



Assessing Manipulative use in Enhancing Learners with Visual Impairments' Understanding of Mathematics in Inclusive Basic Schools in Ghana

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Abstract

Manipulatives have been found to enhance the understanding of mathematical concepts for learners with visual impairments. However, the presence of manipulatives and teachers' perceptions of the use of manipulatives in enhancing Learners with visual impairment's knowledge of mathematical concepts in inclusive basic schools in Ghana have received less attention. The current study aimed to evaluate the manipulatives used to enhance learners with visual impairments in inclusive primary schools in Ghana, addressing the aforementioned issue. To achieve this objective, the researchers used a case study research design. Six inclusive basic mathematics teachers in Ghana were selected for the study based on the presence of a visually impaired learner in a class. This includes three junior high school mathematics teachers and three primary school class teachers. Data was collected through the use of observation and an interview guide. Data was analysed thematically. The findings revealed that the majority of inclusive basic schools involved in the study lack manipulatives for teaching mathematics to learners with visual impairments. The findings revealed that four of the six educators do not employ manipulatives in mathematics instruction within inclusive primary schools, while the remaining two utilize just basic counters and pebbles as manipulatives. The findings further revealed that a majority of the educators hold favorable views regarding manipulatives, recognizing their significant role in aiding learners with visual impairments in grasping mathematical concepts. In conclusion, while manipulatives offer significant advantages for learners with visual impairments' in grasping mathematical concepts, it is evident that such resources are largely absent in Ghanaian inclusive basic schools, and a majority of teachers do not incorporate them into their instructional practices.

Key Words: Basic, Impairment, inclusive, Learners, Manipulative, Visual

Introduction

Mathematics holds significant importance for both society and individuals, thus earning it an essential role within the educational curriculum. Mathematics acts as a fundamental basis for various disciplines, such as physics, chemistry, economics, and commerce (Belbase et al., 2022). Furthermore, mathematics improves students' abilities in problem-solving, critical thinking, and creativity, all of which are essential in the twenty-first century (Kossybayeva et al., 2022). This aspect also holds significant importance in everyday scenarios and prospective careers (Yeasmin, 2017). For instance, fields such as welding, construction, fashion, medicine, carpentry, and others (Acheampong & Awuah, 2025). Consequently, mathematics is mandated as a required

subject across all pre-tertiary educational levels, encompassing inclusive basic schools. This indicates that students in inclusive basic schools are required to study mathematics as part of their curriculum. Inclusive basic schools include learners with visual impairment, who are anticipated to acquire specific competencies in mathematics to assist them in daily life and professional endeavors (Bayram et al., 2015). Studies have shown that mathematics aids learners with visual impairments in interpreting, analyzing, and solving various problems (Mbofana & Chirume, 2022), equipping them with essential tools for independence and self-advocacy (Nannemann, 2021).



Mathematics helps learners with visual impairments gain the self-assurance, perseverance, and empowerment necessary to overcome obstacles in everyday life and in their future careers, according to Yonson (2018). Despite the numerous advantages learners with visual impairment gain from learning mathematics, research has shown that they encounter difficulties in this subject due to their restricted ability to visualize specific mathematical symbols, concepts, and figures (Mungunda, 2023). The capacity of learners to picture mathematical concepts and process information facilitates the development of a conceptual knowledge of essential mathematical principles (Emerson & Anderson, 2018), which is necessary for acquiring advanced abilities and functioning well in their environment.

The spatial characteristics of mathematics necessitate visual perception for a more comprehensive understanding of the majority of notations employed in the discipline (Kapperman & Sticken, 2010). Visual description serves as an effective method for conveying fundamental mathematical concepts to learners (Parame-Decin, 2023). Learners with visual impairment typically face challenges in accessing mathematics because of the prevalence of graphically presented concepts and information within the subject (Oyebanji & Idiong, 2021). This may hinder teachers' ability to effectively communicate mathematical concepts to learners with visual impairment in inclusive classrooms. Teachers must ensure that the strategies chosen for mathematics instruction address the needs of both learners with visual impairments and sighted students. Enhancing learners with visual impairment's comprehension of mathematical concepts in an inclusive classroom can be achieved through the utilization of teaching resources; however, many of these resources necessitate visual components (Emerson & Anderson, 2018).

Educators who work with learners with visual impairment have indicated that these learners encounter problems individually when dealing with mathematics that requires vision (Zebehazy & Wilton, 2014). Rosenblum et al. (2020) also found that Learners with visual impairment often meet different challenges in the mathematics classroom because of the teaching resources and instructional strategies often used (Rosenblum et al., 2020). Research indicates that Learners with visual impairment can learn and excel in mathematics when provided with multisensory experiences and support in the mathematics classroom (Bell & Silverman, 2019). Manipulatives are a teaching

resource that positively influences Learners with visual impairment learning in mathematics (Tjandra, 2023). Learners with visual impairment learning is shaped by kinesthetic and auditory senses; thus, incorporating manipulatives in mathematics instruction may offer a visual representation of mathematical concepts (Maboya et al., 2020). Tjandra (2023) asserts that the use of manipulative tools aids learners in creating concrete visual representations of mathematical concepts, thereby improving their understanding and integration of abstract ideas. Manipulative improves learners' problem-solving abilities, critical thinking, and comprehension of mathematical concepts (Muammar & Suhartina, 2018). Manipulative tools enhance learner engagement and focus during mathematics instruction. Tjandra (2023) posits that manipulatives benefit various learners, including those with vision disability, within the classroom setting. Nahar et al. (2022) demonstrated that LVIs proficient in braille machine usage exhibit strong performance in mathematics. Lafay et al. (2019) support the assertion that manipulatives enhance learners with visual impairment performance in mathematics. Lafay et al. (2019) support the assertion that manipulatives enhance these learners performance in mathematics within an inclusive classroom setting. Manipulatives are extensively utilized in mathematics education to facilitate students' conceptual understanding (Ikawati & Kowiyah, 2021). Manipulatives are prevalent instruments for kids with special needs, and studies indicate that they can enhance students' focus and engagement in mathematics tasks (Sezuni, 2022).

While manipulatives offer advantages for learners with visual impairments in inclusive classrooms, there is limited knowledge regarding the availability of manipulative materials used for mathematics instruction in Ghanaian basic schools. Research indicates that insufficient materials and teaching resources in classrooms in developing countries often hinder learners with visual impairment's ability to study mathematics (Mwakyeja, 2013). This study aimed to evaluate the effectiveness of manipulative use in improving the mathematical understanding of learners with visual impairments in Inclusive Basic Schools in Ghana. This study is significant as it offers insights into the use of manipulatives in inclusive basic schools, specifically focusing on their application during mathematics instruction and the perceptions of mathematics teachers regarding these tools.

Research Questions

1. What kinds of manipulatives are available in your school for learners with visual impairments to succeed in mathematics?
2. What type of manipulatives do teachers in inclusive basic schools use during mathematics instruction?
3. What is the perception of inclusive basic school mathematics teachers in using manipulatives to teach mathematics concepts to these students?

Theoretical Framework

This study was guided by constructivist theory. Constructivist theory is based on the assumption that learners actively participate in instruction to construct their knowledge (Nino, 2023). In constructivism, the process of acquiring knowledge is different from the conventional or traditional way of receiving knowledge, in which learners are passive receptors of knowledge in the classroom (Nino, 2023). John Dewey (1859-1952) indicated that learners learn through interaction with their social environment. This is what Dewey referred to as experiential learning. Dewey believed that learners learn best through hands-on activities or doing. There are three branches of constructivism: cognitive, social, and sociological constructivism. However, cognitive constructivism was considered because it aligns with the study's aim. Cognitive constructivism is developed based on Piaget's cognitive development (Piaget, 1936). Piaget asserted that learners actively construct their knowledge in the classroom (Piaget, 1936). Through this, Piaget indicated that children construct knowledge through four main stages: sensorimotor, pre-operational, concrete operational, and formal operational. Through these four stages, Piaget showed how children build up knowledge actively. Out of the cognitive theory by Piaget that evolved into radical constructivism (Von Glasersfeld, 2014). Radical constructivism indicated that there is no absolute or objective reality and reality is subjective to individual experience (Von Glasersfeld, 2014). For students to actively construct knowledge there should be materials that engage students in active exploration to develop their knowledge (Bada & Olusegun, 2015). Cognitive constructivism guided this study to identify the kinds of manipulatives available in your school for Learners with visual to succeed in mathematics. It also helped to types of manipulatives used by teachers in inclusive basic schools during mathematics instruction. For effective use of manipulatives in the classroom,

teachers' perception cannot be overlooked since it determines whether they use those manipulatives or not.

Research Methodology

A case study under the qualitative research method was adopted for this study (Crewel & Creswell, 2018). A case study was used because it enhances the full understanding of the manipulatives that are used in enhancing learners with visual impairment's knowledge of mathematics in inclusive basic schools in Ghana (Hancock et al., 2021). The case study above also uses an interview (Hancock et al., 2021). Six teachers were selected in three inclusive basic schools in Ghana. This included three junior high school mathematics teachers and three primary school class teachers. The class teachers were included because they teach all subjects, including mathematics, and can give information on the manipulatives available in teaching mathematics in their schools. Data were collected through the use of a structured interview guide. Before the data collection, the researcher sought ethical clearance from the Humanities and Social Sciences Research Ethics Committee at Kwame Nkrumah University of Science and Technology to ensure that the study carries low risk to the participants. In addition, a consent form and participants' assessment sheets were given to each of the six teachers to sign before the data collection. This ensured that the participants got the purpose of the research, the needed information from them, the benefits, risks, and the need to participate in the study (Chervenak & McCullough, 2021). To get access to the participants, the researcher sought permission from the head teachers and the teachers concerned through a letter from the teacher education department at the KNUST. At the junior high school level, the heads of mathematics in all three schools were contacted and sought their approval before the data collection. The data was collected over ten working days because the schools are in different districts, and it was impossible to reach some schools in one day. However, each interview lasted for 45 minutes per participant. The interview data was recorded through the use of the researchers' special audio recorder after the consent of the participants. In addition, the manipulative evidence was recorded in the field notebook. The data collected was analysed thematically.

Results

1. What kinds of manipulatives are available in your school for LVI to succeed in mathematics? Can you please mention them to me?

Teacher 1: *A Bundle of sticks and an abacus, and talking watches, phones, and laptops at their resource center.*

Teacher 2: *Pebbles and counters*

Teacher 3: *Counters, braille, pebbles,*

Teacher 4: *We don't have concrete materials in this school, especially for the teaching of mathematics.*

Teacher 5: *Apart from the braille machine, we don't have any tangible manipulatives for teaching mathematics in my school.*

Teacher 6: *We don't have any materials for teaching mathematics, and everything is chalkboard illustrations.*

The results indicated that most of the inclusive basic schools in which the study was conducted do not have manipulatives in teaching mathematics. This will make the teaching of mathematics concepts very difficult. Only a few schools have some of the basic materials for teaching some of the mathematics concepts.

2. What type of manipulatives do you use in your mathematics lessons?

Teacher 1: *Not all the time, but sometimes I use counters and pebbles.*

Teacher 2: *No, I do not use any manipulative materials when teaching because we do not have them in my School.*

Teacher 3: *Yes, I use some materials like cutout shapes, braille, and counters because they help the learners to understand the mathematics concepts that I teach.*

Teacher 4: *I don't use them because the materials are not available in the school. If you are teaching shapes or fractions, we need some drawing shapes to help them understand the concept, but we don't have. So right now, we just use the blackboard illustration.*

Teacher 5: *I sometimes use counters and pebbles, but most of the time I*

don't use any manipulatives in most of my lessons.

Teacher 6: *I don't use any manipulatives when teaching mathematics because they are not available.*

The results indicated that four out of the six teachers do not use manipulatives when teaching mathematics in inclusive basic schools. While the others do not always use it, but sometimes. This is a serious concern because learners learn best when they touch and feel what is presented to make meaning of what they learn. Therefore, in the absence of teaching material to use, how can they understand the mathematics concepts taught to them?

3. What is the perception of inclusive basic school mathematics teachers in using manipulatives to teach mathematics concepts to these students?

Teacher 1: *Teaching with manipulatives or materials is good as it helps the learners to feel and understand what I am teaching.*

Teacher 2: *Since I am not using manipulatives, however, I think manipulatives will help them to learn.*

Teacher 3: *Manipulatives are good as they facilitate the understanding of mathematics. For example, when teaching shapes, the cutout helps the students to identify the type of shape one is talking about by using their hands to trace the outline.*

Teacher 4: *I don't normally use manipulatives to teach mathematics, but I think it could help the learners to understand the mathematical concepts.*

Teacher 5: *I know manipulatives enhance students' understanding of mathematics concepts.*

Teacher 6: *I have not been using manipulatives, so I don't know how they can help LVI to understand mathematics, but I know teaching resources help during instructions.*

Teachers interviewed indicated that manipulatives are very important in helping learners with visual impairment to understand mathematical concepts. Even though some of them are not using it, they believe that it has a positive impact on Learners with visual impairment's understanding of mathematical concepts.

This could be a result of the fact that learners with visual impairment learn through kinesthetic and auditory senses.

Discussion of the Results

The results indicated that most of the inclusive basic schools in which the study was conducted do not have manipulatives in their schools. This indicates that mathematics teachers may find it difficult to use manipulatives when teaching mathematics concepts in inclusive basic schools in Ghana (Nahar et al., 2022). This is because research has indicated that manipulatives are common tools for students with special needs, and research shows that they can improve students' attention and involvement in mathematical activities (Sezuni, 2022). As a result, mathematics teachers may have to buy some of these manipulatives, improve some, or be forced to teach without these materials. When manipulatives are not used in teaching mathematics, how can the teachers communicate these concepts to learners with visual impairment in the classroom (Tjandra, 2023). This will make teaching mathematics difficult and also make it difficult for learners with visual impairment to understand the mathematical concepts taught to them. Tjandra (2023) also argues that manipulative benefits different learners, including those with visual impairments, in the classroom. Also, this situation will make the teaching of mathematics concepts very difficult. Only a few schools have some of the basic manipulatives for teaching some of the mathematics concepts. This study is in consonance with the finding that only few schools have basic manipulatives like pebbles, counters, etc, for teaching mathematics (Bungao-Abarquez, 2020). This finding is also consistent with the finding that Insufficient materials and resources in schools, particularly in developing countries, can create challenges for learners with visual impairments in learning mathematics (Ahmed, 2017). As supported by Ralejoe (2021) that teaching resources are a major constraint to learners with visual impairment in Ghana. Okoye et al. (2019) also supported this by indicating that one challenge of teaching mathematics to learners with visual impairment is the inadequate of materials in the classroom in Nigeria. These manipulatives are limited for teaching certain mathematics concepts but cannot be used to teach other concepts (Marshall & Swan, 2008).

The results also indicated that four out of the six teachers do not use manipulatives when teaching mathematics concerns in inclusive basic schools. This

is in line with the finding that teachers may not use manipulatives in an inclusive classroom because of lack of skills (Tjandra, 2023). While the others do not use it always, but sometimes. This is a serious concern because learners with visual impairment learn best when touched, and there is no material to use; how can they understand the mathematics concepts taught to them (Maboya et al., 2020). This implies that mathematics teachers teach mathematics abstractly to the learners. Research has indicated that pupils with visual impairment can learn and perform well in mathematics if they are provided with multisensory experience and support in the mathematics classroom (Bell & Silverman, 2019). The reason could be that the teachers do not have access to those manipulatives, or it could be that they have low skill in the use of manipulatives in teaching mathematics concepts, or how to use manipulatives in an inclusive classroom (Tjandra, 2023). The immediate effect is that learners with visual impairment often meet different challenges in the mathematics classroom because of the teaching resources and instructional strategies often used (Rosenblum et al., 2020). This finding is consistent with the following findings; Educators may fail to employ manipulatives in manners that promote active engagement and support inclusive education (Penggunaan & Kunci, 2023). The finding aligns with the observation that educators faced challenges in using manipulatives to support students' cognitive shifts from concrete to pictorial and abstract representations. However, this is against the tenant of Constructivist theory which requires the use of manipulative in teaching learners (Jonassen, 1991). The finding also contradicts the finding that teachers are willing to use manipulative in mathematics classroom (Ekwueme et al., 2015).

Finally, the results indicated that mathematics teachers have a positive perception towards the use of manipulatives (Quane, 2024). This aligns with the findings of previous studies that teachers have a positive attitude towards manipulative use in the classroom (Golafshani, 2013; Carbonneau et al., 2018). This is because they see manipulatives as very important in helping learners with visual impairment to understand mathematical concepts (Maboya et al., 2020; Tjandra, 2023). Even though some of them are not using it, they believe that it has a positive impact on learners with visual impairment's understanding of mathematical concepts. This could be a result of the fact that these learners learn through kinesthetic and auditory senses. Research has indicated that learners



with visual impairment can learn and perform well in mathematics if they are provided with multisensory experiences and support in the mathematics classroom (Bell & Silverman, 2019). When manipulatives are made available to these teachers together with workshops on the use of the manipulatives, these teachers are likely to utilize them in their instructions (Tjandra, 2023). One way to enhance learners with visual impairment understanding of mathematics concepts in an inclusive classroom is the use of teaching resources, but most of these teaching resources also require visual elements (Emerson & Anderson, 2018). The results are consistent with those of Hassan et al. (2015), who investigated how educators perceived the use of manipulative materials to improve the comprehension of visually impaired students during the teaching and learning process. The study's participants were mathematics teachers who expressed a favorable attitude toward the use of manipulatives in inclusive schools.

Conclusion

The study's findings indicated that most of the inclusive basic schools in which the study was conducted do not have manipulatives in teaching mathematics. This makes the teaching of mathematics concepts very difficult for learners with visual impairment. Only a few of the schools have some of the basic materials for teaching some of the mathematics concepts. It was also found that four out of the six teachers do not use manipulatives when teaching mathematics in inclusive basic schools. While the rest do not use it always, but sometimes. Learners with visual impairment learning is influenced by kinesthetic and auditory senses; therefore, teaching them without the use of the appropriate manipulatives could be a challenge for them to understand the mathematics concepts taught to them. The mathematics teachers may not have access to the manipulatives, which might account for their non-usage in inclusive basic schools in Ghana. It could also be that teachers do not have the necessary competencies to use these manipulatives effectively in their lessons, despite the benefits of these materials in an inclusive classroom. The finding also indicated that manipulatives are very important in helping learners with visual impairment to understand mathematical concepts. Even though some of them are not using it, they believe that it has a positive impact on pupil's with visual impairment understanding of mathematical concepts. This could be a result of the fact that learners with visual impairment learn through kinesthetic and auditory senses. This can

affect the quality of instructions received by these learners in the inclusive basic school in Ghana. This can undermine the purpose of inclusive education in Ghana.

Recommendation

Based on the findings of the study, it is recommended that the Ministry of Education, through the Ghana Education Service, should provide enough manipulatives to inclusive basic schools in Ghana. In addition, there should be the provision of resource persons who help assist pupils with visual impairment in an inclusive classroom. Finally, there should be workshops and in-service training for teachers teaching mathematics in inclusive basic schools in Ghana on the use of different manipulatives to enhance learners with visual impairment understanding of mathematics concepts.

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