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ВИКОРИСТАННЯ МАНІПУЛЯТИВІВ У МАТЕМАТИЧНИХ КЛАСАХ ІНКЛЮЗИВНИХ БАЗОВИХ ШКІЛ У ГАНІ

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MANIPULATIVES USE IN MATHEMATICS CLASSROOMS OF INCLUSIVE BASIC SCHOOLS IN GHANA

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АНОТАЦІЯ

Формулювання проблеми. *Математика є важливою складовою життя кожної людини, зокрема й здобувачів освіти з порушеннями зору (ЗПЗ), оскільки сприяє формуванню компетентностей для повсякденного життя та професійній діяльності. Сучасні підходи вимагають розвитку інклюзивних закладів початкової освіти, щоб уникнути дискримінації осіб з інвалідністю. Одним із предметів, який ЗПЗ найскладніше опановують, є математика, оскільки в ній використовуються графічні матеріали, що є важкими для сприйняття ЗПЗ. Дидактичні матеріали допомагають зменшити абстрактність математичних понять, роблячи їх більш «видимими» для ЗПЗ. Попри переваги використання маніпулятивів в інклюзивних початкових класах, бракує досліджень, як ці матеріали застосовуються в інклюзивних початкових школах Гани для покращення розуміння математичних понять. Спираючись на теорію когнітивного та соціального конструктивізму, це дослідження спрямоване на з'ясування того, як учителі математики закладів початкової освіти забезпечують доступність маніпулятивів для ЗПЗ.*

Матеріали і методи. З*астосовано дослідницький дизайн у форматі case study. Проведено інтерв'ю з 6-ма вчителями математики інклюзивних закладів початкової освіти, а дані проаналізовано за допомогою тематичного аналізу.*

Результати. *Результати дослідження засвідчили, що більшість учителів не мають маніпулятивів у своїх школах і, відповідно, не використовують їх у процесі навчання математики. Через відсутність практики застосування маніпулятивів для формування математичних понять більшість учителів не можуть чітко окреслити труднощі під час навчання LVI з використанням таких матеріалів.*

Висновки. *Учителям інклюзивних початкових шкіл Гани доцільно організувати семінари й тренінги щодо використання маніпулятивів у навчанні математики ЗПЗ, щоб підвищити якість їхньої професійної підготовки та ефективність інклюзивного освітнього процесу.*

КЛЮЧОВІ СЛОВА: *математичні класи; учні з порушеннями зору; інклюзивна початкова школа; маніпулятиви; Гана.*

ABSTRACT

Formulation of the problem. *Mathematics is essential in every individual's life, including that of Learners with Visual Impairment (LVI), as it helps them acquire the competencies required in their daily life and profession. There is a growing emphasis on inclusive basic schools to avoid discrimination among people with disability, Such as Learners with Visual Impairment (LVI). One subject that LVI finds difficult to understand is mathematics because it utilizes many graphics that are challenging for LVI to comprehend. Manipulative materials help reduce the abstract nature of mathematical concepts by making them more visible to learners, including those with learning difficulties. Despite the benefits of manipulatives in inclusive primary classrooms, there is a lack of research on how manipulatives are used in inclusive primary schools in Ghana to enhance learners' understanding of mathematical concepts. Guided by cognitive and social constructivism theory, this study explores how basic school mathematics teachers make manipulatives accessible to Learners with Visual Impairment (LVI), the support they provide, the assessment strategies they use, and the difficulties they encounter when using manipulatives to teach mathematics to LVI.*

Materials and methods. *This study employed a case study research design. Six inclusive basic mathematics teachers were interviewed, and the results were analysed thematically.*

Results. *Findings from the study indicated that most teachers do not have manipulatives in their schools and do not employ them during mathematics instruction. The results also showed that, since most teachers do not use manipulatives in teaching mathematical concepts, they were unable to identify the challenges they face when teaching LVI mathematical concepts with manipulatives.*

Conclusions. *Based on the outcome of this study, manipulatives for teaching mathematics, especially to LIVs, should be made available in inclusive basic schools in Ghana. Teachers in inclusive basic schools in Ghana should be given workshops and seminars on the use of manipulatives in teaching mathematics to LVI.*

KEYWORDS: *Mathematics Classrooms; Learners with Visual Impairment; Inclusive Basic School; Manipulatives; Ghana.*

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INTRODUCTION

Mathematics is essential in the life of every student, including learners with visual impairment (LVI). Mathematics equips learners with reasoning and problem-solving skills, which are crucial in the 21st century. As a result of the relevance the subject plays in the daily life of learners, mathematics is seen as one of the compulsory subjects at basic schools, including inclusive basic schools (NBS) in Ghana. Florian (2015) emphasized that inclusive pedagogy aims to support teachers in addressing the diverse needs of individual learners without excluding any students through differential treatment (Lindner & Schwab, 2020). For learners to understand mathematics concepts, students need to develop the skill of extracting information from graphics and applying it to problem-solving tasks (Rosenblum et al., 2018).

Despite the benefits of inclusive education, LVI face challenges in daily activities due to their loss of sight, including difficulties in learning tasks as they lack visual experience, which is a key source of information (Daroni et al., 2018). Ramatea and Khanare (2021) discovered that while teachers, parents, and schools offer assistance to learners with visual impairments (LVI), their educational opportunities may be limited due to various constraints. This limitation in visual information affects their comprehension of concepts, particularly in subjects such as mathematics, where visual instruction is heavily relied upon (Daroni et al., 2018).

However, since graphic materials in the curriculum are primarily visual, many Learners With visual impairment encounter significant difficulties in comprehending them (Zebehazy & Wilton, 2021). Ahmed (2020) noted that many fundamental mathematical concepts are verbally described based on visual observations. Rocha et al. (2021) suggest that individuals with visual impairments may find spatial and directional concepts more challenging to comprehend compared to those without visual impairments. Also, the process of accessing and interpreting information from graphs poses challenges for Learners with visual impairments (Rosenblum & Herzberg, 2015). Research conducted by Aljundi and Altakhayneh (2020) in Jordan revealed that Learners with low vision impairments encounter numerous obstacles in learning mathematics. These Learners often struggle to keep pace with their sighted peers when it comes to mathematical problems that involve visual elements (Zebehazy & Wilton, 2014). Additionally, many teachers of Learners with Visual impairment are aware that their Learners face challenges independently utilizing mathematical graphics (Zebehazy & Wilton, 2014).

To support the success of Learners with visual impairment in mathematics, it is crucial to explore strategies that improve their access to and understanding of mathematical concepts conveyed through graphs (Abrahamson et al., 2019). Implementing equitable pedagogy that engages Learners through various sensory channels beyond vision is necessary for their full participation in teaching (Abrahamson et al., 2019). One such strategy is the use of manipulatives in teaching mathematics in an inclusive primary school. Providing appropriate learning materials is crucial in improving mathematics education for Learners with visual impairment (Oyebanji & Idiong, 2021).

Tjandra (2023) concluded that the incorporation of manipulatives in mathematics instruction can effectively support the learning and integration of Learners with diverse needs. However, educators must be equipped with adequate resources and training to implement manipulatives effectively, and they must also be able to modify manipulatives to cater to the needs of various learners (Tjandra, 2023). Additionally, Okumu (2021) discovered a positive correlation between proficiency in mathematics braille skills and academic performance in mathematics. The use of manipulatives in mathematics education has been proven to enhance Learners' grasp of mathematical concepts and boost their engagement in learning, although this requires specialized training (Tjandra, 2023).

One study conducted by Larbi and Okyere (2016) demonstrated that Learners who incorporated manipulatives in their mathematics education outperformed their peers who did not use manipulatives. Maboya et al. (2020) observed that educators often employed manipulatives mechanically, failing to help Learners move beyond concrete representations of mathematical concepts. According to Quigley (2021), engaging with concrete materials helps learners gain a deeper understanding of mathematical concepts, laying the groundwork for their conceptual knowledge of mathematics.

Emerson and Anderson (2018) observed that Learners with visual impairments demonstrated improved performance on questions related to content when provided with detailed explanations, achieving a maximum correct rate of 29%. In a study by Brawand and Johnson (2016), the effectiveness of methods such as using the Abacus, Braille, tactile graphics, and tangible materials in enhancing mathematical comprehension among Learners with visual impairment was emphasized. Byrne et al. (2023) discovered that manipulatives resources can enhance children's ability to grasp numerical concepts.

Despite the benefits of manipulatives in the inclusive classroom for LVI, teachers' ability to use them effectively with an appropriate teaching strategy is essential in enhancing LVI's understanding of mathematics concepts. Quigley (2021) noted that educators who effectively utilize concrete materials create an environment rich in mathematical opportunities for young learners to analyze concepts and problem-solve. Maboya et al. (2020) found that despite the presence of well-equipped mathematics laboratories, Learners still struggled with the concept-symbol disconnect. Teachers faced challenges in effectively utilizing manipulatives to aid Learners in transitioning cognitively from concrete to pictorial and abstract representations (Maboya et al., 2020). The study conducted by Rule et al. (2011) highlighted a deficiency in teachers' special education skills needed to support Learners with visual impairment in maximizing their potential in mathematics and science.

Additionally, Bell and Silverman (2019) identified concerns regarding the insufficient knowledge of the Nemeth Code among Teachers of the Visually Impaired (TVIs), as well as a tendency to overlook teaching braille math notation to Learners with remaining vision. Furthermore, adult participants with residual vision expressed regret over not having been taught Braille math codes, underscoring the significance of Braille in facilitating participation in the fields of mathematics and science (Bell & Silverman, 2019). This could be a result of the lack of teacher motivation, mentorship in mathematics and science teaching methods, and tools for Learner empowerment, which further discourages Learners with Visual impairment from pursuing these subjects at a higher level (Hayes & Proulx, 2024). For example, Nthibeli et al. (2022) noted that teachers in South Africa were not sufficiently equipped to teach students with autism effectively in inclusive classrooms.

Despite the importance of manipulatives in an inclusive classroom to LVI comprehension of mathematics concepts,

their practical use in the classroom is essential. Despite this, little is known about how manipulatives are used in the mathematics classrooms of inclusive basic schools in Ghana. This is a problem because if these materials are not used effectively, LVI's understanding of mathematics concepts is likely to be compromised. As a result, this study sought to evaluate the use of manipulatives in teaching mathematics in inclusive basic schools in Ghana.

RESEARCH QUESTIONS

1. How do basic school mathematics teachers make manipulatives accessible to LVI during mathematics lessons?
2. What support do the basic school inclusive teachers provide to LVI when using manipulatives in teaching mathematics concepts?
3. What assessment strategies do inclusive basic school teachers use to evaluate Learners with visual impairment when using manipulatives in a mathematics classroom?
4. What kind of difficulty do the inclusive basic school teachers encounter when using manipulatives to teach mathematics to LVI?

THEORETICAL FRAMEWORK

Cognitive and social constructivism theory serves as the theoretical framework for this study. Cognitive constructivism is a theory influenced by Piaget's cognitive development, in which learners are seen as actively constructing their knowledge (Piaget, 1936). Piaget proposed that children progress through four stages of cognitive development – sensorimotor, preoperational, concrete operational, and formal operational – in which they actively build knowledge. The idea of actively constructing knowledge led to the development of radical constructivism (Von Glasersfeld, 2014), which posits that reality is subjective and that there is no absolute truth. For Learners to construct their knowledge effectively, it is important to provide materials and activities that engage them in active exploration and discovery (Bada & Olusegun, 2015). This study is based on cognitive constructivism, as employing manipulatives to teach mathematical concepts in an inclusive classroom, particularly for learners with visual impairments, provides them with hands-on experiences to construct their knowledge independently rather than relying on others for mathematical information during instruction.

Socio-constructivism is developed based on Vygotsky's sociocultural theory (Vygotsky, 1978). This shows that the cognitive development of children is influenced by the cultural and social context in which they live (Vygotsky, 1978). This implies that children's learning is influenced by their personality and the social level. Vygotsky (1978) extended the theory to the interaction that the learner has with the community and family members. McLeod (2020) asserted that there are two significant points in Vygotsky's (1978) theory development. First, the theory suggested that the more skillful, experienced, or knowledgeable individual could be a peer, an elder person, a teacher, or a family member (McLeod, 2020). As a result, learners gain knowledge by interacting with knowledgeable individuals socially (McLeod, 2020). This study selects socio-constructivism theory due to its relevance in inclusive classrooms, where both educators and non-visually impaired learners recognize learners with visual impairments as integral members of the school community. Consequently, LVIs must engage with their sighted counterparts, teachers, and the school community to obtain instructional information for optimal learning. The teacher, who acts as a specialist in knowledge, aids the LVI in grasping mathematical concepts by using manipulatives for instruction. Furthermore, via collaboration and coordination, LVIs and their sighted counterparts coexist to thrive in mathematical education.

McLeod's (2020) second point was the Zone of Proximal Development, which represents the distance between the learner's current level and the level they need to reach through the assistance of an adult. The child's potential for development can only be reached through collaboration and problem-solving with the teacher or high-ability peers (Nino, 2023). In this case, the zone of proximal development refers to the level that a learner needs to reach through partnership, interaction, and encouragement with others rather than the learner alone (Nino, 2023). One of the approaches to teaching is scaffolding, a widely used instructional strategy based on Vygotsky's model of providing support to learners to attain a higher level of understanding (Nino, 2023). In this study, combining both Piaget and Vygotsky can help to identify how basic school mathematics teachers make manipulatives accessible to LVI during mathematics lessons, the support basic school inclusive teachers provide to LVI when using manipulatives for teaching mathematics concepts, the assessment strategies inclusive basic school teachers' uses to evaluate learners with visual impairment when using manipulative in mathematics classroom and the kind of difficulty the inclusive basic school teachers encounter when using manipulative to teach mathematics to LVI.

Manipulatives are physical objects or materials used to represent mathematical concepts, allowing learners to explore, understand, and apply mathematical ideas through hands-on experiences (Tjandra, 2023). These materials can range from everyday objects to specially designed tools, facilitating a concrete representation of abstract mathematical concepts. Typology of Manipulatives include: concrete manipulative (Physical objects such as blocks, counting bears, abacus or base-ten blocks that represent mathematical concepts,), virtual manipulative (Digital tools and simulations that mimic physical manipulatives, accessible through computers or tablets) and tactile manipulative: Materials designed for tactile exploration, such as Braille blocks or tactile graphs, beneficial for Learners with Visual Impairment (LVI).

Manipulatives can be used in various instructional settings to enhance learners' understanding of mathematical concepts (Oyebanji & Idiong, 2021). For all learners, manipulatives offer a hands-on approach to learning, making abstract concepts more tangible, encouraging active participation and engagement in the learning process, and supporting differentiated instruction, which allows teachers to cater to diverse learning styles. For LVI, manipulatives need to be adapted to ensure accessibility and effectiveness. For example, tactile manipulatives that allow learners to explore mathematical concepts through touch, incorporating Braille and large print labels on manipulatives to facilitate understanding. Additionally, the use of digital tools and apps that provide auditory or tactile feedback enhances the learning experience for LVI. Furthermore, the development of customized manipulatives that cater to the specific needs of LVI ensures they can fully engage with mathematical concepts (Oyebanji & Idiong, 2021).

RESEARCH METHODS

Research Approach

A case study under a qualitative research approach was adopted for this study (Crewell & Crewell, 2018). This approach was chosen because the focus of this study was to ascertain how manipulatives are used in inclusive basic schools during mathematics instruction.

Selection of the participants

To achieve this objective, six mathematics teachers were purposively selected from three inclusive basic schools in Ghana. These schools are accepted as inclusive basic schools, where LVI are mixed with regular learners. These teachers include three junior high school mathematics teachers and three primary school mathematics teachers. With the Junior High School, only mathematics teachers were selected. However, the primary teaching method is class teaching. Any teacher teaching in the upper primary or early grade levels teaches mathematics, and as such, is selected to participate in the study.

Data Collection Instrument

Data were collected using a structured interview guide to gather detailed information on the use of manipulatives in inclusive primary schools during mathematics instruction.

Data Collection Procedure

Before data collection, the researcher obtained ethical clearance from the Humanities and Social Sciences Research Ethics Committee of Kwame Nkrumah University of Science and Technology to ensure the study was safe and did not cause harm to any participants. This was followed by a letter of permission from the Department of Teacher Education at KNUST, which allowed us to seek permission from the school and its teachers prior to data collection. The researcher visited the school seven days prior to the data collection day to obtain verbal permission from the teachers and to request that they sign both the consent form and the participants' information sheet. This helped the participants understand the objectives and nature of the study that was conducted. The data collection lasted for ten days, with each teacher using approximately 40 minutes. The interviews were conducted at the convenient places chosen by the teachers in their respective schools. The interview was recorded using the researchers' phone, with the participants' consent, and was password-protected to prevent access by a third party.

Data analysis

The audio data was later transcribed and analyzed thematically, based on the thematic analysis procedure outlined by Creswell and Creswell (2018).

RESEARCH RESULTS

1. How do basic school mathematics teachers make manipulatives (for LVI) accessible to LVI during mathematics lessons?

Availability of Manipulative Materials to make mathematics accessible to LVI

Teacher 1: "The counters are the only materials I LVIs have access to with the help of their sighted peers, who bring them from the environment."

Teacher 2: "The materials are not available in my school, so I am not able to make them accessible to the learners."

Teacher 3: "As for the counting, I will let their friends go for the counters as well for them. They will collect it and bring it to them. I do not let them collect it for themselves, okay."

Teacher 4: "The only material we have in this school for the LVIs is the braille machine and the braille sheets, which are given to the learner beforehand, the instruction."

Teacher 5: "I only give the braille machine to the learners, and no other materials are added since they are not available in this school."

Teacher 6: "I do not give any materials to them; I only use chalkboard illustrations. My school does not have an abacus and all the special materials to teach mathematics concepts to the LVIs."

Use of Existing Braille Resources

Teacher 3: "The braille is with them. They are having it. They know how to braille."

Teacher 4: "The braille machine and the braille sheets are given to the learner beforehand, before the instruction."

Teacher 5: "I only give the braille machine to the learners."

The results indicated that there is an unavailability of special materials, such as an abacus and tactile materials, and hence, mathematics teachers do not employ them during mathematics instruction. The results also indicated that mathematics teachers rely on LVI peers for support in making materials such as counters accessible to learners. Three of the six teachers mentioned the use of Braille by their LVIs.

2. What support do basic school inclusive teachers provide to LVI in the absence of manipulatives when teaching mathematics concepts?

One-on-One Support and Explanation

Teacher 1: "I get close to the students to help them with the use of the manipulatives, which are mostly counters, to assist them in getting the quantities they count right."

Teacher 2: "I go to them and find out if they understand the concept, and give more explanations in the form of a description on the concept being taught to them."

Teacher 5: "I always go to them to find out if they are getting the concepts I am teaching."

Descriptive Method and Adaptation

Teacher 3: "To LVIs, I repeat examples by describing the task to be done slowly to enable them to braille down what is said."

Teacher 4: "I use the descriptive method for them to understand what I am teaching. I sometimes hold their hand to help them describe a concept. I have to describe everything I am doing to them."

Support from Resource Teacher

Teacher 6: "Sometimes, their resource teacher comes around to help them during mathematics instruction to braille the mathematics symbols they are not familiar with..."

Whole-Class Instruction with Adaptation for LVI

Teacher 3: "I explain the concept I am teaching to the whole class with examples."

The results indicated that the support mathematics teachers provide to LVI during instruction includes: one-on-one support and explanation, the use of descriptive methods and adaptation, support from the resource teacher, and whole-class instruction with adaptation for LVI.

3. What assessment strategies do inclusive basic school teachers use to evaluate Learners with visual impairment when using manipulatives in a mathematics classroom?

Class Exercise for All Learners with Accommodations

Teacher 1: "LVIs are given the same questions as their sighted peers; ... I read the questions to LVIs several times. Also, their friends may write it for them and send it to their resource facilitator to braille it for them."

Teacher 2: "I give LVI the same questions as the Learners who can see, and I read the questions aloud for them to braille and answer, which their resource facilitator later transcribes for marking".

Teacher 3: "I will just give all Learners the same exercise, and their colleagues will read for them."

Teacher 4: "I just give them a class exercise in written form. While their friends read it out to them in braille."

Teacher 5: "I give them the same exercise as their sighted peers, who read it out to them in Braille."

Oral Assessment

Teacher 6: "I ask them oral questions to ascertain whether they understand what I am teaching or not."

The results indicated that five teachers assigned the same class exercises to all learners with accommodations, while one teacher asked oral questions during instruction. Giving the same exercise to both LVI and other learners is good practice, as it eliminates discrimination between the two diverse groups of learners. The oral questioning, on the other hand, serves as feedback to the teacher to assess the LVIs' progress in the instruction given.

4. What kind of difficulty do you, as an inclusive basic school teacher, encounter when using manipulatives to teach mathematics to LVI?

Unavailability of Materials

Teacher 1: "The manipulatives are not available in my school, so I do not encounter any problem because I do not use them."

Teacher 4: "I do not use manipulatives in my lessons..."

Teacher 5: "The materials are not available, so I do not use them..."

Teacher 2: "I do not use manipulatives to teach them..."

Teacher 6 mentions not using materials, but frames the difficulty in teaching mathematics to LVI differently.

Lack of Knowledge or Training in Using Manipulatives

Teacher 3: "The resource person for LVI may not know all the concepts and the materials to use in teaching certain concepts in mathematics; therefore, I cannot resort to him for assistance during mathematics instructions."

Teacher 4: "I do not know the manipulatives I can use to teach mathematics to LVI, I do not have any expertise in manipulatives for teaching LVI."

Teacher 3 also mentions a lack of support, which could be seen as related, but is more about the knowledge of the resource person and school support.

Challenges with Braille Mathematical Symbols

Teacher 3: "Brailling mathematical symbols for the learners to use is complicated."

Teacher 5: "But most of the time, the LVIs do not do exercise, they complain that they do not know how to braille special mathematical symbols."

Teacher 6: "Teaching mathematics to LVI is challenging, especially when symbols are involved. "

Lack of Support

Teacher 3: "The school and the resource person do not support us in making the teaching resources..."

The results indicated that the challenges mathematics teachers face include the unavailability of materials, a lack of knowledge or training in using manipulatives, difficulties with braille mathematical symbols, and inadequate support.

DISCUSSION OF THE RESULTS

The results indicated that there is an unavailability of materials to make mathematics accessible to LVI, and therefore, mathematics teachers do not employ them during mathematics instruction. The results also indicated that mathematics teachers rely on LVI peers for support and the use of existing braille resources. Most teachers indicated that they do not have the necessary materials and therefore do not use them during mathematics instruction. This could make LVI struggle to keep pace with their sighted peers when it comes to mathematical problem-solving that involves visual elements (Zebehazy & Wilton, 2014). This contradicts the assertion that providing appropriate learning materials is crucial in improving mathematics education for visually impaired students (Oyebanji & Idiong, 2021). This implies that teachers abstractly present mathematical concepts, thereby making understanding difficult, especially for LVI in the inclusive classroom (Mungunda, 2023). This contradicts the tenet of constructivism, which advocates for the use of materials during instruction (Piaget, 1983; Vygotsky, 1986).

The unavailability of materials significantly impedes the implementation of constructivist principles in mathematics instruction for LVI. According to Vygotsky's theory, practical learning occurs within the Zone of Proximal Development (ZPD), where learners are challenged appropriately with the proper support. Without access to manipulatives, teachers are unable to provide the hands-on learning experiences that are crucial for understanding mathematical concepts, particularly for LVI who

may benefit from tactile or adapted materials. This absence of resources limits the potential for scaffolding and differentiated instruction, key components of effective teaching within the ZPD framework (Vygotsky, 1978).

Others indicated that the materials are made available to the LVI through classmates of the LVI, who can see. One teacher indicated that she gives the braille machine to LVI in her classroom. The given material, for example, braille, may not be fully utilized when teachers lack knowledge on how to use it. Bell and Silverman (2019) identified concerns regarding the insufficient knowledge of the Nemeth Code among Teachers of the Visually Impaired (TVIs), as well as a tendency to overlook teaching braille math notation to Learners with remaining vision. Furthermore, if learners' friends provide the LVI with materials without assisting the LVI in using them during mathematics instruction, this will not benefit the learners. This could be because it is challenging to braille some mathematical symbols and shapes. This could be as a result of the lack of teacher motivation, mentorship in mathematics and science teaching methods, and tools for learners' empowerment, further discouraging LVI from pursuing these subjects at a higher level (Hayes & Proulx, 2024). For example, Nthibeli et al. (2022) noted that teachers in South Africa were not sufficiently equipped to teach students with autism effectively in inclusive classrooms. The study conducted by Rule et al. (2011) highlighted a deficiency in teachers' special education skills needed to support Learners with Visual Impairment in maximizing their potential in mathematics and science.

The results indicated that the support mathematics teachers provide to LVI during instruction includes: one-on-one support and explanation, the use of descriptive methods and adaptation, support from the resource teacher, and whole-class instruction with adaptation for LVI. The reliance on peers for support and the use of existing braille resources can be seen as a form of scaffolding within the ZPD (Vygotsky, 1978). Peers can offer temporary support, helping LVI navigate through challenging mathematical tasks. However, this approach may not always be effective or consistent, as peer understanding and ability to explain concepts can vary. The use of existing braille resources is a positive step towards inclusivity, but it highlights the need for more tailored and comprehensive resources to fully support LVI. This finding underscores the importance of trained educators who can provide targeted support, aligning with Vygotsky's emphasis on the role of more knowledgeable others in facilitating learning.

To provide support to the LVI during instruction, teachers indicated that they approach them to determine if they are grasping the concepts or experiencing issues with certain aspects of the lessons. The support practices reported by teachers, including one-on-one support and explanation, use of descriptive methods and adaptation, support from resource teachers, and whole-class instruction with adaptation for LVI, demonstrate attempts to scaffold learning within the ZPD (Vygotsky, 1978). These practices reflect an understanding of the need for differentiated instruction and support tailored to the individual needs of LVI. The use of descriptive methods, in particular, aligns with constructivist principles by facilitating active engagement and understanding through verbal explanations and adaptations. This aligns with Vygotsky’s sociocultural theory (Vygotsky, 1978), which posits that learners interact with their teachers to develop cognitively. This implies that some of these teachers pay attention to these LVI and make sure that every learner benefits from the classroom instruction. Others indicated that they sometimes receive special assistance from the resource person to help with LVI during mathematics lessons. This is the case where the school has a resource person for LVI to assist them in their learning. The problem arises when some resource persons struggle with mathematical concepts and, as a result, find it challenging to communicate with LVI (Belay & Yihun, 2020). This can affect LVI's understanding of mathematical concepts. This lack of teacher motivation, mentorship in mathematics and science teaching methods, and tools for student empowerment further discourages visually impaired students from pursuing these subjects at a higher level (Hayes & Proulx, 2024). In some cases, where these resource persons are few, and they have to assist different LVI in different classrooms, it becomes difficult to provide adequate support to these LVI, especially in the mathematics classroom (Belay & Yihun, 2020).

Additionally, the results showed that teachers provide the same class exercise for all learners, with accommodations and oral questions during instruction (De Verdier, 2016). The practice of administering the same exercise to both LVI and other learners is a good practice, as it eliminates discrimination among the two diverse groups of learners (De Verdier, 2016). Although giving them the same exercise is beneficial, the issue is how these teachers help learners understand mathematical symbols and how LVI can braille these symbols (Nthibeli et al., 2022). The same exercises could be assigned as a result of the syllabus requirement for teaching mathematics at the basic level. Providing the same class exercises for all learners with accommodations is a practice that aligns with both Piaget’s and Vygotsky’s theories. It promotes inclusivity and recognizes the potential of all learners to engage with the same mathematical content, albeit through different means. This approach supports the constructivist view that learning is an active process and that learners construct knowledge in ways that are meaningful to them. By adapting exercises to meet the needs of LVI, teachers can ensure that these learners are not disadvantaged and can fully participate in the learning process.

Finally, the results indicated that the challenges mathematics teachers face include the unavailability of materials, a lack of knowledge or training in using manipulatives, difficulties with braille mathematical symbols, and inadequate support. The challenges directly impact the ability of teachers to provide effective scaffolding and support within the ZPD (McLeod, 2020). The unavailability of manipulatives may affect their usage during instruction in the inclusive mathematics classroom, as LVI learners learn through kinesthetic and auditory means, thereby impacting LVI performance in mathematics (Okumu, 2021). This also contradicts the tenet of constructivism, which insists on the use of manipulatives or materials in instruction (Piaget, 1983). This contradicts the study by Brawand and Johnson (2016), which emphasized the effectiveness of methods such as using the Abacus, Braille, tactile graphics, and tangible materials in enhancing mathematical comprehension among visually impaired students. Byrne et al. (2023) discovered that manipulative resources can enhance children's ability to grasp numerical concepts.

However, one teacher indicated that they recognize that some mathematical symbols make the lesson difficult, as supported by the finding that many teachers of visually impaired students note that their students face challenges in independently utilizing mathematical graphics (Zebehazy & Wilton, 2014). Numerous mathematics textbooks incorporate visual graphics that contain crucial topic information not well conveyed in either Braille books or digital renditions of the texts (Emerson & Anderson, 2018). Okumu et al. (2021) attribute LVI's poor performance in Mathematics to poor proficiency with the use of the

braille machine. This is because LVI typically uses braille machines to communicate mathematical ideas, and any deficiencies with the use of these braille machines can automatically affect LVI's performance in Mathematics. This finding aligns with the findings of Morelle and Tabane (2019), which shed light on the challenges faced by visually impaired learners in South African township mainstream primary schools. The study highlighted the inadequacies in the implementation of inclusive education, including a lack of proper support, limited adaptation of teaching methods and materials, and inaccessible physical environments within schools.

LIMITATIONS

This study is without limitations. The limitations of this study include a small sample size, a focus on a specific national context (Ghana), and the sole reliance on self-reported interview data. This study was also limited to the use of manipulatives in an inclusive mathematics classroom in Ghana.

CONCLUSION AND RECOMMENDATION

This study aimed to investigate the manipulative use in inclusive mathematics classrooms of basic schools in Ghana. The finding indicated that most teachers do not have access to these materials and hence do not employ them during mathematics instruction. Others indicated that the materials are made available to them through classmates of LVI, who can see them. The fact that these teachers do not use manipulatives in their instruction could hinder the understanding of mathematics concepts by LVI. In addition, it was found that to provide support to the LVI during instruction, some teachers indicated that they approach them to determine if they are grasping the concepts or experiencing issues with certain aspects of the lessons. This helps teachers identify LVI difficulties and address them during or after instruction. Others indicated that they sometimes receive special assistance from the resource person to help with LVI during mathematics lessons. The finding also indicated that teachers give written and oral questions to LVI and other colleagues during instruction. Giving the same exercise to both LVI and other learners is good practice, as it eliminates discrimination between the two diverse groups of learners. In addition, the results indicated that since most teachers do not use manipulatives in teaching mathematics concepts, they were unable to identify the challenges they face when teaching mathematics concepts in inclusive classrooms. However, one teacher indicated that the recognition of some mathematical symbols by LVI makes the lesson difficult, as they cannot visualize those symbols. Finally, sometimes the resource person for LVI may not be familiar with all the concepts and materials, making it difficult to bring them to the learners for use. Based on the findings, it is recommended that heads of the inclusive basic schools in Ghana collaborate with the Ghana Education Service to provide manipulative materials to these schools. In addition, teachers should receive in-service training on how to effectively teach mathematics concepts using specific manipulatives in the classroom. Finally, through professional development sections, resource persons can be provided with assistance on the mathematics concepts taught in various classrooms of inclusive basic schools in Ghana. This will help the resource persons become familiar with the mathematical concepts and symbols, enabling them to effectively communicate these concepts to LVI or assist in braille translation of mathematical concepts.

CONFLICT OF INTEREST

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DATA AVAILABILITY

This is a theoretical study and does not involve the use of any additional datasets.

USE OF ARTIFICIAL INTELLIGENCE (AI) TOOLS

AI tools were not used in the writing of this work.

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