Assistive Technology on Teaching Mathematics to Learners with Visual Impairments in Special Primary Schools in Kenya

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Abstract: **The study was conducted to identify types of Assistive Technology used for teaching Mathematics to learners with visual impairments in special primary schools for learners with Visual Impairments in Kenya. A descriptive research design was employed to achieve the objective of the study. The data have been collected through observational checklist and classroom observation schedule of the selected special primary schools. Purposive sampling technique was used to sample of five deputy head teachers. Study data was analysed manually through narrative means using thematic. The result of the study indicates that there was scarcity of Assistive Technology in special primary schools for learners with visual impairments in Kenya. Largely, Low-Tech Assistive Technology was available while modern Mid-Tech and High-Tech Assistive Technology were visibly lacking. The study recommends that: the government through Ministry of Education to allocate necessary funds for acquisition and physical supply of much needed modern Assistive Technology for teaching Mathematics to special primary schools for learners with Visual Impairments.**

Key words: **Assistive Technology, Visual Impairments, Teachers of Mathematics, Science, Technology, Engineering and Mathematics.**

I. INTRODUCTION

Education in any country plays an invaluably pivotal role in its economic growth and social development According to (Ogula, 2010). Ability to work out Mathematics problems is a necessary and valuable life skill (Stein, 2013). Whether you are paying bill, shopping for groceries or cooking from a recipe, Mathematics skills are important. Further, the basics developments in Mathematics such as equations, subtraction, addition, multiplication and division are implicitly used in everyday application like buying and selling, sharing, counting and measuring. However, it is the process of learning which can be affected by different abilities and disabilities (Manchishi, 2015). Visual Impairments is one of the disabilities that can affect learners' abilities to learn Mathematics and understanding these issues is essential to helping learners overcome them. "Mathematics is the mother science of the abstract world" (Chiu, 2007, p. 64).

Many developing countries in the world have not provided all their school-age children with the opportunity to attend school including those with visual impairments (ICEVI, 2014). The Global campaign on Education for All Children with Visual Impairments (EFAC-VI) was launched in 2006, as a partnership of the International Council for Education of people with Visual Impairments (ICEVI) and the World Blind Union. The EFAC-VI vision stated that by year 2020, all children with Visual Impairments will have to enroll and complete primary education and their educational and social achievement will be at par with their peers who are sighted (ICEVI, 2014).

Ever since the development of visual literacy to bridge communication gaps in space and time, the education of learners with visual impairments has been subject to various successive adjustments in the development of visual literacy (Mugo, 2013). The earliest breakthrough in non-visual literacy was the invention of Braille system of embossed six-dot cells in 1829 by Louis Braille that enabled learners with VI to access content (Heward, 2003). In 1972, Doctor Abraham Nemeth from United States of America published the revised version of the text that created a Braille code for Mathematics which subsequently became an adopted standard (Nemeth, 1972). Nemeth Braille Code is succinct, unambiguous and widely accepted (Nemeth, 1972). All children in United State of America including those with Visual Impairments had learnt to use Mathematical skills in a practical way to solve problems (Rosenblum & Amato (2004).

The use of Technology can support much of the effort towards instruction, access, participation and progress towards learners with visual impairments (Jackson, 2009). According to Kohanova (2006), Linear Access to Mathematic for Braille Device and Audio-synthesis (LAMBDA) appears to supply all needed requirements. The LAMBDA project makes the provision for an integrated system based on linear code and a software management system. Although technology has a crucial impact on the teaching and learning of Numeracy and Mathematics to learners with VI, much of this technology is out of reach to these learners in the developing countries including Kenya (Rowe, 2014). The researcher further noted that this is due to high cost, unavailability and lack of training which is a challenge that must be addressed with immediacy. This makes education and employment especially difficult for learners with Visual Impairments in STEM fields (Mugo, 2013).

In many situations even in our country Kenya where teaching and learning resources are scarce, learners with Visual Impairments use the abacus and Taylor Frame to solve Mathematics, both of which have significant drawbacks (ICEVI, 2014; Mwangi, 2014). According to the Constitution of Kenya (GOK, 2010), persons with disabilities including those with Visual Impairments are entitled to access materials and devices in order to overcome constraints arising from the persons' disabilities. Although the Kenya government has made efforts to assist learners with Visual Impairments to acquire education, very little has been done to the quality of overall instruction of persons with Visual Impairments (Mugo, 2007).

Makinde (2011) observed that the foundation of Science and Technology which is the basic requirement for development of a nation is Mathematics. This observation, affirms and supports the need to provide learners with Visual Impairments with Assistive Technology to enhance their learning of Numeracy and Mathematics which is the main objective being investigated in this study. Further, Rowe argued that "the limited research undertaken in this area shows a considerable deficit in the attainment levels of persons with Visual Impairments in numeracy-based subjects" (Rowe, 2014, p.19). From this background, the current study sought to identify types of Assistive Technology used for teaching Mathematics to learners with visual impairments in special primary schools for learners with visual Impairments in Kenya.

II. PURPOSE OF THE STUDY

The purpose of this study was to identify types of Assistive Technology devices used for teaching Mathematics to learners with visual impairments with no other disabilities in classes seven (7) and eight (8) in special primary schools for learners with Visual Impairments in Kenya.

III. RESEARCH METHODOLOGY

This study adopted a descriptive survey research design to gather the raw data. According to Lodico, Spaulding and Voegtle (2006) descriptive survey design is concerned with `describing behaviours and gathering people's opinions, attitudes, perceptions and beliefs about a current issue in education. Thus, the researcher in this study found the descriptive survey design appropriate because it helped her in the collection of raw data based on the attitudes, opinions, preferences and the demographics of participant deputy head teachers with regard to the use and availability of Assistive Technology when teaching Mathematics to learners with Visual Impairments in special primary schools in Kenya. The targeted population of the study was five deputy head teachers in the five special primary schools selected for this study. Purposive sampling technique was used to sample five deputy head teachers from the selected study sites. Data was collected through observation which was qualitative in nature and was analyzed qualitatively.

IV. STUDY RESULTS AND DISCUSSIONS

The study sought to identify types of Assistive Technology used for teaching Mathematics to learners with VI in special primary schools for learners with Visual Impairments in Kenya. The observation checklists from the five selected special primary schools were filled by the researcher in the library/store in company of the deputy head teacher which had twenty-two (22) items on availability and quantity of Assistive Technology for teaching and learning Mathematics to learners with Visual Impairments in special primary schools in Kenya. The deputy head teacher was asked to tick the Assistive Technology that was available in their special schools.

The data was analyzed at three levels namely: Low-Tech, Mid-Tech and High-Tech in Table 1.1 Ganschow, Phillips and Schneider (2001) grouped Assistive Technology into three categories: low-Tech, Mid-Tech and High-Tech. Low-Tech Assistive Technology are devices that are non-electrical which involve little or no training to manipulate and they are less expensive. Mid-tech AT devices are easy to operate electronically with minimal training. They also require basic maintenance (Alkahtani, 2013). High-tech Assistive Technology is very expensive and they involve complex electronics which require on-going maintenance and extensive training.

The data was analyzed at three levels namely; Low-Tech, Mid-Tech and High-Tech and the results are indicated in Table 1.1.

Table 1.1: Types of Assistive Technology used in teaching Mathematics

Variable	Frequencies (n)	Percentage (%)
Low-Tech		
Cuberithm slate and cubes	5	100
Braillon papers	5	100
Braille books and papers	5	100
Braille rulers and protractors	5	100
Slate and stylus	5	100
Crammer abacus	4	80
Tactual diagrams	4	80
Tylor frame and types	3	60
Tactual symbols and signs	1	10
Tactile graphic kit	0	0
Mid-Tech		
Talking calculators	2	20
Talking books	2	20
Talking clocks and watches	1	10
Talking compasses	0	0

High-tech		
Thermoforms	5	100
Braille writers	5	100
Adapted computer systems	4	80
Braille transcribers	3	60
Electronic travel devices	0	0
Electronic Braille note-takers	0	0
Electronic Braille writers	0	0
Embossers	0	0

This study revealed that majority of the Low-Tech Assistive Technology was available to all the five special primary schools. The Low-Tech Assistive Technology that were available to all the five special primary schools were; cuberithm and cubes, slate and stylus, braillon papers, braille books and papers, braille rulers and protractors. Four fifths of the special primary schools had crammer abacus and tactual diagrams, while three fifths had tylor frame and types. Out of the five special primary schools, none had tactile graphic kit while one fifth had tactual symbols and signs.

Majority of the special schools did not have Mid-Tech Assistive Technology. Two fifths of the special primary schools had talking calculators and talking books. In all the five special schools in Kenya none had talking compasses while a fifth had talking clocks and watches. Among the High-Tech Assistive Technology, all the special primary schools in Kenya had thermoforms and braille writers, while none of them had electronic travel devices, electronic braille note-takers, electronic braille writers and embossers. Three-fifth of the special primary schools had braille transcribers while four fifth of the special schools had adapted computers.

Further, the study sought to establish the actual Assistive Technology that was available in the classroom while learners with Visual Impairments were learning Mathematics. The researcher and research assistant observed nine 35 minutes Mathematics lessons and the results are indicated in Table 1.2.

Table 1.2: The actual Assistive Technology available in the classroom while learners were learning Mathematics

Types of AT available in the classroom	Frequency (n)	Percentage (%)
Low-Tech		
Slate and stylus	8	88.9
Abacus	6	75.0
Cubes and cuberithm	3	33.3
Braille clock	1	11.1
Mid-Tech	0	0.0
High-Tech		
Tablets	1	11.1

The results indicate that the majority of the classroom lesson observations, learners with Visual Impairments were observed using Low-Tech Assistive Technology. Slate and stylus were observed in nearly all the classroom lesson observations, while abacuses were observed in three quarters of the observations. There was no classroom observation lesson where Mid-Tech Assistive Technology was observed, while only a third of the observations High-Tech Assistive Technology were observed. More so, a third of the classroom lesson observations, learners were observed using cuberithm boards and cubes to solve problems related to converting percentages to fractions. Among the six Assistive Technology observed in the classroom lesson observations, five of the Assistive Technology available was low-Tech Assistive Technology and one was a High-Tech Assistive Technology. Talking calculators and talking clocks were not available in the classrooms for learners to use though they were reported to be available in the schools' stores.

Discussion

The findings of the current study established that the special primary schools had majority of Low-Tech Assistive Technology, few of the Mid-Tech Assistive Technology as well as few of the High-Tech Assistive Technology. The Assistive Technology were also conspicuously inadequate to cater for learners needs to use AT in learning Mathematics and especially availability of the modern High-Tech. This is because Low-Tech Assistive Technology is less expensive and they require less or no training, while High-Tech Assistive Technology is very expensive and they involve complex electronics which require on-going maintenance and extensive training. The government of Kenya through Ministry of Education allocates Ksh 8,000 per learner with VI in a boarding special school yearly (Kochung, 2003) which is not enough to purchase the High-Tech Assistive Technology.

This study concurs with findings of several studies reviewed in the literature: Alkahtani (2013), Mariba (2012), Mugo, (2013), Mwangi, (2017) and Wamalwa (2017) who found out that majority of the Low-Tech Assistive Technology were available, while Mid-Tech Assistive Technology and High-Tech Assistive Technology were few. Most of the special primary schools had Low-Tech Assistive Technology than High-Tech Assistive Technology. Alkahtani (2013) carried study in Saudi Arabia and revealed that about ninety four (94%) of the teachers did not use or request Assistive Technology while teaching. However, majority (9%) of the available AT were low-tech, seven percent (7%) Mid-Tech and four percent (4%) High-Tech Assistive Technology.

Mugo (2013) found out that students who were visually impaired at Kenyatta University used only Braille machine to type notes. The author also reported that students with Visual Impairments relied so much on the sighted colleagues to read for them notes though adapted computers were available in the university. More so, Wamalwa (2017) studied on utilization of instructional media to enhance students' learning of English in secondary schools who noted that ninety percent (90%) of the instructional materials for teaching English used print materials; nine percent (9%) used visual materials while about one percent (1%) used audio materials. He stated that if visual and audio materials are available and used effective, they motivate the students. Mwangi (2017) study further revealed that teaching resources for Algebraic concepts in upper primary schools classes in Laikipia County were not adequate available in the classrooms.

On availability of text books, the current study contradicted with the findings by Wamalwa (2017) who noted that English text books in secondary schools in Bungoma County were available and adequate. For a learner who is Blind to learn Mathematics and acquire new knowledge, compensatory tools for learning need to be specified (Brousseau, 1997). The compensatory tools for learning Mathematics include: talking calculators, electronic Braille note taker, computer software such as Mathplay, MathML, Nemeth translator software to mention a few.

This study established that all the special schools had cuberithm, slate and stylus. The result of this study agrees with Mwangi (2014) who revealed that learners with VI used abacuses and cuberithm to work out Mathematics problems. A slate and stylus is helpful as it allows learners with VI to quickly and effectively write out Mathematics computations. Slate and stylus act as the pen and a book for learners with VI in lower institutions. The abacus is a standard arithmetical device which is inexpensive to make and flexible (Rowe, 2014). However, Rowe (2014) noted that the fundamental flaw lies in the operation of the abacus. It's designed to operate from left to right whereas occidental arithmetic process largely works from right to left. This method of learning is not only extremely difficult to learners who use Braille, but also very different from instructions given to sighted peers when they are learning Mathematics (ICEVI, 2014).

Graphic kit was not available in all the five selected primary special schools. Tactual symbols and signs were available in only one special primary school for learners with Visual Impairments. Slightly above half of the special primary schools had Mid-Tech Assistive Technology. Talking calculators and talking clocks were not available in the classrooms for learners to use though they were reported to be available in the schools' stores. Mid-Tech Assistive Technology is easy to operate electronically with minimum training.

Regarding availability of High-Tech Assistive Technology for teaching Mathematics to learners with Visual Impairments in special primary schools revealed that; all the five selected schools had manual Braille writers and a thermoform and none of the schools had electronic braille note-takers, electronic writers, electronic travel devices and embossers. This result was not in line with that of Mugo (2013) and Wawire *at el.,* (2009) who revealed that majority of High-Tech Assistive Technology were available, few of Mid-Tech Assistive Technology and none of Low-Tech Assistive Technology was available in higher institutions. This is because higher institutions usually have many channels of getting assistance in terms of equipment and also cash to purchase as compared with lower institutions. According to Muigai (2017 the main roles of the missionaries was to provide instructional materials and equipment to reduce educational limitations presented by special educational needs. A manual Braille machine has six keys and is used by learners with Visual Impairments to type the answers after computation while a thermoform is a High-Tech Assistive Technology that is used for duplicating Mathematical examination Braille papers for learners with Visual Impairments.

Adapted computer systems were available in four fifths of the special schools. Despite the availability of adapted computer system in the schools, ToM were not observed utilizing it to teach Mathematics to learners with Visual Impairments in classes seven and eight. Adapted computer system had been donated by a non-governmental organization called InABLE who had employed instructors to teach learners with Visual Impairments on it basic use after lessons. Ahmed (2015) highlighted examples of useful computer systems that learners with Visual Impairments can easily work with especially those who have difficulty accessing visual materials on the computer screen or in print form. These computer systems include: Optical Braille Recognition Software, Refreshable Braille Displays, Scanner with Optical Character Recognition and Speech Output Systems. Ahmad (2015) further noted that audio materials such as audio cassettes and talking books of recorded lessons may be used by learners with Visual Impairments.

Electronic Braille note-taker, electronic Braille machine and an embosser (modern High-Tech Assistive Technology) were not available in all the five selected special primary schools while three special primary schools had a Braille transcriber. This finding disagreed with the study conducted by Kohanova (2006) who found out that learners in primary school level were observed using electronic note books for making notes. Electronic Braille note-taker is a portable device which is useful to learners with VI because it has an integrated refreshable Braille display and utilizes the eight key Braille input system (Tebo, 2009). Cook and Hussey (2002) argued that yesterday's high-tech is tomorrow's Low-Tech and they further acknowledged that "as the field of Assistive Technology advances, there will be new considerations that will further stretch our concepts and force new ways of categorizing and describing Assistive Technology" (p. 9).

The Theory of Didactical Situation enhances that availability of Assistive Technology for Mathematics teaching cultivate positive attitudes towards the subject to a learner with Visual Impairments when doing or learning the activity that leads to acquisition of new knowledge (Brousseau, 1997). This study supports this theory in the fact that all ToM of Mathematics were observed at least using Assistive Technology though majority of the Assistive Technology were Low-Tech Assistive Technology. The author further argued that, the availability of the Assistive Technology usually guides the choice of problem solving strategy.

V. CONCLUSIONS

Based on the study's findings presented above, the study concludes that the inadequate use of Assistive Technology for teaching Mathematics to learners with Visual Impairments in special primary schools is real and this gap has contributed to lack interest in working out Mathematics problems by learners with Visual Impairments leading to a decline of Mathematics performance as a subject among learners with Visual Impairments. The study also concludes that: these learners will continue to lack vital modern life skills they need to acquire and use in their pursuit of developing their lifelong careers. The study recommends that

VI. RECOMMENDATIONS

The government through Ministry of Education should allocate adequate funds for the acquisition and supply of much needed modern Assistive Technology equipment for teaching Mathematics to learners with Visual Impairments to special primary schools such as Braille electronic note takers, talking calculators, electronic travel device, audio Mathematics text books which will widen access to Science, Technology, Engineering and Mathematics (STEM) to learners with visual impairments.

From the related literature in this study, poor performance in Mathematics seems to be rampant at the primary school level. There is need to carry a similar study in the pre-schools and secondary schools for learners with Visual Impairments.

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REFERENCES

[1]. Ahmad, K. F. (2015). Use of Assistive Technology in inclusive Education: Making room for diverse learning needs. *Journal of Transience,* 6(2), 62-77

[2]. Akpan, J. & Beard, L. (2014). Assistive Technology and Mathematics education. *Universal Journal of Education Research,* 2(3), 219–222. Retrieved August 2016 http://www.hrpub.org.

[3]. Alkahtani. K. D. (2013). Teachers' knowledge and use of Assistive Technology for students with Special Educational Needs. Riyadh. *Journal of studies in Education*. http://dx.doi.org/10.5296/jsc.v312.3424.

[4]. Brousseau, G. (1997). *Theory of Didactical Situations in Mathematics*. Balacheff: Kluwer Academic Publisher.

[5]. Chiu, M. (2007). *Mathematics as mother/basic of Science in affect: Analysis of Timss2003 Data*. Chengch University, Department of Education.

[6]. Cook, A. & Hussey, S. (2002). *Assistive technologies: Principles and practices;* 2nd edition. Philadelphia, PA: Elsevier Health Sciences.

[7]. Ganschow, H., Philips, L. & Schneider, D, (2001). Closing the gap: Accommodating students with language learning disabilities in college. *Topics in language Disorder*, 21 17-37.

[8]. Government of Kenya. (2010).*Constitution of Kenya*. Nairobi: Government Printer.

[9]. Heward, L. W. (2003). *Exceptional children: an introduction to special education;* 7th edition. U.S.A. Merrill Prentice Hall.

[10]. International Council for Education of People with Visual Impairment (2014). *Expanding Educational Opportunities.* Volume XXVII.

[11]. Jackson, M. (2009). *Technologies supplying curriculum access for students with disabilities.*Washington: NCAC.

[12]. Kochung, R. (2003). *A report of the task force on special needs education appraisal exercise.* Nairobi: Government Printers.

[13]. Kohanova, I. (2006). *Teaching Mathematics to non-sighted students: with specialization in solid geometry*. Comenius University Bratislava: Published Doctoral Thesis

[14]. Lodico, G., Spaulding, D. & Voegtle, K. (2006). *Methods in Educational research: From theory to practice*. USA: Jossey Bass.

[15]. Makinde, D. (2011). Impact of Mathematics and science research on national development A paper presented at the First Kenyatta University International Mathematics Conference, Nairobi, Kenya on 8th June 2011.

[16]. Manchishi, S. (2015). *Factors contributing to low achievement levels in Mathematics among Hearing Impairment learners:* Case study of selected schools of Lusaka, Zambia University. Published M.ED. Thesis.

[17]. Mariba, A. (2012). Challenges facing teachers and students in the use of instructional technologies: A case study of selected secondary schools in Kisii County, Kenya. Kenyatta University: *Unpublished M.ED Thesis.*

[18]. Mugo, B. C. (2013). Assistive Technology and access to quality instructional for Blind and visually impaired students. A comparative study of Kenyatta University, Kenya and Syracuse University, USA. Kenyatta University: *Unpublished PhD Thesis.*

[19]. Mugo, B.C. (2007). Instructional technology in the facilitation of learning by visually impaired learners in upper primary classes in Kenya. Kenyatta University: *Unpublished M.Ed Thesis.*

[20]. Muigai, S. C. (2017). Historical analysis of educational developments for persons with visual impairments in Kenya (1945 - 2013): Focus on Nairobi City, Kiambu and Meru Counties. *Unpublished M.Ed Thesis.*

[21]. Mwangi, M. W. (2014). Pedagogical challenges facing mathematics teachers of learners with vision at Thika primary school for the Blind, Kiambu County. Kenyatta University: *Published M.Ed Thesis.*

[22]. Nemeth, A. (1972). *The Nemeth Braille code for Mathematics and Science notation, 1972 revision.* Louisville, KY: APH. 4 BC. New York: McGraw-Hill Companies, Inc.

[23]. Ogula, P.A. (2010). *A guide to research proposal and report writing.* Nairobi: Catholic University of Eastern Africa.

[24]. Rosenblum, L. & Amato, S. (2004). *Preparation in and use the Nemeth Braille Code for Mathematics by teachers with visual impairments*. Retrieved 8th September 2016 http://scholar.google.com/scholar?=braille

[25]. Rowe, S. C. (2014). Counting on Technology: Critical solutions for education STEM subjects in Developing countries. *Journal of expanding educational opportunities,* 27(2), 17-21.

[26]. Stein, C. (2013). *Hearing Impairment and ADHD: how they affect students' ability to learn Mathematics* Georgia. Georgia College and State University.

[27]. Tebo, R. L. (2009). *A resource guide to assistive technology for students with visual impairments.* Bowling Green State University: Published M.Ed Project.

[28]. Wamalwa, E. (2017). Utilization of instructional Media to enhance Students' Learning if English in Bungoma North District's Secondary Schools, Bungoma County. A paperpresented at 34th Postgraduate seminar programme on 20th July 2017.

[29]. Wawire, V., Elarabi, N. and Mwanzi, H. (2009). Higher educational access and retention opportunities for students with disabilities: Strategies and experiences from selected public universities in Egypt and Kenya. *The institute of International Education*, 117-134