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Teaching Mathematics to Blind Students in Ethiopia: Knowledge of Ethiopian Primary School Mathematics Teachers

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Abstract:

This study aimed to assess Ethiopian primary school mathematics teachers' knowledge of teaching mathematics to blind students. The study employed a descriptive survey design. A total of four hundred twenty-five sample participants were chosen from Addis Ababa, Oromia, Sidama, and South Nation, Nationalities and Peoples' Region Primary school mathematics teachers using proportionate random sampling technique. Data was collected through structured questionnaire and analyzed using the Statistical Package for Social Science (SPSS). Descriptive and inferential statistics were used to describe the results. Results revealed a significant lack of both technological (84.7%) and pedagogical (92.11%) expertise. This deficiency critically undermines the principles of inclusive education in Ethiopia, hindering blind students' equitable access to a compulsory subject and limiting their development of essential mathematical literacy. Statistical analysis indicated a significant gap between expected and calculated mean knowledge levels ($p<0.05$), with no significant correlation found across demographic factors. This highlights a systemic failure within teacher education, directly impacting blind students' right to quality education and future socio-economic participation, thereby contradicting national and international inclusive development agendas focused on equality and human rights. The study underscores the urgent need for a paradigm shift in teacher training to embrace the Technological Pedagogical and Content Knowledge (TPCK) framework, fostering truly inclusive classrooms and ensuring blind students can achieve their full potential and contribute to national development.

Keywords: Blindness, Knowledge, Mathematics, Teachers

INTRODUCTION

Mathematical understanding and logical reasoning are crucial abilities that form the backbone of a well-rounded education. They equip individuals with sharp reasoning skills, keen attention to detail, and essential knowledge necessary for meaningful contributions to society (Laura, 2020). In today's technology-driven environment, the role of mathematics is becoming increasingly important in various everyday situations, ranging from managing personal finances to tackling complex challenges.

Mastery of mathematics fosters critical thinking abilities that transcend mathematical situations, greatly impacting decision-making and various other areas of life (Agrawal, 2004). Acknowledging its critical importance for personal growth and societal advancement, mathematics is a key component of school curricula Worldwide, typically required from primary through secondary education. Mathematics is considered as mandatory for sighted students in both elementary and secondary education in Ethiopia.

Nevertheless, the door to mathematics is locked for persons with blindness for decades even though Ethiopia was a pioneer in teaching mathematics to students with blindness. Before the 1974 revolution, North American missionaries not only built schools but also brought about independence on the lives of persons with blindness by introduced Braille and hands-on tools like tactile geometry kits, proving that blindness was no barrier to learning algebra or physics (Sissay, 2022). Yet today, many students are denied this legacy not because they can't learn, but because the system fails to adapt.

Ethiopia's progress in teaching mathematics to students with blindness came to an abrupt halt when the military regime seized power after Emperor Haile Selassie's fall. The new government severed ties with the West, aligning instead with Soviet-led socialist allies; a shift that had devastating consequences. Foreign missionaries, who had been instrumental in pioneering special education for Ethiopians with disabilities (especially blindness), were expelled overnight (Sisay, 2022),

This wasn't just a bureaucratic change; it was a human tragedy. Students with blindness lost their teachers and their chance to learn mathematics and other natural science subjects. The regime didn't just disrupt education; it denied basic human rights, treating disability as an afterthought rather than a priority.

While Ethiopia backtracked in upholding the educational and other human rights of persons with disabilities including those with blindness, the global community was moving in the opposite direction. Scholars, disability rights activists, and UN agencies began championing a radical idea: *Disability isn't an individual flaw; it's a societal failing*. Influenced by the social model of disability, thinkers like Oliver (2013) argued that the real barriers facing people with disabilities exist outside themselves in inaccessible systems, prejudiced policies, and outdated attitudes. The question wasn't *"How can people with disabilities adapt?"* but *"Why won't society change?"*

To answer this fundamental question, Ethiopia has taken significant steps to re-address the educational needs of students with disabilities, driven by a commitment to equality and inclusion. The country's Constitution (1994) lays a strong legal foundation, affirming that all international human rights agreements; including those protecting persons with disabilities, are binding under Ethiopian law (Article 9:4). Most importantly, it declares that 'human rights are "inviolable and inalienable" (Article 10:1) and guarantees equal access to education and public services for all (Articles 25 & 41:3).

True to these principles, Ethiopia ratified the UN Convention on the Rights of Persons with Disabilities (CRPD) in 2010, signaling a national pledge to inclusive education. To turn policy into practice, the Ministry of Education developed a 10-year Master Plan, aligning with the Education Sector Development Program (ESDP V) and international best practices. This plan wasn't just paperwork; it was a roadmap for change, emphasizing adaptive technologies and tailored teaching methods to make mathematics accessible for students with blindness (MoE, 2016). This is a big matter because mathematics isn't just a school subject; it's rather a life skill. Research shows that mathematical literacy empowers people to solve everyday problems, from managing finances to making informed decisions (Zhang, 2016; Driscoll & Watson, 2014). Ethiopia's education policy and other relevant programmatic documents recognize this, affirming that every child, regardless of ability, deserves the tools to learn and thrive.

The Federal Ministry of Education a ten-year Master Plan for Special Needs /Inclusive Education (2016-2025) clearly delineates strategies aimed at facilitating learning and ensuring school attendance for students with diverse needs, including those with visual impairments through training inclusive teachers and stresses the importance of flexible arrangements along with the necessary services and aids for subjects like mathematics (MoE, 2016). Research indicates that blind students can achieve mathematical proficiency comparable to their sighted counterparts when offered tailored educational methods (North Carolina State Board of Education, 2014; Zhang, 2016), underscoring the significance of accessible and suitable teaching.

Teachers play a critical role in identifying and addressing the specific educational requirements of all students, including those with blindness. The Ministry of Education's Master Plan (2016) acknowledges the essential need for enhancing teacher capacity to modify the general curriculum and to apply individualized teaching strategies. Nonetheless, research shows that educators frequently encounter considerable difficulties when teaching mathematics to blind students due to the limitations of available tools and a lack of specialized training (Adler, 2000; Gueudet et al., 2012; Mumtaz, 2000; Van L. et al., 2021).

The Technological, Pedagogical, and Content Knowledge (TPCK) framework (Mishra & Koehler, 2006) underscores the combined knowledge and skills that teachers must possess to effectively integrate technology into their instruction. This model is especially relevant for mathematics education for blind

students, who depend on assistive technologies and adapted teaching methods to access mathematical ideas. Although the significance of assistive technology in supporting the achievements of blind students is recognized (Pogrund & Smith, 2012; Zhou et al., 2011, cited in Van L., 2021), concerns persist regarding the adequacy of teacher training in this domain.

Considering the vital role of teachers in enabling inclusive mathematics education for blind students and the identified gaps in existing research within the Ethiopian context (Yohannes B., 2007, focused on sighted students), this study aimed to evaluate the understanding of Ethiopian primary school mathematics teachers regarding the teaching of mathematics to blind students. It specifically focused on their awareness and comprehension of assistive technologies/devices and appropriate instructional strategies tailored for this student group. The study sought to address the following research questions:

1. What is the extent of knowledge among mathematics educators regarding the assistive and digital tools that facilitate mathematics teaching for visually impaired students?

2. How well-informed are primary school mathematics educators about accommodating mathematics instruction for blind learners?

METHODOLOGY

Research Approach

This research utilized a descriptive survey design to evaluate the current understanding of primary school mathematics teachers in Ethiopia about instructing mathematics to visually impaired students. This approach is well-suited for outlining the attributes of a specific group, in this instance, the awareness levels of educators in relation to particular pedagogical and technological dimensions of inclusive mathematics teaching.

Operational definition in this study:

a. TPCK: Technological Pedagogical and Content Knowledge
b. Blind: a total loss of sight with braille reading and writing preferences for education and other life related activities
c. Knowledge: understanding and comprehending to blind students' needs with appropriate pedagogical, technological and content knowledge.

Participants In The Study

The participants comprised primary school mathematics teachers (grades 1-8) from both urban and rural educational institutions, encompassing both boarding and non-boarding schools where blind students were enrolled. Teachers were selected from four significant regions in Ethiopia: Addis Ababa City Administration, Oromia, Sidama, and the South Nations, Nationalities, and Peoples' Region (SNNPR). These regions were chosen due to their relative stability during the data collection phase.

Sample Size And Selection Method

An initial sample size of 386 primary school mathematics teachers was calculated using Cochran's formula (Cochran, 1963), which is appropriate for large populations where the exact size is unknown. The calculation was based on a 95% confidence level and a proportion (p) of 0.5 to maximize variance. To address possible attrition, an additional 10% was included, leading to the distribution of questionnaires to 425 primary schools mathematics teachers.

To ensure proportional representation, a proportionate random sampling technique was utilized to select participants from each of the four regions based on the total number of primary school mathematics teachers in those areas. Within each chosen school, the lottery method was applied to randomly select participating mathematics educators, as the number of teachers in each institution was generally known.

The formula used is: $n = z^2pq/e^2$, where n represents the sample size, Z^2 is the statistical value associated with the confidence level (95%), e denotes the desired precision level, p is the estimated proportion of a characteristic within the population, and q is calculated as 1 - p. Thus, the calculation yielded: $n = ((1.96)^2(.5)(.5))/((.05)(.05)) = 386$.

Data Collection Tool

A structured questionnaire consisting of 24 items was created to gather information on teachers' Knowledge regarding assistive technologies/devices (14 items) and accommodative classroom techniques (10 items) for teaching mathematics to blind students. Each item provided three fixed response options: 'no knowledge' (scored 0), 'limited knowledge' (scored 1), and 'adequate knowledge' (scored 2). Definitions were established for 'limited knowledge' (average mean score of 50-75%) and 'adequate knowledge' (average mean score ≥ 75%) to classify the responses.

The questionnaire was subjected to a thorough development procedure, which included peer reviews by specialists in special needs education and mathematics instruction, as well as a pilot study to evaluate clarity and practicality. Content validity and the content validity index (CVI) were determined in accordance with the guidelines proposed by Yusoff MSB (2019), resulting in an acceptable pilot study validity index of 0.89.

Data Analysis

The data gathered via the questionnaires were analyzed using the Statistical Package for Social Sciences (SPSS version 21) software. Descriptive statistics, such as frequencies, percentages, and means, were utilized to summarize the demographic information of the respondents and their knowledge levels concerning assistive technologies and accommodative strategies. Inferential statistics, including independent samples t-tests and Analysis of Variance (ANOVA), were

employed to explore potential differences in knowledge levels across various demographic factors (age, gender, qualifications, teaching experience, and subject specialization) and to compare the mean knowledge level against a predetermined mean that indicates adequate knowledge. A 95% confidence interval ($p < 0.05$) was applied to assess statistical significance. Among the 425 distributed questionnaires, 412 completed and valid responses were analyzed.

RESULTS

Demographic Characteristics of Respondents

The demographic profile of the study participants (see Table 1) revealed that the most common age group among respondents was 30-40 years, comprising 49.8% of the total, followed by those aged 41-50 years at 30.3%. In terms of gender, male Mathematics teachers represented 76.7%, while female Mathematics teachers made up only 23.3%. The majority of respondents had teaching experience ranging from 11 to 20 years (50.2%), followed by those with 5 to 10 years of experience (30.6%). A small fraction had less than 5 years of experience (1.8%), and only 0.2% had over 30 years of teaching experience. Additionally, 17% of respondents fell into the category of 21-30 years of experience. When examining specific experience in teaching blind students, 32.1% had instructed blind students for 1-10 years, 28.7% for 11-20 years, and 2.9% for 21-30 years; however, a notable portion (31.6%) reported never having taught blind students.

Regarding educational qualifications, the majority of respondents held diplomas (88.1%), while 8.5% possessed a first degree, and 3.4% had a Certificate from a Teacher Training Institute (TTI). In terms of their subject specialization, 46.2% indicated that they were trained in mathematics education, whereas nearly half of the respondents (45.2%) came from non-mathematics backgrounds. Despite this, many of these educators were teaching mathematics without adequate pedagogical or content knowledge in the subject. Teaching blind students requires educators who not only comprehend the unique needs of these children but are also often specially trained to apply their expertise and teaching strategies accordingly. Alarmingly, 86.4% of respondents stated they had never received any form of training in special needs education, and 95.8% reported lacking any skills training to support blind students in learning mathematics. Moreover, 73.3% indicated that they had not received any on-the-job training from colleges, universities, or local education offices related to this matter.

Table 1: Demographic Characteristics of the Respondents (n= 412)

Variables	Category	Number (n)	Percentage
Age	20-30	66	16%
	31-40	205	49.8%

	41-50	125	30.3%
	>50	16	3.9%
Sex	Male	316	76.7%
	Female	96	23.3%
Total teaching experience in years	<5	8	1.9%
	5-10	126	30.6%
	11-20	207	50.2%
	21-30	70	17.0%
	>30	1	0.2%
Teaching experience specific to blind students in years	0	130	31.6%
	1-10	144	35%
	11-20	125	30%
	21-30	3	3.2%
Qualification	Diploma	363	88.1%
	First Degree	35	8.5%
	Certificate of TTI	14	3.4%
Subject of certification	Mathematics	209	50.7%
	Non-mathematics	203	49.3%
Training in Special Needs/Inclusive Education (n=412)	No	356	86.4%
	Yes	56	13.6%
Special needs and inclusive education skills training	No	395	95.9
	Yes	17	4.1
School type (n=412)	Unit class in regular school	39	9.5
	Regular school/inclusive	343	83.3
	Special boarding school for the Blind	30	7.3

Preliminary Insights on Teaching Mathematics to Blind Students

The initial findings (see Table 2) from this research indicate that a significant portion of schools in Ethiopia (51.7%) are equipped with Inclusive Education Resource Centers (IERCs). These centers are designed to enhance teacher training, assess the learning requirements of students, facilitate remedial instruction for those with special educational needs, and serve as a repository for teaching materials and resources tailored for students with disabilities, particularly blind students. Nevertheless, the existence of an IERC alone does not enhance the effectiveness of mathematics instruction for blind students. In the Ethiopian educational landscape, no significant differences were found in the mathematics teaching effectiveness between schools equipped with IERCs and those without them. A staggering 73.1% of mathematics educators reported that they had never

participated in any in-service training from local colleges or universities, which would assist them in implementing suitable and inclusive instructional strategies for blind students during mathematics lessons. Consequently, 73.3% of these teachers required blind students to leave the classroom during mathematics sessions. An overwhelming 95% of these educators attributed their decision to expel blind students from mathematics classes to their own lack of knowledge and skills required to accommodate these students adequately. Only a small fraction of teachers (4%) indicated that the absence of appropriate mathematics teaching resources was a barrier in their schools. Additionally, 1% (n=3) of teachers justified sending blind students out of class based on negative perceptions—that blind students are incapable of learning mathematics (0.7%) or that mathematics is irrelevant to them (0.3%). Conversely, Zhang (2016) emphasized that mathematics skills are essential for all students and asserted that blind students possess the same potential to learn and excel in mathematics as their sighted peers. Furthermore, a study funded by the North Carolina State Board of Education underscored the significance of mathematics in daily life and highlighted the necessity for it to be accessible to all students, tailored to their preferred learning styles.

In contrast, mathematics teachers who had undergone training in Special Needs Education through either in-service or pre-service programs demonstrated a greater capacity to accommodate blind students during mathematics classes. However, they primarily relied on oral teaching methods (93.8%) due to their inadequate pedagogical training to meet the distinct needs of these students. A small percentage (6.2%) of teachers did not implement any strategies to include blind students in their lessons. Among those teachers who allowed blind students to remain in class, none employed suitable or adaptive instructional strategies to facilitate these students' access to the subject matter. The Federal Ministry of Education's Master Plan (2016), which was intended to be enacted between 2016 and 2025, prioritized making mathematics and other natural science subjects accessible to blind students by equipping teachers with the skills necessary to adapt the mainstream curriculum and utilize effective instructional strategies. However, the analysis of this study revealed that mathematics educators struggled to integrate blind students into their lessons due to a lack of understanding regarding both the available assistive technologies and the necessary adaptive instructional strategies.

Table 2: Preliminary Information (n=412)

Items	Category	Number (n)	Percentage
Inclusive Education Resource Center (IERC)	No	199	48.3
	Yes	213	51.7
Training from Colleges/Universities/and/or the nearby Woreda education office	No	301	73.1
	Yes	111	26.9

Actions towards Blind students during mathematics session	Let them go out	302	73.3
	Let them stay in class	110	26.7
justification to let blind students go out of mathematics class	Lack of knowledge on how to address their needs	286	95%
	Blind students cannot learn mathematics	2	0.7%
	Mathematics has nothing to do with the blind students	1	0.3%
	Lack of learning support resources	12	4%
Strategies employed to teach mathematics if teachers let blind students stay in the mathematics sessions	Oral teaching	105	93,8%
	Using appropriate instructional strategies	0	0
	I do not know	5	6.2%

Primary School Mathematics Teachers' Knowledge of Assistive Technologies/Devices (Technological Knowledge)

The evaluation of primary school teachers' understanding of teaching mathematics to visually impaired students within the Ethiopian context concentrated on two critical components: familiarity with assistive technologies/devices (item=14) and implementation of classroom accommodations (item=10). Participants answered 14 questions related to assistive devices/technologies for mathematics (table 3) and 10 questions regarding classroom accommodation strategies (table 4). Each response was classified into three fixed categories: no knowledge (0), limited knowledge (1), and adequate knowledge (2). Limited knowledge was defined as an average mean score between 50-75, while adequate knowledge was considered a score of 75 or above.

Analysis from this study indicated that 76.2% (n=314) of mathematics teachers lacked any understanding of the abacus and its functionalities, while only 23.8% (n=98) reported having limited knowledge on the subject. None of the participants demonstrated adequate knowledge regarding the abacus, despite its common perception as a low-tech tool for teaching numbers and basic operations including addition, subtraction, division, and multiplication. Concerning the

graphic calculator, used for setting and interpreting graphs, only 2.2% and 0.2% of the mathematics teachers claimed they possessed limited and adequate knowledge, respectively; a striking 97.6% of primary school mathematics teachers reported having no knowledge of this tool.

Braille serves as the reading, writing, and arithmetic medium for individuals with visual impairments. However, the analysis revealed that 76.2% of primary school mathematics teachers lacked the knowledge to create, read, and write Braille notations in general and specifically for mathematics. The Nemeth Braille code, created by blind professor Abraham Nemeth in 1946 during his doctoral studies for mathematics and scientific notation, utilizes standard six-dot Braille cells for tactile reading for the visually impaired. Alarmingly, 100% of primary school mathematics teachers were unaware of this specific code. Regarding tactile instruments, 83.3%, 86.9%, 80.1%, 96.8%, 100%, and 86.4% of teachers reported having no knowledge about tactile protractors, tactile rulers, tactile meters, tactile graphs, tactile images, and tactile calculators, respectively. Furthermore, 100% of primary school mathematics instructors were unaware of mathematics aid software such as ASTeR (Audio System Technical Reader), Duxbury Braille translator, and tools for illustrating geometric figures and graphs. These knowledge deficiencies contribute to the continued exclusion of blind students from mathematics and other natural science subjects.

It can be concluded that the valuable experiences of foreign missionaries during the imperial government era have not been documented effectively. The Ethiopian primary school mathematics teachers appear to lack familiarity with the TPACK model (Technological, Pedagogical, and Content Knowledge) established by Mishra and Kohler (2006), which is essential for teaching mathematics to students with visual impairments. The Ministry of Education of Ethiopia's special needs master plan (2016) stresses the importance of building teachers' capacities to utilize educational technologies and adapt the main curriculum to meet the requirements of blind students, ensuring they are no longer excluded from any subject. The findings of this study suggest that the teacher training approaches in Ethiopia require significant reevaluation in this context.

Table 3: Technological Knowledge (n=412)

Assistive technologies	Category	Number (n)	Percent	Cumulative Average		
				0	1	2
Basic abacus and its operation	0	314	76.2			
	1	98	23.8			
	2	0	0			
Graphic calculator	0	402	97.6			
	1	9	2.2			
	2	1	0.2			

Braille formation, reading and writing	0	360	87.4	84.7	9.11	6.19
	1	52	12.6			
	2	0	0			
Tactile protractor	0	343	83.3			
	1	69	16.7			
	2	0	0			
Tactile ruler	0	358	86.9			
	1	54	13.1			
	2	0	0			
Tactile meter	0	330	80.1			
	1	82	19.9			
	2	0	0			
Tactile graphs	0	399	96.8			
	1	13	3.2			
	2	0	0			
Tactile pictures	0	412	100			
	1	0	0			
	2	0	0			
Nemeth brail code for mathematics	0	412	100			
	1	0	0			
	2	0	0			
Unified English Braille code for mathematics	0	323	78.4			
	1	99	31.6			
	2	0	0			
Illustration of geometric figures and graphs	0	412	100			
	1	0	0			
	2	0	0			
Duxbury braille translation	0	412	100			
	1	0	0			
	2	0	0			
Audio-system technical reader (ASTeR)	0	412	0			
	1	0	0			
	2	0	0			
Talking calculator	0	356	86.4			
	1	56	13.6			
	2	0	0			

Key: (0= no any knowledge, 1=limited knowledge, 2=adequate knowledge)

Primary Schools Mathematics Teachers' Knowledge on Accommodative Classroom Instructions (Pedagogical Knowledge)

It is essential for teachers to be proficient in accommodative instructional strategies within the classroom (**see Table 4**), leveraging their pedagogical knowledge. The essence of effective teaching lies in pedagogical expertise, which distinguishes a competent teacher. Nonetheless, when addressing the needs of blind students, who primarily learn through tactile methods, it was found that a significant percentage of primary school mathematics teachers lacked essential knowledge. Specifically, 90.8%, 94.2%, and 94.9% of these teachers reported having no understanding of how to transform visual concepts into tactile formats, create specialized teaching aids for blind students, and prepare materials in braille, respectively. Furthermore, all primary mathematics teachers acknowledged their lack of knowledge in developing tactile pictures or diagrams, a crucial aspect of teaching geometry.

Additionally, 96.8% and 95.1% of teachers indicated they were unaware of how to create tactile graphs and mental arithmetic strategies tailored for teaching mathematics to blind students in Ethiopia. Students with special educational needs, particularly those who are blind, require tailored teaching materials, equipment, methodologies, and content that aligns with their unique educational needs and interests. However, a concerning 85.7% and 87.4% of primary school mathematics teachers admitted they had no knowledge of how to convert mathematics text into braille or adapt mathematical aids and equipment for blind students, respectively.

In summary, the study's findings clearly indicated that the average score for all knowledge items was 35.3412, signifying that Ethiopian primary school mathematics teachers lacked the knowledge necessary to teach mathematics to blind students using assistive technologies and accommodating instructional methods. This shortfall suggests that Ethiopian teacher education programs and curricula have overlooked the technology component of the TPCK model, which has negatively impacted the engagement and success of blind students in various socio-economic areas. The TPCK model, originally proposed by Mishra and Cohler (2006), posits that an effective teacher is one who possesses the ability and skills to integrate Technological, Pedagogical, and Content Knowledge when addressing a subject, particularly in the context of teaching mathematics.

Table 4: Accommodative Classroom Instructional Strategies (n=412)

Classroom accommodative strategies for math	Category	Number (n)	Percent	Average		
				0	1	2
Convert visual concepts to non-visual experience	0	334	90.8			
	1	38	9.2			
	2	0	0			
Prepare blind specific teaching aids	0	388	94.2			
	1	24	5.8			

	2	0	0	92.04	7.91	0.05
Prepare mathematics braille text materials	0	391	94.9			
	1	21	5.1			
	2	0	0			
Tactile pictures, diagrams development	0	412	100			
	1	0	0			
	2	0	0			
Tactile graphs development	0	399	96.8			
	1	13	3.2			
	2	0	0			
Development of mental arithmetic	0	392	95.1			
	1	20	4.9			
	2	0	0			
Construction of two/three dimensions of tactile graphs/pictures	0	405	98.3			
	1	7	1.7			
	2	0	0			
Recording and presenting Audio	0	318	77.2			
	1	94	22.8			
	2	0	0			
Adapting mathematics text materials	0	353	85.7			
	1	57	13.8			
	2	1	0.5			
Adapting mathematics materials/aids	0	360	87.4			
	1	52	12.6			
	2	0	0			

DISCUSSION

The findings of this study reveal a significant and concerning lack of technological and pedagogical knowledge among Ethiopian primary school mathematics teachers regarding the instruction of blind students. The overwhelming majority of teachers surveyed reported having little to no knowledge of essential assistive technologies such as the abacus, graphic calculators, Braille (both general and Nemeth code), tactile learning materials (protractor, ruler, meters, graphs, pictures, calculator), and specialized mathematics software. Similarly, a substantial proportion of teachers lacked awareness of appropriate accommodative classroom instructional strategies necessary to include blind students effectively in mathematics lessons.

This deficiency in both technological and pedagogical knowledge directly contradicts the Ethiopian government's stated commitment to inclusive education, as evidenced by various policies and strategic documents, including the Ten-Year Master Plan for Special Needs Education/Inclusive Education (MoE, 2016). The

Master Plan explicitly emphasizes the importance of teacher capacity building in utilizing educational technologies and adapting the mainstream curriculum to meet the needs of blind students. However, the current reality, as highlighted by this study, indicates a significant implementation gap.

The historical context, as briefly explored in the findings, offers a stark contrast. The reported success of missionary-led education prior to 1974 in teaching mathematics to blind students through the use of tactile tools and Braille underscores that blindness is not an impediment to learning mathematics when appropriate resources and knowledgeable educators are available. The subsequent decline in such inclusive practices within the mainstream system represents a missed opportunity and a failure to build upon earlier successes.

The study's findings strongly suggest that the Technological Pedagogical and Content Knowledge (TPCK) model, which emphasizes the integration of technology, pedagogy, and content knowledge for effective inclusive teaching (Mishra & Koehler, 2006), is not adequately addressed in the current Ethiopian primary teacher education framework. The lack of training and awareness regarding assistive technologies and accommodative strategies leaves teachers ill-equipped to implement inclusive practices in their mathematics classrooms, leading to the exclusion of blind students. This aligns with Yohannes B.'s (2007) earlier findings on barriers to mathematics teaching in Ethiopia, which included pedagogical knowledge gaps and the lack of resources, and extends it to the specific context of teaching blind students.

The fact that demographic variables such as age, sex, qualification, teaching experience, and subject specialization did not significantly correlate with teachers' knowledge levels suggests that the issue is systemic rather than isolated to particular teacher profiles. This further emphasizes the need for broad and comprehensive reforms in inclusive teacher education and professional development.

CONCLUSION

This study unequivocally demonstrates a significant deficit in the technological and pedagogical knowledge of Ethiopian primary school mathematics teachers required to effectively teach blind students. The lack of familiarity with assistive technologies and accommodative instructional strategies directly hinders the implementation of inclusive education policies and perpetuates the exclusion of blind students from mathematics education. This knowledge gap appears to be a systemic issue, not significantly influenced by teachers' demographic characteristics, highlighting a critical deficiency in the current teacher education and training frameworks. Addressing this deficiency is paramount to ensuring the right of blind students to access quality mathematics education, develop essential life skills, and participate fully in socio-economic opportunities.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed to improve the knowledge and capacity of Ethiopian primary school mathematics teachers in teaching blind students in an inclusive classroom setting.

1. **Revamp Pre-Service Teacher Education Curriculum:** The curriculum for pre-service mathematics teacher training programs must be thoroughly revised to include comprehensive and practical modules on:
    - The specific learning needs of blind students in mathematics.
    - The use and operation of various assistive technologies relevant to mathematics education (e.g., abacus, Braille codes, tactile materials, accessible software).
    - Effective accommodative instructional strategies for inclusive mathematics classrooms.
    - The principles and practical application of the TPCK framework in the context of teaching mathematics to blind students.
2. **Implement Intensive In-Service Training Programs:** Develop and deploy mandatory and ongoing in-service training programs for practicing primary school mathematics teachers focusing on:
    - Hands-on training in the use of assistive technologies for mathematics.
    - Practical strategies for adapting curriculum and instruction to meet the diverse needs of blind students.
    - Collaborative learning and peer support networks for teachers working with blind students.
    - Raising awareness and addressing potential negative attitudes towards the mathematical capabilities of blind students.
3. **Integrate Technology and Resource Provision:**
    - Ensure that Inclusive Education Resource Centers (IERCs) are adequately equipped with a range of assistive technologies and tactile learning materials for mathematics.
    - Provide teachers with access to training and ongoing support in utilizing these resources effectively.
    - Explore and promote the use of accessible digital mathematics resources and software.
4. **Foster Collaboration and Knowledge Sharing:**
    - Encourage collaboration between teacher training institutions, the Ministry of Education, organizations of persons with disabilities (OPDs), and experienced educators in the field of visual impairment.
    - Facilitate the sharing of best practices and resources for teaching mathematics to blind students.
5. **Conduct Further Research:** Future research should explore the perspectives and experiences of blind students themselves in mathematics classrooms, investigate the effectiveness of different inclusive teaching

strategies, and examine the impact of teacher training interventions on student outcomes.

By implementing these recommendations, the Ethiopian education system can take significant steps towards ensuring that blind students are no longer excluded from mathematics education and are provided with the necessary support to achieve their full potential.***

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