



Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics: A qualitative research approach

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ABSTRACT

Empirical evidence has shown that children's mathematics achievement in South African has been on the low trend. However, no study has explored the practitioners' application of conceptions of mathematical knowledge in enhancing learners' achievement in mathematics. The study examined how practitioners apply mathematical knowledge to enhance early learning of mathematics. In this study, a qualitative research methodology was employed. The study also looked into how teachers in rural early childhood development (ECD) centers use their ideas of mathematical knowledge to foster young children's early mathematics learning in these environments. The researchers' investigation into the mathematical expertise held by practitioners and how they apply it in ECD contexts was made possible by mathematical knowledge for teachers theoretical framework, which served as the study's foundation. In order to help interpret the facts, the study was also set within an interpretivist paradigm. Five practitioners were chosen using a purposive sampling technique from the five ECD centers used for the study. The data were gathered using semi-structured interview questions and observation schedules. The gathered data were examined using a thematic analysis, which resulted in the formation of themes and sub-themes. The study's findings showed that because the five ECD centers consistently used conventional methods to teach early mathematics to the children who attended the centers, the practitioners in those centers were deficient in their application of conceptions of mathematical knowledge to enhance early learning of mathematics. The need for equipping practitioners with the knowledge and abilities to teach mathematics (subject and pedagogy) in early childhood is strengthened by this study.

Keywords: application, conceptions of mathematical knowledge, early childhood centers

INTRODUCTION

According to Linder et al. (2013), making clearer children's observations of mathematics in their natural environment should be the main job of practitioners in the early years of teaching mathematics. Additionally, it's crucial to link and expand on what kids already know (Baroody et al., 2009). When children are playing, as shown by Strauss (2015), they create ideas, feel safe and make sense of their previous ideas of what they experience. However, Baloyi-Mothibeli et al. (2021) found that numerous difficulties have been encountered

in the teaching and learning of mathematics in South African foundation schools. This is clear from pupils' low mathematics performance, which has recently attracted a lot of attention (Umugiraneza et al., 2017). Only 16% of South African third graders performed above average in mathematics, while the remaining 84% do not (Spaull & Kotze, 2015). According to the Department of Basic Education of South Africa ([DBE], 2015 as cited in Umugiraneza et al., 2018), only 20% of grade 12 students achieved a 50% or higher on a mathematics test. This kind of ugly trend in mathematics performance can be improved when practitioners can connect to what children already know and observe the child's observations of mathematics. Practitioners in early childhood settings require a strong understanding of mathematics in order to successfully capture the learning opportunities within the child's environment and provide a variety of acceptable resources and demanding activities. By properly applying their conceptions of mathematical knowledge, practitioners will be able to provide scaffolding that expands the child's mathematical thinking while also acknowledging the child's contribution. In a well-established early childhood development (ECD) center, parents are also able to fully support their children's education, therefore the researcher is curious to find out how teachers in the distant OR Tambo Inland District apply their notions of mathematical knowledge to increase children's math skills.

Literature

Early children's mathematical comprehension foretells their future achievement, and research on early mathematics suggests that a strong foundation in mathematics learning and understanding is the key to children's academic future success. Young children need precise mathematics that is taught in a suitable method, taking proper procedures and steps into consideration, in order to advance properly. According to Lema (2019), many activities engaged in enhancing mathematics in the early years entail relating concrete experiences to abstract concepts. Teachers must therefore be able to provide and influence young children with enough information and skills through the application of their mathematical understanding if high-quality education is to be expected. As a result, it is clear that there is a need for early childhood professionals with the necessary training to conduct high-quality programs. However, little is known about how early childhood educators in the rural OR Tambo Inland District of the Eastern Cape Province use their conceptions of mathematical knowledge to develop mathematics. The use of mathematical knowledge in early childhood education is well documented in the literature.

According to Kotsopoulos and Lee (2014), research reveals that the greatest time to introduce young children to mathematics is during this period, when their brain is quickly developing, as young children are naturally curious during their first five years. Early exposure to mathematics also aids in the early development of reasoning and critical thinking abilities in children, laying the groundwork for future academic achievement. As a result, practitioners who want to improve children's arithmetic skills should be aware that math may be taught through play and that learning math is simple when the kid is using toys, games, songs, and books that are already a part of his or her regular learning environment. However, while the literature suggests that play is important for children's mathematical development, little to nothing is mentioned about how rural practitioners interpret play and play theories for their approach to teaching math to kids. Furthermore, Gifford (2016) shows that young infants naturally pose and solve problems, which is how they learn. Because it allows children to relate prior information to new situations and fosters flexibility and creativity, problem-solving is an essential component of mathematical understanding. Therefore, it is crucial that kids believe they are capable problem solvers who like a challenge and can make it through even the most trying circumstances. According to Piaget (1986), object permanence is a cornerstone of children's intelligence, showing that they are aware that an object exists even if it is not present. At that stage, kids keep looking for things as a method of problem-solving. Therefore, if children's early problem-solving abilities are linked to their mathematics understanding and expertise, this is the best indicator of how successful they will be in the future. However, despite the fact that much has been written about the value of problem-solving abilities in children's mathematical development, little is known about how teachers in rural ECD centers might include these abilities into their teaching methods for mathematics.

Selmi et al. (2015) emphasize the value of knowledge and skills while pointing out that mathematics skills go beyond learning numbers and how to connect them. Instead, a significant portion of early mathematics focuses on a broad understanding of abstractions and generalizations that help young children connect ideas,

develop logical thinking, and analyze events that happen in their environment. On the other hand, while connecting numbers is not the basis of studying math, the practical application of math knowledge is a key to comprehending it better at this point. As a result, the abstractions cover mathematical ideas that kids can understand, such how to add one or two items. When children apply their early arithmetic skills to other scenarios that are similar in older grades, this shows that mathematics in youngsters may not be an issue. According to the Department of Basic Education of South Africa (DBE, 2015), children develop and learn in a supportive indoor, outdoor, and outdoor environment. Due to the length of time spent in early childhood group situations, these environments have a significant impact on how children grow. However, as Sotuku et al. (2016) note, inadequately constructed ECD physical environments not only pose health and security threats to young children's learning, but also obstruct the learning and freedom that children should be able to experience. Tadesse (2016) contends that through engaging with others and using their five senses to manipulate and examine objects, young infants may develop and learn about their surroundings (including people, nature, and objects). This demonstrates the importance of the learning environment on children's academic growth. In order to foster children's innate curiosity to explore, play, and learn, the physical environment must do so. The literature emphasizes the importance of learning environments in children's learning, but it does not explain how educators in centers serving underserved rural communities can foster an environment where mathematics is promoted through play, exploration, social interaction, and the use of children's five senses to manipulate and examine objects. Additionally, studies on the benefits of outdoor play focus on specific areas including social, mental, and physical development, which is important for practitioners because it is linked to the development of motor skills (Gray et al., 2015). However, little is said about how teachers in rural ECD centers help young children develop their motor abilities in mathematics. Therefore, it is necessary to investigate how practitioners apply their ideas and comprehension of how to foster an atmosphere that is favorable for teaching and learning mathematics in rural areas, particularly in the OR Tambo Inland District.

Daries (2017) argued that when professionals are close to children, they can give them the chance to develop, learn, and thrive as engaged learners. Additionally, Noviyanti and Suryadi (2019) stated that possessing mathematical expertise is a talent that teachers should possess in order to enhance the quality of their mathematics instruction and is utilized to carry out the activity of teaching. This link should therefore be made during professional development training, which should also emphasize fostering accurate knowledge regarding the development of children, identifying, and resolving children's problems, connecting children's potentials, shaping children's characters, enhancing learning, and preparing children for life so that their actions are directed towards positive personal, communal, and global development. Because of this, professionals working in early childhood settings ought to be better able to comprehend children's needs and participate as social justice activists. Therefore, the study explored how practitioners of OR Tambo Inland District apply their conceptions of mathematical knowledge in the holistic development of children's early mathematics learning. In line with that, Nahdi and Jatisunda (2020) indicate that conceptual and procedural knowledge should serve as the foundation for conceptions of mathematical knowledge. The foundation of procedural knowledge, sometimes referred to as procedural skill (procedural fluency), is conceptual understanding. Additionally, although conceptual knowledge entails a comprehension of mathematical relationships, procedural knowledge focuses on comprehending the procedures and conventions of mathematics. Procedural knowledge also refers to a set of instructions that must be followed in order to solve mathematical issues.

Therefore, practitioners should use their conceptions of mathematical knowledge in a way that emphasizes the importance of children's knowledge of the connection between conceptual understanding and procedural skills, in the hopes that children will be able to understand a concept and have the skills to select the steps that will be used to solve mathematical problems. Additionally, practitioners have a duty to actively introduce mathematical concepts, procedures, and language using a range of pertinent experiences and research-based techniques (National Council of Teachers of Mathematics, 2013). As early childhood is the cornerstone of education, improving math skills in kids should therefore be a top priority. Therefore, professionals who organize and plan activities to assist children's learning and developing requirements are preferred. In order to encourage and support children in learning mathematics effectively, ECD mathematics practitioners must first assess what children already know (prior capital and cultural knowledge) and what

they need to acquire (new concepts/knowledge). However, there is little information in the literature about how teachers in rural OR Tambo Inland District ECD centers should integrate procedural and conceptual knowledge when enhancing mathematics. The literature focuses a lot on the procedural and conceptual knowledge that practitioners should concentrate on when teaching mathematics to young children. Thus, the main objective of this research was to explore how practitioners in rural ECD classrooms employ conceptions of mathematical knowledge to improve early mathematics. Based on that, the main research question posed for the research was: How do practitioners apply conceptions of mathematical knowledge in rural ECD centers to improve early mathematics?

Theoretical Framework

The study used Ball and Bass's (2000) mathematical knowledge for teachers (MKT) as its theoretical foundation. The main focus of MKT theory is on the specific knowledge that teachers must possess in order to carry out their duties as educators. MKT has been found useful in a number of contexts, as was mentioned above. It serves as a framework for the discussion of teachers' mathematical expertise and contributes to the creation of teacher education programs and teaching aids (Ball & Bass, 2000). The MKT theory is employed in the study since it incorporates the ideas on the mathematical expertise practitioners ought to possess when performing the activity of teaching mathematics. MKT also include teaching kids how to solve issues, responding to their inquiries, and assessing their work, therefore it necessitates a knowledge of the academic program. It also entails organizing classes, assessing students' work, creating, and grading assessments, explaining students' progress to parents, creating, and managing homework, taking care of equity issues, and defending one's choices to the school principal (Ball & Bass, 200). Therefore, when teaching children mathematics, practitioners should concentrate on the tasks involved in education and analyze the mathematical requirements of these tasks. In order to promote children's mathematical growth, interactive classroom teaching activities and all associated tasks are promoted.

METHODOLOGY

Research Approach

A qualitative research methodology was used in this study. The qualitative research approach is described by McMillan and Schumacher (2009) as an investigation of people's individual and collective social behaviors, attitudes, and perceptions. Using this methodology, the researcher was able to comprehend a phenomenon (the use of mathematical concepts) from the perspectives of the participants (Creswell, 2014).

Participants

Practitioners from rural ECD centers in the Eastern Cape Province's OR Tambo Inland District participated in the study. Using a purposive sampling technique, five early childhood professionals were chosen (Robson & McCartan, 2016). Five practitioners in all were chosen as information-rich participants for the area of interest, one from each of the five centers (practitioners use of conceptions of mathematical knowledge). The inclusion criteria for the selection were, as follows:

1. must have spent at least five years as an ECD practitioner,
2. must be teaching in rural ECD center, and
3. must possess minimum certificate for teaching at ECD center.

Instrument for Data Collection and Procedure

An interview guide containing list of relevant questions was used for data collection. Some of the interview questions are, as follows:

1. How well equipped are you based on your education and training with respect to the aspects of mathematics that are pertinent to ECD?
2. What function do you play as a teacher of mathematics?
3. How can you increase a child's parents' or guardians' involvement in their children's growth and mathematics education

4. How do you account for the variety of backgrounds that children come from and how does this affect the way that they learn math?
5. How can you utilize your understanding of mathematics to help youngsters learn?
6. How can you create an environment that promotes mathematics learning?

Five early childhood professionals took part in the validation of the semi-structured interviews to better understand how they use conceptions of mathematical knowledge to encourage young children to learn mathematics in circumstances that are relevant to their daily lives (Nieuwenhuis, 2016). To ensure the reliability of the interview guide, the researchers used a tape recorder to record information on the concepts of mathematical understanding. Additionally, during interviews, probes were used to enabling participants to offer thorough details and receive a fitting response. Each of the inquiries posed in relation to practitioners' ideas of mathematics expertise. The researchers recorded field notes referring to observations into how practitioners apply their ideas of mathematical expertise to improve mathematics.

When gathering information, the researchers respected the autonomy of the pertinent ECD centers, the authority of the departments, including the Department of Social Development, and the authority of the center managers of the relevant ECD centers. In order to better understand the phenomenon of the study, which was how practitioners perceived mathematical knowledge, an interview guide with questions linked to it was employed (Creswell, 2014). Data was gathered during the interviews using a recording tape, and participants were prodded for additional information. The study also employed observations to learn more about what went on at the centers, including how practitioners used their ideas of mathematical abilities to improve the teaching of early mathematics. The observational schedule became necessary in order to have real life observation of the application of conceptions of mathematics knowledge during the practitioners' classroom instruction.

Ethical Considerations

The University of the Free State Faculty of Education's research ethics committee approved the ethical clearance for this study. Besides, the researchers ensured that participants' rights, informed permission, protection from harm, and vulnerability of the participants were all covered.

Data Analysis Procedure

Thematic analysis was utilized in the study to find patterns or themes in qualitative data (Braun & Clarke, 2006). Segments of the study's data were transcribed, then codes, categories, and themes were applied (Creswell, 2014).

RESULTS

This section of the study examined how practitioners employed conceptions of mathematical knowledge to improve mathematics in rural ECD contexts. The results were organized in themes and sub-themes.

Theme and Sub-Themes: Face-to-Face Interviews

Theme: Using ideas of mathematical knowledge to improve early mathematics by practitioners

Sub-theme one: Use of mathematics in the ECD lesson: The pedagogy used by practitioners in the teaching of early mathematics is the subject of this sub-theme. Some examples of the mathematical knowledge explored in this research include practitioner knowledge of mathematics curriculum, mathematics content and pedagogical knowledge practitioners gained during education and training programs, practitioner knowledge of designing mathematics learning environments, Practitioner knowledge of play theories in mathematics. Practitioners were asked how they apply their foundational mathematical knowledge in their classrooms, and their responses revealed that some centers had a plan for how to guide activities during instructional practices:

P2: "Children did not always understand what I was teaching, but I am attempting to teach through activities that involve directed play. Children forget because some of the activities are more difficult

for them than others, and because some of the activities are done in English, which is not their native language, in rural settings. For example, when doing reversal, or subtraction, there were five little ducks on the tree, but one of them fell, causing the rollover. Given that this procedure requires attention, focus, and understanding, I have to teach it for a week or two.”

However, practitioners in other centers employed conventional teaching techniques to get kids ready for school, and they gave these responses:

P4: “I only use charts to teach children counting because there is not room for a mathematics play area. They enter numbers into their books after that. We also count with our fingers.”

P5: “We do not go too far in mathematics; we just use our fingers to calculate. When children are asked, “How many animals are there?” they discover numbers and count.”

According to the data above, activities were directed by practitioners while children paid attention to them and responded as a class during the development of mathematics. There was no individualized instruction, only whole-class instruction.

Sub-theme 2: Supervision of kids both inside and outside during play: The study found that when practitioners discussed play and learning, they often referenced free play, which was further broken down into free-play indoor and free-play outdoor activities. These perceptions could be related to practitioners’ ignorance of the connection between play and learning. When the researcher questioned people about play, the following comments were received:

P4: “While the kids play independently outside, I find time to work on personal projects like planning for tomorrow.”

P3: “I just watch when they quarrel and let them play swing and see-saw on their own.”

The aforementioned findings point to a lack of context and content, particularly when it comes to outside play and the development of early mathematics. The replies also showed that practitioners in OR Tambo Inland District ECD centers lack a basic understanding of play and play theories, which is why they viewed outdoor play as a method to squeeze in some work time while kids were having fun. However, professionals who are knowledgeable about the topic and teaching methods of early mathematics are able to comprehend how to include play—both indoor and outdoor—into their activities and interpret children’s growing mathematical thinking. This research requires practitioners who are competent in the content, pedagogy, and philosophies of play (both indoor and outdoor play).

Observations

The observations were made in order to see what was naturally occurring at the research site (McMillan & Schumacher, 2009). In order to understand how practitioners employed their notions of mathematical knowledge to improve mathematics in children, the researcher examined learning environments. The observations revealed details on the learning environments, classroom activities, and instructional practices.

Learning environments

The observations showed that the centers were operating in locations that were also used for tenant housing; as a result, there was not enough room for the practitioners to set up play areas. Additionally, there were various charts, counting blocks, numbers, shapes with names, days of the week, months of the year, alphabets, seasons of the year, and a few samples of the kids’ work against the walls.

Classroom activities

The results of the observations showed that teachers controlled the classroom activities, and the kids picked up knowledge by adhering to the rules. Children would also be permitted to use toys and equipment for mathematics throughout the lesson, with the teacher directing them afterward. Additionally, books were given to the kids with instructions on how to write some of the numbers.

Instructional practices

The practitioners employed standard teaching methods that directed activities during the growth of mathematics. The kids also paid attention to the directions and cooperated in their responses. There was no individualized instruction, only whole-class instruction.

DISCUSSION OF THE FINDINGS

The emphasis of this sub-theme, on the application of mathematical understanding in the ECD class, was on practitioners' teaching approaches (pedagogy) in the early development of mathematics. The study's conclusions indicate that some early childhood centers' practitioners possessed the knowledge and abilities necessary to integrate play into teaching and learning. Lema (2019) further argues that many activities engaged in enhancing mathematics in the early years entail connecting real-world experiences with abstract concepts. Similar to this, Noviyanti and Suryadi (2019) claimed that possessing mathematical knowledge is a skill that teachers should possess in order to enhance the quality of their mathematics instruction and is utilized to carry out the function of teaching. Therefore, practitioners have the ability to equip and influence young children in the centers as implementers of mathematical knowledge. Nevertheless, teaching and learning in the OR Tambo Inland District were focused on getting the kids ready for school. Therefore, the current study recommends that practitioners be encouraged to learn about child development and early childhood mathematics programs through professional development training and seminars.

During a discussion with practitioners about how they employed play-based mathematics activities to help children grasp mathematics more, the sub-theme, guiding of children during indoor and outdoor play, came up. Additionally, the researcher found misconceptions about the connection between free play and learning, which was further divided into indoor and outdoor free play activities, when practitioners discussed play and learning. Practitioners also held the view that varied learning experiences needed to be incorporated into the classroom because learning and stimulation should not constantly occur. However, according to DBE (2015), the play learning environment includes both indoor and outdoor spaces that are beneficial to children's growth and learning. Due to the length of time spent in early childhood group situations, these environments have a significant impact on how children grow. Additionally, Tadesse (2016) emphasizes the significance of including play in mathematics instruction, which is effective when the learning environment is suitable for young children to grow and learn about their world. Nevertheless, the study's findings revealed that teachers at the OR Tambo Inland District ECD centers viewed outdoor play as a method to squeeze work in between watching children play mindlessly. As a result, this study asks for practitioners who are skilled at creating learning environments that are appropriate for the development of mathematics as well as in the content and pedagogy of play (both indoor and outdoor play).

The researcher took images and observed practitioners to examine how they employed their ideas of mathematical knowledge in their educational methods. The researcher was a non-participant observer, and the observations were concentrated on interactions that took place as practitioners' understanding of mathematics developed. The learning environment, classroom activities, and instructional approaches all played a role in the observations' conclusions. Similar to this, the learning environment was also examined, where the researcher found that in the indoor learning settings of some centers, it was challenging for the practitioners to create play areas because the centers were operating in areas also used for the habitation of the tenants. The swings and slides in the outdoor play area also required maintenance and repairs. The environment at these centers made it challenging for professionals to establish indoor and outdoor play activities that promote mathematical development. Gray et al. (2015) point out the relevance of outdoor play, which focuses on certain areas like social, mental, and physical development and is crucial to practitioners since it is connected to the growth of kids' motor abilities. Additionally, students would sit on the floor in some centers where there was only a carpet and no chairs. Due to space limitations, there were no indoor play facilities, and the outside play area only included jungle gyms, swings, and slides that were in terrible need of maintenance. Additionally, teachers guided the activities in math classes and gave the kids books to write some of the numbers in accordance with their directions. As a result, the study's conclusions showed that practitioners at these centers adopted traditional techniques of instruction while teaching mathematics. Additionally, whole-class education was used, which had issues because little one-on-one time was given, and

it was challenging to identify learning disabilities in kids using this approach. These outdated methods of instruction demonstrated the lack of early mathematics pedagogical understanding among practitioners.

Limitations

The results only apply to the sample of five practitioners from five early-childhood centers because the study's main focus was on practitioners as its units of analysis. Generalizations to the full population are challenging to establish because the study only included participants from five OR Tambo Inland District participants and five ECD centers as a limited sample. Future studies should therefore combine different techniques to provide data at the population level.

CONCLUSION AND RECOMMENDATIONS

The results of the study demonstrate that these centers used standard teaching strategies to scaffold what (topic) and how (method) of learning, such as telling, direct instruction, and demonstrations. Furthermore, it was found that the ECD practitioners do not apply their conceptions of mathematical knowledge in enhancing early childhood learning of mathematics. Therefore, practitioners must heavily rely on their subject-matter expertise, which is frequently lacking in rural ECD centers of OR Tambo Inland District, Eastern Cape Province, in order to promote early mathematics in children. Thus, the researchers recommend the followings:

1. The Department of Basic Education should provide practitioners with the content and pedagogical knowledge and skills necessary to improve mathematics in young children.
2. Practitioners should work with other centers to share ideas on how to incorporate play into the teaching of mathematics to children.
3. The curriculum designers should create curriculum materials that not only give practitioners classroom practice guidelines but also stimulate practitioners' learning as they use them.

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