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ORIGINAL RESEARCH

Manipulatives: mediators of mathematics development for foundation phase learners

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Abstract

This paper explores the effectiveness of using physical objects, or manipulatives, in teaching mathematics to Foundation Phase learners aged to 8 in the Eastern Cape Province of South Africa. The study is grounded in Piaget's Theory of Cognitive Development and uses a qualitative research design. Ten videos were selected, and clinical interviews were conducted with each learner individually while they used manipulatives. The data was analyzed thematically. The study found that manipulatives are an inexpensive and effective resource for teaching mathematics, as they enable children to understand key concepts through hands-on experience, and later connect these ideas to abstract concepts. Based on these findings, the study recommends that teachers and learners incorporate manipulatives in all units of the mathematics curriculum for effective teaching and learning in lower grades.

Keywords: Hands-on; Learner performance; Manipulative; Problem solving

Introduction and Background

The use of manipulatives in teaching mathematics has a long-standing tradition and solid research history (Golafshani, 2013). Manipulatives are concrete objects that can be viewed and physically handled by learners to demonstrate or model abstract concepts. They are practical tools that children can pick up and manipulate to help them understand the abstract notions of numbers and the ways in which they work in the number system. Examples of manipulatives include blocks, counters, popsicle sticks, pattern blocks, and base ten blocks.

The history of manipulatives for teaching mathematics spans over two hundred years, with important influences from innovators and researchers such as Maria Montessori, Jean Piaget, Zoltan Dienes, and Jerome Bruner. Each of these researchers emphasized the importance of authentic learning experiences and the use of concrete tools as an important stage in the development of understanding (Boz & Erdogan, 2020). Piaget suggests that children begin to understand symbols and abstract concepts only after experiencing the ideas on a concrete level, while Dienes extended this to suggest that children whose mathematical learning is firmly grounded in manipulative experiences are more likely to bridge the gap between the world in which they live and the abstract world of mathematics.

In 2013, the National Council of Supervisors of Mathematics (NCSM) issued a position statement on the use of manipulatives in classroom instruction to improve learner achievement. To develop every learner's mathematical proficiency, leaders and teachers must systematically integrate the use of concrete and virtual manipulatives into classroom instruction at all grade levels.

Research over the past forty years has generally found that manipulatives are a powerful addition to mathematics instruction. Studies by Suydam & Higgins (1977), Parham (1983), and Sowell (1989) found that achievement in mathematics could be increased by long-term use of manipulatives.

Manipulatives play a key role in young children's mathematics understanding and development. The use of manipulatives helps

bridge the gap between the abstract idea and the concrete level of understanding of a learner. For example, using manipulatives helps bridge abstract mathematical concepts with concrete understanding. Physical blocks can make addition and subtraction more tangible for young children by allowing them to physically add and subtract. Pie charts or fraction circles make fractions easier to visualize by showing how a whole is divided into equal parts. Pattern blocks aid in understanding geometry by letting learners manipulate shapes to explore concepts like symmetry and angles. Base ten blocks help students grasp place value by representing units, tens, and hundreds, making it easier to understand the construction and operation of numbers. These hands-on tools transform abstract ideas into more accessible, tangible experiences for learners.

Thus, it is important for leaders and teachers to systematically integrate the use of manipulatives into classroom instruction at all grade levels to improve learner achievement in mathematics.

Mathematical manipulatives are essential tools in young children's development and understanding of math concepts (Moyer, 2001). These concrete objects allow learners to manipulate and interact with them, leading to a deeper understanding of important mathematical ideas. By using simple physical objects that learners can visualize, touch, and move, teachers can facilitate their learners' comprehension of mathematical concepts in an inexpensive and effective manner. However, it is important to note that no single strategy or tool can improve learners' proficiency in mathematics in isolation.

Research suggests that the use of manipulatives, when purposefully integrated with other evidence-based strategies such as metacognitive development or structured interventions, can enhance learning outcomes for learners. By physically interacting with manipulatives, learners can engage their senses and access their spatial and kinesthetic intelligence, resulting in a stronger retention of information (Moyer, 2001). Mathematical concepts are often abstract, consisting of numbers, symbols, and words, but concrete and virtual manipulatives can help to solidify these abstract ideas into more concrete concepts. This is particularly beneficial for learners who may struggle with the introduction of new mathematical concepts, as the use of manipulatives can help to make these concepts more accessible. Additionally, providing learners with concrete materials during math lessons has been shown to improve their attitudes towards mathematics (Bjorklund, 2014). Overall, the use of manipulatives in mathematics education can help learners to connect their physical experiences with mathematical concepts, leading to more meaningful and effective learning outcomes.

In Foundation Phase, there exists a need to understand the role and effectiveness of manipulatives in mediating teaching and learning processes. However, the extent to which manipulatives effectively mediate teaching and learning outcomes remains unclear.

This article, therefore, examines how manipulatives can be utilized to teach mathematics in Foundation Phase classrooms and the impact they have.

To respond to this aim, the paper responds to the following questions:

(1) How do manipulatives mediate teaching and learning of mathematics for Foundation Phase learners?

(2) What specific learning gains can be observed in Foundation Phase learners when manipulatives are used in teaching mathematics?

Theoretical framework

This paper is based on Jean Piaget's Theory of Cognitive Development, which provides a framework for understanding the various theories that attempt to explain the use of manipulatives in mathematics instruction.

Cognitive Development Theory

The Cognitive Development Theory emphasizes the role of human intelligence and states that children are not passive recipients of knowledge, but actively construct their own understanding through exploration, observation, physical activities, and interaction with others. As individuals engage with the world and reflect on their experiences, they create their own mental

representations and integrate new information into their existing knowledge structures (schemas). To optimize learning, learners should be actively involved in the learning process rather than receiving information passively. Manipulatives are considered a constructivist approach to learning because they encourage learners to engage actively in the process of discovery. According to Piaget's constructivist theory of learning, learners should be given the materials and basic direction, but encouraged to explore and ask questions before and during the lesson. Piaget suggests that young children are better able to learn mathematical concepts when using concrete objects. Learning, in Piaget's view, is a social process that occurs within a social context, as learners and teachers work together to construct knowledge. As knowledge cannot be simply transmitted, the aim of teaching is to create experiences that facilitate the construction of knowledge (Liggett, 2017; Piaget, 1970). Piaget proposed that children engage in a continuous process of revising their existing knowledge or understanding of the world in order to better align it with reality. This process of cognitive development involves restoring a balance, or equilibrium, between a child's cognitive structures and the physical and social realities they encounter. As a result of this process, a child's thinking undergoes qualitative changes that shape their perceptions and preconceptions.

According to Liggett's (2017: 92) study, the use of manipulatives in teaching math can be traced back to Piaget's theory that young children need hands-on experiences to comprehend abstract mathematical concepts. Piaget believed that children cannot learn solely through lectures and explanations, and that they learn best through engaging in learning experiences. Furthermore, Piaget's theory emphasizes the social aspect of learning, as knowledge is constructed through collaboration between learners and teachers in a social context. The goal of teaching is not to directly impart knowledge to learners, but to provide experiences that facilitate their construction of knowledge. Piaget also proposed that children go through four stages of cognitive development (Golfashani, 2013). Piaget's Theory of Cognitive Development outlines four distinct stages of intellectual growth in children. The first stage, the Sensorimotor Stage, occurs from birth to age two, where infants and toddlers learn through sensory experiences and manipulating objects. The Preoperational Stage, from age two to seven, is characterized by children's ability to think symbolically and use words and pictures to represent objects. In the Concrete Operational Stage, from age seven to eleven, children develop the ability to think logically about concrete events. The final stage, the Formal Operational Stage, from age twelve and up, involves an increase in logical thinking, deductive reasoning, and understanding abstract concepts. Piaget believed that there is a qualitative shift in how children think as they progress through these four stages, providing insight into children's intellectual development.

Therefore, the use of Jean Piaget's Theory of Cognitive Development as the theoretical framework in this paper is rooted in key aspects of Piaget's theory that closely align with the use of manipulatives in education. Piaget's constructivist approach emphasizes that learners actively construct their understanding through interaction and exploration, which mirrors how manipulatives are used in mathematics instruction. His identification of cognitive development stages, particularly the Preoperational and Concrete Operational stages, supports the idea that manipulatives are effective in helping young learners move from concrete experiences to abstract thinking. Piaget also highlighted the importance of social interaction and collaboration in learning, which is often facilitated by manipulatives in group settings, leading to deeper cognitive development. The theory further suggests that active engagement and exploration are crucial for learning, and manipulatives provide an ideal hands-on approach that encourages experimentation and discovery. Lastly, the qualitative shifts in thinking that Piaget described as children progress through cognitive stages are supported by manipulatives, which help learners transition from concrete to abstract reasoning (Piaget, 1970).

Review of Related Literature

According to Kontas (2016), the word 'manipulative" has its roots in the Latin word 'manipulus' which means hand. Originally, the English words derived from this root such as "manipulate", and "manipulation" referred to the

skillful handling of physical objects by hand. Over time, these words also came to mean skillful management or utilization of something, and the ability to treat or operate with precision, as if using one's hands or mechanical means. In essence, the term “manipulative” can be used to describe the skillful handling of something, whether it be an object or a situation, to achieve a desired outcome.

What are manipulatives

Mathematics manipulatives refer to physical or digital objects that serve as hands-on teaching aids to model mathematical concepts and allow learners to concretize abstract ideas, establish connections between manipulatives and abstract mathematical concepts, and develop long-term mathematical skills (Kontas, 2016; Cass, Cater, Smith & Jackson, 2003; Holmes, 2013). These manipulatives can be anything from blocks, shapes, counters, sticks, or cut-out cardboard that provide learners with a tangible way to explore and solve mathematical problems (Maria, 2022). By manipulating these concrete materials, young learners can better understand abstract concepts and develop the necessary skills to excel in mathematics.

Manipulatives are physical objects that are utilized as teaching tools to facilitate hands-on learning of mathematical concepts. These objects serve as models to illustrate mathematical ideas in three-dimensional form or through objects that learners can physically manipulate. By using manipulatives, learners can explore mathematical concepts in an engaging and interactive way, utilizing materials found in their own environment. As Larbi and Okyere (2017) and Smith (2009) suggest, manipulatives are useful tools that can aid learners in forming a deeper understanding of mathematical concepts. Manipulatives are physical models that young children can touch and manipulate to explore and find solutions to problems. They can be utilized to introduce new concepts, reinforce previously taught lessons, or help correct any poor habits.

The importance of using manipulatives in teaching mathematics

Manipulatives have been widely acknowledged as valuable tools in teaching for many years. However, some educators remain reluctant to utilize them in their instruction. According to Boggan (2010), teachers who incorporate manipulatives in mathematics lessons for younger learners can significantly enhance their learning outcomes. The use of manipulatives is beneficial for learners of all abilities and levels, as supported by both educational research and learning theory in the classroom (Boggan, Herper, & Whitmire, 2010).

According to Boggan et al. (2010) and research on the benefits of manipulatives, the use of manipulatives can support learners in transitioning from concrete experiences to abstract reasoning in mathematics. By physically manipulating objects, learners can begin to grasp mathematical processes and procedures. Additionally, when used effectively, manipulatives can help learners connect mathematical ideas and integrate their knowledge, resulting in a deeper understanding of mathematical concepts. Studies have shown that the use of manipulatives can lead to increased mathematics achievement. Furthermore, learners who have the chance to work with manipulatives often report a higher level of interest in mathematics. According to research, the utilization of manipulatives has been found to enhance both the short-term and long-term retention of mathematics among children (Chang, 2008; Boggan, et al., 2010). Additionally, the use of concrete objects has been shown to improve the overall math classroom environment and children's comprehension of mathematical concepts. The incorporation of manipulatives in mathematical learning not only leads to better mathematical outcomes but also reduces math anxiety, especially when learners are given the opportunity to reflect on their experiences. In subjects where manipulatives are used, learners have a higher likelihood of achieving success compared to those who do not have access to manipulatives (Boggan, et al., 2010). Manipulatives can be a valuable tool for learners in gaining a better understanding of core mathematical concepts, as well as enhancing their overall learning experience. By utilizing physical objects, lessons can become easier to comprehend and more engaging.

Incorporating manipulatives into the learning process can cater to a variety of learning styles that may otherwise be missed if solely

relying on traditional teaching methods. Education experts suggest that learning occurs in three stages, as described by Jean Piaget: concrete, pictorial, and abstract (Hurst & Linsell, 2020). By manipulating physical objects, learners can delve into the first level of understanding, the concrete stage, and explore concepts on a more tangible level.

D'angelo and Ilieve (2012) found that incorporating manipulatives in mathematics education can enhance learners' understanding of mathematical concepts. The use of manipulatives enables learners to transition from concrete experiences to abstract reasoning and facilitates critical thinking and connections between math concepts. By allowing learners to independently explore the chosen manipulatives, they gain access to otherwise difficult-to-understand concepts and processes that might require teacher intervention.

According to several sources, including Cockett (2015) and Dinsmoor (2022), the effective use of manipulatives in teaching can increase learners' understanding and engagement. Manipulatives can help learners comprehend visual concepts by providing visual aids, scaffolding learning, and involving them in the learning process. In mathematics education, manipulatives are often considered essential instructional materials for promoting active and engaging lessons that facilitate teaching and learning, as argued by Kontas (2016) and Tunc, Durmus, and Akkaya (2011). Furthermore, manipulatives can aid in the conceptualization and interpretation processes for learners. Kocaman (2015), Kontas (2016), and Cope (2015) suggest that manipulatives not only benefit learners' cognitive development but also enhance their psychomotor skills by engaging multiple senses such as sight, touch, and hearing.

Reasons behind the use of manipulatives in teaching mathematics

According to research cited by Jones (2019), the brain's learning process starts with concrete experiences, such as hands-on manipulatives, followed by pictorial representations, and finally abstract concepts. The use of multiple senses in learning is known to enhance the learning experience. By using manipulatives, which are concrete objects that learners can handle and observe, children can construct their own understanding of mathematical concepts before learning the algorithms. Additionally, Souza (2008) suggests that manipulatives provide learners with the opportunity to observe and model more abstract math concepts. According to Jean Piaget, children develop an understanding of symbols and abstract concepts only after they have grasped and interacted with these ideas in a tangible, concrete manner. Several studies indicate that prolonged use of manipulatives can enhance a learner's performance in mathematics. Moreover, manipulatives can stimulate learners' curiosity and engagement while working with them, making the learning process feel more like play. The use of manipulatives encourages exploration, discovery, and experimentation, which can make problem-solving both more enjoyable and less challenging. According to the National Research Council (2001), manipulatives can facilitate the learning process by engaging multiple senses, such as sight and touch, and promoting discussion and communication skills. In contrast to completing a worksheet, using manipulatives can be more effective in this regard. Furthermore, the use of manipulatives can be particularly beneficial when teachers work closely with learners over an extended period, helping them to establish connections between the physical object, its corresponding symbol, and the underlying mathematical concept.

According to Souza’s research in 2008, learners who participate in basic hands-on activities while listening to information are more likely to remember the details of what they have heard. By engaging in activities such as sketching, building with blocks, and cutting with scissors, learners are better able to concentrate on the topic being presented. When learners finish a hands-on activity and discuss what they have created, they take on the role of a teacher and complete the final stage of the learning process, which involves explaining the concept to other learners. This teaching experience not only improves the learner's speaking and presentation abilities, but also reinforces the message that expertise can be found everywhere, and that learning is an ongoing process of exchanging information with others.

According to Hattie (2012: 134-136), there are several rationales for incorporating manipulatives into mathematics instruction, including:

- Bridging the gap between concrete and abstract mathematical concepts by offering a tangible representation that facilitates understanding.
- Providing learners with models to aid their cognitive processes, including memory retention and effective communication of mathematical ideas.

The effective teaching of mathematics involves encouraging learners to establish connections between different mathematical representations, in order to develop a deeper understanding of mathematical concepts and procedures, as well as using them as tools for problem-solving. The use of manipulatives is an effective way of providing learners with an additional representation for challenging mathematical concepts.

- Manipulatives are particularly useful for engaging learners and enabling differentiation, as learners progress through varying levels of proficiency by utilizing manipulatives to comprehend complex mathematical ideas. They also provide a foundation for teachers and learners to engage in dialogue, listening, and hands-on learning.
- Moreover, manipulatives empower learners to take charge of their own learning. By using manipulatives to create and work with representations, organize their thoughts, and communicate their ideas, learners develop a positive attitude towards mathematics and gain ownership over their learning process.

How mathematics manipulatives should be used in teaching

Improving learners' proficiency in mathematics cannot be achieved by relying solely on a single strategy or tool. However, integrating manipulatives in conjunction with other evidence-based strategies, such as promoting metacognitive skills or providing structured interventions, is more likely to result in positive learning outcomes. When used properly, manipulatives can be beneficial to young learners. It is crucial for children to comprehend the underlying mathematical concepts rather than simply manipulating the objects. According to Boggan et al. (2010), there are probably as many incorrect methods of teaching with manipulatives as there are ways of teaching without them. It is important to select math manipulatives that are appropriate for learners and align with the specific goals of the math program. The complexity of the materials should gradually increase as learners develop a deeper understanding of mathematical concepts (Boggan, et. al, 2010; Seefeldt & Wasik, 2006). In addition, teachers should encourage learners to engage in unstructured play with the manipulatives. They should also provide opportunities for learners to work with materials that have open-ended objectives and specific preset goals. This approach will enable learners to explore their own questions and generate multiple solutions.

According to Carbonneau, Marley, and Selig (2013), incorporating physical objects that learners can visualize, touch, and manipulate into the classroom can be an inexpensive and effective method for exploring mathematical concepts and encouraging learning. When used in moderation and as a tool for scaffolding, manipulatives can assist learners in problem-solving, reasoning, and transferring their understanding. However, it's crucial for teachers to exercise their judgment regarding how long to use manipulatives and when to remove them to avoid overreliance. Teachers should also ensure that there is a clear rationale for using a particular manipulative or representation to teach a specific mathematical concept.

According to Carbonneau et al. (2013), manipulatives can be a valuable tool for developing learners' understanding of increasingly complex mathematical concepts. To fully benefit from the use of manipulatives, teachers should encourage learners to recognize the connections between the concrete materials and the abstract mathematical ideas they represent. This requires teachers to guide learners in making links between the manipulatives and the mathematical concepts they illustrate, while also encouraging the development of related mathematical images, representations, and symbols. However, it is

important to note that learners should not become overly reliant on manipulatives to solve problems. Instead, manipulatives should serve as a means of illuminating the underlying general relationships between mathematical concepts, rather than simply providing a solution to a particular problem. Teachers can achieve this by helping learners appreciate the limitations of concrete materials and encouraging them to think beyond the immediate task or question.

Manipulatives ought to serve as a temporary support system, akin to a scaffold, that can be eliminated once learners attain self-reliance in the subject matter. It is crucial to reflect on how manipulatives can assist learners in acquiring the skills needed to perform math without them before employing them. Regardless of age, manipulatives can be employed to aid learners at any point in their learning process. The choice to discontinue the use of manipulatives should be determined by the learner's enhanced comprehension and knowledge, rather than their age, as stated by the OECD (2014).

Methods

Research design

This paper employs qualitative enquiry, specifically a phenomenological approach to gain in-depth of student thinking through probing and recording of gestures and engagement with manipulatives, employing clinical interviews. Clinical interviews as used by Van Hiele in mathematics aim to understand learners 'thinking levels (Fuys, Gedes and Tischler, 1988). Also, Clements and Sarama used clinical interviews to explore learners developmental thinking levels (Clements and Sarama, 2012). In this paper, clinical interviews are employed to investigate the role or influence of manipulatives in learning of mathematics in Foundation phase. Clinical interviews provide access to expressions, gestures, and manipulation to gain understanding of their thinking processes. These interviews were videotaped to capture well all the learning processes and learners 'expressions. Both researchers observed the tapes transcribing and documenting for interpretation, notes were shared for triangulation.

The videotaped observations, combined with the researchers' reflections on these experiences, align well with phenomenological research, which seeks to uncover the essence of participants' experiences and the meanings they ascribe to them. This paper used data from an NRF funded Grade R project where the principal investigator is the second author of the paper. The data analyzed in this paper comes from clinical interviews designed to tease out learner levels of mathematical development. These interviews provide Grade R/ Reception class learners with manipulatives and pictures to use during the process. These clinical interviews were videotaped by the researcher and assistants in the Eastern Cape Province of South Africa. Clinical interviews were conducted with individual learners in the beginning of the year during the learners' first week at school and these interviews were videotaped as a technique for data collection. The authors then transcribed observing these videotapes of individual learners who were using manipulatives. The second author shared her transcription with the first author for triangulation also to accommodate language translation as she speaks the same home language as the learners which is isiXhosa

The qualitative inquiry combines data collection and analysis techniques to gain a comprehensive understanding of the underlying reasons and processes of a given phenomenon, rather than solely providing a quantitative expression (Leedy & Ormrod, 2015; Neuman, 2010). Its emphasis is on the "why" rather than the "what" of social phenomena, relying on human experiences as the basis for making meaning in their daily lives. This approach seeks to provide a more holistic and in-depth comprehension of the research topic.

Therefore, observation of the videotapes were employed and documented in this paper. According to Maree (2021), Baden and Major (2013), and Creswell (2009), observation is a systematic approach that entails selecting and closely monitoring the actions, features, and traits of living organisms, objects, or events by means of watching, listening, reading, touching, and documenting. Out of 65 video tapes of interviewed learners from the Eastern Cape Province of South Africa, this paper focuses only on 10. The

selection of the ten had no criteria but focused on audibility and clarity.

Data analysis

The process of examining, purifying, altering, and shaping data with the aim of uncovering valuable insights, proposing findings, and assisting in decision-making is known as data analysis. Following the viewing of ten video recordings that showcased how Grade R learners utilized hands-on tools for learning and playing, the researcher scrutinized their responses to working with these manipulatives. Thematic analysis was used to analyze data in this paper which were gathered through qualitative inquiry and clinical interviews with Grade R learners. T Both researchers took their captured data and coded it to identify themes. The codes were then triangulated by the researchers for similarities, contradictions and patterns. Researchers conducted an iterative process of referring to the data to qualify their codes. The credibility of the results produced by qualitative research depends on its trustworthiness, as emphasized by scholars such as Moser (2022) and Seoka (2019). This process ensured trustworthiness of the findings. These codes were grouped into similar categories and their response to the research questions. Semi-themes emerged and were integrated with literature on manipulatives and three analytical themes came out that are: Use of manipulatives, Emerging strategies for manipulatives and Values of manipulatives.

Results

Three themes were identified from the analyzed data:

1. Use of manipulatives.
2. Emerging strategies for manipulatives.
3. Values of manipulatives.

Use of manipulatives

The benefits of using manipulatives in Foundation Phase mathematics align with South Africa's CAPS policy, which promotes hands-on learning to enhance conceptual understanding. CAPS advocates for concrete materials to help learners grasp abstract concepts, support diverse learning styles, and foster both achievement and a positive attitude towards mathematics, contributing to a solid foundation in early education (Department of Basic Education, 2011).

The paper found out that there are significant benefits of using manipulatives in mathematics education for Foundation Phase learners. The findings reveal that the incorporation of manipulatives not only enhances mathematical achievement but also fosters a positive attitude towards learning mathematics. For example, Figure 1 below demonstrates diverse approaches of learners on free play with geometrical shapes. The researcher asked learners to play with the shapes with no interference and only asked probing questions when she observed some structures.

Figure 1 shows that learner A sorts shapes according to similar colours, while learner B tesselate similar shapes regardless of colour in twos, first he combined two rhombi, then he tessellated two triangles each to form a square, on the other hand learner C put two similar shapes on top of each other again regardless of colour small red circle on top of a green circle, a yellow small triangle on top of a big red triangle and a small yellow square on top of a big green square. When the researcher probed more asking questions the following were the learner responses:

Researcher: Ndibona unamaqembu amathathu ngawantoni? Meaning (I see three groups can you tell me what are they about?

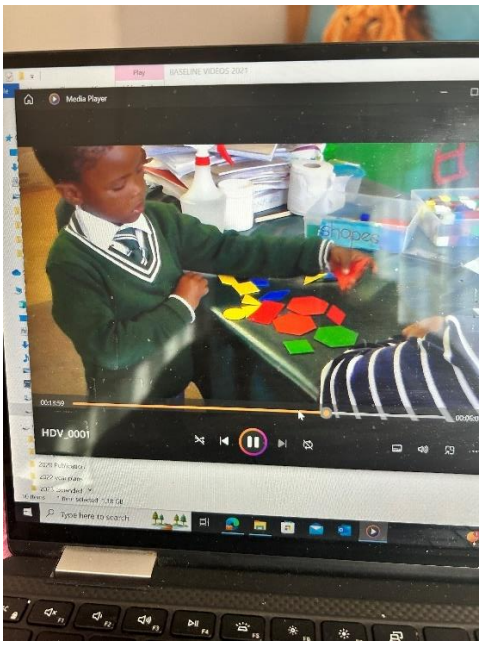
Learner A: Ndidibanise ezifanayo zodwa. Meaning (I grouped similar ones together)

Researcher: Zifana ngantoni? (What makes them similar?)

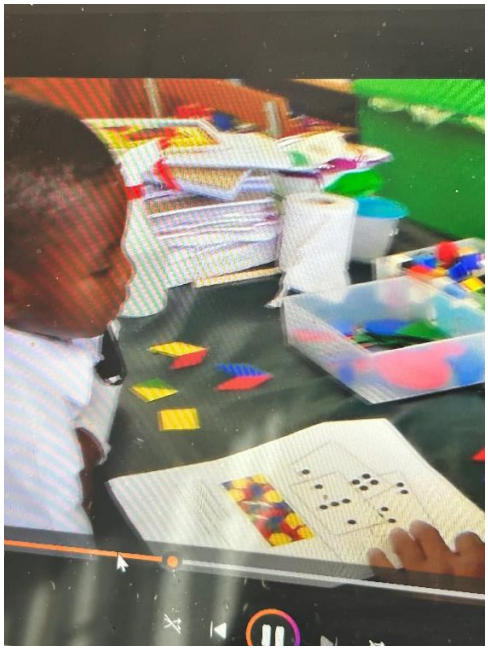
Learner A: Zifana ngemibala, zigreen (pointing at the green ones), ziyellow (pointing at the yellow group) ezi zibomvu (pointing at the red group bomvu means red) In summary the leaners says they are groups by colour and using English colur names for green and yellow but isiXhosa for red.

Figure 1: Grade R learners 'free play activities

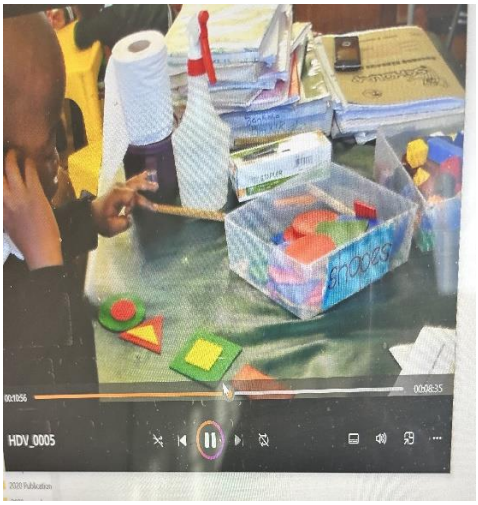
A



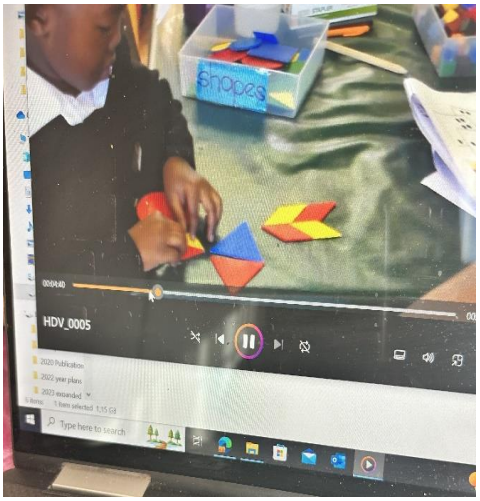
B



C



D



For learner B the following occurred:

Researcher: Khawutsho wenzeni apha? Meaning (What were you doing here?)

Learner B: ndenza ezinye iisheyiphi meaning (I am making other shapes)

Researcher: Khandifundise wenze njani? (Please teach me what you have done?)

Learner B: Ndithathe eziyi two ezitsolo ndazidibanisa ndenza ifish. (I put two of the sharp shapes together and made a fish, referring to two rhombii)

Researcher: Ezinye? (What about others?)

LearnerB: Ndidibanise oonxantathu benza isikwere. (I put two triangles together and made squares)

Learner C presented his play as follows:

Researcher: Khandixelele zezitheni ezi?

Learner C: Ndidibanisa ezifanayo , izangqa (pointing cirlces) oonxanathu pointing triagles kunye nezikwere pointing squares. This means he uses his lanuange explaining that he brings together circles, triangles and squares.

Learner D has a different approach which he explains as follows:

Researcher: Wenzeni apha khandicacisele.

Learner D: Ndidibanisa ezifanayo zibeyi four. Lena ndidibanise ezitsolo zenza ifish, enye ndidibanise oonxanthathu ababini nezitsolo ezimbini ndenza ikayiti. (This means I took four sharp ones that look the same and made a fish. Then I took two triangles and two sharp ones to make a kite.)

It is important to note that learner A did not attend preschool while all others did. Data collected revealed that when learners use manipulative materials, they produce greater achievement in mathematics than not using them in a Foundation Phase class. The paper also found that learners who attended preschool and who worked with manipulatives outperformed those who did not. This is evident from the data collected that manipulatives do offer benefit to young learners. This was supported by Golafshani (2013) who said that learners who used manipulatives during their preschool years performed better in mathematics than those who did not attend. Those who attended and used manipulatives in preschool were able to count and able to identify shapes and colours with ease.

From the collected data, learners enjoyed playing with manipulatives and toys. Therefore, their attitude and love towards working with mathematics improve when working with manipulatives. This can also be improved by teachers who are knowledgeable about the use of manipulatives when teaching mathematics. Manipulatives also help learners to understand mathematical concepts well. Working with manipulatives also helps learners to boost their learning and beneficial in improving their learning in mathematics (Moyer & Jones, 2004). When those learners interacted with manipulatives, they made some unnoticed mathematical connections, and this improves their mathematical understanding of concepts. Another reason for using manipulatives in teaching young children is that different learning styles should be applied by the teacher (Back, 2019). The use of manipulatives allows learners to construct their own imaginative models for mathematical ideas and process. They acquire knowledge through experience rather than using intelligence to solve problems. Working with manipulatives also keeps learners focused throughout.

It was fun for them and stayed focused throughout. The researcher observed that learners were active, engaged and interested in the interviews when learners were engaged with manipulatives. Carnabonneau, Marley and Selg (2013) support this by saying that mathematics manipulatives make learning mathematics interesting and enjoyable. When working with manipulatives, learners were dealing with concepts in the real world, rather than in a book problem or pencil-and-paper problem. They were inquiring knowledge through experience rather than abstraction and using a great range of intelligence to solve problems. Learners were able to count numbers using manipulatives, i.e., they were able to count sides of a rhombus, square and rectangle. They were able to relate manipulatives to their everyday experiences. They could identify different shapes found in class and their homes. Learners were able to know different shapes and colours by engaging themselves with manipulatives. They learn to create different objects by using different mixtures of manipulatives. Therefore, this helps learners to solve mathematical problems with hands-on approach. Math manipulatives make learning math interesting and enjoyable (Carbonneau,et al, 2013).

Therefore, manipulatives are a powerful tool in mathematics education for young learners. They not only support the development of mathematical skills but also make learning enjoyable and meaningful. The data supports the notion that manipulatives foster a positive learning environment, encourage active participation, and help learners build strong foundational knowledge in mathematics.

Emerging strategies for manipulatives

The use of manipulatives for teaching counting, shape recognition, and engagement aligns with South Africa's CAPS policy, which supports the development of foundational mathematics skills. CAPS promotes concrete materials to help young learners understand abstract concepts, encourages active participation

and play-based activities, and highlights the use of culturally relevant resources to accommodate diverse learning styles and foster a positive attitude towards mathematics (Department of Basic Education, 2011).

Manipulatives are needed for learners to learn counting. The findings of this paper show that during the interview learners used resources to respond, for example:

The teacher asked them about their age.

Learner F counted her finger and counted up to 7 to shown her age.

The teacher again asked number of their family members. They were able to count them, for example:

Learner C said they are 6 in their family.

Lastly, she asked them the number of books that they have at their respective homes.

They responded by saying 4, 5, 6, etc.

Learners grabbed sets of manipulatives of different shapes, sizes, and colors. They then counted, 1, 2, 3, etc. This was easy for them. Therefore, the mathematics manipulatives acted as baseline form of reference for the teacher and her children. With these manipulatives we could see that the learners understood how to count when asked various questions by the teacher (See examples of questions asked by the teacher above).

This shows that learners were learning to count. Bottle tops, counters and blocks were used to count by learners. Learners were counting from 1-23, 1-30, 1-39, etc using manipulatives. Some repeated and skipped the numbers and it became better with the use of manipulatives.

Young kids are usually very reluctant to learn something forcefully. If the teacher uses force to teach them, they may become reluctant to learn mathematics. Young kids always enjoy when teachers play with them. One of the best ways to teach them mathematics is using manipulatives, like in the data that was collected for this paper. The young kids were enjoying engaging themselves with manipulatives.

It is very important for young children to be familiar with shapes. Shapes identification is needed for learning ground for developing geometry skills. Manipulatives can also be used by teachers to teach shapes. Manipulatives also help teach the concept of shapes to young children in a participative manner. In the data collected for this paper, the teacher allowed the children to play with different objects. Learners arranged, pack, and sort manipulatives. This made them to learn more about shapes. In the collected data, the teacher was teaching them about different shapes such as square, rectangle, circle, rhombus, etc. A shape such as a square was a new concept to most of the learners. The teacher taught them about different shapes, like square, rectangle, circle, rhombus, etc. The teacher asked her learners to match those shapes with items inside the classroom. Their responses were:

Learner A: *Table*.

Learner B: *Picture board*.

Learner C: *Notice board*.

Shapes are an important part of building math reasoning in a child. Judging shapes, sizes, heights and distance find its best use while engaging with them. This help children to come to terms with shapes the fun way. Learners sorted blocks by colours and later were involved with patterns to fill with the blocks. Color sorting, like what learners were instructed to do in the collected data, is the best way to teach young learners colors. The teacher also asked them to be creative in their choices of colors in making the patterns. In that way, children were enjoying learning shapes by being involved hands-on. With this practice, learners will be able to retain the concepts of shape and color better. Shapes, like, for example in the collected data, were used by learners to explore and build colorful patterns. Shape cognition is always there in young children. Children are familiar with manipulatives as they play since infanthood. In the collected data, children tried to fix, pack, arrange and match manipulatives to form shapes. These shape manipulatives can teach learners about shape, size, and color at the same time.

Working with manipulatives in teaching mathematics to young learners highlights their effectiveness in enhancing counting skills, shape recognition, and engagement, but also reveals

several knowledge gaps that warrant further exploration. These gaps include a limited focus on advanced mathematical concepts beyond basic counting and shapes, a lack of longitudinal data on the retention and transfer of skills acquired through manipulatives, and insufficient emphasis on the teacher's role in fostering higher-order thinking. The use of shapes and colors do not address the diversity of manipulatives and their cultural relevance, the impact on learners with different learning styles and abilities, or the need for professional development to equip teachers with the necessary skills to use manipulatives effectively. Addressing these gaps could lead to a deeper and more comprehensive understanding of the role of manipulatives in early mathematics education.

Values of manipulatives

The value of manipulatives in mathematics education is reinforced by South Africa's Curriculum and Assessment Policy Statement (CAPS), which highlights the need for hands-on, experiential learning. CAPS supports the use of concrete materials like manipulatives to aid in understanding mathematical concepts, boost engagement, and create a positive learning environment. The policy also emphasizes manipulatives' role in accommodating various learning styles and alleviating math anxiety through active participation and exploration, reflecting findings from educational research (Department of Basic Education, 2011).

There are potential gains made by using mathematical manipulatives when teaching mathematics. Research found out that learners who attended preschool and used manipulatives performed well in mathematics (Larbi & Okyere, 2017). Research conducted in this paper indicated that teacher plays an important role in creating mathematical environment that provides learners with manipulatives that enhance their thinking skills. This study also showed that learners use manipulatives to aid their learning. Manipulatives reinforce math concepts in this paper such as shapes, colors and counting. By working with manipulatives, learners showed a deep understanding of elementary and advanced math skills that can be of great use in future. Results in this paper also indicate that manipulatives help improve the environment in the mathematics classroom. When learners were working with manipulatives and were given a chance to reflect their own experiences, not only mathematical learning enhanced, but learners' math anxiety was reduced. They were freely engaging themselves with manipulatives. Exploring manipulatives provides an exciting classroom environment and promotes in learners a positive attitude toward learning (Moch, 2001). This study found out that learners enjoyed themselves when engaging with manipulatives. Moch supported this benefit by saying that, using manipulatives helps make learning fun. Therefore, manipulatives help engage learners, increasing their interest as they work with manipulatives. While working with manipulatives in this research, learners felt more like playing, especially since it involved exploration.

Learners in this study were engaged with using sight, touch and hearing to work with new concepts and encourage communication skills with their teacher. When working with manipulatives, learners get to see, touch, and hear mathematics. The involvement of children's senses in the learning experience can be achieved using manipulatives or real objects in mathematics. By not utilizing manipulatives, we neglect the learning styles of those who prefer a hands-on approach. Research has shown that learners tend to enjoy using manipulatives, which facilitates their active participation and interaction. Rather than passively listening to a teacher's explanation, learners who use manipulatives are more engaged in the learning process. The current paper demonstrates that using manipulatives effectively can enhance learners' understanding and engagement by providing visual aids, scaffolding, and opportunities for active learning. Dinsmoor (2022) further supports this notion by stating that manipulatives cater to learners' needs and allow them to experiment with tangible objects to gain a deeper understanding of mathematical concepts. The use of manipulatives is particularly beneficial for young children as they develop their own connections and grasp mathematical concepts. On the other hand, there is a lack of exploration into how manipulatives can support the development of more complex mathematical skills, the specific strategies teachers can use to maximize the effectiveness of manipulatives, and how these

tools cater to diverse learning styles in different educational contexts. There is also limited discussion on the long-term impact of manipulatives on learners' mathematical development beyond the classroom.

To improve the coherence of this paper, adjustments were made to integrate the "Trustworthiness" into this section. The study ensured dependability by clearly outlining its processes, achieved transferability by adhering to the specific geographical context, and maintained confirmability through the verification of transcribed data using video recordings. In this section, references were made to these trustworthiness steps, such as cross-verifying data to reflect learners' experiences accurately and highlighting consistent strategies observed across contexts. By doing so, the paper presented a more coherent narrative, enhancing the research's credibility and reliability.

Conclusion

According to research presented in this paper, incorporating manipulatives into mathematics lessons can lead to a better understanding of mathematical concepts among learners. Stein and Bovalino (2001) suggest that incorporating manipulatives into mathematics lessons in meaningful ways can help learners grasp concepts with greater ease, resulting in more effective teaching. Manipulatives are considered essential tools for stimulating mathematical thinking and teaching mathematics to young children, and introducing concrete mathematics to them at an early age can significantly enhance their mathematical competence (Ilieve, 2012). Young children also tend to enjoy learning mathematics when manipulatives are used and using them can not only increase their mathematical achievement but also provide them with additional strategies for solving math problems. Dinsmoor (2022) further supports this statement by stating that the use of manipulatives can enhance learners' learning experiences, bridge the gap between the physical and abstract, and foster life-long learning in curious young learners. Overall, using manipulatives in mathematics education can help children build strong mathematical foundations and gain a deeper understanding of mathematical concepts that serve as the basis for their conceptual mathematical knowledge.

Recommendations

The teaching and learning of mathematics with manipulatives can be guided by the following recommendations:

i. Teachers should play a crucial role in teaching concepts using math manipulatives. This involves providing clear instructions to learners on how manipulatives can be used to achieve desired results.

ii. Manipulatives can act as a scaffold that can be gradually removed once learners achieve independence. To facilitate this transition, learners can imagine using manipulatives even when they are no longer physically present. As learners master concepts, the responsibility for learning should shift from the teacher to the learners, and the teacher should assume the role of facilitator rather than dominant content expert. Eventually, learners should move towards an abstract approach once they are ready to work without manipulatives.

iii. When selecting manipulatives, teachers should consider learners' interests as well as the curriculum. Additionally, for younger children (such as those in Foundation Phase), teachers should be mindful of the risk of choking hazards and provide appropriate supervision during manipulative activities.

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