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Exploring Content And Pedagogical Knowledge Using The Vak Approach For Early Math Addition

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Abstract

The Visual, Auditory, and kinesthetic (VAK) approach in early childhood education teaching and learning process has a significant impact on mastering mathematical concepts among preschoolers. The present paper aims to discuss the understanding of Content Knowledge (CK) and Pedagogical Knowledge (PK), specifically in early mathematics, among preschool teachers in Malaysia. Furthermore, this paper also explores how six preschool teachers transformed CK and PK while teaching additional topics by applying VAK approaches. The interview transcription was analyzed using Atlas. Ti version 8 software to evaluate and update the data and to examine the emerging themes. Based on the triangulation technique, the analysis showed that all research participants have a robust understanding of CK and PK. They can also apply VAK approaches while teaching early mathematics, especially for additional topics. This study can raise awareness of the importance of best practices in teaching early mathematics using the (VAK) approach because it is an active and fun learning process for preschoolers.

Keywords: Content Knowledge (CK), Pedagogical Knowledge (PK) Visual, Auditory, Kinaesthetic (VAK), Early Mathematics

Introduction

Preschool teachers in Malaysia can adopt various approaches; nine have specifically been listed by the National Preschool Standard Curriculum (NPSC). In teaching and learning early mathematics, teachers must understand the principles and know how to explain mathematical concepts effectively to preschoolers (Björklund et al., 2020). Hence, Shulman (2013) highlighted that content and pedagogical knowledge are the two most significant types of knowledge teachers should master. The former represents the area related to the content in early mathematics, while the latter relates to the strategies in specific teaching practices. As per Shulman (2013), the teacher knowledge base includes two crucial elements: content knowledge (theories, principles, and concepts) and pedagogical knowledge (teaching

approaches and strategies). Content knowledge is profoundly understanding concepts, while pedagogical knowledge focuses on effectively presenting and explaining concepts to preschoolers (Zurek, Torquati & Acar, 2014). As per Shing, Saat, & Loke (2015), PCK combines content and pedagogical knowledge during teaching. Many PCK studies have emphasized teachers' knowledge of integrating content and pedagogical knowledge (Shing, Saat, & Loke, 2015; Adi Putra et al., 2017).

Mastering content and pedagogical knowledge should align with the teachers' teaching experience. It is commonly acknowledged that experienced teachers have a set of knowledge in teaching strategies, a thorough understanding of the students, and a higher level of confidence in teaching a concept (Munna & Kalam, 2021). Nonetheless, there have also been some cases where experienced teachers need more content and pedagogical knowledge, especially when required to teach subjects unrelated to their expertise (Akbari & Moradkhani, 2012). Therefore, throughout their career as educators, teachers should practice lifelong learning to reinforce their understanding of content and pedagogical knowledge for quality teaching strategies (Shulman, 2013; Shing, Saat, & Loke, 2015). Furthermore, Sockett's (1987) opinion on the importance of content and pedagogical knowledge is recognized by Shulman (2013), who claimed that transformation of knowledge would occur when teachers utilize a diverse range of content and pedagogical knowledge and convey knowledge to students of various backgrounds. Since its introduction in the early 1980s, Shulman's theory of content and pedagogical knowledge has remained relevant. Berry, Loughran, and van Driel (2008) have also emphasized that content and pedagogical knowledge are the two most significant elements of a teacher's professional knowledge repertoire.

It should also be highlighted that preschool children have a variety of learning styles, as each child experiences varied development (Björklund, van den Heuvel-Panhuizen, & Kullberg, 2020). Accordingly, The National Association for the Education of Young Children (NAEYC) frequently highlights the best practices for teaching and learning approaches relevant to children's development in education (NAEYC, 2020). Developmentally Appropriate Practices (DAP) further emphasize that children's teaching and learning process must be conducted through activities relevant to their age, abilities, talents, and interests (Kim & Han, 2015). Activities such as playing, inquiring, exploring and investigating, experimenting, and making projects are strongly encouraged in DAP (Kim & Han, 2015; NAEYC, 2020). One of the most effective ways preschool children apply the DAP is through activities encompassing visual, auditory, and kinaesthetic (VAK) elements.

The VAK approach to learning is connected to Bruner's Cognitive Development Theory (1964). According to this theory, children's behaviour and cognition change through enactive, iconic, and symbolic modes of development. Bruner emphasized meaningful interactions during instructional activities to help preschoolers create understanding. Visual learners benefit from flashcards, charts, pictures, and manipulative materials. Auditory learners thrive with lectures, reading, and singing, whereas kinaesthetic learners excel in hands-on activities involving psychomotor movements. Hence, multi-sensory approaches are valuable for preschoolers to comprehend information (Obaid, 2012). Based on Abbas Pourhosein Gilakjani (2012), children can have a combination of one, two, or three learning styles. Therefore, including all three elements in lessons creates an impressive and enjoyable learning experience.

Despite increased attention to early mathematics education, only a few studies have explored content and pedagogical knowledge (Chen et al., 2013), even though evaluating effective teaching requires examining the application of this knowledge in the classroom (Shing, Saat,

& Loke, 2015). In Malaysia, issues with content and pedagogical knowledge among preschool teachers have been evident since the implementation of preschool classes in 1992 (Puteh & Ali, 2011; Chee et al., 2017). Research has shown that preschool teachers often need more understanding of early mathematics content (Chee et al., 2017; Gilar Jatisunda et al., 2021; MOE, 2012) and struggle with pedagogy alignment (MOE, 2012).

This article explores preschool teachers' knowledge and pedagogical skills in early mathematics in Negeri Sembilan, Malaysia. The investigation was conducted thoroughly during preschool teaching, examining teachers' understanding of early mathematics content and their diverse teaching strategies for preschoolers' comprehension. Preschool teachers' pedagogical knowledge is crucial for effective teaching and learning (Khalil et al., 2022). Adequate content knowledge and solid pedagogical skills are essential to enhance student comprehension (Depaepe, Verschaffel, & Kelchtermans, 2013; Kutluca & Nacar, 2021). A comprehensive study of content knowledge and pedagogical approaches in early mathematics among preschool teachers is vital due to their significant role in children's understanding. Therefore, the current study aims to investigate preschool teachers' content knowledge and pedagogical knowledge in early mathematics subjects. The underlying research questions are as follows: a) what is the content knowledge of preschool teachers in early mathematics?; b) how is the pedagogical knowledge of preschool teachers translated into early mathematics teaching?

Methodology

The research used a qualitative case study and multiple case studies approach. Six preschool teachers from Seremban, Negeri Sembilan, were purposively sampled as research participants. They are graduate students of the Malaysian Institute of Training Teachers (MITT), majoring in Preschool Education, with 10 to 25 years of teaching experience at government preschools. Participants signed a letter of consent before the interview process, ensuring their voluntary participation and confidentiality of data. The participants are labeled as I1, I2, I3, I4, I5, and I6 for research findings representation. Their demographic profile is summarized in the table 1 below;

Table 1:
Review of Participants' Demographic Profile

Participant	Teaching Experience	Specialization	Education Background
I1	25 years	Preschool	Bachelor's Degree
I2	14 years	Preschool	Bachelor's Degree
I3	Ten years	Preschool	Bachelor's Degree
I4	17 years	Preschool	Master's Degree
I5	13 years	Preschool	Master's Degree
I6	13 years	Preschool	Bachelor's Degree

Four experts have been asked to review the built-in protocol questions concerning the validity of the interview content. The experts included preschool mathematics lecturers, two early childhood education lecturers, and teachers who also served as the Primary Coaches (PC) of preschoolers with over 20 years of preschool teaching experience. This scenario-shaped instrument assessed preschool teachers' content and pedagogy knowledge, specifically in early mathematics subjects. The instrument was adapted from (McCray & Chen, 2012) and

(ETS, 2018) by taking into consideration both (MOE, 2010; MOE 2017). Crucial components incorporated in this scenario included early mathematical concepts, the diversity of pedagogical approaches in early mathematics subjects, the materials used, and the children's reviews of the scenario, illustrating that one of the early mathematical concepts was being applied. Next, an observation of the six preschool teachers was conducted, and any ambiguities that might arise during the observation were subsequently addressed in a second interview. This follow-up interview was conducted by the researcher following the teaching session and was performed using the stimulus recall interview (SRI) approach.

Next, to further evaluate the reliability of this study, the interview data were grouped and analyzed through the triangulation process. According to (Creswell, 2014), triangulation is "a form of cross-validation that will seek similarities in data by comparing survey respondents, comments, environments, and methods to identify the resulting outcomes". Furthermore, (Michael Quinn Patton, 2014) identified four types of triangulation, namely (a) method triangulation, (b) investigator triangulation, (c) theory triangulation, and (d) data source triangulation. A reliability test was performed through this triangulation method, encompassing a combination of data sources through interviews, observations, and document analyses to study a phenomenon. The triangulation approach was purposely selected for this study to verify the reliability of the theme or unit found in the interview analysis.

The data collected from interviews, teaching observations, document analysis, and the checklist underwent an Atlas software coding process. This process included open coding, axial coding, selective coding, and memo writing, which are referred to as "super codes" because they are not tied to specific texts but rather to the codes themselves (Friese, 2019). The relationship between these codes was visually represented using graphical representations. To ensure the validity and reliability of the transcript analysis, an evaluation of themes was conducted by external experts. This group consisted of qualitative experts, mathematicians, and preschool education experts. The identified themes or units from the interview data analysis were further tested for reliability using Cohen's Kappa Index.

Result and discussion

Content Knowledge of Preschool Teachers in Early Mathematics

The first interview protocol question was designed to extract the teachers' understanding of the early mathematical concepts described in the Scenario 1 passage. Based on the data, the six participants, namely I1, I2, I3, I4, I5, and I6, acknowledged that the scenario contained early mathematical concepts. For example, I4 explained, "If we look at this scenario, this kid is playing ... playing while studying. Moreover, sometimes, we did not notice him learning while playing. So, among the elements, many early mathematical elements exist." The same answer was also obtained from I2, who mentioned, "Okay... I can see elements of each…yes, early mathematics, okay, there are..". The code extracted from the study participants was 'There is' or 'There are'. Table 2 below presents similar answers uttered by participants for question (a) in the scenario above for the theme of Knowledge of Early Mathematics.

Table 2:

The Theme Of Knowledge Of Early Mathematics

Participant	Sentence Phrase	Code
I1	“There is indeed"…	There is
I2	"Okay... I can see there are elements of each… yes, early mathematics, okay, there are.”	There are
I3	“Haah, there is.”	There is
I4	"If we look at this scenario, this kid is playing ... playing while studying. Moreover, sometimes, we did not notice him learning while playing. So, among the elements, there are many early mathematical elements in it."	There are
I5	“There is.”	There is
I6	“Yes, there are.”	There are

Next, the second question was to discover whether the research participants could identify any early mathematical concepts in Scenario 1. The same answer of the addition operation was given by all research participants using the codes such as "added", "adding", and "add". For instance, I4 explained that "plus operation is ... that is adding a block unit", and the same answer was also obtained from I5, who mentioned, "add concept ... add operation there is there". Table 3 illustrates the theme of Early Mathematics Addition Operation based on the resemblance of answers to the questions obtained from the participants.

Table 3:

The Theme Of The Early Mathematics Addition Operation

Participant	Sentence Phrase	Code
I1	"First, the operation added ..."	Added
I2	“Aaah ... this is operation added. Aaah... the operation is added."	Added Add
I3	“Add”	Add
I4	"The plus operation is ... adding a block unit."	Adding
I5	"The concept of adding ... added operations there."	Added
I6	"First add ..."	Add

Then, in the third question, the research participants who identified the concept of addition in Scenario 1 were asked to prove their understanding by giving any evidence or example of the activities in Scenario 1. The code extracted from the participants was 'big'. All of the answers produced by the participants were associated with the addition operation concerned with changes in size or volume, either getting bigger or larger. As indicated by this response from I5, "For example, Leon, when he finds the size of the track, it does not fit with the airplane built, so Leon adds the number of blocks for the small airplane space and to the big runway. There are operations added". I3 described, "He already knew why he could add .... why it did not fit because it was small. He added two more sets of wooden blocks to increase the size of the runway to become a big size." Table 4 below presents the similarity of answers

obtained from all six participants based on Scenario 1 for the theme of Keywords Addition Operation, with the code 'Big'.

Table 4:
The Theme Of Keywords Addition Operation

Participant	Sentence Phrase	Code
I1	"Operation was added when they found that big aircraft did not fit the runway because it was small, so he added another two blocks to the biggest runway ... so close that there was an extra operation."	Big
I2	"Uhm ... if it is near here, we can add more ... then he is small, it is big ... he is building it using blocks, okay. Twelve units of blocks, so he adds two units of the block from the small size, then it becomes a bigger airplane runway."	Big
I3	"He already knew the real reason why he could add .... why it did not fit because it was small. He added two more sets of wooden blocks to increase the size of the runway to become a big size. "	Big
I4	"He said when the plane's parking space was not big enough because it was small ... he took another block with two more blocks to extend the airplane's parking space ... this operation is more."	Big
I5	"For example, Leon, when he finds the size of the track, it does not fit with the airplane built, so Leon adds the number of blocks for the small airplane space and to the big runway. There are operations added".	Big
I6	"It is clear that the added element is ... adding two small block units on each side of the blue airplane to make it a bigger runway and add a small block on each side of the little red plane parking space from the blue. There is a process of adding one and two wooden blocks.	Big

The answers to the three questions above were analyzed to address the first research question. According to Oppermann, Anders, and Hachfeld (2016), a preschool teacher with excellent content knowledge can easily identify the mathematical concept applied in a child-play scenario. The findings of this study revealed that all six participants, namely I1, I2, I3, I4, I5, and I6, were equipped with the knowledge of early mathematical content based on their observation of children's mathematical activities through the scenario above. Nevertheless, the results are contradictory to (Chee, Mariani, Othman, & Mashitah, 2017) and (MOE, 2012), which suggested that preschool teachers in Malaysia possess lack of understanding of the subject content outlined by the National Preschool Standard Curriculum (NPSC).

Pedagogical Knowledge of Preschool Teachers in Early Mathematics

The interview protocol's first question was asked to evaluate the teachers' understanding of early mathematical concepts based on quotes included in the scenario. 'Measurement' or 'measure' were the codes that emerged from the participants' answers. The data shows that all six participants, I1, I2, I3, I4, I5, and I6, could identify the mathematical concept introduced in scenario 2, which is the non-standard unit theme. For example, I3 explained, "If I understand this, she wants to introduce the size, high and low. There are also paper clips, shirt buttons, and a string of hooks to measure. Maybe this is to measure non-standard

materials." The same answer was also obtained from I6, "This measures the height of objects, mineral water bottles of various sizes, rulers of all sizes ... these are non-standard units." Table 5 below records the similarity of answers extracted from the participants for the first question based on Scenario 2 for the theme of the Early Mathematical Concept of Non-Standard Units.

Participant	Sentence Phrase	Code
I1	“Yes, this is a non-standard unit measurement.”	Measurement
I2	“This measures the height by using the four objects and will count ... these are non-standard units.”	Measures
I3	"If I understand this, she wants to introduce the size, high and low. There are also paper clips, shirt buttons, and a string of hooks to measure. This is to measure non-standard materials.	Measure
I4	“That is the concept measurement of non-standard units.”	Measurement
I5	“Measurement of materials or objects using materials is for non-standard units.”	Measurement
I6	“This measures the height of objects, mineral water bottles of various sizes, rulers of all sizes ... these are non-standard units.”	Measures

Table 5: The theme of the Early Mathematical Concept of Non-standard Unit

The interview protocol's second question was asked to examine the extent of the preschool teachers' understanding of the pedagogical practice for early mathematics subjects based on the scenario described above. The two codes detected from the research participants' responses were group activities and student-centered. Furthermore, it was also evident that all six participants could identify the pedagogical practices in this scenario. The findings suggest that the research participants have the right pedagogical knowledge in preschool mathematics teaching. For example, I2 explained, "Her teaching technique includes group activities and is student-centered. Meanwhile, I5 described that "Her strategy is group-focused and "student-centered. Table 6 below demonstrates the similarity of responses produced by the study participants for question (b) based on Scenario 2 for the Pedagogical Knowledge of Preschool Early Mathematics theme.

Table 6:

The Theme Of Pedagogical Knowledge Of Preschool Early Mathematics

Participant	Sentence Phrase	Code
I1	"She uses a group activity and student-centered approach."	Group & Student-centered
I2	"Her teaching technique includes group activities and is also student-centered."	Group & Student-centered
I3	"The first one is a group, and the second is pupil-centered."	Group & Student-centered
I4	"First, she employed group activities and then a student-centered approach."	Group & Student-centered
I5	"Her strategy is grouped and focused on students."	Group & Student-centered
I6	"The approach used by Ms Mariam is a group activity, and besides that, she also focuses on students."	Group &Student-centered

Based on the responses to these two questions, it is proven that the research participants have excellent early mathematical knowledge as they could identify the exact early mathematical concepts embedded in Scenario 2. This finding is in line with past research conducted by (McCray & Chen, 2012), who have discovered that preschool teachers can identify the content of knowledge in early childhood mathematics even when the preschoolers are playing. Oppermann, Anders, and Hachfeld (2016) also acknowledged that preschool teachers have a high sensitivity toward early mathematical knowledge content. Hence, all six participants have the relevant pedagogical knowledge of early mathematics as they have successfully identified the approach or strategy employed by Ms. Mariam, the preschool teacher in Scenario 2. This finding correlates with previous research that found that preschool teachers have good pedagogical knowledge in terms of approach and style for teaching and learning (Chee et al., 2017). Overall, the findings of both questions are supported by existing literature, indicating that preschool teachers are capable of analyzing play situations and identifying the early mathematical concepts using the combination of content knowledge, pedagogical knowledge, and teaching practices in tandem with the student's development (McCray & Chen, 2012; Oppermann, Anders & Hachfeld, 2016).

Applications of Visual, Auditory, and Kinaesthetic (VAK) Approach in the Early Mathematics Topic of Addition

In this study, visual, auditory, and kinaesthetic applications (VAK) were implemented using teaching aids (TA) during early mathematics teaching, especially for the addition operation. Subsequently, the triangulation process was conducted to test the reliability and validity of the data. The source triangulation data was selected among the four approaches proposed by Michael Quinn Patton (2014) and incorporated the interview transcript, teaching observation, and document analysis. Data equations can be seen in I1, I2, and I4 from their responses regarding the VAK applications during the teaching of addition. See Appendix 1 (Tables 7, 8, 9).

These findings show that three participants, i.e., I1, I2, and I4, have sufficient pedagogical knowledge in early mathematics teaching of addition operation, especially in utilizing the

appropriate TA for teaching. The selection of materials or objects that the child can touch and see clearly thus enhances the learning process. The choice of materials that serve as a counting tool coincides with Bruner's theory, where it has been claimed that children learn through the enactive and iconic modes (Myers, 2021). Children can visualize the mathematical concepts in their minds easily based on the use of physical objects, which can be perceived during playing or learning. Moreover, it has been found in previous research that teachers who are equipped with pedagogical knowledge will use appropriate teaching tools and strategies to create effective and meaningful teaching processes for children (Depaepe, Verschaffel, & Kelchtermans, 2013). The presence of auditory elements in the process of teaching addition operations was performed by three participants in this study. I1, I2, and I4 have been found to apply the counting all operating methods in counting activities that involved the participation of all preschoolers. Based on the findings, it is evident that the three research participants were well-versed in the early mathematics content of the addition operation. The teachers designed teaching sessions to introduce and demonstrate the ways to calculate all or count all to the preschoolers as one of the calculation techniques for addition other than the method of counting.

The approach adopted by these three teachers implies that I1, I2, and I4 have clearly understood the early mathematics concepts, especially involving the addition topic. For example, I2 described "the concept of counting all this is that he combines all and he calculates the result of the

addition. For example, 5 + 5 =. The pupil will calculate from the left number of 5 and 5 on the right. When calculating, the pupils will combine all and all about ... when counting, pupils will calculate in sequence like 1,2,3,4,5,6,7,8,9 and 10." This finding correlates with the summary of how children can calculate the operations outlined in the Math Matters book (Atkins, 2015). For instance, the count-all method was employed to solve 2 + 5 =? by showing two fingers on one hand side and five fingers on the other before adding the number of the fingers to start counting from the first number.

Implementing the kinaesthetic approach in teaching shows that these three participants possess good pedagogical knowledge. Their teaching style was centered on the preschoolers, starting with selecting a TA, which was easily accessible to pupils, followed by a demonstration of how to use the tools as part of the calculation method. The kinaesthetic element was incorporated when the pupil moved the counting tools one by one while calculating the number, as shown by the teacher. It should be mentioned that this example is also supported by a recent study that found that preschool teachers have been utilizing pedagogical knowledge that complements the implementation of teaching and learning in preschool classes (Kutluca & Nacar, 2021).

The findings have thus indirectly demonstrated that VAK elements were actively applied by the study participants, namely I1, I2, and I4, as this approach was appropriate for teaching early mathematics to preschoolers. The results are consistent with an earlier study, which concluded that children benefit from a well-rounded learning approach involving observation, participation, and engagement with their surroundings (Björklund, van den Heuvel-Panhuizen, & Kullberg, 2020). By providing opportunities for children to explore their environment through hands-on experiences, they can develop critical thinking skills, creativity, and problem-solving abilities that will serve them well throughout their lives. Through observation, children learn to identify patterns in the world around them and make

connections between different concepts. The learning process through the senses is also crucial for cognitive development, where information is processed based on what the children see, hear, and do (Ahmad et al., 2016)

Conclusion

The study presented valuable insights into the significance of preschool teachers' content and pedagogical knowledge in early mathematics instruction. This research marks the first empirical evidence of such knowledge among preschool teachers in Malaysia. The findings indicate that mastering content and pedagogical knowledge is crucial for children to excel and become competent in early math. Numerous studies have shown that the quality of interaction between teachers and students, specifically involving the former's content and pedagogical knowledge, determines the success of preschool education. As a result, it is recommended that MITT emphasize these two types of knowledge at the basic teaching level, which will be further developed through CPD training for preschool teachers.

Additionally, expanding VAK application in early mathematics teaching can create more enjoyable learning experiences for children while adhering to the Developmentally Appropriate Practices (DAP). This approach aligns with cognitive theoretical learning by emphasizing hands-on activities, social interaction, self-learning, and active learning outcomes relevant to childhood education. By enhancing these areas consistently, teachers can better understand the subject matter and be better equipped to implement new approaches to convey information to students effectively.

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