

Teachers' Beliefs in Enhancing Number Concepts through Manipulatives in the Foundation Phase in Rural Schools



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ABSTRACT

Mathematical manipulatives promote children's understanding of number concepts and problem-solving skills. Nevertheless, teachers face the challenges of limited manipulatives and a lack of curriculum support in mathematics, especially in rural areas. The Montessori model of approach explains that using real-world materials and pedagogical practices enhances children's mathematical concepts. This paper, therefore, explored teachers' beliefs in enhancing number concepts through manipulatives in the foundation phase in rural schools. The study was conducted in Limpopo, South Africa, with six foundation phase teachers purposively sampled due to their similar experiences in teaching mathematics in rural schools. An interpretivism case study design was employed to elicit rich and in-depth data within qualitative research to explore teachers' beliefs on using manipulatives to enhance number concepts. Semi-structured interviews and non-participant observations were used to collect data from the participants. The findings revealed that teachers use manipulatives to develop children's number concepts, shapes and mathematical skills. Despite the limited manipulatives, they improvise by creating materials and integrating games. It is suggested that teachers in rural schools must be creative in designing their manipulatives and use games requiring fewer manipulatives to teach mathematics. This paper contributes to the pedagogical and professional knowledge on addressing the challenge of limited manipulatives in rural schools by using Montessori's model approach to create real-world manipulatives and integrate play-based pedagogy to enhance children's mathematical and problem-solving skills.

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INTRODUCTION

Curriculum policies across various regions actively promote using manipulatives in early childhood and foundation phase classrooms, recognising their significant role in enhancing hands-on learning and deepening mathematical understanding. Globally, the United Nations Children's Fund (UNICEF) mandates that teachers should provide adequate toys, manipulatives, play-based pedagogy and other learning materials to teach young children.¹ The Common Core State Standards for Mathematics (CCSSM) implemented by most regions in the United States emphasise that using manipulatives in early

¹ UNICEF, "Learning through Play: Strengthening Learning through Play in Early Childhood Education Programmes," UNICEF Press, 2018, <https://www.unicef.org/sites/default/files/2018-12/UNICEF-Lego-Foundation-Learning-through-Play.pdf>.

grades accelerates kindergarten children's understanding of mathematical concepts.² Similarly, England's curriculum, Early Years Foundation Stage (EYFS), encourages using concrete objects in mathematics as they assist with counting and problem-solving skills.³ In support, the National Council of Teachers of Mathematics (NCTM) maintains that using manipulatives enhances children's mathematics skills.⁴ The South African curriculum advises mathematics teachers to employ manipulatives such as flashcards and abacuses to teach mathematical concepts in early childhood education.⁵

The term "manipulatives" refers to a wide range of concrete and physical materials used as teaching and learning resources to encourage children to understand mathematical concepts through direct experience with objects.⁶ Furthermore, manipulatives are regarded as beneficial in teaching and learning number concepts in early childhood classrooms, as teachers can use manipulatives such as pictorial representations to enhance children's grasp of number concepts.⁷ Several theorists believe that using concrete materials enhances children's holistic skills,⁸ while other scholars corroborate that manipulatives can be used to teach mathematics education.⁹ It was significant to explore teachers' beliefs in enhancing number concepts through manipulatives in the foundation phase in rural schools.

Teachers in rural schools face significant challenges in implementing manipulatives for number concepts teaching due to limited resources, inadequate training and a lack of curriculum support. This challenge contributes to poor achievement in mathematics, even in higher grades. Lamentably, evidence from the Trends in International Mathematics and Science Study (TIMSS) shows South African learners continue to perform poorly in mathematics compared to other regions.¹⁰ This could result from poor teaching approaches in the foundation phase, resulting in disengagement and lack of confidence, causing learners to develop negative attitudes toward mathematics. Numerical concepts play a vital role in learning mathematics as they feature in all content areas, including numbers, operations, relationships, patterns, functions and algebra, space and shapes, measurement and data handling.¹¹ Thus, teachers must effectively enhance learners' number concepts to enhance their mathematical knowledge. Therefore, ensuring high-quality pedagogical approaches in the foundation phase fosters mathematical proficiency and achievement in higher grades.

Various manipulatives can enhance learners' number concepts in the foundation phase. These manipulatives include counters, place-value mats, base-ten blocks, and fraction strips (among others), which are used by Foundation Phase teachers globally to promote children's understanding of mathematics.¹² Research confirms that children develop early reasoning skills and a grasp of mathematical

² Katja Robinson et al., "Variation in Mathematics Content Coverage, Instructional Grouping, and Representational Strategies," *The Elementary School Journal* 124, no. 2 (December 1, 2023): 270–96, <https://doi.org/10.1086/727474>.

³ Julian Grenier and Caroline Vollans, *Putting the EYFS Curriculum into Practice* (Sage, 2022).

⁴ Salvador Llinares, Konrad Krainer, and Laurinda Brown, "Mathematics Teachers and Curricula," in *Encyclopedia of Mathematics Education* (Cham: Springer International Publishing, 2020), 600–604, https://doi.org/10.1007/978-3-030-15789-0_111.

⁵ Department of Basic Education, *Curriculum and Assessment Policy Statement for History* (Pretoria: South Africa, 2011).

⁶ Alberto Arnal-Bailera and Mónica Arnal-Palacián, "Pre-Service Teachers Develop Their Mathematical Knowledge for Teaching Using Manipulative Materials in Mathematics," *Eurasia Journal of Mathematics, Science and Technology Education* 19, no. 9 (September 1, 2023): em2318, <https://doi.org/10.29333/ejmste/13470>.

⁷ Arnal-Bailera and Arnal-Palacián, "Pre-Service Teachers Develop Their Mathematical Knowledge for Teaching Using Manipulative Materials in Mathematics"; Ana Barbosa and Isabel Vale, "A Visual Approach for Solving Problems with Fractions," *Education Sciences* 11, no. 11 (November 12, 2021): 727, <https://doi.org/10.3390/educsci11110727>.

⁸ Maria Montessori, *The Montessori Method-Scientific Pedagogy as Applied to Child Education* (anboco, 2016); Jean Piaget and Margaret Cook, *The Origins of Intelligence in Children*, vol. 8 (International universities press New York, 1952); Jerome Seymour Bruner, *Toward a Theory of Instruction* (Harvard university press, 1974); Lev Semenovich Vygotsky and Michael Cole, *Mind in Society: The Development of Higher Psychological Processes* (Cambridge, Massachusetts: Harvard University Press, 1978).

⁹ Rebecca Tope. Adesokan, "'Rejuvenating the Teaching of Primary Mathematics through the Use of Manipulatives.'" , 6, No. 2 (2024)," *Sapientia Foundation Journal of Education, Sciences and Gender Studies* 6, no. 2 (2024); Matodzi G Sikhwari and Nosisi N Feza, "Manipulatives: Mediators of Mathematics Development for Foundation Phase Learners," *African Perspectives of Research in Teaching and Learning* 8, no. 2 (2024): 63–78.

¹⁰ Vijay Reddy et al., "Mathematics Achievement and the Inequality Gap: TIMSS 1995 to 2015," in *South African Schooling: The Enigma of Inequality* (Cham: Springer International Publishing, 2019), 169–87, https://doi.org/10.1007/978-3-030-18811-5_9.

¹¹ Department of Basic Education (DBE), *Curriculum and Assessment Policy Statement Grades 7-9: Natural Sciences* (Cape Town: South Africa, 2011).

¹² Sikhwari and Feza, "Manipulatives: Mediators of Mathematics Development for Foundation Phase Learners"; Andrea Marquardt Donovan and Martha W. Alibali, "Toys or Math Tools: Do Children's Views of Manipulatives Affect Their Learning?," *Journal of Cognition and Development* 22, no. 2 (March 15, 2021): 281–304, <https://doi.org/10.1080/15248372.2021.1890602>.

concepts by using manipulatives.¹³ Additionally, a recent study found that teachers who effectively use concrete and virtual manipulatives in lessons create a mathematically rich environment that encourages young learners to think critically and solve problems.¹⁴ This confirms that manipulatives are essential for effectively teaching number concepts in early childhood classrooms. Consequently, it was necessary to explore the beliefs held by Foundation Phase teachers in enhancing number concepts through manipulatives in rural schools, since these are said to drive their practice both worldwide and in the South African context. The paper seeks to better understand how their beliefs and practices are connected. In essence, this paper explores teachers' beliefs in enhancing number concepts through manipulatives in the foundation phase in rural schools. The question that underlies this study is this: *What are teachers' beliefs in enhancing number concepts through manipulatives in the foundation phase in rural schools?*

LITERATURE REVIEW

Teachers' approaches affect learners' development, and all these approaches are shaped by assumptions about what works best when educating future mathematicians.¹⁵ There has been a growing movement toward using a more constructivist approach in number concepts classrooms. However, little is known about using manipulatives in teaching number concepts in the foundation phase, especially in rural schools.

Creating a manipulative world in the foundation phase classrooms

Learners need access to many physical objects to understand the concepts and calculations taught thoroughly.¹⁶ Also, they need to explore physical items to discover their novel uses. This is consistent with the postulation that children's minds develop through manipulating materials.¹⁷ Mathematical concepts are easier to grasp through tactile experiences.¹⁸ This is supported by the contention that when learners go from tangible to abstract mathematical concepts, their comprehension of mathematical operations develops. This is congruent with the Montessori method, which holds that children learn addition, subtraction, multiplication and division operational skills by first using manipulatives.¹⁹

The current South African curriculum policy and literature maintain that manipulatives play a vital role in teaching mathematics by assisting learners in developing problem-solving abilities.²⁰ The DBE policy document and guidelines advocate for incorporating a variety of resources into foundation phase mathematics classrooms to significantly improve learners' mathematical knowledge, problem-solving and reasoning skills. Moreover, when learners work with a tangible item, it helps them solve mathematical problems.²¹ In addition, providing learners with concrete maths materials promotes their problem-solving

¹³ Sum Kwing Cheung, Winnie Wai Lan Chan, and Joyce Lok Yin Kwan, "An Investigation into the Concreteness of Manipulatives in Mathematical Instruction: Do the Object and Its Label Matter?," *Early Childhood Research Quarterly* 65 (2023): 275–83, <https://doi.org/10.1016/j.ecresq.2023.07.005>.

¹⁴ Aidong Zhang and Carrie Cutler, "Using Manipulatives In Face-To-Face, Hybrid, And Virtual Early Childhood And Elementary Mathematics Methods," *The AMTE Handbook of Mathematics Teacher Education: Reflection on Past, Present and Future—Paving the Way for the Future of Mathematics Teacher Education* 5 (2024): 265.

¹⁵ Eva Thanheiser, "What Is the Mathematics in Mathematics Education?," *The Journal of Mathematical Behavior* 70 (June 2023): 101033, <https://doi.org/10.1016/j.jmathb.2023.101033>.

¹⁶ Warren Colman, *Act and Image: The Emergence of Symbolic Imagination* (Routledge, 2021).

¹⁷ Sani Mukhtar Muhammad et al., "The Effect of Using Manipulatives on the Performance Of Pupils in Primary School Mathematics," *Journal of Mathematical Sciences & Computational Mathematics* 4, no. 2 (January 2, 2023): 223–32, <https://doi.org/10.15864/jmscm.4206>.

¹⁸ Muhammad et al., "The Effect of Using Manipulatives on the Performance Of Pupils in Primary School Mathematics."

¹⁹ Immaculate Kizito Namukasa and Kinful Lartebea Aryee, "Pedagogical Knowledge for Teaching Mathematics in Montessori Schools," *International Electronic Journal of Mathematics Education* 16, no. 3 (June 23, 2021): em0646, <https://doi.org/10.29333/iejme/11005>; Evangeline Bungao- Abarquez, "The Use of Manipulative in Teaching Elementary Mathematics," *International Journal of Linguistics, Literature and Translation* 3, no. 11 (November 30, 2020): 18–32, <https://doi.org/10.32996/ijllt.2020.3.11.3>.

²⁰ Stamatios Papadakis, Michail Kalogiannakis, and Nicholas Zaranis, "Teaching Mathematics with Mobile Devices and the Realistic Mathematical Education (RME) Approach in Kindergarten," *Advances in Mobile Learning Educational Research* 1, no. 1 (2021): 5–18, <https://doi.org/10.25082/AMLER.2021.01.002>; Peter Liljedahl et al., "Problem Solving in Mathematics Education," 2016, 1–39, https://doi.org/10.1007/978-3-319-40730-2_1.

²¹ Papadakis, Kalogiannakis, and Zaranis, "Teaching Mathematics with Mobile Devices and the Realistic Mathematical Education (RME) Approach in Kindergarten."

abilities.²² Therefore, in line with the literature, teachers would benefit from understanding the Montessori approach and being empowered to apply its principles in their professional practices.

Using manipulatives in the early years

Findings of a study that explored using physical manipulatives (concrete objects) in teaching mathematics in twenty-six (26) states of the USA indicated that physical manipulatives benefit children's early learning experiences in mathematics, spatial awareness, literacy and science skills.²³ These findings concur with the Montessori view of using manipulatives to boost mathematics performance in early years' educational settings. Similarly, research was conducted using a mixed-methods methodology to collect data in South Australian schools to investigate the influence of manipulatives on young children's attitudes towards mathematics by analysing children's drawings, written descriptions, interviews and observations.²⁴ The findings indicate that children enjoy mathematics because of manipulatives, which contribute to a clear vision that promotes understanding of mathematics concepts and improves academic competence. In contrast, the transition between enactive, iconic, and symbolic experiences in teaching mathematics can contribute to children's negative attitudes.

The contribution of manipulative materials in teaching geometric figures to Portuguese elementary school children was explored by employing qualitative and interpretative approaches.²⁵ The data was collected through children's (aged six) written records and audio and video recordings of their activities. The findings revealed that manipulatives assist young learners in constructing different shapes and other geometric figures. Further, a study conducted in KwaZulu-Natal (South Africa) examined foundation phase pre-service teachers' opinions of using manipulatives to enhance children's competencies and reasoning skills in number operations.²⁶ The study used qualitative research techniques to collect data from 31 pre-service teachers by perusing participants' records and conducting interviews. The findings observed an improvement in mathematics performance when children used manipulatives. The above studies acknowledge the importance of using manipulatives in the early childhood and foundation phases. However, the researchers aligned the findings with the Montessori model in this research study.

Core understandings of how manipulatives support number concepts in rural foundation phase classrooms

Using manipulatives to enhance several concepts in rural schools revolves around improving children's interest and interaction with the subject. To understand the overarching notions of using manipulatives in early childhood to teach number concepts in rural schools, where access to digital resources may be limited, it should be understood that hands-on manipulatives like LEGO® Bricks, counting beads and locally available objects serve as effective alternatives to bridge learning gaps.²⁷ Evidence supports the use of high-quality and relevant manipulatives as interactional tools for light-hearted play and deep mathematical inquiry.²⁸ However, the mere presentation of manipulatives does not guarantee the acquisition of a conceptual understanding of mathematics; instead, teachers must understand how to skillfully and astutely integrate manipulatives in early childhood lessons to enhance children's mathematical skills.²⁹ Teachers who incorporate manipulatives into their mathematical lessons should

²² Liljedahl et al., "Problem Solving in Mathematics Education."

²³ Elizabeth M. Byrne et al., "Educational Interventions Involving Physical Manipulatives for Improving Children's Learning and Development: A Scoping Review," *Review of Education* 11, no. 2 (August 15, 2023), <https://doi.org/10.1002/rev3.3400>.

²⁴ Kate Quane, "Evaluating Factors That Influence Young Children's Attitudes towards Mathematics: The Use of Mathematical Manipulatives," *Mathematics Education Research Group of Australasia*, 2022.

²⁵ Rita Ponte et al., "Revisiting Manipulatives in the Learning of Geometric Figures," *Frontiers in Education* 8 (June 29, 2023), <https://doi.org/10.3389/educ.2023.1217680>.

²⁶ Zanele A. Ndlovu and Lytton Chiromo, "Pre-Service Mathematics Teachers' Development Process in Using Manipulatives in Number Operations," *South African Journal of Childhood Education* 9, no. 1 (September 5, 2019), <https://doi.org/10.4102/sajce.v9i1.698>.

²⁷ Caryl R. Ramirez and Katlyn U. Tabirao, "Overcoming Numeracy Enigma through Mathematics Manipulative Tools," *International Journal of Research Publications* 124, no. 1 (April 16, 2023), <https://doi.org/10.47119/IJRP1001241520234947>.

²⁸ David E Rowe and Mechthild Koreuber, "Proving It Her Way," *Emmy Noether, a Life In*, 2020.

²⁹ Mantlhake J. Maboya, Loyiso C. Jita, and Godsend T. Chimbi, "South African Teachers' Beliefs and the Use of Manipulatives to Resolve the Concept-Symbol Schism in Mathematics Learning," *Universal Journal of Educational Research* 8, no. 11 (October 2020): 5414–24, <https://doi.org/10.13189/ujer.2020.081144>.

have a firm grasp of when, why and in which aspect of mathematics each tool is most appropriate.³⁰ In addition, the complexity of the toy should be proportional to the learner's mathematical ability.³¹

THEORETICAL FRAMEWORK

Among other theorists on using manipulatives, the Montessori model influences teachers' beliefs in using various manipulatives to enhance several concepts in the foundation phase.³² Therefore, according to Montessori, the best way for learners to fully grasp mathematical concepts is through direct experience with materials.³³ Confirm that the Montessori model further enlightens teachers on various approaches, such as using real-world shapes to learn fractions, playing with beads and stamp materials, using strip boards and committing key mathematics concepts to memory.³⁴ Similarly, children grasp mathematical concepts more easily through tactile experiences.³⁵ Using Montessori's model, teachers start with tangible manipulatives to help learners understand abstract concepts in mathematics and enhance their comprehension of mathematical operations and arithmetic number concepts.³⁶ This model provides a robust framework to support teachers using manipulatives to enhance learners' number concepts in rural schools with limited resources.

METHODOLOGY

An interpretivist paradigm was used in this study to delve into children's subjective experiences engaging with Montessori materials. This paper's theoretical lens aligns with the philosophical assumptions of the interpretivist research paradigm, which emphasises the sense-making of experiences from participants' viewpoints.³⁷ A qualitative research design was employed to elicit rich, in-depth data in social settings that examined teachers' perceptions of the topic.³⁸ An interpretivist case study design explored teachers' beliefs in teaching number concepts through manipulatives in the foundation phase in rural schools. This approach allowed for an incisive examination of multiple instances within participants' real-life contexts by comprehensively understanding the phenomenon from various perspectives.³⁹ In addition, the researcher gathered data to distinguish similarities and differences regarding teachers' beliefs, perceptions, experiences and insights across mathematics teaching in rural schools, highlighting common themes and unique variations.

A total of six foundation phase teachers from three rural schools were purposively selected to participate in this study. The selected schools were within Quintile 2 designation by the DBE (i.e. they are no-fee paying schools because they fall into a socioeconomic category that is classified as 'poor'). The DBE supports these schools in providing manipulatives in their subjects, including number concepts. A common characteristic among these teachers was using manipulatives to teach mathematics in rural schools' early childhood classrooms.⁴⁰ Semi-structured interviews and non-participant observations were conducted to collect data from the participants. An interview schedule was designed with open-ended questions; probing questions allowed the participants to reflect on their beliefs and assisted the interviewer

³⁰ Melihan ÜNLÜ, "How Do Preservice Mathematics Teachers Use Manipulatives to Teach Mathematics?," *Acta Didactica Napocensia* 15, no. 2 (December 31, 2022): 343–55, <https://doi.org/10.24193/adn.15.2.16>.

³¹ Danielle S. Fox et al., "Diversity of Spatial Activities and Parents' Spatial Talk Complexity Predict Preschoolers' Gains in Spatial Skills," *Child Development* 95, no. 3 (May 20, 2024): 734–49, <https://doi.org/10.1111/cdev.14024>.

³² Montessori, *The Montessori Method-Scientific Pedagogy as Applied to Child Education*.

³³ Namukasa and Aryee, "Pedagogical Knowledge for Teaching Mathematics in Montessori Schools."

³⁴ Ginger Kelley McKenzie et al., *The Inclusive Classroom: Creating a Cherished Experience Through Montessori* (Rowman & Littlefield, 2021).

³⁵ Muhammad et al., "The Effect of Using Manipulatives on the Performance Of Pupils in Primary School Mathematics."

³⁶ Namukasa and Aryee, "Pedagogical Knowledge for Teaching Mathematics in Montessori Schools"; Abarquez, "The Use of Manipulative in Teaching Elementary Mathematics."

³⁷ Muhammad Naeem et al., "A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research," *International Journal of Qualitative Methods* 22 (2023): 16094069231205788.

³⁸ Mohsen Hejsalembrahmi, Bui Thanh Khoa, and Bui Phu Hung, "Qualitative Research in Social Sciences: Data Collection, Data Analysis, and Report Writing," *International Journal of Public Sector Performance Management* 9, no. 4 (2022): 1, <https://doi.org/10.1504/IJSPM.2022.10038439>.

³⁹ Kavita Dehalwar and Shashikant Nishant Sharma, *Fundamentals of Research Writing and Uses of Research Methodologies* (Edupedia Publications Pvt Ltd, 2023).

⁴⁰ Md Mizanur Rahman, "Sample Size Determination for Survey Research and Non-Probability Sampling Techniques: A Review and Set of Recommendations," *Journal of Entrepreneurship, Business and Economics* 11, no. 1 (2023): 42–62.

in uncovering the underlying issues and perspectives. The interviews were recorded to increase the validity of the research findings.⁴¹

Additionally, non-participant observations were used to see how teachers implemented the teaching of number concepts through manipulatives in the foundation phase in their classroom. Thus, the researcher explored teachers' teaching of number concepts through manipulatives in the foundation phase in rural schools. The data from the observation were used to corroborate teachers' responses regarding their beliefs during the interviews. An observation sheet with questions was used to gather data from teachers' classroom practices on using manipulatives to enhance number concepts. Teachers' beliefs in enhancing number concepts through manipulatives in the foundation phase in rural schools, expressed during the interviews, were validated with the researcher's interpretations and descriptions made during the classroom observations.⁴² Validation of the teachers' views was done to ensure the reliability of the findings.⁴³

Thematic analysis was used to analyse the two data sets (interviews and non-participant observations) to interpret the subjective beliefs of teachers enhancing number concepts through manipulatives in the foundation phase.⁴⁴ The data gathered from semi-structured interviews were prepared for analysis by transcribing the audio-recorded data into text as required by qualitative research. Data from the observations were recorded in text using an observation sheet. The researcher started by manually coding data, converting it to a PDF format, and importing it into Atlas.ti and coded it electronically. Codes were generated from the keywords of the research questions. The researcher used multiple coding to increase the validity and consistency of the data. The researcher first coded and recoded the data, and an independent researcher assisted with co-coding the data to ensure quality.⁴⁵ A total of 205 codes were generated from the interviews and observations, and then grouped into categories guided by the reviewed literature. Lastly, the categories were grouped into emerging themes that assisted in the discussion of the findings of this paper.⁴⁶ Considering perspectives on the formulation of themes, two themes emerged that linked with the research question and the theoretical framework underpinning this study.⁴⁷

Ethical Considerations

Before the data collection processes, the Research Ethics Committee of the University of South Africa approved the ethics application, reference 2020/10/14/64019209/07/AM. Each participant was given a consent form for perusal and signing (if agreeable). Participants were also informed of the exit clause, which allowed them to leave at any stage of the research process if they felt unsafe or uneasy without being penalised. Audio recording (with consent) and verbatim transcriptions were executed according to the interview schedule to guarantee the reliability of the information gleaned from the interviews. The verbatim transcriptions were repeatedly read and checked against the audio recordings to identify and correct anomalies.⁴⁸ The researcher ensured that the interview schedule and observation sheet were in order before collecting data and used member-checking as a further tool to verify the gathered information in the transcriptions.

⁴¹ Jennifer A. Jones and Robert Donmoyer, "Improving the Trustworthiness/Validity of Interview Data in Qualitative Nonprofit Sector Research: The Formative Influences Timeline," *Nonprofit and Voluntary Sector Quarterly* 50, no. 4 (August 7, 2021): 889–904, <https://doi.org/10.1177/0899764020977657>.

⁴² Tone Lindheim, "Participant Validation: A Strategy to Strengthen the Trustworthiness of Your Study and Address Ethical Concerns," in *Researching Values: Methodological Approaches for Understanding Values Work in Organisations and Leadership* (Springer International Publishing Cham, 2022), 225–39.

⁴³ Phil Coleman, "Validity and Reliability within Qualitative Research for the Caring Sciences," *International Journal of Caring Sciences* 14, no. 3 (2022): 2041–45.

⁴⁴ Virginia Braun and Victoria Clarke, "Conceptual and Design Thinking for Thematic Analysis," *Qualitative Psychology* 9, no. 1 (February 2022): 3–26, <https://doi.org/10.1037/qup0000196>.

⁴⁵ Mona Alhasani and Rita Orji, "Promoting Stress Management among Students in Higher Education: Evaluating the Effectiveness of a Persuasive Time Management Mobile App," *International Journal of Human-Computer Interaction* 41, no. 1 (January 2, 2025): 219–41, <https://doi.org/10.1080/10447318.2023.2297330>.

⁴⁶ Braun and Clarke, "Conceptual and Design Thinking for Thematic Analysis."

⁴⁷ Naomi Elliott and Agnes Higgins, "Surviving Grounded Theory Research Method in an Academic World: Proposal Writing and Theoretical Frameworks," *Grounded Theory Review* 22, no. 01 (2023): 164–76; Cynthia Grant and Azadeh Osanloo, "Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for Your 'House,'" *Administrative Issues Journal Education Practice and Research* 4, no. 2 (2014), <https://doi.org/10.5929/2014.4.2.9>.

⁴⁸ Eleanor Knott et al., "Interviews in the Social Sciences," *Nature Reviews Methods Primers* 2, no. 1 (2022): 73.

PRESENTATION OF RESULTS

The participants reported that the availability of manipulatives significantly impacted their teaching strategies and beliefs. Their beliefs were shaped by their lived experiences and broader worldviews. Furthermore, it was noted that teachers' beliefs tend to become more firmly rooted in the practical challenges they encounter in their classrooms. The findings also highlighted the limitations of using manipulatives to support the development of number concepts among foundation phase learners in rural schools. As a result, their beliefs and perspectives could seem disconnected from reality if the challenges they face are not understood.

Navigating the lack of manipulatives in rural schools

The participants stated the challenge of limited manipulatives in rural schools. For example, S3E6 expressed strong emotions regarding the challenges faced by rural schools, which include the lack of adequate manipulatives to enhance the foundation phase learners' number concepts. S3E6 and S1E1, respectively said:

The schools in rural areas are disadvantaged because they do not have manipulatives/resources to participate in teaching and learning... (S3E6)

Even when I plan my mathematics lessons, I do not incorporate the use of manipulatives, which are limited in our classrooms... (S1E1)

On a lighter note, S3E6 emphasised that teachers need to be creative and innovative about their approaches in their teaching and learning activities, despite the challenges they face in rural schools. S3E6 articulated:

Nevertheless, as creative educators, we create our games from boards. I always use outdoor games, such as Back-to-Nought, which helps learners count. (S3E6)

S3E5 highlighted using board games like Snakes and Ladders because they can be created from boards.

I use games like Snakes and Ladders... which need a die and board with numbers to help learners count and understand numbers. (S3E5)

The issue of inadequate manipulatives was witnessed during the observation. It showed that a lack of manipulatives negatively affected participants' lesson implementation activities in enhancing learners' number sense. S1E1, S1E3, and S3E6's classroom observation verified their responses during the interview sessions about the shortage of manipulatives in enhancing foundation phase learners' number concepts, especially in rural schools. The results from the observations supported the interview results, because the participants were resorting to improvised manipulatives such as stones, sticks, and bottle tops to support mathematical concepts in the foundation phase. While the improvisation of manipulatives reflected teachers' beliefs, the concrete manipulatives were limited in revealing their experiences and views in developing deeper mathematical understanding in learners in the rural schools. The results indicate a gap in the disconnection between the participants' beliefs about the role of manipulatives and the use of relevant materials to enhance number concepts in the foundation phase in rural schools. Conversely, S2E4 highlighted during the interview conversations that the educators occasionally share the manipulatives within their phase (foundational level). This divergence shows that the participants attempt to address the challenge of a lack of manipulatives through collaboration and improvisation.

From belief to practice: Integrating play-based learning and improvised manipulatives in early mathematics education

The teachers believe that using play-based learning and improvised manipulatives significantly enhances several concepts for foundation phase learners, even though they face challenges in their classroom implementation.

It makes learners understand number concepts more. In addition, concrete materials make all the learners interested in the numbers. (S2E3)

Manipulatives help to boost learners' confidence in mathematics and encourage participation; it is a way of motivating learners. (S3E5)

The interviews indicated that teachers are innovative and have adaptive approaches to enhancing learners' number concepts due to limited manipulatives. This was evident from S3E5 about using games and play activities that do not require cost manipulatives.

I always use outdoor games such as Back-to-Back, which helps learners count and sense numbers. We count 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 while learners stretch their arms forward, upward, downward and side by side. ...It develops gross motor skills. (S3E5)

I use play-based learning to enhance learners' understanding of mathematics concepts. (S1E2)

Triangulating the responses from the interviews with the classroom observation, it was evident that teachers experienced a shortage of manipulatives in teaching mathematics. Despite that, it was satisfying to observe S1E1, who created cards from recyclable materials to engage learners in card games during mental mathematics to enhance their number concepts, sense, and names. In addition, participants such as S2E4, S3E5 and S3E6 used musical and physical play-based learning to enhance learners' number concepts. Teachers' use of creative manipulatives, innovative approaches, and integration of play-based learning reflects their belief in improving number concepts for foundation phase learners in rural schools. The results echo that the participants' innovative approaches expose a strong pedagogical belief in the role of hands-on learning to enhance number concepts in the foundation phase, even within under-resourced rural schools. Nevertheless, a significant gap emerges due to the limited high-quality manipulatives, as they constrain the in-depth conceptual understanding of the role of manipulatives and play-based pedagogies in teaching and learning mathematics in the foundation phase.

DISCUSSION

Theme 1: Navigating the realities of manipulatives scarcity in rural schools

This theme links well with the research question, as it signifies the challenges and practical strategies the participants use in manipulative scarcity foundation phase classrooms in rural schools. By understanding Naeem et al., the teachers' beliefs are not hypothesised; they are somewhat shaped by the realities of their experiences in their foundation phase classrooms.⁴⁹ Thus, the scarcity of manipulatives in rural schools exposes how teachers view them as significant for enhancing number concepts in the foundation phase. It reflects their flexibility and improvisational approaches in integrating recycled materials, musical games, and play-based pedagogies. The findings from S3E6, S1E1, and S3E5 's interview responses highlight that teachers in rural schools face significant challenges due to the lack of manipulatives, which aligns with the literature indicating that resource availability affects effective mathematics instruction.⁵⁰ This study's participants (S345) relied on improvised manipulatives, corroborating the literature.⁵¹

On the other hand, Montessori's model emphasises hands-on learning through manipulatives.⁵² In contrast to Montessori's view, there is no evidence from the findings about hands-on manipulatives in enhancing learners' number concepts. The innovative approaches of creating board games or using physical play implemented by S3E6 and S3E5 in their mathematics classrooms support the view that emphasises the fundamental role of teachers in integrating available manipulatives creatively in their teaching and learning activities when faced with inadequate support.⁵³ The disconnect between teachers'

⁴⁹ Naeem et al., "A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research."

⁵⁰ Stamatios Papadakis et al., "Attitudes towards the Use of Educational Robotics: Exploring Pre-Service and In-Service Early Childhood Teacher Profiles," *Education Sciences* 11, no. 5 (April 27, 2021): 204, <https://doi.org/10.3390/educsci11050204>.

⁵¹ Namukasa and Aryee, "Pedagogical Knowledge for Teaching Mathematics in Montessori Schools."

⁵² Montessori, *The Montessori Method-Scientific Pedagogy as Applied to Child Education*.

⁵³ Maboya, Jita, and Chimbi, "South African Teachers' Beliefs and the Use of Manipulatives to Resolve the Concept-Symbol Schism in Mathematics Learning."

beliefs and practices in their classrooms may not significantly impact optimal conceptual understanding of number concepts despite their creative improvisations. As a result, this paper suggests that policymakers need to implement intervention strategies to guide teachers in creating creative adaptations that align with the CAPS policy in the foundation phase. Finally, there should be equal provision of manipulatives in schools regardless of their background to promote equitable learning opportunities in rural schools.

Theme 2: Rethinking Montessori’s model of approach in enhancing number concepts through play-based and improvised manipulatives

The connection between theme 2, the research question and the theoretical underpinning of this paper is evident in the findings. Montessori’s model emphasises the use of concrete and hands-on manipulatives to develop mathematical understanding to young learners.⁵⁴ Although Montessori’s manipulatives are limited in rural foundation phase classrooms, teachers’ beliefs guide them to rethink and adapt this model by integrating improvised and play-based manipulatives in enhancing learners’ number concept skills. The findings indicate that participants such as S3E6, S1E1 and S3E5 understand the significance of the Montessori model by using locally available resources and play activities to support learners’ number concepts. The findings further revealed that teachers had strong beliefs in the significance of the role of manipulatives in enhancing number concepts. This statement confirms that and affirms that tactile experiences deepen mathematical understanding.⁵⁵ Similarly, the Montessori model emphasises the need to use tangible objects to transition from concrete to abstract mathematical thinking, which was evident from the observations when S1E1, S2E4, S3E5, and S3E6 used outdoor and play-based learning activities with concrete manipulatives and thereafter moved to abstract number concept skills. The efforts of S3E5 in using games, including Back-to-Nought and Snakes and Ladders, in enhancing learners’ number concepts are supported in research on using alternative manipulatives to bridge learning gaps in resource-constrained environments.⁵⁶

These findings confirm that participants used innovative approaches such as recycling materials and playing outdoor activities to improve number sense despite lacking manipulatives. This is consistent with Piaget’s perspective that children acquire cognitive skills through active material manipulation, and, similarly to Montessori’s view, manipulatives help promote good attitudes about mathematics. The way teachers incorporated games in their teaching approaches to mathematics shows that learners were engaged and interested in the lesson; this is also evident from S2E3 and S3E5’s interview responses.⁵⁷ To address the gaps raised in the findings of this paper, there is a need for the curriculum to align the use of manipulatives in rural schools with the implementation strategies of hands-on and play-based pedagogies to enhance number concepts in the foundation phase.⁵⁸ In addition, teachers in rural contexts should be equipped with the skills to use improvised manipulatives to teach mathematics effectively. Finally, this paper also supports the contention that teachers need to know how to appropriately modify and combine manipulatives for the best results of maximal learning.⁵⁹ Addressing these gaps, as indicated in the findings of this research paper, strengthens the enactment of teachers’ beliefs on the role of manipulatives and maintains play-based pedagogy to respond to Sustainable Development Goal 4 on enhancing the quality of education in the foundation phase, especially in rural areas.

RECOMMENDATIONS

The paper reveals that while rural teachers in the foundation phase understand using manipulatives to enhance number concepts, resource limitations often constrain them. However, educators demonstrate

⁵⁴ Namukasa and Aryee, “Pedagogical Knowledge for Teaching Mathematics in Montessori Schools.”

⁵⁵ McKenzie et al., *The Inclusive Classroom: Creating a Cherished Experience Through Montessori*; Muhammad et al., “The Effect of Using Manipulatives on the Performance Of Pupils in Primary School Mathematics.”

⁵⁶ R. Ramirez and U. Tabirao, “Overcoming Numeracy Enigma through Mathematics Manipulative Tools.”

⁵⁷ Byrne et al., “Educational Interventions Involving Physical Manipulatives for Improving Children’s Learning and Development: A Scoping Review”; Quane, “Evaluating Factors That Influence Young Children’s Attitudes towards Mathematics: The Use of Mathematical Manipulatives.”

⁵⁸ Papadakis et al., “Attitudes towards the Use of Educational Robotics: Exploring Pre-Service and In-Service Early Childhood Teacher Profiles.”

⁵⁹ ÜNLÜ, “How Do Preservice Mathematics Teachers Use Manipulatives to Teach Mathematics?”

remarkable resilience and creativity in adapting their teaching strategies. Their ability to integrate play-based learning and improvised manipulatives aligns with Montessori's theoretical framework, supporting hands-on experience to enhance mathematical comprehension. In light of these findings, the author recommends these achievable, practical, theoretical and policy strategies:

- The educators can adapt Montessori's manipulatives by using bottle tops and other recyclable materials, promoting a sense of number concepts, capacities, quantities and volumes to foundation phase learners.
- Educators need to be trained in using low-cost or creative manipulatives to align with the mathematics outcomes in the South African curriculum. The educators need to be introduced to digital manipulatives in a less technology-accessible accessibility, especially in rural schools.
- Finally, educators must be supported in integrating indigenous knowledge manipulatives such as traditional counting beads and storytelling to develop learners' appreciation of their background, culture and identity.

CONCLUSION

This paper explored teachers' beliefs in enhancing number concepts through manipulatives in the foundation phase in rural schools. The findings from the semi-structured interviews and non-participant observation indicated that participants lack limited cost manipulatives to enhance learners' number concept skills in the foundation phase. However, the teachers who participated in this research showed creativity by improvising manipulatives from recycled materials and integrating play-based pedagogies and game-based learning. This paper addresses a pressing gap between curriculum needs and sustainable education in rural schools where manipulatives are scarce to teach foundation learners mathematical concepts. Thus, teachers with lived experiences and scarce resources can adopt Montessori's model to align with the implementation of mathematics practices in rural foundation phase classrooms. Further research could investigate an integration of play-based pedagogies and manipulatives in a technology-enhanced environment to enhance learners' mathematics skills in rural schools.

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