

The pedagogical content knowledge (PCK) of nursery school teachers in teaching and learning of geometry: A review of literature

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Abstract

This article explores studies that investigated pedagogical content knowledge (PCK) of teachers, especially those at the nursery level, in teaching and learning mathematics, specifically geometry. It represents a review of literature on what is PCK, and its effectiveness in teaching and learning of mathematics specifically geometry in early foundation of education. We discussed about what different studies found on PCK of nursery school teachers. We conclude that children at nursery level need to be taught by the experienced and more educated teachers. Also, to better assist them it is essential to provide ongoing trainings, and they should acquire PCK more effectively during their study before they begin teaching services.

Keywords mathematics, geometry, nursery school teachers, pedagogical content knowledge

Introduction

Teacher knowledge is a key factor which influences student's academic achievement (Joohi, 2010). Rendering to Shulman (1987), this knowledge can be classified into seven types: knowledge of content, knowledge of pedagogy, knowledge of curriculum, knowledge of pedagogical content, knowledge of learners, knowledge of educational contexts, and knowledge of educational aims. The study focused on pedagogical content knowledge (PCK) apart from other categories of knowledge as it is the type of knowledge most prospective to differentiate the understanding of the specific content from that of the pedagogy for teaching that content. Nursery student's upcoming appreciative of mathematics especially Geometry requires an early foundation built on an excellent, inspiring, and teacher who have an effective PCK. However, some

teachers are not able to define geometric shapes. They have some misconceptions regarding geometric shapes (Cantürk-günhan & Çetingöz, 2013). Therefore, this study aimed to under-see the mathematics teachers' PCK at the foundation level of education in teaching and learning of geometry.

Children's performance in mathematics is greatly influenced by their mathematics teachers' both content and pedagogical knowledge to teach mathematics (Baumer & Mareike, 2013; Keller et al., 2016; Ngware et al., 2008). The teacher who is expected to teach topic matter to students need to prove knowledge of that topic. Even if theories' knowledge and different approaches of teaching are essential to play a secondary role for a teacher to be qualified (Shulman, 1986). However, the literature shows that better PCK of the teacher results in higher children's academic performance (Baumer & Mareike,

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2013; Keller et al., 2016; Ngware et al., 2008). Children begin to learn math earlier as soon as they start an elementary school. Preliminary from infancy and continuing during the course of the nursery school education. It is at this period when children start to develop basic skills, concepts and misconception about math. Nowadays, the majority of parents have realized the importance of nursery school education as the foundation for their children for further learning. That is why nursery school teachers are getting more demand to have good competences in teaching. It is understandable that, how students accomplish their tasks at a higher education level depends a lot to their elementary education practices, especially in nursery school education. Therefore, you can't expect to have future strong mathematicians when you did not train or construct the early foundation mathematics in young children.

Significance of the study and research questions

One of the most important levels of education that help in building human capital and contribute towards the attainment of the knowledge-based economy is pre-primary education (MINEDUC, 2018). Knowing that children's performance in mathematics is greatly influenced by their mathematics teacher's PCK (Baumer & Mareike, 2013; Keller et al., 2016; Ngware et al., 2008). The literature has shown that many students have poor performance and mathematics anxiety during their elementary studies (Jolejole-Caube et al., 2019; Joohi, 2010; Reyes, 2019). We therefore ask ourselves if the student's poor performance is linked to lack of PCK for their mathematics teachers at the level where they are, or if it is the result of how students were taught during their elementary education. To this end, the researcher aims at carrying out this study especially at nursery level with the purpose to describe the PCK of nursery teachers in teaching and learning of

mathematics especially geometry, which affects children's achievement. Therefore, the research problem was to under-see the nursery school mathematics teachers' PCK at the foundation level of education in teaching and learning of geometry. The researcher chose to carry out this research at nursery schools' level because as mentioned above this is the foundation level of education.

However; based on the definition of PCK as introduced by Shulman (1987), Gess-newsome (2002, p.6) argued that PCK has three components explicitly knowledge of content, knowledge of pedagogy, and knowledge of context. The same for Yusof & Zakaria (2015, p.27), and for them they considered knowledge of context as student knowledge. This study aims to examine the PCK of nursery school' mathematics teachers. However, at my knowledge, there is few researches of this kind conducted in nursery schools. As a motivation that the findings and recommendations of this study will be helpful to the Ministry of education for the effective development of nursery school mathematics teachers.

The meaning of Pedagogical Content Knowledge (PCK)

Gess-newsome(2002) suggested that for a teacher after having content knowledge s/he must ask him/herself the following questions:

- What are the prerequisites of my children and what will be difficult or easier for them?
- What shall I do to help my children comprehend this idea?
- What resources are there to assist me?
- How shall I evaluate what my children have learned?

These questions are describing the knowledge base for a teacher and distinguish a work of teacher from that of a subject matter specialist such knowledge is commonly known as PCK. Simply PCK is a teacher's awareness of

means to support schoolchildren comprehend the particular subject matter. It is commonly believed to be an integration of common knowledge of pedagogy and knowledge of subject matter (Gess-newsome, 2002; Shulman, 1987; Yusof & Zakaria, 2015).

According to Shulman (1986), PCK has three elements namely: knowledge of the subject matter; knowledge of pedagogy (teaching approaches), and knowledge of the learner. However, Grossman, Comeaux, & College (1990) argued that the concept of PCK includes four major components: knowledge of why subject must be taught; knowledge of the learners' conceptions and misconceptions; knowledge of the subject curriculum; as well as knowledge of instructional strategies. Pinamang & Penrose, (2017); Sibuyi, (2012) argued that some teachers have satisfactory knowledge of subject matter but have inadequate teaching approaches knowledge and children's misconceptions knowledge on the specific subject topics that they taught. Also, it is known that the lack of subject matter knowledge disturbs other forms of teacher's knowledge (Carpenter et al., 1989).

According to Shulman (1987), PCK is the mixture of knowledge of content plus knowledge of pedagogy for a better understanding of how a certain topic or issue is organized to the interest and ability of the learner. PCK connects the content knowledge of the specific subject with the practice of teaching that subject (Ball et al., 2008). However it was found that knowledge of mathematics (content knowledge) is obligatory but not enough to effectively teach mathematics (Ye, 2019), that is why a PCK is regarded as the complex interaction of three basic forms of knowledge: (i) subject matter knowledge; (ii) teaching approaches

knowledge, and (iii) knowledge of learner which goes beyond of being in isolation (Joohee Lee, 2010; Shulman, 1987).

Hence, it is the responsibility of the teacher to use and integrate those elements (see Figure 1) in order to be a productive and effective

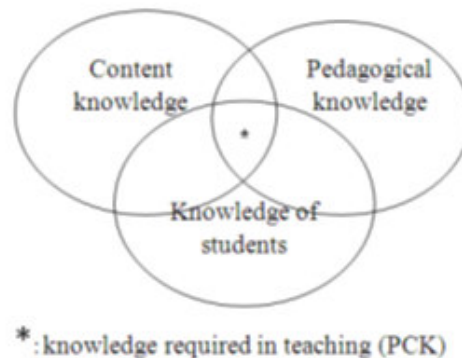


Figure 1 Schematic diagram showing the interdependence of the three PCK elements; Yusof & Zakaria (2015)

teacher. Effective use of PCK around a specific subject (Mathematics) requires developing a dynamic connection among these three forms of knowledge located in irreplaceable contexts. To guarantee that every circumstance is unique, and no particular mixture of content and pedagogy will apply for every teacher, every course, or every teaching view. Thus for effective teaching, the teacher must possess both the mastery of the content to be taught and be able to explain it so that it can be understood by children (Joohee, 2010). The combinations of PCK elements offer a critical resource for teaching mathematics. They can help the teacher anticipate what children can know and do. In simple words, PCK distinguishes the work of the teacher from that of a scientist.

Effectiveness of elementary school teacher's PCK in teaching and learning of Mathematics especially geometry

People use math skills and knowledge several times in their daily life that is why math must be taught since foundation level of education. The main objective for teaching mathematics

in nursery school is for preparing the children to learn mathematics in primary education. Nursery school math education helps them make sense of the world around them and teaches them to reason and solve problem. Especially engagement of young children in geometry taught can support their overall mathematical and cognitive development (Lenhart, 2010). Also, as geometry can be found in the surrounding, its study enhances their appreciation of the world around them, inspire their academic curiosity regarding the surroundings, support them recognize the world in which they live and to foster new interest through occasions to discover, examine and experiment.

Always it is better for children to learn through playing and interacting with real materials. Which form a relevant base for all teaching and learning process of math especially the topic of geometric figures. Teaching and learning of geometry thoughts should be an integral part of everyday life actions in early childhood education as they support kids to focus on their reflection abilities and offer them experience through investigation of geometric figures (Bose et al., 2013). These activities should be done as much as possible for the reason that mathematics, especially geometry' materials are easier to find, not demanding as well as background and concept of math are formed from day-to-day homebased activities.

Mathematical (content) and methodical (pedagogy) knowledge types, are essential for effective teaching and learning of mathematics especially the elementary geometric concepts by the teacher (Romano, 2017). Miserably, several children are being taught by teachers who have an inadequate understanding of mathematics (content knowledge) and appropriate instructional methods (pedagogical knowledge). Although many types of research argued that having subject matter knowledge by the teacher leads

to increases in the capacity to connect mathematical topics and the way that emphasizes conceptual understanding is used during teaching (Brown and Borko, 1992). Nursery school teachers PCK is important because those who possess math PCK are likely to implement their teaching practice and its absence hinders the operation of a mathematics-related curriculum (Meadows & Lee, 2003; Lee, 2005). However spatial sense is the foundation of geometry, the nursery school teachers are found to have lowest PCK on it which have a negative effect on the implementation of math curriculum (Joohi, 2010).

Eye analysis of visual forms is initially used by young children to learn mathematics especially form diagrams. During the development of these diagrams, primarily children stay relying on photographic matching to differentiate figures. However, they can know components and some properties of familiar shapes (Clements et al., 2008). Generally, teachers PCK are dynamic in the teaching of mathematics particularly, geometry. Considerable energy is exercised in teaching geometry as, it is a vital area in mathematics but several research studies provided evidence that understanding of a geometrical concept by children is not at the expected level (Björklund, 2015). This issue may be that it is the result of nursery school teachers who do not possess adequate content and appropriate instructional strategies regarding mathematics, especially Geometry.

In the Rwandan nursery competence-based mathematics curriculum developed in 2015, there are geometric materials is mainly focusing on Geometric figures (square, triangle, and circle). With the purpose of making learners able to make figures (square, triangle, and circle) in different things, to draw them, say number of sides and to distinguish them. In 2018 the National Pre-Primary Education Minimum Standards and

Guidelines for Rwanda were also developed as a reference document to be used for planning, implementation, and assessment purposes by all pre-primary service providers. However, Maniraho (2017) argued that teachers displayed content knowledge difficulties (these influence other forms of knowledge including PCK) within some areas including geometry. They were asked to describe a shape, to indicate if the shape was possible or not, and other related questions. They did not exhibit consistency in their answers. It is also known that for nursery students it is better to explore geometric shapes by drawing rather than merely teaching the names and features of the shapes (Doverborg, 2001). Also, it is good for them to learn geometric shapes by manipulating them and play with concrete materials and this makes math learning meaningfully.

Nursery school teacher's PCK in teaching and learning of geometry

The kids' mathematics successes critical influence is the teachers' pedagogical content knowledge. Early math skills of the teacher is strictly connected with kids' math attainment and cause great advantages in their upcoming work and businesses (Joohi, 2010). However, Cantürk-günhan and Çetingöz (2013) were interested in pre-school preservice teacher's subject matter knowledge (SMK) and PCK of elementary geometric figures. Their study engaged case study technique where students studying at nursery school teaching department at a national university participated. The data obtained by using semi-structured interview, lesson plan analysis, and analysis and interpretation of video recording of teaching practice session were made through content analysis. By a qualitative analysis method, PCK was evaluated based on the themes defined under PCK's frame work. The outcomes indicated that preservice teachers at preschool department had some difficulties when labeling geometric figures

and they did not use the mathematical language excellently.

The study conducted by Maniraho (2017) aimed to define the types and stages of PCK of Rwandan math grade six teachers and also to observe in what way this relays to their knowledge of content, their teaching, and their children's successes and found that teachers demonstrated content knowledge worries within some areas including geometry. Where they were requested to specify if the figure was possible or not and others associated questions. In addition, the incorrect choices of the teachers caused the researcher to ask himself how they present and describe basic geometry figures to their learners.

In a study conducted by Joohi (2010) aimed to investigate nursery school teachers' PCK of math, where eighty one nursery school teachers participated in the study. The Survey of Pedagogical Content Knowledge in Early Childhood Mathematics (SPECKECM) being applied for data gathering. The obtained data were analyzed using ANOVA and t-test, found that nursery teachers with advanced marks on PCK of math more repeatedly employed higher worth mathematics teaching in their schoolrooms. However, it was also found that the higher PCK of math of nursery teaches depend a lot on more are educated and more are experienced. The same with Chuang & Ho (2011) suggested that the teaching experience period is absolutely associated with early childhood teachers' pedagogical knowledge, content knowledge and pedagogical content knowledge.

Based on that it seems that children at nursery level need to be taught by the experienced and more educated teachers for better acquisition of math skills and for better future. But consequently, not the case and seems to be difficult because none is going to teach more than 10 years in nursery school and if s/he did, will be not qualified cause if s/he get qualified (get a degree) s/he looks for another job.

Hence it requires to give an ongoing training to an in-service teachers and better preparation of pre-school's pre-service teachers.

Nursery school teachers need to have strong PCK in mathematics especially geometry so that their children understand nursery school geometry concepts which help them to have success in their next levels of education (Lenhart, 2010). The teachers knowledge of PCK comes from their educational courses, experience and professional development (Lenhart, 2010) but unfortunately some teachers do not have so much experience or satisfactory educational background in geometry and that hinder their PCK knowledge which has effect on children's learning.

Conclusion and recommendation

Knowledge and skills are crucial to individual's development throughout their lives. They are gained competently and successfully if teachers play a big role in enabling knowledge attainment. Their contributions are not only crucial but also irreplaceable as there is no and there will be no any technology that will replace them. The major role of the teachers in teaching and learning process, has placed teaching competence at the most important part in a knowledge acquisition process especially at the foundation level of education.

The study investigated the nursery school mathematics teachers' PCK at the foundation level of education in teaching and learning of geometry. The study found that nursery school teachers have limited pedagogical content knowledge regarding geometric topic as they have some difficulties when labelling geometric figures, they demonstrate content knowledge worries within geometry area (Cantürk-günhan & Çetingöz, 2013; Maniraho, 2017). The teachers knowledge of PCK comes from their educational courses, experience and professional

development (Chuang & Ho, 2011; Joohi, 2010; Lenhart, 2010).

The nursery school teachers are recommended to give the active participatory learning activity to their learners so that they will construct their own understanding. Successful teaching of Mathematics must be that children will learn best by annoying to make sense of ideas on their own, with the teacher as a facilitator by helping them along with the means.

Also, nursery school mathematics teachers they are advised to applying different methods and techniques while teaching geometry topic at this level of education. To relate math content with real-life examples because children are obviously conscious of the attribute of math especially geometry when they manipulate and play with tangible tools. Which help them to shape the base for later study (Joohi, 2010). This study encourages teachers to use playing based teaching approaches in their teaching, so as to motivate their children to construct their own knowledge. To better support nursery teachers, it is crucial for schools, and any other educational stakeholders to offer them occasions to improve a better understanding of methods to teach mathematics through giving them an ongoing training. Also based on the results of many studies (Bose et al., 2013; Cantürk-günhan & Çetingöz, 2013; Chuang & Ho, 2011; Joohi, 2010), it is recommended that when preservice teachers are being taught they should attain subject matter knowledge (SMK) and PCK successfully, and they should be given the opportunities to implement what they have learnt in their surrounding work places.

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