Lee (2010)'s view, teachers who correlate math subjects with children's daily lives, make mathematics subject more significant for young children.

In the study conducted by Björklund (2015), it was found that teachers' participation in children's activities gives them the ability to instigate and explain mathematical concepts, thoughts, as well as main beliefs to the children in sympathetic ways. The same study revealed that children improve their learning when they take pleasure in the activities they are involved in. Equally, Dağlı et al. (2019) explained that children understand pre-primary mathematics content mostly by doing and experiencing personally. To this end, it requires teachers who are competent to lead children to better academic performance.

### **Pre-primary teachers' competencies needed for teaching mathematics.**

Teacher competencies is a set of cognition, orientation, and skills that teacher can achieve in the process of education to promote the physical, intellectual, emotional, social, and spiritual development of learners (Moghtadaie & Taji, 2018). As pre-primary mathematics content is needed for future academic success, pre-primary school teachers are expected to be equipped with specific competencies in terms of knowledge, skills, and attitudes (Lillvist et al., 2014), to offer learning opportunities that foster all dimensional developments of the learners (Bertschy et al., 2013). Teachers' competence is the main factor for pre-primary children since it is from it that a teacher can determine the key features such as knowing what, knowing why, and knowing how to lead and organize pre-primary school activities with children (Lillvist et al., 2014).

The study carried out by Ukobizaba et al. (2019) on teachers' activities that make children develop a conceptual understanding of mathematical content showed that

providing tasks that facilitate learners to develop, making mathematics significant, and making a link between mathematics topics with learners' daily experiences characterize effective mathematics teachers. In the same pipeline, in her study on what kinds of knowledge pre-primary teachers need to have when they are working with children mathematical learning, it was shown by Björklund (2015) that pre-primary teachers who participate in children's activities gain opportunities to introduce mathematical concepts to the children in meaningful situations. Additionally, effective teachers provide everyday activities to offer prosperous chances to children to carry out and build up numerical competencies. Hence, it requires the special kind of teacher knowledge that includes all these competencies to help teachers facilitate children in their learning process.

### **Different models of teaching and learning mathematics in pre-primary schools**

Studies have investigated teachers' knowledge including pedagogical content knowledge (Chikiwa et al., 2019; Maniraho, 2017; Sen & Samanta, 2015). The pedagogical content knowledge as it has been explained earlier was firstly conceived by Shulman (1986). In his model, Shulman described how teachers can use analogies, representations, illustrations, demonstrations, and give examples and explanations about the subject matter to be taught to effectively offer it to learners. Building from Shulman's (1986) views about teachers' Pedagogical content knowledge, many studies agree that PCK is the teacher's knowledge which is in the connection between content knowledge and pedagogical knowledge (Lee, 2010; McCray & Chen, 2012; Tian & Huang, 2019).

Studies on teachers' PCK for teaching and learning mathematics have been conducted

*Mukandayambaje, E. & Maniraho, J. F.* (Danışman & Tanişli, 2017; Maniraho, 2017; Ramdhany, 2010; Sutawidjaja & Irawati, 2017) and it has been reported that teachers' mathematical knowledge is essential but not enough to teach mathematics. PCK is the teacher's knowledge required to make the content (like mathematics) reachable to learners (Krauss et al. 2008). Shulman (1987) developed a model consisting of seven different types of teacher knowledge including the PCK category. Building on Shulman's model, Ball et al. (2008) developed a model focusing on the type of professional knowledge required by teachers for teaching mathematics subjects. In their model, they described the sub-categories of PCK which are: knowledge of content and student (KCS), knowledge of content and curriculum (KCC), and knowledge of content and teaching (KCT).

Some studies done on investigating teachers' PCK in teaching mathematics were conducted through PCK's sub-categories (Chikiwa, 2017; Maniraho, 2017). For instance, (Maniraho, 2017) (Maniraho, 2017) opted to use KCS and KCT in his study because these two sub-categories reflect both teachers' theoretical and practical PCK. Teachers' theoretical PCK is determined by the teachers' orientations towards their lesson plans, curriculum, and knowledge of misconceptions and difficulties presented by the learners, whereas teachers' practical PCK is the teachers' practice of teaching in the classroom and actions that respond to learners' mistakes (Ramdhany, 2010). Also, if teachers have self-confidence in their mathematical capacity their children also feel confident in the content being taught (Oppermann, et al., 2016) since teachers' lack of mathematical content for teaching leads their learners to poor performance in mathematics (Asante & Mereku, 2012). Therefore, teachers need to have PCK for

mathematics content and learning activities as it plays a great function not only in their teaching but also in their learners' achievement.

### **The insufficient of competencies among pre-primary teachers**

Studies on teachers' competencies in teaching mathematics at the pre-primary level have been conducted (Lee, 2010; Tian & Huang, 2019). Several types of researches showed that pre-primary teachers have a low conceptual understanding of pre-primary mathematical content (Lee, 2010; Bäckman, 2012; Anders & Rossbach, 2015; Oppermann et al., 2016; Zhang, 2016; Tian & Huang, 2019). Despite the crucial role of teachers' conceptual perception of initial math in predicting children's learning at the classroom level, the study conducted by Zhang (2015), revealed that teachers lacked a full consideration of basic knowledge in mathematics, children arithmetical learning, and effectual arithmetical instruction strategies. Again, Tian and Huang (2019) observed that pre-primary teachers lacked a profound understanding of PCK in early grade mathematics. In their study, Tian and Huang (2019) argued that pre-primary teachers lacked a serious analysis and, conversely, focused on general teaching methods rather than mathematical concepts.

The study carried out by Clements et al. (2014) on early grade background research with emphasis on mathematics, explained that nearly all of the early childhood teachers lacked adequate comprehensive knowledge of mathematical learning strategies, and more specifically, they detected those early childhood teachers did not hold a practical procedure for identifying and addressing the difficulties that children encountered with mathematical problems. For instance, in the studies conducted by Lee (2010), Anders and Rossbach (2015), Oppermann et al. (2016), Zhang, (2016), and Tian and Huang (2019), only questionnaires were used as an

assessment tool for measuring pre-preprimary teachers' PCK and this showed that pre-primary teachers' practical PCK was not considered. Clearly, even if the study carried out by Sumpter (2019) on teachers' emotional direction towards mathematics showed that most pre-primary school teachers articulated a positive connection towards mathematics, pre-primary teachers' PCK is still low.

### **A way forward to developing competencies among pre-primary teachers**

Successful recognition of what positively affects teachers' PCK empowers teachers to successfully implement their appropriate teaching strategies. Even if the level of education and years of teaching experiences were found to be the most pointers of high PCK in mathematics Lee (2010), Danışman and Tanişli (2017), and Kultsum (2017) declared out that content knowledge is one of the important factors that expand more teachers' awareness of increasing their professionalism since it positively influences the teaching and learning process. Likewise, Osmanovic (2018) pointed out that reflective practice of teaching quality positively contributes to the professional learning and development of teachers. The author added that a reflective practice about the way of teaching serves as a tool to test solutions and different ways of working to improve the process of learning and teaching. Also, Andronache et al. (2014) argued that a positive attitude towards teachers' profession plays a crucial role in helping teachers to easily develop their future children's intrinsic stimulus for learning. Furthermore, Kingsley (2018) observed that teacher's positive attitude towards the profession can be exhibited by teachers' job satisfaction because factors such as irregular payment of salaries, poor conditions of school facilities, etc., do not stimulate teachers and make lesser their confidence in their work. According to Soibamcha (2016), the success of education

depends on the teachers' effort as they are the key persons who supply quality education. Therefore, continuing progression development is a way to develop teachers as professionals by improving their teaching abilities in the class (Mahlase, 2014).

### **Conclusion**

The present study reviewed the Pre-primary school teachers' pedagogical content knowledge (PCK) to effectively teach and learn mathematics. The analysis of the reviewed literature showed that Pre-primary mathematics is a helpful subject since it is through mathematics that children construct a solid base for school achievement. Pre-primary teachers need to be equipped with pedagogical content knowledge to be able to transform the mathematical content into a form that is understandable to young children for the sake of helping them develop mathematical skills that lead them to successful learning. It was also reviewed that Pre-primary teachers' pedagogical content knowledge of mathematics is a great knowledge for children's mathematics achievement. Even if the literature showed that numbers and operations prepare a basis for pre-primary children's prospect of educational achievements in mathematics, however, it was noticed that pre-primary teachers' PCK of mathematics showed that pre-primary teachers have a low conceptual understanding of pre-primary mathematics content.

### **Educational Implications and Recommendations**

The present study on pre-primary teachers' pedagogical content knowledge has some important implications on teaching and learning of pre-primary mathematics content. To this end, the paper is significant for all pre-primary educators and researchers in mathematics education.

- Pre-primary school teachers' should acknowledge and take into consideration the crucial role of PCK in children's activities to boost their capacity of creating effective classroom management that strongly

supports children's learning achievement.

- Pre-service and in-service pre-primary teachers need to be trained on pre-primary mathematics pedagogical content knowledge to bridge the gaps shown by the literature regarding the problem they have, concerning their pedagogical content knowledge in mathematics subject.
- There is an important need for further research on pre-primary teachers' PCK on numbers and operations because this area plays a significant role in children's mathematics achievement and further learning of mathematics at the primary level.

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