



LEARNING BEYOND SIGHT AND SOUND: THE ROLE OF MULTI-SENSORY APPROACH IN SHAPING MEASURING SKILLS IN DEAFBLIND LEARNERS

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Abstract:

Measuring skills are a backbone to independent. For one to go to workplace, cook, wash and even purchase items, measuring skills are needed. The study therefore explored the effectiveness of multisensory learning strategies on development of measuring skills among deafblind learners in foundation stage in Kenya. Mixed research approach with descriptive survey design was adopted. The target population of fifty two (52) learners in foundation stage of learning and twenty eight (28) teachers was derived from five institutions for deafblind learners in Kenya. A sample population of forty four (44) learners and twenty five (25) teachers were incorporated in the study. The data collection tools included teachers' questionnaires, open observation guide and teacher's interviews. The key findings of this study were that the level of development of measuring skills among learners who are deafblind is still low ($M = 1,86$) which was rated as approaching expectations (AE). Multisensory learning approach (MLA) also has a statistically significant influence on development of measuring skills among learners in foundation stage in Kenya ($\beta = 0.348$, $t = 2.401$, $p = .021$). This study recommends that the frequency and intensity of adoption of multisensory learning approach among learners who are deafblind should be increased.

Keywords: measuring skills, foundation learning, pre-numeracy, multi-sensory, deafblind, mathematics

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1. Background

Deafblindness, is a unique condition characterized by significant impairments in both vision and hearing. The severity of these impairments makes it difficult for the senses to compensate for one another (Nordic Centre for Welfare and Social Issues, 2018). Statistics reveal that in Africa, majority of the people with disabilities such as the deafblindness experience high rates of poverty making it vital for the Africa Agenda 2063 to emphasize on the achievement of inclusive and sustainable socio-economic development, with a vision of eradicating poverty and promoting sustainable economic growth across Africa by the year 2063. Kenya Agenda 2030 and the Sustainable Development Goals (SDG) emphasize on the importance of leaving no one behind and ensuring quality and equity in education for all and including those with disabilities. Measuring skills are a backbone to independent living which in turn helps eradicate poverty. For one to go to workplace, cook, wash and even purchase items, measuring skills are needed.

With the fact that prior study acknowledges measuring skills as being vital for independent living it becomes important to establish the most efficient and reliable pedagogical strategy to be used so as to facilitate the development of this important skills. MLA have been shown to enhance measurement understanding across diverse contexts. In Brazil, Galvão *et al.* (2018) investigated teaching plane geometry in an inclusive setting using a mixed-methods case study with ninth-grade students, including one LDB. A pedagogical intervention based on Historical-Cultural Theory employed modified manipulatives, and pre- and post-tests assessed students' conceptual understanding. Findings indicated that multisensory methods, especially manipulatives with clear objectives, supported learners including those with disabilities in developing mathematical understanding. However, the study was conducted with older learners in an inclusive setting rather than exclusively LDB, and it focused on plane geometry rather than foundational measurement skills. This highlights the need for empirical evidence on the influence of MLA on measuring skills among LDB in the Foundation stage.

Marie and Elizabeth (2023) investigated how tactile manipulatives affected ninth-grade learners' performance in mathematics within the Philippines. They adopted a quasi-experimental design. Findings indicated a substantial improvement in the achievement of learners in the experimental group. As much as this study illustrated the merits of tactile MLA, it majored on older learners without disabilities, it focused on general mathematics performance unlike the current study that purely looks at measuring as a competency. The study also prioritized tactile sensory modalities over other sensory channels. Thus, its applicability to LDB in foundational stage is special schools remains limited.

In Kenya, Pwokah *et al.* (2026) explored the teaching of numeracy skills among learners with hearing impairment using multi-modal pedagogical techniques in primary school. The study revealed substantial improvement in the engagement of learners, retention and comprehension of numeracy concepts when tactile, visual and interactive

methods were adopted. The study, however, majored on learners with hearing impairment alone, leaving out LDB. It was restricted to one region in Kenya and only addressed numeracy skills in general, rather than specifically measuring skills. These limitations highlight a gap in understanding how effective MLA is, for LDB, in the foundation stage of developing measuring skills

An analysis of the reviewed literature shows several gaps. First, despite the fact that learners' difficulties in numeracy are well-documented, most of the studies focused on general mathematical development rather than on measurement skills. Second, while MLAs have been shown to improve learning, most of the studies focus either on a single sensory modality or fail to explicitly conceptualize MLA as a pedagogical strategy. Third, most of the existing studies target older learners and those without disabilities, with minimal emphasis on LDB.

Within African and Kenyan contexts, the evidence base is limited, with very few studies investigating the role of MLA in supporting measurement skill development. Additionally, existing studies fail to adequately address the unique learning needs of LDB, who heavily rely on multisensory input as a result of dual sensory impairments. The absence of context-specific, population-specific, and skill-specific research represents a significant gap in the literature. This study, therefore, sought to address this gap by examining how multi-sensory approaches can be effectively utilized to facilitate the development of foundational measurement skills among LDB in Kenyan educational settings. The objectives of the study were:

- To establish the multi-sensory learning approaches adopted by LDB while learning measuring skills,
- To establish the level of development of measuring skills among learners who are deafblind, and
- To establish the influence of multi-sensory learning approaches on measuring skills development among deafblind learners in the foundation stage.

3. Material and Methods

3.1 Design

This research employed a mixed research approach, adopting a descriptive survey design. The descriptive survey design was essential for offering numerical descriptions of specific segments of the population, illustrating current conditions, and explaining events as they occur or are expected to occur (Shiniji & Adlin, 2024). The main importance of a descriptive survey is to gather data on existing situations or conditions, establish standards or norms for comparison, and inform future planning. Shiniji and Adlin (2024) recommend this design because it facilitates efficient data collection through questionnaires in a relatively short period, making it more practical than other methods.

3.2 Population and sampling

The target population comprised 52 learners who are deafblind and 28 teachers teaching measuring skills at the foundational level from 5 institutions for learners who are deaf-blind in Kenya. The five institutions were purposively selected based on the fact that they are the only existing institutions for learners who are deaf-blind in Kenya. 48 (16 female and 28 male) learners who are deafblind, aged between 6 and 18 years, were selected purposively based on the fact that they had residual senses (residual hearing, sight or both hearing and sight). 28 teachers were also selected purposively since they are foundation-level teachers teaching these measuring skills. The census population was then used to select all 44 learners and 25 teachers, leaving out 10% of the population that was used for piloting.

3.3 Data collection instruments

Structured questionnaires for learners and teachers' interview guides were used to collect data for this study. Questionnaires were used to collect data regarding multi-sensory learning approaches adopted by learners while learning measuring skills as well as the level of development of these skills. Teachers were interviewed to establish the use of multisensory approaches among learners and their perceived influence of these approaches on development of measuring skills among learners who are deafblind.

4. Results and Discussion

4.1 Findings and Discussion

This section presents results and discussions of the study findings. The results are organized around key themes which include; multi-sensory learning approaches adopted, extent of measuring skills development and finally, influence of multi-sensory learning approaches on measuring skills development among learners with deafblindness.

- **Objective 1: Multi-sensory learning approaches adopted while learning measuring skills**

Multi-sensory learning approaches adopted by learners with deafblindness varied among learners with some adopting two sensory modalities while others adopting three sensory modalities while learning measuring skills as indicated in Table 1 below:

According to Table 1, multi-sensory approaches that involve combination of tactile and other modalities were the most adopted. Specifically, the combination of tactile and visual strategies had the highest mean ($M = 3.68$), tactile, auditory and visual recorded the mean ($M = 3.61$), tactile, auditory, and kinesthetic ($M = 3.45$) visual, auditory, and tactile ($M = 3.43$), and visual, auditory, and kinesthetic strategies ($M = 3.30$) tactile and visual strategies had the highest mean ($M = 3.68$), tactile and auditory ($M = 3.45$) and tactile and kinesthetic ($M = 3.43$). Combinations relying less on tactile engagement, such

as auditory and visual ($M = 3.34$) and auditory and kinesthetic strategies ($M = 3.27$) were moderately adopted. The lowest adoption was observed in visual and kinesthetic strategies ($M = 3.14$).

Table 1: Multi-sensory learning approaches adopted while learning measuring skills

	Mean
Tactile and Visual Strategies	3.68
Tactile and Auditory Strategies	3.45
Tactile and Kinesthetic Strategies	3.43
Auditory and Visual Strategies	3.34
Auditory and Kinesthetic Strategies	3.27
Visual and Kinesthetic Strategies	3.14
Tactile, auditory and Visual Strategies	3.61
Tactile, Auditory and Kinesthetic Strategies	3.45
Visual, Auditory and Kinesthetic Strategies	3.30
Visual, Auditory and Tactile Strategies	3.43
Visual, Auditory, Kinesthetic and Tactile Strategies	2.91

The predominance of tactile-based strategies confirms that touch serves as the primary sensory channel among learners with deafblindness. It also confirms that these learners rely on their most reliable residual sense. Additionally, instructions that emphasizes touch are likely to yield higher engagement and comprehension. Muhammad *et al.* (2025) indicated that learners with sensory impairment heavily depend on tactile engagements as the main mode of accessing information. This strategy supports concept formation since they explore concrete objects, which helps them to compensate for the auditory and visual input limitations. The high mean in tactile and visual strategies can be explained by Volpe and Gori (2019) who states that combining tactile with visual modalities provide multi-channel reinforcement which enhances retention, attention and comprehension. The high score may also be as a result of some of the learners with deafblindness possessing residual vision which enables then the benefit from visual inputs when combined with touch.

The moderate means of tactile-auditory ($m = 3.45$), Tactile-kinesthetic ($M = 3.43$), Visual, auditory and tactile ($M = 3.43$) and auditory-visual ($M = 3.34$) indicate moderate adoption of these modalities. This suggests that as much as learners try to integrate sensory modalities, the integration is not optimized fully possibly because there is limited guidance from the teachers which may occur as result of limited training among the teachers in matters of multi-sensory learning approach. This may affect the teacher's ability to guide learners with deafblindness on effectively blending different sensory inputs into a coherent learning experience. Larsen and Dammerlyer (2021) established that teachers often use multi-sensory strategies in isolation instead of integration thus reducing their effectiveness. This could be as a result of limited training this approach. Visual, auditory, kinesthetic and tactile strategies recorded the lowest mean ($M = 2.92$).

This is a likely indication that fully integrated MLA involving all the four sensory

modalities is least adopted. The inability to integrate all the four sensory modalities could be as a result of heterogeneity of Deafblind learners. Masuku (2024) explains that the differences in the sensory functioning, additional disability and age at onset requires a tailored rather than generalized MLA without which full integration of MLA becomes less practical. Another possible reason could be the cognitive processing consideration. As much as MLA may be beneficial, excessive and poorly coordinated input may lead to cognitive overload especially for Deafblind learners who need structured, sequential learning experiences instead of simultaneous stimulation across many sense (Sweller, 2012). Additionally, Mayer (2020) demonstrates that learning is enhanced only when relevant sensory modalities are stimulated and declines when exposed to too many simultaneous stimuli.

To validate the quantitative data, teachers were asked to give details on the level to which MLA is adopted by deafblind learners while learning pre-numeracy skills. Their responses elucidated 2 themes: MLA adopted and factors influencing its adoption. On the theme of MLA adopted, teachers stated that a variety of MLA are adopted by LDB and at no given scenario can a deafblind learner learn by engaging only one sensory modality. They stated that most of the time deafblind learners engage either two or three sensory modalities. Verbatim on this theme were reported:

“Deafblind learners engage more than one sense while learning not only pre-numeracy skills but all learning areas.” (Teacher 03)

“Deafblind learners engage multiple sensory modalities and among those engaged, tactile modality dominates.” (Teacher 12)

“MLA adopted by Deafblind learners range from tactile, visual, auditory and kinesthetic approaches. However, rarely do they simultaneously adopt all the four modalities.” (Teacher 17)

Based on the verbatim, teachers stated that deafblind learners engage multiple sensory modalities during learning. Teachers indicated that these learners do not rely on a single sensory modality; instead, they engage two or more senses simultaneously across learning activities, including pre-numeracy skills. The data further revealed that when tactile sense is integrated with other sensory modalities such as sight, hearing and movement approaches, learners develop more skills.

Under the theme of factors influencing adoption of MLA among deafblind learners, teachers reported that the MLA adopted by the learner depends on the individual characteristics of the learner. Verbatim were reported:

"Learners engage multiple senses while learning pre-numeracy skills however, the sensory modalities adopted by the learner depends on the learner's residual sense." (Teacher 6)

"MLA adopted by learners depends on the individual ability of the learner, active learners engage multiple sensory modalities while learning." (Teacher 10).

"Some learners engage two, three and even four sensory modalities depending on their ability." (Teacher 14)

This verbatim show that choosing and combining of sensory modalities explicitly depends on individual learner characteristics. Teachers highlighted that learners' residual senses are key in determining the sensory modalities to be utilized. Furthermore, learners' individual ability and level of activeness were also reported to have an influence on engagement, with more active learners using multiple sensory modalities. Variations were also observed, with some learners engaging two, three, or even four sensory modalities depending on the task being carried out, residual sense and learner's ability.

These qualitative results strongly align with the quantitative findings. Teachers emphasized that LDB engage two or three sensory modalities concurrently and rarely engages only one sensory modality. Teachers also reported that tactile modality is supreme among LDB. This is reflected in the quantitative data with all high ranked strategies including combination of tactile and other modalities. This convergence confirms that tactile-based combinations form the cornerstone of MLA for LDB. Furthermore, the qualitative data indicated that the choice of a sensory modalities depends on learners' residual senses, abilities, and level of activeness. This explain the variation in mean scores across different modality combinations. The relatively lower mean for strategies that involve the adoption of all the four modalities ($M = 2.91$) may be a reflection of individual learner limitations, as very few learners can effectively engage four modalities simultaneously.

The quantitative study findings were further triangulated by open observation guides. Learners were observed while adopting MLA in learning pre-numeracy activities and the scenarios were recorded then analyzed:

In Scenario 1, Learner 2 from School A was provided with a peg board activity. The teacher communicated through sign language, directing her to pick up the pegs and insert them into the corresponding holes. The learner selected each peg, examined it closely by bringing it near her eye, and tactually explored the board to locate an appropriate hole before accurately placing the peg into position. She repeated this process consistently until all the pegs were correctly fitted into the board.

In Scenario 2, Learner 7 from School B was provided with beads for a sorting activity. The teacher gave verbal instructions directing him to select beads that were circular in shape. Initially, the teacher offered physical guidance to help him identify and

pick the correct circular bead. With time, the learner began working more independently he picked each bead, explored and manipulated it with his hands, and then decided whether it was circular. If it was circular, he handed it to the teacher; if not, he placed it back into the jar.

In Scenario 3, Learner 16 from School C was provided with blocks for a construction activity. The teacher gave verbal instructions on how to fix the blocks. Before placing each block, the learner picked it up, explored and manipulated it with his hands, and brought it close to his eye for inspection. He then fixed the block into position with the teacher's assistance.

In Scenario 4, Learner 40 from School D participated in a measurement activity under the teacher's guidance. The teacher stood beside him at one corner and prompted him to take steps toward the opposite corner. Each step taken was followed by loud counting until they reached the other end, combining movement with verbal counting to enhance learning.

Scenario one clearly illustrates the effective adoption of MLA in supporting skill acquisition among LDB. The teacher initiated the activity using sign language, which demonstrated intentional use of visual sensory input as part of MLA. During task execution, the learner engaged multiple senses simultaneously. First, she visually examined the peg by bringing it close to her eyes, indicating reliance on visual perception to understand the object's features. Second, she tactually explored the pegboard, using touch to locate the holes before inserting the peg. This tactile exploration suggests that the learner was integrating touch with vision to guide accurate placement. Third, the act of picking and inserting the pegs required kinesthetic involvement, as she coordinated finger movements and controlled hand positioning to align the peg with the hole. The integration of visual (seeing the peg and hole), tactile (feeling the board and hole), and kinesthetic (manipulating and inserting the peg) inputs reflects a well-implemented MLA strategy.

The second scenario demonstrates the application of MLA in supporting shape discrimination. The teacher began by giving verbal instructions, engaging the learner's auditory sense to understand the task requirement. At the beginning, the learner required physical guidance, indicating the use of tactile and kinesthetic support to scaffold understanding. As the activity progressed, the learner independently picked beads and manipulated them tactually, using his hands to explore their shape. The tactile exploration allowed him to perceive roundness through touch, while kinesthetic involvement supported motor control and object rotation for inspection. The combination of auditory instruction, tactile exploration, and kinesthetic manipulation strengthened the learner's understanding of the concept of "circular."

The third scenario illustrates the structured use of MLA to support the learner's construction and fine motor skills development. The teacher initiated the activity through verbal instruction (auditory). During the activity, the learner actively engaged multiple senses. First, he picked and manipulated the Duplo blocks with his hands (tactile and

kinesthetic). Second, he brought the block close to his eye (visual). Overall, the integration of auditory, tactile, visual and kinesthetic modalities demonstrates effective MLA adoption. On the other hand, scenario four demonstrates the application of MLA during a measurement activity involving distance estimation using steps. The teacher physically positioned herself beside the learner and guided him from one corner to another, indicating structured kinesthetic engagement. The act of stepping from one point to another actively involved the learner's kinesthetic senses. At the same time, the teacher and learner counted loudly with each step. This incorporated the auditory modality.

The qualitative scenarios confirm the quantitative results that learners predominantly use tactile-centered multi-sensory combinations, while full integration of all four sensory modalities occurs less frequently.

The quantitative findings of this study indicate that the combination of sensory modalities involving the tactile sense was the most highly adopted. Specifically, tactile and visual strategies ($M = 3.68$) ranked highest, followed by tactile, auditory, and visual ($M = 3.61$), tactile, auditory, and kinesthetic ($M = 3.45$), and visual, auditory, and tactile ($M = 3.43$). These results suggest that tactile input plays a central role in learning among LDB. These study findings are in line with recent studies like Alotaibi (2024) and Delport (2021), who emphasize the fact that learners with sensory impairments rely heavily on their most functional residual senses, particularly touch, to construct meaning and develop foundational skills. Similarly, Shoaib *et al.* (2023) found that tactile-supported instruction significantly enhances engagement and comprehension in early mathematical concepts among learners with sensory impairments. The predominance of tactile-based strategies also aligns with Quarta *et al.* (2018) and Fitri, Mustaji, and Bachri (2018), who reported that MLAs that integrate tactile experiences with visual or auditory inputs improve conceptual understanding by providing concrete and experiential learning opportunities. The current study's high mean scores for tactile combinations reinforce the argument that hands-on and manipulative-based strategies are particularly effective in pre-numeracy instruction for LDB.

In contrast, combinations that relied less on tactile engagement, such as auditory and visual ($M = 3.34$) and auditory and kinesthetic ($M = 3.27$), recorded moderate adoption levels. This may be because such approaches require learners to process abstract information without direct physical interaction. This observation is supported by Haggerty (2019), who noted that learners with dual sensory impairments often experience challenges when instruction is not grounded in tactile or concrete experiences. On the other hand, triangulation of quantitative findings using interview data further reinforced these results. Teachers consistently reported that LDB engage multiple sensory modalities during learning and rarely rely on a single sense. These results agree with Clemens *et al.* (2023) and Maqbool and Ashraf (2023), who established that multisensory engagement enhances cognitive processing and supports skill acquisition among learners with special needs. Qualitative findings further revealed that tactile modality is dominant but is often integrated with other modalities such as visual,

auditory, and kinesthetic approaches. Teachers emphasized that the choice of modalities depends on learners' residual senses, abilities, and level of activeness. This supports findings by Roseli *et al.* (2024) and Twum and Antwi (2022), who reported that learner characteristics play a critical role in determining the effectiveness of multisensory strategies.

- **Objective 2: Extent of Measuring Skills Development**

Extent of development of measuring skills among learners with deafblindness was measured on a 4-point scale ranging from 1- Below Expectations (BE), 2- Approaching Expectations (AE), 3- Meeting Expectations (ME) and 4- Exceeding Expectations (EE). The findings were summarized on Table 2.

Table 2: Extent of measuring skills development among learners with deafblindness in the foundation stage

	Mean
Learners' Ability to Differentiate Objects in the Classroom	2.45
Learners' Ability to Compare Heavy and Light Objects	2.41
Learners' Ability to Carry Out Filling and Emptying Objects	2.49
Learners' Ability to Identify Kenyan Currency in Notes	1.92
Learners' Ability to Identify Kenyan Currency in Coins	2.20
Overall Mean Of The Level Of Acquisition Of Measurement Skills	2.29

The descriptive statistics in table 2 indicate a relatively AE (M = 2.29) level of acquisition of measurement skills among deafblind learners. Specifically, the mean score for learners' ability to differentiate objects in the classroom (M = 2.45), and the ability to compare heavy and light objects. (M = 2.41), ability to carry out filling and emptying objects (M = 2.49), ability to identify Kenyan currency coins (M = 1.92), and ability to identify Kenyan currency notes (2.20).

The moderate mean of measuring skills (M = 2.29) is a likely indication that LDB have not fully developed the basic competencies in measuring and can only perform such tasks with the help of the teacher. This finding suggests that most of the learners still depend on the teacher's prompts to carry out the tasks, which could be as a result of a dual sensory loss which inhibits incidental learning and makes the LDB fully rely on the teachers. This is equally an eye-opener to teachers who may need to strengthen experiential learning and hands-on activities, and leave nothing to chance.

The low mean in identification on coins (M = 2.20) and notes (M = 1.92) demonstrates that deafblind learners continue to struggle with converting abstract and symbolic measurement skills to real-life situations. It indicates that learners have a bigger weakness in the identification of paper money. This could be due to the fact that Kenyan currency notes rely on visual features for identification, such as printed symbols, differences in size and colour. The learners have either limited vision or no vision at all which contributes to low development of this skill. They need tactile materials to fully interact with abstract mathematical content like currency notes. When adaptations are

not made, meaningful relationships between symbols and monetary values may not be developed by deafblind learners. Insufficient real life experience to currency may also limit understanding as Piper *et al.* (2019) illustrates that learners who are blind and those with deafness have poor performance in applied numeric tasks because of limited exposure to experiential learning.

The averagely higher performance in identification of coins ($M = 2.20$) as compared to notes could be associated to the fact that coins have distinct tactile features like weight, edges and size which are easier to be identified by learners. Musango *et al.* (2024) established that three dimensional tactile materials and real objects enhance mathematical comprehension by bridging concrete and symbolic learning. The low performance in currency identification therefore suggests that there is a gap between classroom instructions and functional pre-numeracy skills. It calls for integrating real life materials like handling money activities into teaching to improve retention.

The ability of the learners to compare heavy and light objects ($M = 1.91$) indicates that majority of the learners have difficulty comprehending and applying the weight comparison concept without the help of the teacher. Quane (2023) argues that mathematical concepts like measuring are hard learners with sensory impairments to comprehend especially when instructions miss concrete, hands on manipulatives. Limited performance among deafblind learners in comparing light and heavy objects could therefore be possibly because the concept of weight is abstract and needs repeated comparison which may have been insufficiently given. Nicholas (2020) further illustrates that deafblind learners heavily rely on tactile exploration and yet subtle weight differences are hard perceive when guidance is not offered by the teacher. This links the low means to inadequate use of tactile measuring tools which are vital for enhancing conceptual understanding of weight.

The moderate performance in differentiation of objects in the classroom ($M = 2.45$) shows that LDB have emerging knowledge to differentiate objects in a classroom. This could be as a result of the skill being strongly aided by tactile cues which is the core sensory channel for LDB. Studies emphasize that object manipulation and touch are core to the development of intellectual and conceptual understanding in LDB (Nicholas, 2020) Additionally, it may be as a result of frequent interaction with the objects in the classroom which may have enhanced familiarity. The score was however low which suggests that there is insufficient exposure to objects which could be due to dual sensory loss, inadequate reinforcement and possibly limited variety of tactile experience (Brum & Bruce, 2023) indicates that understanding of measuring among learners with sensory impairment heavily relies physical manipulation and consistent reinforcement.

The ability of the learners to fill and empty containers had the highest score ($M = 2.49$) although overall still low which suggests that deafblind learners perform better in procedural and hands on tasks. The possible reason could be because these activities are majorly experimental and concrete which makes it easy for learners to comprehend. The activities also involve direct manipulation and on spot feedback which enhances

learning. Brum and Bruce (2023) explains that learners need collaborative and repeated examination of real and tactile objects to acquire stable conceptual representations. However, when repetition is limited and progress complexity lacks, full mastery of this skill may be restricted.

The overall pattern of current studies results indicate that deafblind learners have better performance in tactile, repetitive and concrete tasks but continue to struggle with less structured, abstract and symbolic concepts like comparison of weight and identification of currency. This pattern is in line with Nicholas (2020) and Brum and Bruce (2023) who points out that deafblind learners depend heavily on tactile modality for intellectual development. These results show the vital role of MLA with tactile features and the need for functional, consistent and structured and individualized learning experiences. Additionally, the findings concur with studies revealing that learners who are visually impaired heavily depend on the sense of touch and hearing for learning numeracy concepts, making hands-on experiential activities very effective (Maguvhe, 2015). Similarly, Esplendori *et al.* (2022) states that engagement of tactile modality supports mathematical concept understanding especially when visual input is missing.

Further, the challenges experienced by learners in identification of currency are in line with Al-Azawei *et al.* (2023) observation that mathematical tasks that involve symbolic representation and visual features are difficult for learners with visual impairment since they have limited exposure to information that is presented visually. This is a likely explanation of the relatively low performance in currency notes identification in comparison to coin identification since coins give more tactile cues.

Overall, the findings indicate that although learners are approaching the expected level of competence in measurement skills, targeted instructional support is required to enhance mastery, particularly in abstract and symbolic aspects of measurement. This includes the use of tactile teaching aids, real-life learning experiences, and multisensory instructional strategies to bridge the gap between experiential understanding and conceptual knowledge.

- **Objective 3: Influence of Multi-Sensory Learning Approach on Development of Measuring Skills**

In order to determine the influence of MLA on development of measuring skills among LDB simple regression analysis was done to predict acquisition of measurement skills from the MLA. The finding is as indicated in Table 3, 4 and 5.

Table 3: Model significance on influence of
 MLA on acquisition of measurement skills among deafblind learners

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.880	3	.293	2.998	.042 ^b
	Residual	3.915	40	.098		
	Total	4.795	43			
a. Dependent Variable: Measurement skill						
b. Predictors: (Constant), Age, MLA, Years of exposure						

Table 3 indicates that the overall model was statistically significant $F(3, 40) = 2.998, p = .042$, suggesting that the combination of these predictors accounted for a significant portion of the variance in measuring skills.

Results of the model summary on the influence of MLA on acquisition of measurement skills from multiple regressions were presented in Table 4.

Table 4: Regression analysis of model summary on influence of MLA on acquisition of measurement skills among LDB

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.428 ^a	.184	.122	.31285	.184	2.998	3	40	.042
a. Predictors: (Constant), Age, MLA, Years of exposure									
b. Dependent Variable: Acquisition of measurement skills									

Regression model in Table 4 indicate that MLA accounted for 12.4% (adjusted $R^2 = .122$), $p < .05$ variance in acquisition of measurement skills before controlling the effect years of exposure and age. MLA explained 18.4% (R^2 Change = .182), $p < .05$ variation in acquisition of measurement after controlling for the effect of years of exposure and age.

Following Cohen *et al.* (2017) guidance, the next step is to evaluate the regression coefficient to establish how each predator contributes uniquely to the model. They emphasize that the fact that the overall model is significant doesn't imply that all predictors are significant individually. Only by inspecting β coefficients and associated p-values can the variables that uniquely contribute to predicting measuring skills be established.

Table 5: Results of coefficient on influence of MLA on acquisition of measurement skills among LDB

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.657	.254		6.519	.000
	MLA	.012	.005	.348	2.401	.021
	Years of exposure	-.065	.045	-.210	-1.437	.159
	Age	.006	.068	.013	.090	.928
a. Dependent Variable: Measuring skill						

The results on table 5 indicated that the overall regression model was statistically significant, $F(3, 40) = 2.998, p = .042$, and explained 18.4% of the variance in measuring skills ($R^2 = .184$; Adjusted $R^2 = .122$). Examination of the regression coefficients showed that MLA was a significant predictor of measuring skills ($\beta = .348, p = .021$), indicating that higher adoption of MLA was associated with better performance in measurement tasks. In contrast, number of years in the foundation stage ($\beta = -.210, p = .159$) and learners' age ($\beta = .013, p = .928$) were not statistically significant predictors. These findings

suggest that adoption of MLA uniquely supports learners' acquisition of measuring skills, independent of age or the duration of early education.

Quantitative findings were triangulated using teacher's interview guide. Teachers were asked to respond on the question on how influences acquisition of measurement skills among deafblind learners. Thematic analysis of teachers' responses yielded two major themes: perceived effectiveness of MLA and challenges and barriers to effectiveness. Under the theme of perceived effectiveness of MLA in learning measurement skills, some teachers acknowledged that MLA can be effective but emphasized that this effectiveness is conditional upon the nature of the measuring task and its complexity. For instance,

"Measuring is a bit technical for the learners. I only teach measuring distance using steps during orientation and movement and MLA is effective." (Teacher 2)

"MLA is effective based on what they learn and not what is in the curriculum." (Teacher 3)

"The effectiveness of MLA when learning measuring skill depends on what the learner is learning. If the concepts are so complex, not even MLA can make them understand but if the measuring concepts being taught are not complex, MLA becomes very effective." (Teacher 8)

The teachers' views show that they see MLA as an important strategy when learners engage in tasks that involve manipulation of physical objects and when learning is practical and in line with learners needs.

Under the theme of challenges and barriers to effectiveness was prominent, teachers stated that the curriculum content is too heavy for LDB to understand and apply even with adoption of MLA.

"First, the content that LDB are expected to cover based is too complex for them. So based on that as long as LDB are learning the content in the curriculum, MLA cannot be effective but with what I let them learn, MLA is effective." (Teacher 1)

"How can I make a learner who is totally blind get the concept of Kenyan currency notes? MLA is very effective but if we were to measure in relation to what the curriculum describes, it becomes very hard." (Teacher 5)

These challenges reflect a broader concern that traditional curricular expectations for measurement including understanding arbitrary units and formal measurement systems, may exceed the developmental readiness of learners with significant learning barriers.

In an attempt to validate results on the adoption of MLA, triangulation was done using an open observation guide to establish how MLA influences the acquisition of measurement skills among learners. The findings were thematically analyzed.

In scenario 1, Learner 3 from School A was engaged in an activity to measure the distance between the school dining hall and the classroom. The teacher supported her physically, and together they walked while counting each step aloud. After reaching twelve steps, they arrived at the washroom door. The teacher informed the learner that they were at the door. In response, the learner removed her trousers, explored the door and the toilet bowl through touch, and then sat on it. On the following day, with the teacher's assistance, the learner again walked toward the washroom while counting steps. Upon reaching twelve steps, she independently stopped, demonstrating that she had understood that twelve steps indicated arrival at the washroom door.

In the second scenario, Learner 5 from School A engaged in an activity involving filling and emptying water into a container. With the teacher's guidance, the learner fetched water using a jug from a pail and poured it into a larger container while they counted together each time the learner emptied the water in the jug. In the counting process, learner 5 could not clearly articulate the numbers but instead produced vocal sounds. After emptying five jugs, the larger container was filled. The learner stopped fetching more water to add to the container, and despite the teacher's prompts to continue, she resisted pouring more water.

In the analysis of the two scenarios, the first one demonstrates the effectiveness of repetitive, experiential and structured learning in helping the LDB develop spatial awareness and measurement concepts. The teacher linked a numerical concept (twelve steps) to a specific location (the washroom door) through guided step-counting and physical support. Initially, the learner relied heavily on the teacher's verbal cue to recognize arrival at the destination. Nevertheless, on day two, the learner self-reliantly stopped after making twelve steps, suggesting mastery of the association between the steps that were counted and the washroom door. This demonstrates effective understanding of the measurement of distance using arbitrary units and reveals the ability of the learner to relate movement, number and environment constructively. It also demonstrates how engaging multiple sensory modalities like kinesthetic (walking), auditory (counting aloud and verbal instruction), and tactile (touching the toilet bowl and the door) aids memory and functional independence.

The second context depicts the learner's growing comprehension of measuring quantity, capacity, and number through functional hands-on experience. Through continuously using a jug to fill and empty a container, the learner was exposed to one-to-one correlation, with each jug symbolizing one counted unit. After pouring 5 jugs into the container, the learner independently stopped adding more water, and even with the teacher's prompts, he resisted since he knew the container was full. This shows that she had understood the concept of capacity and the idea of concrete caps. The resistance shows cognitive knowledge rather than rebellion; she likely detected that adding more

water was not necessary because the container was already full. The context depicts purposeful learning through hands-on activities, demonstrating advancement in number sense, comprehending measuring of capacity and the ability to employ the information practically. The learner also engaged multiple sensory modalities while carrying out the various activities. For instance, tactile sense (Holding the jug), auditory (Counting verbally), and kinesthetic (movements made in the process of fetching and filling water in the container).

These results are in line with the study by Carbonneau *et al.* (2013), who established that pedagogical strategies that integrate tangible manipulatives tend to improve learners' performance in mathematics. The study highlighted that manipulatives are efficient when they aid intellectual comprehension, which is a vital segment in comprehending measuring concepts like volume and capacity. The positive beta coefficient ($\beta = .345$) in this study equally implies that sensory-rich and experiential learning through hands-on activities reinforces learners' mastery of measurement concepts.

More support is given by Shurr *et al.* (2021), who confirmed that mathematics mediations involving visual and physical supports substantially enhanced the results of learners with disabilities. These findings support the current findings that the pedagogical approach (multi-sensory learning approach) plays a significant role in the development of measuring skills among learners with deafblindness. Similarly, Cuturi *et al.* (2022) established that multisensory learning environments improve mathematical comprehension through engaging multiple sensory modalities, thereby encouraging stronger cognitive processing of measuring tasks. Additionally, Gulati *et al.* (2024) confirmed that MLA produced a positive but moderate statistical significance effect, differing across studies based on the methodology adopted.

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

MLA's that involve combination of tactile and other sensory modalities were the most adopted while combinations relying less on tactile engagement, such as auditory and

were moderately adopted. On the other hand, LDB rarely integrate all the four sensory modalities while learning measuring skills.

There is low proficiency across all measurement subskills among LDB was recorded with mean of Approaching Expectations implying that majority of these learners can only perform measuring tasks with teachers' prompts.

The coefficient of the influence of MLA on acquisition of measuring skills was ($\beta = 0.348, t = 2.401, p = .021$) This suggests that use of MLA was associated with an increase in the acquisition score.

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Conflict of Interest Statement

This work does not have any conflict of interest.

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