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MULTI-SENSORY PATHWAYS TO PRE-NUMBER SKILLS AMONG DEAFBLIND LEARNERS

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Abstract:
Children learn to learn through their senses. Deafblind learners face significant challenges because they cannot fully rely on vision and hearing, so they need other ways to make sense of the world around them. This calls for strategies such as learning by doing. The study explored the multisensory learning approaches used by deafblind learners in the foundation stage while learning pre-number skills. Quantitative research approach and descriptive survey design were adopted. The target population comprised 52 deafblind learners and 28 teachers teaching pre-number skills in the foundation stage from five institutions for deafblind learners in Kenya. 44 learners and 25 teachers formed the sample population. Teachers' questionnaires were used as data-collection tools. The validity of the data collection tools was ensured through expert judgement, while reliability was assessed using the test-retest method. A correlation coefficient of .75 was confirmed. Before the study, informed consent and assent were acquired from the parents of the learners and teachers. Additionally, confidentiality and beneficence guided all interactions and data handling. The key findings of this study were that tactile sensory modality is the most adopted multisensory approach among deafblind learners, with exploring objects by touch recoded the highest mean, followed by the use of concrete materials, representing numbers using realia and manipulating objects being the least adopted tactile strategy while learning pre-number skills. The second most adopted multi-sensory strategy is kinesthetic, visual, and the least utilized is the auditory sensory modality. This study recommends intensive adoption of tactile and kinesthetic strategies during the learning of pre-number skills. Schools should also ensure the availability of

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manipulative and tactile resources, such as counting objects, textured materials, and real-life objects, to support experiential learning of pre-number concepts.

Keywords: multi-sensory strategies, pre-number, deafblind, mathematics, foundation learning

1. Background

Children learn to learn through exploration and by taking part in what they learn. They understand new ideas through moving, touching and trying out things. For a deafblind learner, he neither has the full ability to see nor to hear, and as a result, learning is a great challenge. They cannot fully depend on vision and hearing, thus need other ways to make sense of the world around them. This calls for strategies such as learning-by-doing. Multisensory experiences become vital as they facilitate learners to move, touch, use residual vision and hearing, as well as experience real objects to learn. Papazafiri (2025) documented that tactile exploration strategies, such as pressing, manipulating objects, shaking, and touching, are used by learners with deafblindness to understand taught concepts. Such strategies are therefore vital in the development of pre-number skills among learners with deafblindness.

Studies show that when learners use more than one sense, they understand and remember better (Siti *et al.*, 2023; Bérubé, 2023). This makes learning easier and more meaningful. Learners with deafblindness mostly rely on touch to explore their environment. The compensatory theory explains that when one sense is limited, other senses become stronger (Rutjens & Kay, 2016). For example, learners can feel objects to understand size, shape, and quantity. These skills are important for pre-number development, such as counting, grouping, and comparing objects.

The use of tactile sensory modality has been found to be effective in teaching learners with disabilities. In the US, researchers found that children learn better when they touch and explore real objects (Bryant, 2022), while in Indonesia, a multi-sensory approach effectively addresses the diversity of learners' styles, enhances concept comprehension and fosters an inclusive learning environment (Nurjanah *et al.*, 2024). In Pakistan, Maqbool and Ashraf (2023) found that engaging children through tactile, auditory, and visual activities significantly improved their ability to classify objects and demonstrate early categorization skills compared to traditional instruction. This helps them learn things like size, shape, and number.

Visual, tactile and kinesthetic sensory modalities have also been found to be effective in the development of pre-number skills among children in early years. In Italy, Quarta *et al.* (2018) examined multisensory environments and established that integrating visual and auditory sensory modalities improves the attention and incidental learning outcomes of children compared to a single sensory modality. Multisensory prompts facilitated cognitive processing and categorization skills of children between the ages 6 and 10, emphasizing the importance of multisensory approaches in the academic

development of learners. The study, however, mainly focused on learners without disabilities and general intellectual outcomes, leaving out domain-specific pre-number skills and excluding learners who are deafblind.

Similarly, Fitri, Mustaji, and Bachri (2018) evaluated the influence of MLA in developing cognitive engagement and academic performance among children in primary education contexts. Their findings revealed that integrating auditory, kinesthetic and visual sensory modalities improved the retention and understanding of academic content among learners. While the study highlights the importance of MLA, it was carried out among regular learners and focused on general academic outcomes, leaving out foundational skills like pre-number. This gap emphasizes the need for a study that examines the influence of MLA on the acquisition of pre-number skills among LDB.

Research in Africa reinforces the value of multisensory strategies. Busari *et al.* (2023) found that sensory-rich and activity-based approaches significantly improved understanding, motivation, and retention among early learners in Ghana. Similarly, Delport (2021) in South Africa employed a non-equivalent pre-test post-test design and demonstrated that learners exposed to arithmetic manipulatives in a multisensory teaching approach outperformed those receiving standard instruction. In Cameroon, Ngong (2019) established that the multisensory learning approach greatly enhanced the phonological awareness skills of learners with dyslexia, thereby boosting their overall performance in reading.

In Kenya, Pwokah, Awori, and Muthee (2026) investigated the use of multi-modal instructional techniques in teaching numeracy skills among learners with hearing impairment in selected primary schools in Kenya. The study reported significant improvements in learners' engagement, comprehension, and retention of numeracy concepts when visual, tactile, and interactive strategies were employed. However, the study focused on learners with a single sensory loss and was restricted to the Rift Valley region, and addressed general numeracy rather than measuring skills specifically. These limitations indicate a gap in understanding the effectiveness of multi-sensory pathways for learners with deafblindness.

2. Statement of Problem

Deaf-blindness makes it difficult for learners to communicate, learn, and understand the world around them. Around the world, about 0.2% to 2% of people are deafblind, and about 1.8 million children are affected, especially in developing countries (Sense International, 2024). These learners need special support in school so they can learn well. Learning for most children depends heavily on vision and hearing; however, learners with deafblindness cannot rely on these senses. As a result, they experience severe barriers to mobility and cognitive development. Studies show that these learners often have significantly lower school attendance rates, with some data indicating attendance ratios as low as 30% in primary school and 42% in secondary schools compared to peers without disabilities (World Health Organization [WHO], 2024). In addition, academic

outcomes for learners with sensory impairments, including deafblindness, are reported to be considerably lower than those of learners without disabilities (Piper *et al.*, 2019).

Pre-number skills are important as they help learners prepare for future math learning, without which they fail to develop advanced mathematics, which leads to independence. However, deafblind learners often find it difficult to develop these skills because they cannot depend on sight and hearing to learn (National Center on Deaf-blindness, 2023).

Because deafblind learners have limited access to incidental learning, their understanding of the world is restricted mainly to what they can touch and physically experience. This makes multisensory approaches essential for their learning. However, although multisensory learning is widely recognized as an effective strategy that enhances understanding, its application among deafblind learners remains inconsistent and insufficiently documented in research and practice. This creates a gap between recommended teaching practices and what is actually implemented in classrooms. This gap hinders the development of effective instructional strategies and policies needed to improve learning outcomes for this vulnerable group of learners.

This study, therefore, sought to examine the multisensory approaches utilized by deafblind learners in the foundation stage, with the aim of addressing existing gaps in practice and improving educational outcomes.

3. Theoretical Framework

This study was guided by A. Jean Ayres's (1920) sensory integration theory, which explains how the brain takes in information from the senses and makes sense of it. A. Jean Ayres believed that children learn better when their brains can organize what they see, hear, touch, smell, and feel. When the brain works well in this way, a child can understand the world and respond correctly. Sensory integration involves many senses. These include sight, hearing, touch, taste, and smell. It also includes movement and body awareness. The brain brings all this information together so that a learner can act in a meaningful way. For example, a child can listen to instructions, look at objects, and use their hands at the same time. This helps the child learn new skills.

When sensory integration is working well, learners can pay attention, follow instructions, and understand what they are learning. They can also develop important skills like counting, writing, and solving problems. However, when sensory integration is not working well, learners may have difficulties. They may struggle to focus, become confused, or find it hard to learn simple skills. This theory is very useful in education, especially for learners with deafblindness. Teachers use multi-sensory approaches to help students learn better. For example, learners can touch real objects, move items while counting, and explore materials with their hands. These activities help the brain connect sensory experiences to learning. Sensory Integration Theory shows that learning depends on how well the brain processes sensory information. When learners use their senses together, they can understand things more easily and learn more effectively.

3. Material and Methods

3.1 Design

The study adopted a quantitative research approach with correlation design. Quantitative research approach was adopted as it facilitates the collection and analysis of numeric data to use in measuring the pre-number skills and to discover patterns in the data. Correlation research design facilitated the examination of the effectiveness of multisensory strategies on pre-number skills development among learners with deafblindness. This design is chosen because it effectively assesses whether and how strongly dependent and independent variables are related (Kothari & Garg, 2024).

3.2 Population and Sampling

The target population consisted of 52 deafblind learners and 28 teachers teaching pre-number skills in 5 institutions for deafblind learners in Kenya. The institutions were selected purposively as they are the only institutions for deafblind learners in Kenya. 44 deafblind learners were purposively selected as they had residual senses (residual hearing, sight or both hearing and sight). 28 teachers were also purposively selected based on the fact that they are foundation-level teachers teaching pre-number skills.

3.3 Data Collection Instruments

Structured questionnaires for learners were used to collect data for this study. Questionnaires were used to collect data regarding multi-sensory learning approaches adopted while learning pre-number skills, as well as the level of development of these skills among the learners. The questionnaires were completed by teachers on behalf of deafblind learners, as such learners lack the ability to write.

3.4 Validity and Reliability

The validity of data in this study was ensured through two strategies. One, experts in the area of study reviewed the items and their input was considered. Second, the items were obtained from the Kenya Institute of Curriculum Development for learners with special needs, thus ensuring content validity. Reliability was ensured through the test-retest method, and a correlation coefficient of .075 was established.

3.5 Ethical Considerations

Securing ethical approval from a recognized Kenyan Internal Review Board (IRB) or equivalent ethics committee is a non-negotiable prerequisite. The research must adhere to the highest scientific and ethical standards required for educational research in Kenya (Natade & Kabesa, 9th-10th September 2023). Given the direct involvement of vulnerable groups, specifically children and learners with special educational needs (SEN) (Mungai, 2015), stringent protocols must be followed. Detailed informed consent will be secured from parents or guardians. Crucially, the process will also incorporate active, age-appropriate assent from all child participants. Data security, anonymity, and the

principle of beneficence (maximizing benefit and minimizing harm) will guide all interactions and data handling (Natade & Kabesa, 9th-10th September 2023).

4. Results and Discussion

The multi-sensory approaches adopted by learners with deafblindness were put in four categories: tactile, kinesthetic, visual and auditory strategies. A 5-point rating scale was used to measure the level of adoption with Very Large Extent=5, Large Extent=4, Moderate= 3, and Low=2 and Never Adopts=1. Means were then calculated based on each multi-sensory approach. The findings are presented in Table 1.

Table 1: Multi-sensory Strategies Adopted by Deafblind Learners while Learning Pre-number Skills

Multi-Sensory Strategy	**Mean**
Tactile Strategies	
Learner uses real objects while counting	3.45
Learner explores objects by touch during counting activities	3.62
Learner uses concrete manipulatives to represent quantity	3.57
Learner uses tactile objects to represent numbers	3.56
Learner manipulates objects to understand numbers	3.51
Mean Tactile Strategies	**3.34**
Auditory Strategy	
Learner integrates sound cues like clapping and tapping when undertaking pre-number tasks	3.34
Learner responds to the sound signal during pre-number learning activities	2.59
Learner verbally repeats number concepts	2.54
Learner adopts consistent verbal routines during pre-number tasks	3.06
Learner reinforces the pre-number task by the use of musical activities	2.52
Mean Auditory Strategy	**2.81**
Visual Strategies	
Bright and high-contrast materials are used by learners	2.96
Learner uses visual symbols during pre-number tasks	3.22
Learner tracks objects visually during pre-number tasks	3.12
Learner demonstrates number concepts using visual cues	3.45
Mean Visual Strategy	**3.19**
Kinesthetic	
Learner engages in movement-based activities like stepping during pre-number tasks	3.80
Learner coordinates the counting sequence with body movement	2.89
Learner integrates pre-number tasks into daily routines that involve movement	3.74
Learner acts out physically the number concepts	2.56
Mean Kinesthetic Strategy	**3.25**

Table 1 indicates that multi-sensory learning approaches are adopted at different levels in teaching learners with deafblindness pre-numeracy skills. The overall means show that tactile strategies were the most frequently adopted (M = 3.34), followed by kinesthetic (M = 3.25), and visual (M = 3.19), while the least frequently adopted MLS was auditory (M = 2.81). This finding suggests that learning pre-number skills among deafblind learners is

highly focused on movement and touch, as these strategies are more accessible to these learners. Learning through multiple sensory modalities enhances comprehension as it gives learners an opportunity to experience concepts directly.

Tactile strategy was the most adopted (M = 3.34). Under the specific indicators of tactile strategy adoption, exploring objects by touch recoded the highest mean (M = 3.62), use of concrete materials (M = 3.57), representing numbers using realia (M = 3.45-3.56) and manipulating objects (M = 3.51). This implies that learners are engaged in tactile activities while learning pre-number concepts to a large extent. Deafblind learners comprehend pre-number concepts better when they touch and manipulate objects that represent numbers, especially due to limited or absent vision and hearing. To such a learner, holding two spoons helps them get exposed to the meaning of number two as they feel the numbers as well as quantities, thus making abstract concepts easy to comprehend. Learning through touch is vital for deafblind learners as it gives them an opportunity to construct meaning through direct physical interactions. McLinden *et al.* (2018) explain that hands-on experiences substantially enhance early mathematical comprehension among learners with sensory impairment.

Auditory strategies scored a mean of 2.81, with sound cues like clapping being adopted more (M = 3.34) while verbal repletion and music being less frequently utilized (M = 2.54 and 2.54), which means learners adopt this strategy on average; however, it is tending towards low adoption. It implies that this strategy is less effective for deafblind learners. As much as some of the learners responded to sound cues, the adoption of repetition and musical rhythm was low. This could be because these learners have limited or no access to sound, which makes it hard for them to respond to auditory input. Sound only may fail to be clear and meaningful enough to support learning, even if residual hearing is present among deafblind learners. Dammeyer (2014) confirms that sound cues are often unreliable for deafblind learners, which reduces their effectiveness in learning. Nicholas (2020) also established that auditory approaches are only effective when combined with tactile or/and/or visual strategies. This implies that at no time should auditory approaches be adopted alone without being supported by other sensory modalities.

Visual strategies recorded a mean of 3.19, showing an average adoption rate, suggesting that visual approaches have the ability to enhance learning among deafblind learners, especially if learners have residual sight. Specifically, the use of visual symbols had a mean of 3.22, tracking objects visually (M = 3.12) and use of visual cues to understand numbers (M = 3.45). The vision of deafblind learners varies significantly. Some may have tunnel, peripheral, blurred and low vision, and as a result, they benefit differently from visual instructional strategies. Learners with low vision are supported more by visual materials like enlarged objects and highly contrasted materials. Schneider (2021) supports the use of visual strategies by stating that such approaches help learners to connect symbols to meaning. Visual approaches, therefore, enhance learning among deafblind learners but should be adapted depending on the vision of the learner.

Kinesthetic strategies scored 3.25, indicating average adoption. Learners' ability to engage in movement activities like clapping and stepping had the highest mean of 3.80, using daily routines with movement was the second most highly adopted across all indicators (M = 3.74), while the learners' ability to coordinate movement with counting had a mean of 2.86. Movement is a very important approach to learning for deafblind learners as it allows them to get exposed to concepts via their bodies. For instance, stepping five times helps a learner to understand counting in a concrete way. Lobo and Winsler (2006) established that movement-based learning enhances the development of mathematical comprehension through action. West *et al.* (2022) also explained that physical activity enhances learning and memory, more so when learners participate actively. Kinesthetic strategies are therefore highly suitable for deafblind learners as they allow them to learn through direct exposure

The study reveals that tactile and kinesthetic approaches are the most effective for deafblind learners, since they depend less on sight and hearing and more on physical experience. Visual strategies may be important for a learner with residual vision, while auditory approaches are the least adopted as a result of limited access to sound. This means that deafblind learners learn best when they move and touch, and when visual and auditory support is adapted to their individual needs. The finding reinforces the importance of integrating multiple sensory modalities to enhance learning. Manja *et al.* (2022) confirmed that multi-sensory learning fosters understanding and memory by engaging different sensory modalities at the same time. McLinden *et al.* (2020) also reinforced that deafblind learners need multi-sensory learning strategies as they require alternative ways of accessing information.

5. Recommendations

MLA should consistently be incorporated in learning pre-number activities to enhance conceptual understanding and learner engagement. Additionally, schools should ensure the availability of manipulative and tactile resources, such as counting objects, textured materials, and real-life objects, to support experiential learning of pre-number concepts. Teacher capacity should also be enhanced through workshops and in-service training focused on designing and implementing effective MLA approaches, particularly for learners with special educational needs.

6. Conclusion

Multi-sensory strategies involving tactile and kinesthetic modalities are the most adopted, while the auditory modality is the least utilized by deafblind learners.

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Conflict of Interest Statement

This work does not have any conflict of interest.

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