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Pedagogical Content Knowledge on Early Mathematics Among Malaysia's Preschool Teachers: A Literature Review

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Abstract--- *Early childhood education in Malaysia refers to the programmes provided for children from birth to the age of eight. The programmes include related activities from kindergarten, preschool, to primary Year Two. The National Preschool Standard Curriculum (NPSC) focuses on a student-centred learning curriculum. Such knowledge is necessary to enable preschool teachers to make teaching and learning a fun and meaningful experience for preschoolers in Malaysia. Improvement in the quality of teaching and learning (T&L) of preschool teachers is closely linked to the teachers' PCK, which has the potential to enhance their teaching profession. The purpose of this paper is to explain the concepts and requirements of early mathematical PCK in a preschool education. The qualitative study is based on analysis of documents, journals, and books related to the discussions of PPK. The library methodology involves inductively and deductively analysing previous studies using Shulman's model to identify early mathematical concepts and interests. The findings suggest that preschool teachers' mastery of PCK can enhance their skills and understanding of early mathematics. The studies have also found that students who achieved excellent results at the primary or secondary level had basic mathematical learning from the preschool level. Such a trend needs to be addressed by the MoE and educators who are aware of the importance of early mathematics from preschool. This study is expected to shed light on the importance of improving the quality of preschool teachers' delivery of early mathematics teaching.*

Keywords--- *Early Childhood Education, Preschool, Pedagogical Content Knowledge (PCK), National Preschool Standard Curriculum (NPSC), Early Mathematics.*

I. INTRODUCTION

One of Malaysia's initiatives to strengthen the country's education system is to transform the preschool education curriculum, beginning with the formation of the National Preschool Standard Curriculum (NPSC) in 2010, which was subsequently updated in 2017. According to Hussin et al. (2008), such progress was in line with UNESCO's declaration of "Education for All" and the policies of "No Left Behind Children." This priority serves as a signal for preschool teachers to constantly update their knowledge of curriculum content and increase their competency in pedagogical practices to stay relevant to current and future needs.

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However, some of the teachers today have been noted with a deficit in the quality of teaching proficiency, particularly in teaching and learning mathematics (Tengku Zawawi, 2009). Such shortcoming contradicts the NCTM (2000) principle, which emphasises effective teaching by means of providing a conducive environment as well as encouraging students to think, question, and solve problems. The lack of such factors may cause students, particularly the disadvantaged ones, to become bored, frustrated, and resentful of mathematics and mathematical learning (Tengku Zawawi, 2009). Some teachers still use the teacher-centred method of chalk-and-talk to convey mathematical concepts (Abdul Razak & Nor Asmah, 2010). In addition, previous studies have shown that Malaysian children's level of competency in early math skills is moderate (Norhaizian & Sharifah Noorul Akmar, 2011; Rohaty, 2012). Indirectly, both findings of this study in Malaysia provide indicators of the level of readiness of preschoolers (MOEs) to study mathematics in Year 1 still need attention in the area of improvement for improvement.

Western studies have emphasised the importance for children to learn early math skills as these skills can form a strong foundation for higher learning in the future (Brenneman et al., 2009; Clements & Sarama 2008; Copley, 2010; Ginsburg et al., 2008; National Council of Teachers of Mathematics, 2000; National Research Council (NRC), 2009). Children who lack early math skills tend to have a deficit in math, causing them to be less interested in learning mathematics and struggle with higher-level math skills in mainstream education.

Children learn math through their experiences, whether in or outside a classroom. The role of preschool teachers is very important for children to understand mathematical concepts correctly. Teachers need to be knowledgeable and innovative of how to teach and why and how students need to learn math (Abdul Razak & Nor Asmah, 2010; McCray & Chen, 2012; Shulman, 1986). Before the teaching-and-learning process takes place, preschool teachers need to understand the mathematical concepts first so that the children can learn and understand the mathematical concepts well. Therefore, preschool teachers need to have the PCK of early childhood mathematics. Errors in the interpretation of these early mathematical concepts might convey a different picture to the children's mind, causing them to make mistakes in the real meaning of mathematics and methods for solving math problems (Norly, 2014). Preschool teachers' PCK in early mathematics should be prioritised to further strengthen the knowledge and skills of preschool children. Therefore, this study attempts to examine the information related to the concept and requirements of early mathematical PCK in preschool education.

II. METHODOLOGY

Today, providing quality preschool education is a choice for parents. According to Rao et al. (2000), the improvement of quality of childhood education requires management changes, which include improvement in the quality of teaching staff and the programmes offered. This opportunity should be taken by everyone who understands the importance of PCK to children's education. This study attempts to examine the information that has led to the need for PCK for preschool teachers, particularly those who are involved in early mathematics subjects at the preschool level. This study is a library study that involves the study of literature and related documents.

III. PEDAGOGICAL CONTENT KNOWLEDGE

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Shulman (1987) defines Pedagogical Content Knowledge (PCK) as a representation that blends content and pedagogy as an understanding of how a particular topic, problem, or issue is organized, represented, and adapted to suit diverse student interests and abilities, which translates into a form teaching. The PCK proposed by Shulman is the result of the integration of content and pedagogy to form an understanding of how topics, problems and teaching issues are organized, represented and adapted based on the various interests and abilities of students (Norasliza & Zaleha, 2008). This means that teachers need to know how to teach and transform their knowledge specifically according to different levels of student development (Lee, 2010).

In this study, PCK is the ability preschool teachers of the Ministry of Education (MoE) preschool in the classroom to mix, integrate, translate and transfer PCK in Early Mathematics components so that it can be easily understood by preschool students through content knowledge, pedagogical knowledge and student cognitive knowledge.

The Content Knowledge (CK) is defined as knowledge relating to facts or concepts within a single subject domain. This means that teachers need to have a clear understanding of the structure and content of a subject domain such as mathematics, science and biology (Shulman, 1987). In the simplest terms, content knowledge is knowledge of the subject (Siti Mistima & Effandi, 2014).

Meanwhile, Pedagogical Knowledge (PK) is described by Shulman (1986) as something behind the knowledge of subjects with various dimensions or methods as the teaching and learning process takes place. Knowledge of pedagogy is a system of a long process involving planning, teaching, assessment, group work, questioning and feedback (Zamri & Magdeline, 2012). In other words, pedagogical knowledge is the way teachers are taught by pedagogical knowledge, in particular, the approaches and techniques used in teaching (Jain et al., 2017).

For student cognitive knowledge (SCK) Shulman (1987) used the term knowledge of student and student characteristics. But when Shulman's PCK idea was reviewed by Fennema & Franke (1992), Ball (2011); Ball et al. (2008), Thames and Ball (2010), McCray and Chen (2012) all use the term cognitive knowledge students. Meanwhile, Mccray (2008) defines students' cognitive knowledge or student knowledge as identifying preschool teachers' teaching practices in mathematics that integrate mathematical content taught with preschool students' understanding. A variety of student interests and backgrounds will provide a benchmark for teachers to identify the needs and abilities of the student (Abdul Jalil et al., 2011).

IV. PEDAGOGICAL CONTENT KNOWLEDGE MODEL

The PCK has been widely researched in an effort to understand its concept. Scholars are aware of the imbalances and flaws in Shulman's recommendation and proposed some modifications. Shulman's suggestions on PCK have been explored and interpreted theoretically and empirically in previous studies (Abell, 2008; Berry et al., 2008; Park & Oliver, 2008; Boyd et al., 2010), yet the researchers have yet to arrive to a consensus on the definition of PPK as each component plays a role in educational development (Zhang, 2015).

The development of PCK is invaluable as some researchers managed to identify new constructs (Abell, 2008; Niess, 2011). Some researchers have even used new terms without mentioning PPKs, such as craft knowledge (van Driel et

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al., 1998), mathematical knowledge for teaching (Hill et al., 2004), professional knowledge for effective teaching, and content knowledge for teaching (Zhang, 2015). There is also a recent discussion on the application of technology in the teaching subject, known as Technology Pedagogical and Content Knowledge (Koehler & Mishra, 2005; Rohaan et al., 2011; Schmidt et al., 2007; Mueller & Hurtig, 2010).

Regardless of the differing opinions and interpretations, PCK has been widely accepted as a construct for studying teachers' competence in teaching (Zhang, 2015). Past researchers have agreed that PCK relates to the understanding of how a topic, problem, or issue is planned, represented, and adapted to the various interests and abilities of students in the teaching process (Shulman, 1987). Therefore, with this PCK, the teacher will design teaching, evaluate and understand his or her students, and make a decision about the teaching.

1) Fennema & Franke Model (1992)

Fennema and Franke (1992) proposed a conceptual model to help increase understanding of PCK (Figure 2). The model proposes the combination of content knowledge, pedagogical knowledge, and student cognitive knowledge to form the PCK, which is intended to make a teaching practice as effective as possible.

The model suggests that the components of teacher knowledge should not be viewed as separate entities and that the three components must come together to enhance the nature of the PCK and to make teaching practice more effective. Also, Fennema and Franke's model is unique because each component is dynamic and interactive. Teacher's trust is taken as an external factor affecting all teachers' knowledge. It is this belief factor that concerns Fennema and Franke to the PCK.

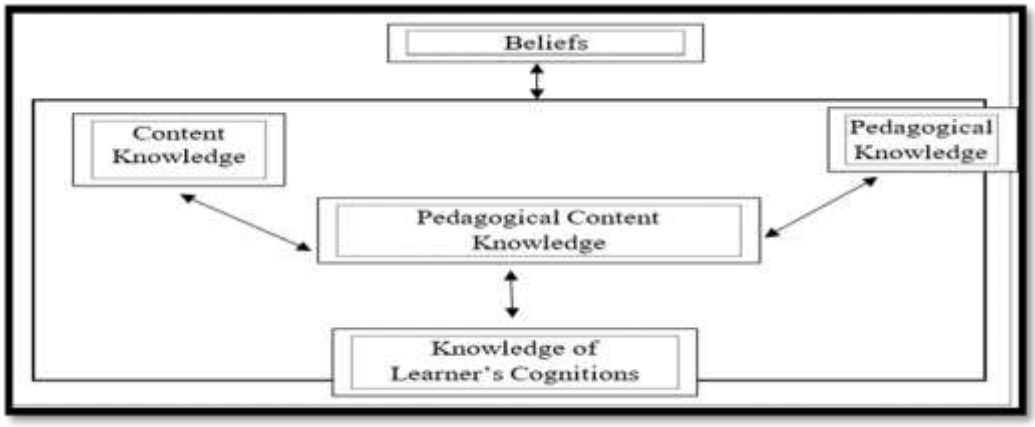

Figure 1: Fennema & Franke Model (Teachers' Knowledge: Developing in Context): From the Handbook of Research on Mathematics Teaching and Learning (1992)

The natural and dynamic nature of PCK has been explored by researchers after Shulman. The trend reflects the development of the PCK itself as this model can be varied across different processes and situations (Shulman, 1987). The variety of these PCK models it is what makes the model unique.

2) Ball et. al. Model (2008)

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Deborah Loewenberg Ball and Liping Ma are two of the earliest leaders in the research on teaching efficiency of mathematics in secondary education (Zhang, 2015). In the beginning, Ball (1988) requested pre-service teachers in primary schools to evaluate their level of mathematics content (PPK) knowledge. Of the nineteen pre-service teachers interviewed by Ball, only five were able to explain in detail their mathematics teaching procedures in the classroom. Ma (1999) then referred to Ball's studies to conduct comparative studies between the US and Chinese teachers. The study found that Chinese teachers have more comprehension of knowledge in mathematics than their United States counterparts (Jang, 2013). These studies then led to the study by Hill et al. (2005), who found a positive link between the PCK of primary school mathematics teachers and their students' achievement.

Ball and colleagues (2008) have also conducted several studies and reviews to understand the effectiveness of teaching from the content knowledge for teaching. They then have continually emphasised the importance of identifying the uniqueness and need for knowledge of teaching content for a more effective teaching process (Zhang, 2015). Thus, the Mathematical Knowledge for Teaching becomes a model related to the knowledge and skills required by teachers to implement high-quality teaching of mathematics (Ball et al., 2008; Thames & Ball, 2010; Jang, 2013).

The Mathematical Knowledge Model for Teaching contains three components of PCK and other elements. The model is divided into several types of subject knowledge. In one PPK there are (a) common content knowledge related to mathematical subjects that are well understood by teachers, (b) specialised content knowledge related to mathematics teachers and used only in professional teaching, and (c) knowledge content of horizon, which refers to a teacher who has an awareness of how each math topic relates to different ages or grades in a curriculum. Another difference of the Mathematical Knowledge Model for Teaching is the addition of the element of curriculum knowledge, content knowledge, and student knowledge of content and teaching (Figure 2).

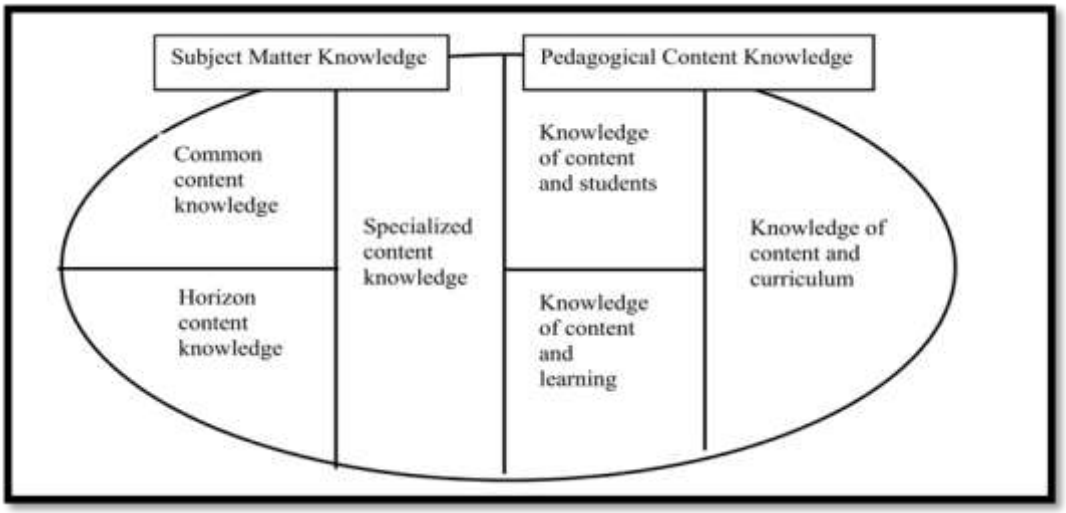

Figure 2: Mathematical Knowledge Model for Teaching (Ball et al., 2008)

3) McCray and Chen Model (2012)

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Pedagogical content knowledge (PCK) is a form of knowledge needed for effective teaching. In simpler terms, PCK is a combination of teachers' comprehensive understanding of what to teach, who to teach, and how to teach them (Shulman, 1986; 1987). Shulman's idea was later refined by McCray and Chen to introduce a PCK model for early mathematics teachers in early childhood education (Figure 3).

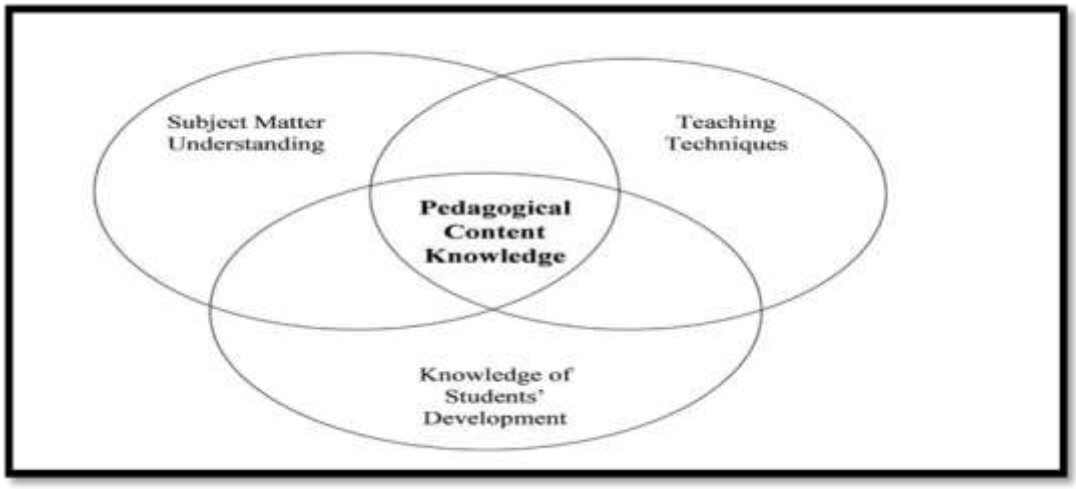

Figure 3: The PCK Model of McCray and Chen (2012)

This model uses a PCK-based approach that involves three main components: (a) how best to teach what is called Subject Matter Understanding, (b) how to teach and teach who the student is related to the Teaching Technique or Teaching Approach and (c) what is the content and to whom is the Knowledge of Student's Development. The PCK model is found to be a commendable guide for preschool teachers in the preparation, implementation, and evaluation of effective teaching-and-learning processes in the classroom of Early Mathematics.

The three components of the model presented by McCray and Chen (2012) are described in detail in terms of their specific disciplinary nature. Teachers' understanding of pedagogical content knowledge is a catalyst for quality teaching and learning processes (Zhang, 2015). The first component is how to refer to content knowledge in early mathematics content standards based on the National Pre-School Standard Curriculum (NPSC) (2016) and how the content relates to each other (subject comprehension). The second component is how people refer to appropriate strategies and examples to illustrate early mathematical concepts for students aged 4+ and 5+ (teaching techniques). The third component is the knowledge of teachers to understand early mathematical concepts in students' new thinking based on diverse student backgrounds and experiences (student development knowledge) (McCray & Chen, 2012). Indirectly, this model can help preschool teachers to systematically conduct their teaching-and-learning activities by following the steps in the suggested components.

V. THE IMPORTANCE OF PEDAGOGICAL CONTENT KNOWLEDGE IN EARLY MATHEMATICS

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The constructs of the pedagogical content knowledge (PCK) in Early Mathematics are content knowledge (CK), student cognitive knowledge (SCK), and pedagogical knowledge (PK). Each of these three constructs has its strengths, and therefore, all constructs are interdependent. Therefore, all three constructs are of interest to preschool teachers for the teaching of early mathematics.

The first interest is content knowledge (CK) construction. This construction refers to the knowledge of content in the Early Mathematics curriculum. Preschool teachers need to be familiar with curriculum and teaching aids such as scanners, charts, manipulative tools, ICT media use, and worksheets. They also need to understand that the Early Mathematics curriculum can facilitate their understanding of the topics and issues that their students are learning. Preschool teachers must also understand how to relate a topic to the environment and other subjects. According to Charlesworth and Lind (2007) based on Piaget's theory of children learning Early Mathematics through sensory and psychomotor skills. Knowledge on content in the Early Mathematics curriculum would enable preschool teachers to effectively implement their teaching-and-learning process as they convey a complex content through an easy-to-understand method, particularly in fun and meaningful activities for children.

The second construct relates to students' cognitive knowledge (SCK). This component consists of two types of knowledge, namely the existing knowledge needed to learn a topic and the knowledge of the difficulties and misconceptions of students on an Early Mathematical concept. In early childhood education, the needs of Developmentally Appropriate Practice (DAP) approach, as described in the National Preschool Standard Curriculum (NPSC), are important as well as students' cognitive knowledge. According to Smith (2009), preschool teachers need these two dimensions: (a) complete knowledge of cognitive, physical, and emotional development according to the age of each child, and (b) knowledge of interested children, their abilities, and knowledge as a result of cultural influences and home environment. The failure of preschool teachers to apply the cognitive knowledge of students based on the Developmental Appropriate Practice has negatively impacted children's overall development (Jain et al., 2017). Therefore, a preschool teacher's mastery of students' cognitive knowledge through a clear and understanding of the developmental philosophy of their developmental apprenticeships can help him or her to master the lesson, plan, and implement it based on a student's age, self-esteem, ability, a talent.

The third construct is pedagogical knowledge (PK). Pedagogical knowledge is an important skill for determining the quality of teaching and learning to help students master a skill and increase their self-motivation (Grossman & McDonald, 2008). It is clear here that teachers' pedagogical knowledge is related to specific techniques, approaches, and strategies proposed in teaching and learning, the aim being to help children understand more effectively. There are two types of pedagogical knowledge in PCK: (1) knowledge of the teaching strategies of a subject and (2) knowledge of the teaching strategies of a topic (Jain et al., 2017; Tengku Zawawi, 2009). The Review National Pre-School Standard Curriculum (NPSC) (2016) outlines nine strategies that can be used by preschool teachers in a teaching-and-learning process. Among the strategies are student-centred learning, play-based learning, and inquiry-based learning. In a preschool education, pedagogical knowledge should be associated with clear, specific practices, the use of concrete materials (artificial materials), and cross-functional integration. Therefore, preschool teachers need to be smart in

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identifying appropriate approaches in teaching Early Mathematics to meet the needs and objectives of preschool students' learning.

It is clear that early mathematics' teaching and learning (T&L) in preschool is informal process, such as interacting with teaching aids, classmates and teacher support where the skills are developed and reinforced to children throughout the preschool classroom (Charlesworth & Lind, 2007). National Council of Teachers of Mathematics (NCTM) (2000) strongly emphasises that children learn mathematical skills through understanding a mathematical process. In the National Pre-School Standard Curriculum (NPSC) (2016), the results of early mathematics learning at the end of a teaching-and-learning process are to (a) foster interest in mathematics through a variety of everyday activities and experiences, (b) master basic math concepts, and (c) improve thinking and problem-solving skills. Preschool teachers in Malaysia need to master these PCK to create a conducive learning environment for conducting fun early math activities that are in line with children's development in preschool.

VI. CONCLUSION

Preschool education requires quality and effective early mathematics education to create meaningful learning for children. Early Mathematics is a core subject that students need to master as early as at the preschool level before they can develop the knowledge and skills in primary or secondary levels. Due to the importance of Early Mathematics, the National Preschool Standard Curriculum (NPSC) has placed the subject as a component of preschool learning. In the Curriculum and Assessment Standard Document (2017) for preschool, Early Mathematics is placed along with the components of Early Science and ICT Technology under the auspices of Science and Technology. The implementation of LINUS in 2010 was also part of the efforts of the ministry to increase the level of mastery of numeracy skills among lever one primary school students such as Primary One, Primary Two, and Primary Three. Therefore, preschool teachers must master the PCK and take the initiative to design and develop strategies to address every obstacle so that they can provide a meaningful, effective, and enjoyable learning experience of early mathematics. Such measure coincides with the preparatory steps of preschool students before they move on to Year One. Some studies have shown that student participation in preschool helps to improve their excellence in early mathematics, while other studies have shown that students' achievement in mathematics at the secondary level begins in preschool. As such, preschool teachers must have an understanding and skills of PCK in early mathematics to help improve the mastery of early mathematics over the age of six.

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