EFFECTIVENESS OF ASSISTIVE TECHNOLOGY ON TEACHING MATHEMATICS
TO LEARNERS WITH VISUAL IMPAIRMENTS IN SPECIAL PRIMARY
SCHOOLS IN KENYA

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OF DOCTOR OF PHILOSOPHY IN THE SCHOOL OF EDUCATION
SPECIAL NEEDS EDUCATION KENYATTA UNIVERSITY

FEBRUARY 2019
DECLARATION

I declare that this thesis is my original work and has not been presented in any other university/institution for consideration of any certification. This research thesis has been completed by referenced sources duly acknowledged. Where text, data, graphics and tables have been borrowed from other sources, including the internet, these are specifically accredited and references cited using current APA system and in accordance with anti-plagiarism regulations.

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DEDICATION

This work is dedicated to my beloved husband Solomon and to my three children Rachael, Ian and Ann whose support enabled me to pursue this course at this level.
ACKNOWLEDGEMENT

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# ABBREVIATIONS AND ACRONYMS

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<tr>
<td>AE</td>
<td>Affective engagement</td>
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<tr>
<td>AT</td>
<td>Assistive Technology</td>
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<tr>
<td>BE</td>
<td>Behavioural engagement</td>
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<td>EFAC-VI</td>
<td>Education for All Children with visual Impairments</td>
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<tr>
<td>ICEVI</td>
<td>International Council of Education of Visually Impaired</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>KIE</td>
<td>Kenya Institute of Education</td>
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<td>LAMBDAA</td>
<td>Linear Access to Mathematics for Braille Device and Audio-synthesis</td>
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<td>MOE</td>
<td>Ministry of Education</td>
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<td>MT</td>
<td>Attitudes to learning Mathematics with Technology</td>
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<td>MTAS</td>
<td>Mathematics and Technology Attitudes Scale</td>
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<td>STEM</td>
<td>Science, Technology Engineering and Mathematics</td>
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<td>TDS</td>
<td>Theory of Didactical Situation</td>
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<td>ToM</td>
<td>Teacher of Mathematics</td>
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<td>VI</td>
<td>Visual impairments</td>
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ABSTRACT

There has been a problem in Mathematics of learners with VI as a result of inadequate AT and reluctance of teachers to apply appropriate teaching strategies when teaching Mathematics using AT in special primary schools. To address these problems, four objectives were formulated to identify types of AT that were available, teaching strategies, their role and factors that had influenced their use of the AT. Therefore, the purpose of this study was to evaluate on effectiveness of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya. The study was guided by the Theory of Didactical Situations in Mathematics (Brousseau, 1997). A descriptive research design was adopted to carry out the study. The study was conducted in five counties namely: Kisumu, Siaya, Mombasa, Meru and West Pokot. Purposive and stratified random sampling techniques were used to sample the study participants. The researcher sampled the following study participants, all from whom the study’s data was collected: twenty learners with VI selected from classes seven and eight, their ten teachers of Mathematics and the five deputy head teachers of the selected special primary schools. The total study sample therefore, comprised of thirty five participants. Interview guides, observation schedule and observation checklist based on the four study objectives were used to gather the information. Study data was analysed manually through narrative means using thematic information arrangement approach following the order or chronology of the study’s six research objectives. The qualitative data generated from the structured interview guides was analysed through descriptive statistics based on Statistical Package for Social Sciences (SPSS) version 18.0. The main study finding was scarcity of AT 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. Major factors noted to influence the use of AT were; TOM lacked training in Mid-Tech and High-Tech AT, high cost of AT, costly maintenance and no time set on the time table to teach AT skills. The findings also indicated that many learners with VI had positive attitudes towards the use of AT in their learning of Mathematics. The study concluded that; inadequate use of AT especially Mid-Tech and High-Tech is real and this has contributed to lack of interest in working out Mathematics problems leading to a decline of Mathematics performance; there is a training gap among teachers of Mathematics on modern Mid-Tech and High-Tech AT and AT plays a vital role in teaching Mathematics to learners with VI. Based on the findings, the main recommendations were that: the government through Ministry of Education to allocate more funds for the physical supply of AT to special primary schools for learners with VI, ensure teachers of Mathematics are trained and also conduct regular classroom supervisions to ensure efficient use of all available AT in the special primary school.
CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction

This chapter presents the background to the study, statement of the problem, purpose, objectives, research questions, significance, limitations, delimitations, theoretical framework, conceptual framework and operation definition of terms.

1.2 Background to the Study

Education in any country plays an invaluably pivotal role in its economic growth and social development (Ogula, 2010). Ogula also noted that, Mathematics is the fundamental that seeks an understanding of a number of disciplines which play a crucial role in socio-economic development. According to MOE (2009), education also plays a crucial role in helping a nation achieve its national aspirations. It is through education that a country produces and determines the type of human resource that will determine the required development. This is why the educational aspirations of a country are expressed in its National goals which are broad long term statements of intended achievements for all levels of education.

Ability to work out Mathematic 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 (VI) 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). Mathematics is considered as the most important science because its development affects the development of other sciences such as physics, biology and technology. This therefore, it may be a hindrance to vocational development (Pau, 2008).

The general aim of teaching Mathematics to learners with VI is to produce a learner who will be able to use a Mathematical way of thinking and problem solving both in familiar and unfamiliar situations in everyday life. However, the difference comes in when we consider the time taken in acquisition of skills and the highest level of attainment (MOE, 2001). The learner with VI will require specialized teaching, compensatory tools, more time and a more effective teaching strategy.

Nowadays we are witnesses to rapid expansion of information and communication technologies that require new technicians all the time whose education is based on Mathematics as well (ICEVI, 2014). World Bank of 2006 (as cited by ICEVI, 2014, p. 2) noted that, 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. 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 VI 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 VI had learnt to use Mathematical skills in a practical way to solve problems (Rosenblum & Amato (2004).

Nemeth (1972) stated that learners with VI used the Nemeth Code for Braille Mathematics notations to gain access to and produce Mathematical work. Without the ability to read and write the symbols that represents Mathematical concepts, the field of Mathematics is closed to learners with VI to solve problems. More so, the development and deployment of Science, Technology, Engineering and Mathematics (STEM)
education tools for VI had dramatic impact in the United States of America and to a much larger extent in developing countries, where incidence of vision loss is much greater, especially among school-age children.

In spite of braille development, the challenge lies on the slowness of braille reading. This is a challenge that stems from the fact that finger reading through touch is slower compared to sighted. Individual with Disability Education Act (IDEA, 2004) states that learners with disabilities including those with VI should be granted equal access to education and further provides additional special education services. According to Rothstein (2014), more learners with VI in developing countries are discovering literacy through Braille and AT. In additional, Chomba (2017) noted that the Technological devices should be used to enhance Braille and not to replace it.

With the advancement of technology, computer adapted hardware, software and other AT for learners with VI and Braille printout can make a greater improvement to the education of these learners. Most of the Slovak children in United States of America who were visually impaired attended special schools. Flanagan (2008) established the positive and negative effects on learner’s achievement on the use of Technology. The author noted that “a number of new technologies are emerging to support and enhance learning in our schools” (Flanagan, 2008, p. 1). At the lessons of Mathematics, learners with VI used Braille books with tactile pictures. To make notes they used electronic notebooks and for calculations they used mechanical typewriter (Kohanova, 2006).
In recent years there has been a surge in research and development of technology-based solutions to the teaching of STEM subjects for learners with VI in the developed countries. These include; Mathplayer, Talkmaths, Refreshable Braille displays, advanced scientific talking calculators and other tools which are changing lives every day to learners with VI (Suzuki, Yamaguchi & Gardner, 2011). From audible representation of graphs and charts, to more complex solutions involving the use of Mathematical coding, such innovation software provides a variety of methods of learners who use Braille to access, interact with and create Mathematical content (Rowe, 2014). Technical subjects such as STEM have been particularly challenging for learners with VI. Rapp and Rapp (1992) reported that learners with VI were less likely to participate in advanced Mathematic classes. However, despite this supposed difficulty, there was evidence that learners with VI could perform well in STEM subjects and even excel at them (Cryer, 2013).

The government of the Republic of Zambia through the Ministry of Education recognized the rights of persons with disabilities to have access to good and quality education (Manchishi, 2015). A study conducted by Manchishi (2015) in Zambia revealed that learners with disabilities and special needs in the country faced many challenges when learning Mathematics which make them lag behind their sighted peers. In her study, she revealed that teaching and learning materials were inadequate and ToM were not enough and not all of those available were well qualified, supportive and with positive attitudes towards teaching Mathematics to learners with Hearing Impairments despite the
commitment of the government to provide good and quality education to learners with disabilities.

The national survey in Zambia carried out by Akakandelwa and Munsanje (2012) and ICEVI’s (2010) surveyed on the teaching of Mathematics to learners with VI in Kenya’s mainstream secondary schools. Both surveys identified a considerable lack of suitable AT resources in the field of Mathematics. They concluded, “Failure to equip these learners, their teachers and education specialists with the appropriate resources means that most children with VI performed below par in their studies and were inevitably required to drop Science and Mathematical subjects” (ICEVI, 2014, p. 19).

Assistive Technology is not the teacher, rather it is a tool that is used by the teacher to widen a learner’s reach and should complement and enhance what a teacher does naturally (Young, 2008). According to Dwyer (1994), educator typically experiences five (5) stages in order to fully integrate AT in the classroom. The five stages include: entry, adoption, adaptation, and appropriation as well as the invention stage. Entry stage is the first stage which is characterized by ToM having doubts about AT as changes begin in their classrooms. The second stage is adoption which is identified by ToM using AT to support traditional text-based drill and practice. In adoption stage, when the ToM integrates AT effectively into the curriculum, learners’ attendance increases. Adaptation is the third stage where ToM thoroughly integrates AT into traditional classroom practice, learners produce more work faster, they are more actively engaged in learning and their productivity increases.
The fourth stage is appropriation where ToM and learners use appropriate AT. In this stage learners highly involve AT skills and they can learn on their own. Also ToM gains a perspective on how they can change the learning experience and finally learners work patterns and communication become collaborative rather than competitive. Invention is the last stage an educator experiences in order to integrate fully the AT. Invention stage ToM view knowledge as something learners construct rather than something that can be transferred and view learning as creative, an active and socially interactive process.

Wawire, Elarabi and Mwanzi, (2009) revealed that, the Egyptians and the Kenyan students with VI had enrolled for Education, Arts and Humanity courses. None of the students with VI had registered or enrolled for courses that included a background in Mathematics and Sciences. The three authors concluded that, the major barrier to academic and social engagement is lack of an adapted curriculum for students with disabilities in almost all courses. This practice limits the courses that students with disabilities take to those that do not need scientific manipulation or field or laboratory work and that research should be devoted to revising the curriculum in all areas to adapt them to the special needs of student with disabilities.

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 VI in STEM fields (Mugo, 2013). The lack of Technology also makes the dream of attending a university of Technology very distant for learners with VI.

Teaching using computer-based instruction enables teachers to take a back seat while learners including those with VI workout problems with the help of the computer (Kautz, 2016). Obukowicz (2009) pointed out that there are various Math Toolbars which explain various Mathematics related vocabulary items which also include interactive models that explain Mathematics concepts. Mathtype is an advanced math toolbar-based program that offers the learner with VI symbols they need to use to write equations or solve Mathematics problems on the computer. Other toolbar-based programs are Mathpad and Mathpad Plus which makes Mathematics assignments easier to do for learners with VI on the adapted computer.

The rise on the use of AT leads to a far greater number of persons with VI succeeding in Mathematics based subjects and also entering into jobs where degree of Mathematical knowledge is essential (Rowe, 2014). Computers have opened up a whole world of
communication possibilities for people with VI as a system of communication (Akpan & Beard, 2014). This study therefore, sought to account for types of AT available in teaching and learning Mathematics to learners with VI in special primary schools for the Blind in Kenya which represents a developing country.

A computer is a High-Tech AT that manipulates information or data. A computer has two parts; the hardware and the software which the user of the device relies on both. Hardware refers to the physical structure which includes keyboard, mouse and internal parts. According to Hirvonen (2002) a headphone consists of two ear shells namely: the cup and the transducer which is connected to by the headphone band. The cup creates the volume around the ear where electrical signals are transferred into the sound waves by the transducer.

Despite the crucial role Technology play on teaching and learning of Mathematics for Persons with visual impairments, (Rowe, 2014) further noted that the technologies were usually not available to the developing countries. Rowe (2014) study focused on limitations in teaching STEM subjects to learners with VI in developing countries. Moreover, the researcher argued that, due to the changing world of Technology, this area of study was very significant.

In many situations even in our country Kenya where teaching and learning resources are scarce, learners with VI use the abacus and Taylor Frame to solve Mathematics, both of which have significant drawbacks (ICEVI, 2014; Mwangi, 2014). The abacus is a
standard arithmetical device which is inexpensive to make and flexible (Rowe, 2014). However, 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 with VI, but also very different from instructions given to sighted peers when they are learning Mathematics (ICEVI, 2014).

According to the Constitution of Kenya (GOK, 2010), persons with disabilities including those with VI 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 VI to acquire education, very little has been done to the quality of overall instruction of persons with VI (Mugo, 2007).

In grading of candidates’ performance at the Kenya Certificate of Secondary Education level, candidates with VI can only take one science subject which is Biology, while their sighted peers take two science subjects (Kochung, 2003). This practice was found to disadvantage learners with visual impairments especially when it comes to career choice and admission to the few competitive places in institutions of higher learning (Kochung, 2003). According to National Research Council of Kenya (2012), Mathematics is a subject that has been recognized as the mother of all learning with other subjects deriving their concepts from it in both the sciences and arts. The council further highlighted that Mathematics is also an international language and is essential in almost every field such
as measuring in fashion, handling money, angles in sports, technology and economics, consequently, a good performance in Mathematics is importance.

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 VI with AT 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 VI in numeracy-based subjects” (Rowe, 2014, p.19).

Kenya Institute of Curriculum Development carried out a Needs Assessment Survey on the challenges contributing to low achievement in Mathematics and Sciences in the Kenya Certificate of Secondary Education examinations (MOE, 2010). The result showed that Mathematics and Science posed the biggest challenge to most learners including those with VI. In response, the institute developed General Science and Mathematics Alternative “B” curricula that would address the needs of learners with VI at secondary level.

Aims and objectives of Mathematics as set by the curriculum developers usually provide direction to the teachers of Mathematics and to all learners including students with VI (KIE, 2002). Further, according to MOE (2009) one of the Special Needs Education objectives in Kenya is to provide comprehensive educational materials, equipment and
cadre of trained teachers. Mugo (2013) researched on Assistive Technology and access to quality instruction for students with VI at the university level and revealed that there was scarcity if AT for general teaching. Further, Wairimu (2013) investigated on instructional technology for teaching Mathematics to learners who were low vision in integrated public primary schools and found out that ToM applied direct teaching while teaching Mathematics. Moreover, Rowe (2014) stated that “There is an unacceptable lack of empirical research on the teaching and learning of numeracy and Mathematics in low-income environments. There is a significant paucity of relevant empirical data, with majority of studies lacking rigour and being primarily anecdotal” (Rowe, 2014, p. 20). Whilst the more economically developed countries continue to invest heavily in technology-based solution, the VI in low-income countries are being placed data considerable disadvantage. There is a desperate need to bring technology-based solutions into classrooms in low-income countries and thus into the hands of children who are in dire need of crucial resources.

In addition, Burgos (2015) stated that, “numerous researchers find that training for technology appropriations is lacking, especially within the special education discipline” (p. 4). Persons with VI in Kenya represented about one percent of the total population and about four percent of persons with disabilities (Government of Kenya, 2010). The eye is the most important gateway of the mind in any human being (Barghoutti, 1973). Since this is lacking in learners with VI, compensation for the loss of that sight is needed; hence, more attention and efforts ought to be directed towards the provision of
appropriate materials/equipment, appropriate teaching strategies and qualified teachers to teach Numeracy and Mathematics to learners with VI (Mugo, 2007). Despite Mathematics being an important subject in our life, many learners with VI leave class eight without any Mathematics skills necessary for life interactions. This study therefore, specifically focused on evaluating on effectiveness of Assistive Technology in teaching Mathematics to learners with VI in classes seven and eight in special primary schools for learners with VI in Kenya.

1.3 Statement of the problem

Poor performance in Mathematics by learners with VI in the National Exams revealed by the Kenya National Examination Council year in year out in Kenya, remains a serious concern to teachers of Mathematics, the parents, curriculum planners and to the general public (Njoroge, 2011). Mathematics subject had registered the lowest mean grade of C minus as compared with the other examinable subjects (Republic of Kenya, 2015; 2014). Learners with VI at primary school level usually miss out an opportunity to get quality instruction when learning Mathematics. These learners usually lag behind their sighted peers in terms of acquiring quality education and in competing for the ever elusive job opportunities in the market. They also require specialized and meaningful utilization of Assistive Technology which is needed in order to benefit from the instruction in the classroom (Gargiulo, 2012). This has led to low access of Science and Technology courses at the university by this group of learners (Wawire et al., 2009).
Improvement in Mathematics performance at primary school level will lead him/her to pursue Science and Technology subjects at secondary level which include Mathematics, Physics, Chemistry and Computer Studies. With positive attitudes towards Mathematics, he or she can perform quite well in these Science subjects in the Kenya Certificate of Secondary Education and be at par with the learner who is sighted. This further will promote this learner with VI to pursue Science and Technology courses in the University/College and join good careers. In conclusion, there will be promotion in functional ability for learners with visual impairments with regard to self-reliance, ease to obtain basic life necessities and finally able to compete for life opportunities.

Studies done in developed and developing countries had mostly focused on AT in higher institutions and also had focused on general subjects. There was no specific study that had focus on AT for teaching Mathematics to learners with VI in special primary schools. Mugo (2013) conducted a comparative study of Syracuse University, USA and Kenyatta University, Kenya, to investigate on Assistive Technology and Access to quality instruction for students with visual impairments. The study found out that higher institutions for students with VI had a serious scarcity of AT and the instructional strategies and the methodologies used did not meet the needs of the students in general learning.

Another study carried out by Kautz (2016) in a developed country investigated on strategies for teaching developmental Mathematics to students at the college level. The
study revealed that; the instructors used direct instruction, avoided the use of group work and they did not use games or manipulations while teaching Mathematics. This was an indication of poor teaching strategies in regular colleges. Mugo (2007) investigated on instructional technology in the facilitation of learning to learners with VI in upper primary classes in Science, English, Kiswahili, Mathematics, Social and Christian Religious Education subjects. The researcher found out that the suitable strategies were; class discussion, peer tutoring, question and answer, assignments and arithmetic calculations. In Mugo’s study, the focus was based on five subjects and there was a need for a study to specifically focus on strategies for teaching Mathematics.

The studies have looked at AT in higher institutions and AT in general teaching, but they have not focused specifically at AT that were used in teaching Mathematics in lower institutions. A study to find out the types of AT that were in use, teaching strategies employed by ToM, factors that had influenced the use of AT and their role on teaching Mathematics in special primary schools was therefore viable. This study therefore, evaluated on effectiveness of AT on teaching Mathematics to learners with VI in special primary schools for the learners with VI in Kenya.

1.4 Purpose of the study

The purpose of this study was to evaluate the effectiveness of Assistive Technology used for teaching and learning Mathematics to learners with VI in classes seven (7) and eight (8) in special primary schools for learners with VI in Kenya. The study specifically
focused on types of AT, factors that had influenced the use of AT, teaching strategies and their role in teaching Mathematics since the knowledge of AT help can to improve the Mathematics performance of learners with VI.

1.5 Objectives of the study

i. To identify types of Assistive Technology used for teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya

ii. To determine factors influencing the use of Assistive Technology in teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

a) To determine teacher competencies required for teaching Mathematics to learners with visual impairments using Assistive Technology.

b) To determine the attitudes of learners with visual impairments towards learning Mathematics using Assistive Technology in special primary schools for learners with VI in Kenya.

c) To evaluate the affordability of Assistive Technology used for teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.
iii To identify strategies employed by teachers when using Assistive Technology to teach Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

iv To investigate the role of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

1.6 Research questions

i. Which types of Assistive Technology is used for teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya?

ii. Which factors influence the use of Assistive Technology in teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya?

a. Which teacher competencies are required when teaching Mathematics to learners with visual impairments using Assistive Technology?

b. What are the attitudes of learners with visual impairments towards learning Mathematics using Assistive Technology in special primary schools for learners with VI in Kenya?

c. How affordable is Assistive Technology in teaching Mathematics to learners with visual impairments in special primary schools in Kenya?
iii. Which strategies do teachers employ when using Assistive Technology to teach Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya?

iv. What is the role of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya?

1.7 Significance of the study

Contribution to stakeholders

The research findings on AT revealed by this study may help arrest the failure concerns in STEM subjects in national exams among parents, teachers and learners with VI.

Parents of learners with VI will understand the role of AT and hence facilitate in equipping the special schools for the Blind with the appropriate AT.

Teachers of Mathematics may equip themselves with the appropriate teaching strategies for teaching the subject.

Learners with VI in special schools for leaners with VI may check their attitudes towards learning Mathematics using AT.

The findings of the research may increase the learning of STEM subjects to learners with VI in Kenya and enable them acquire jobs requiring numerical content without constraints.
Contribution to policy makers

The findings may sensitize the Kenya government on the need to provide the latest Assistive Technology for teaching and learning Mathematics to learners with VI.

The findings may make the government to prioritize it resources in purchasing modern AT and training of teachers on AT.

The findings of the study will enable the government through Ministry of Education to ensure that Mathematics content is covered adequately using AT.

Contribution to literature

The finding of this study will add new knowledge of literature to the studies dealing with teaching of Mathematics to learners with VI.

1.8 Limitations and Delimitations of the study

1.8.1 Limitation of the study

The following is the limitation of this study;

The study focused only a sample of class seven (7) and eight (8) learners with VI in the selected special primary schools for learners with VI in Kenya. Therefore, the results were not generalized to learners in other classes.
1.8.2 Delimitations of the study

The study was delimited to learners with VI with no additional disabilities in classes seven (7) and eight (8) who were learning Mathematics, their teachers of Mathematics and deputy head teachers due to time limitation.

The study was also limited to only special primary for learners with VI, thus it did not investigate effectiveness of AT towards teaching Mathematics in integrated programmes for learners with VI due to financial constraints and limitation of time.

1.9 Assumptions of the study

The study was based on the following assumptions namely:

1. Teachers use Assistive Technology to teach Mathematics in special primary schools for learners with VI.

2. Selected participants had been taught Mathematics using AT.

3. Participants were to give honest responses and volunteer to participate during the raw data collection.

1.10 Theoretical and conceptual Framework

1.10.1 Theoretical Frame work

The study was guided by the Theory of Didactical Situations (TDS) in Mathematics. The TDS was developed by Brousseau Guy in 1979. The term situation refers to learner’s environment as handled by the teacher for whom it appears as a tool in teaching process.
As any theory, the TDS works on the basis of set of principles. The first two principles are knowledge and learning which are supplemented by a conception of the roles that ToM and the learners with VI have to play in the classroom. TDS opposes direct teaching and therefore, the essential role of the ToM is to find out the problems or situations that will be given to learners that will provoke the expected learning. The role of the learner is to engage in Mathematical problems in a way that is coherent with the professional scientific practice. Didactical system is represented as a system of relationship between three sub-systems; teacher of Mathematics (T), learner with VI to learn Mathematics (L) and the knowledge (K).

**Figure 1:1 The Didactical System**

The ToM choses problems in such a way that the learner with VI can accept them, must make the learner act, speak, think and evolve by their own motivation. The careful and sensible choice rests on the epistemological assumption which is the third principle. It
state that, for every piece of Mathematical knowledge there is a fundamental of situations to give an appropriate meaning. The fourth principle specifies further the concept of learning in the TDS which emphasis the learner’s autonomy is a necessary condition for the genuine learning of Mathematics.

For a learner with VI to learn Mathematics and to obtain new knowledge in Mathematics, TDS emphasis the need to clearly specify the didactical contract in sense what kind of compensating tools him/her used to solve a Mathematical problem. Compensating tools include talking calculators, talking clock, electronic note taker, electron braille typewriter, and adapted computers which activate the learner with VI to activity that leads to acquisition of new knowledge.

Kohanova (2006) used TDS to establish overview of actual situation of teaching Mathematics and also to test the utilization and efficiency of Linear Access to Mathematic for Braille Device and Audio-synthesis system to students with VI in primary level, secondary and university level in Slovakia. The researcher found out that the problem of accessibility of Mathematics to students with VI had a solution of integrating Linear Access to Mathematic for Braille Device and Audio-synthesis editor in to the teaching of Mathematics.

Kohanova (2006) using this theory found out that there were soft wares which were friendly to students with VI enabling them to calculate, read and write Mathematics problems the way that is also accessible for their sighted peers and ToM. This theory
therefore, helped the researcher in the current study to evaluate on the types of AT available, factors that had influenced the use of AT, the teaching strategies and the role of AT in teaching Mathematics to learners with VI in special primary schools for learners with visual impairments in Kenya.

1.10.2 The Conceptual Framework

![Diagram](Diagram.png)

**Figure 1.2 Effectiveness of Assistive Technology**

- **Types of Assistive Technology**
  1) Low-Tech
  2) Mid-Tech
  3) High-Tech

- **Factors influencing use of Assistive Technology**
  1) Teacher competency
  2) Attitude of learners towards Mathematics and technology
  3) Affordability of AT

- **Teaching Mathematics to learners with visual impairments**

- **Strategies employed when using Assistive Technology**
  1) Direct instruction
  2) Group work
  3) Constructivist
  4) Stating objectives
  5) Manipulation

- **Role of Assistive Technology**
  1) Motivation
  2) Achievement
  3) Increase independence
  4) Increased interaction
  5) Curiosity aroused more
  6) Greater exposure
As conceptualized in Figure 1.2, teaching of Mathematics to learners with VI is influenced by several factors. These factors includes: types of AT used by teachers to teach Mathematics, teaching strategies employed by ToM, teacher competency when teaching using AT, attitudes of learners with VI towards learning Mathematics using AT and affordability of AT in special primary schools for learners with VI.

The types of AT used when teaching Mathematics are categorized into three levels: low-tech AT, mid-tech AT and high-tech AT. Several teaching strategies are employed by ToM while teaching Mathematics using AT in special primary schools for learners with VI. These teaching strategies include; direct instruction, group work and constructivist, manipulation, stating objectives, games and use of technology. AT plays a crucial role in teaching Mathematics to learners with VI. Some of its role is to motivate the learner throughout the lesson, improves his or her Mathematics scores and increases independence, greater interaction, greater curiosity arousal and greater exposure of the learner with VI.
1.12 Operational Definition of Terms

**Affordability** – Having enough money to purchase AT and adequate time to teach Mathematics to learners with VI (Turnbull, 2010).

**Assistive Technology** – Refers to any item, piece of equipment, or product system, whether acquired commercially off-shelf, modified or customized that is used to increase, maintain or improve the functional capacities of a learner with visual impairments (Alkahtani, 2013).

**Competency** – Training skills and the level of knowledge on Assistive Technology by teachers of Mathematics.

**High-Tech Assistive Technology** – Devices that are expensive and they involve complex electronics which require ongoing maintenance and extensive training (Ganschow, Philips & Schneider, 2001)

**Learner with visual impairments** – Refers to those learners with no vision at all and those with low vision which is not enough to allow them read print and had no other disabilities. They use Braille to learn Mathematics.

**Low-Tech Assistive Technology** – Devices that are non-electrical which involve little or no training to manipulate and they are less expensive (Ganschow, Philips & Schneider, 2001)
Mid-Tech Assistive Technology – devices that are easy to operate electronically with minimum training (Ganschow, Philips & Schneider, 2001)

Role – Importance/outcome of Assistive Technology

Special schools – Mixed boarding schools for learners with visual impairments

Teaching strategies – Refers to teaching methods the instructor uses to instruct learners and those experiences in teaching that make the attainment of knowledge/skills interesting and appealing to learners (Kautz, 2016).
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, the researcher discussed related literature on; types of Assistive Technology (AT) for teaching and learning Mathematics to learners with visual impairments (VI), factors that influenced the use of AT in teaching Mathematics to learners with VI, teaching strategies employed by teachers of Mathematics (ToM) when using AT to teach Mathematics to learners with VI and finally, the role of AT on teaching Mathematics.

2.2 Types of Assistive Technology for teaching Mathematics to learners with Visual Impairments

Assistive Technology is a tool used to unlock teaching or learning and expand the horizons of learners with VI which allows them to lead a productive, independent and healthy life (Jackson, 2009). AT devices usually supplements Braille literacy enhancing communication in teaching or learning and expand the world of persons with VI as their means of communication in many significant ways (Chomba, 2017; Mugo, 2013).

A study from Saudi Arabia, Alkahtani (2013) investigated the types AT that were available in the schools. The study adopted qualitative approach which was supplemented with qualitative approach. The data was collected from 127 participants using
questionnaires which were submitted electronically and analyzed using a computer statistical software programme i.e. Statistical Package for Social Sciences (SPSS). The study participants were general teachers and special education teachers who had computers and internet access. Sample size in the results were different due to the fact that, some participants failed to respond to all questions. The study revealed that ninety-one percent (91 %) of the teachers reported that “Assistive Technology was not available for use in their schools” (p. 9). Further, the study also pointed out that availability of low tech devices were approximately nine percent (9 %) which was the most, mid tech devices were seven percent (7%) while high tech devices were reported by only (4%). The researcher noted, “many Assistive Technology devices provide children with disabilities with equal opportunities to participate in active environments with predictive activities that are aligned to their abilities” (p. 2). This study was conducted in a developed country to investigate on types of AT in general teaching using questionnaires targeting one hundred and twenty seven general teachers and special education teachers. However, the current study was conducted in a developing country specifically focusing on AT for teaching Mathematics targeting learners with VI in classes seven and eight and their ToM using direct observation.

Kohanova (2006) from Europe conducted a descriptive survey research study to investigate on the actual situation of teaching Mathematics in Slovak special primary schools. The researcher used observation to collect the data from special primary schools. The researcher found out that in primary school level the learners were observed using
Braille books with tactile pictures (low-tech), electronic note books (high-tech) for making notes and mechanical type writers (high-tech) for calculations. This study adopted a descriptive survey research design in special primary schools in a developed country, but the current study adopted a descriptive survey design which specifically focused special primary schools in a developing country.

In another comparative case study, Mugo (2013) interviewed twenty-two (22) students and eight (8) staff who gave AT services to student with VI. The study was conducted in a developing country (Kenyatta University) and a developed country (Syracuse University from United States of America). The study focused on awareness of the University student participants regarding the AT which was available for them by the time of the study. During the interviews, the respondents from Kenyatta University were first asked to mention the AT devices they knew which were available in their University. The following seven (7) types of high-tech AT devices were mentioned: “Braille machines, thermoform machine, computers, Job Access with Speech, None Visual Desktop Access, Dolphin pen and Closed Circuit Television” (p. 107). Further, the same students from Kenyatta University were asked to mention the AT devices which they knew about but did not get access to in their University. The students mentioned; “Braille note, Braille sense, telescope, talking calculators and voice output reading machines” (p. 107).

The study found out that the kind of AT services the students with VI received from the university were mainly provision of the Braille machines from the office of disability
services. Also the students reported that they were allowed into the University library to use the few computers with trial version of Job Access with Speech. On how they accessed the books and other reading materials in the library, the study quoted, “…they have to depend on their sighted readers to read the materials for them since it was in print” (p. 108).

Interviews were also conducted on the same matter to students from the Syracuse University, a developed country from the United States of America. On the AT devices the students were aware of in their University they reported the following: ipads, ipods, Closed Circuit Televisions, magnifying sheets and computers with screen reader software (Job Access with Speech & Kurzweil 1000). The Technology that they reported to have been aware of and were not within the University included: Braille sense, book sense, Cicero text reader, magnifying cameras, lamps with magnifying lenses, talking calculators, talking clocks and watches, and Braille watches. The students reported that they learnt about the AT that were not available in the University through the internet and through visiting institutions which deals with the Technologies for persons with VI.

Services that all the nine (9) students received from the Syracuse University included: accessing books in the library, orientation on how to access the University web, registration and provision of letters authorizing other stakeholders in the university to provide appropriate services to the students and assistance with note taking during lectures. The study revealed that, students from both Universities (in developed and developing countries) were aware of modern AT which would have increased their
independence in education. Moreover, the study concluded that “the students lacked enough knowledge of AT that were available for them both in and outside the University” (Mugo, 2013, p. 113) which would have helped them to use those that were available in the institution. From the study findings, most of the AT that were available and the students were aware of in the higher institutions of learning were mainly Mid-Tech AT and High-Tech AT. This study was carried out in a university, a higher institution of learning focusing on awareness of the University students regarding the AT which was available for them by the time of the study on general teaching using interviews, but the current study was conducted in special primary schools for learners with VI in Kenya specifically focusing on AT which was actually available for teaching Mathematics to learners with VI.

Wawire, Elarabi and Mwanzi (2009) conducted a comparative study in Kenya and in Egypt under the umbrella of the Africa Higher Education Collaborative Programme on access and equity to higher education. The study was carried out in six public universities in each of the two countries. Kenya public universities included: Kenyatta University, University of Nairobi, Moi University, Egerton University, Jomo Kenyatta University Science and Technology and Maseno University while public Universities from Egypt included: Alexandria, AinShams, Zagzag, Helwan, Assiut and Almenia. The three researchers investigated on enrolment of students with disabilities by area of specialization and the provision of learning facilities for those students. The data was collected from University records on disabilities but due to poor record keeping of
disability data by the Universities, the researchers had to compute some data manually from the overall students’ records. The researchers observed that students with physical disabilities had the highest percentage on enrolment followed by those with VI as compared with other disabilities.

Further, the three (3) researchers observed that majority of the students with VI had enrolled on theoretically based courses which included Arts and humanities. The learning facilities that were available in the selected public universities for students with VI were: “Braille transcribers, readers and audio reading equipment” (p. 27). The study by Wawire et al., (2009) was conducted in higher institutions of learning (regular university) using records, focusing on the learning facilities that were available for students with VI, Hearing Impairments and physical disability in general subjects. However, the current study was carried out in lower institutions of learning (special primary school) using observation checklists and classroom observation schedules specifically focusing on AT for teaching Mathematics to learners with VI.

Wamalwa (2017) carried out a descriptive survey using questionnaires on utilization of instructional media to enhance students’ learning of English. Teachers of English from Bungoma County in Kenya participated in the study. The study found out that text books for teaching English were available and enough. Further, the study revealed that most (90%) of the instructional media that were used in the classroom to enhance students’ learning in English were printed materials, nine percent (9%) were visual and about one percent (1%) were audio. The study was conducted in regular secondary schools from
one county focusing on English using questionnaires to collect the raw data, but the current study used direct observation to collect the raw data from special primary schools in five counties focusing on Mathematics.

Mariba (2012) conducted a case study in a regular school to investigate the use of instructional Technologies in Kisii County. The data was collected using interview guides, questionnaires and observational schedules in ten County public secondary schools. Mariba found out that most of the instructional Technologies were available but inadequate in terms of quantity. Also, the researcher noted that not all instructional Technologies were easily accessible to both the students and the teachers for teaching and learning. Mariba’s of 2012 study had adopted a descriptive case research design to investigate on the use of instructional technologies in one county using questionnaires, interview guides and observational schedules in a regular secondary school, but the current study adopted a descriptive survey design to investigate AT for teaching Mathematics in a wider scope (five counties) using observational schedules and observation checklist in special primary schools for learners with VI in Kenya.

Similarly, Mwangi (2014) investigated on adequacy of teaching resources that were used to teach Mathematics in Thika special primary school for learners with VI. The study adopted a descriptive case research design which employed qualitative and quantitative approaches with questionnaires and interview schedules. The study noted that abacuses and cuberithm board and cubes were the common AT that were used by ToM. The study was carried out in one special primary school for learners with VI adopting a descriptive
case research design using questionnaires and interview guides, but the current adopted a
descriptive survey research design using observation checklists and observation
schedules to collect the raw data in five special primary schools from five counties.

Summer (2014) investigated on software known as vOICe. vOICe is an algorithm
software that converts simple gray scale images into musical soundscapes. The three
middle capitalized letters stands for “oh I see’ (Doward, 2014). The vOICe is able to
scans images from left to right, converts shape information into sound as it sweeps. For
example, a series of ascending musical notes represents a diagonal line which stretches
upward from left to right. The software was discovered by Dutch engineer Peter Meijer in
1992. Further Summer (2014) noted that in 2007, Amendi and his colleagues at the
Hebrew University of Jerusalem started training persons with VI on how to use vOICe.
After training the person for seventy (70) hours, he/she went from hearing simple lines
and dots to seeing the whole images. More so, the person with VI was even able to
navigate around the room by sound cues when a head-mounted camera was attached to a
computer and a head phone.

2.3 Factors influencing the use of Assistive Technology in teaching Mathematics

2.3.1 Teacher competencies in teaching Mathematics through Assistive Technology.
The level of expertise and training of the teachers regarding the use of technology was
one of the major challenge in the efficient use of AT in Inclusive Education (Petty, 2012).
). Further, UNESCO (2014) noted that the use of AT was rarely covered in teacher
training programmes, thus, teachers typically did not acquire the skills to support learners
with disabilities while teaching them. Quality teacher training is required for effective usage of AT (Toit, 2015). Thus, the research emphasized on the importance of identifying clear indicators that shed light on how teachers were trained as well as on how they used Information and Technology in education for better results. According to Akpan and Beard (2014), AT is introduced in the classroom at all levels as a tool for teachers to help deliver teaching instructions to all learners including those with VI to workout Mathematics problems. Integrating technology into teaching provides learners with knowledge and skills of using the required hardware and software that translated across the curriculum (Grabe & Grabe, 2003).

Burgos (2015) carried a descriptive research study to examine the competencies of AT specialists in Florida K-12 public schools. The researcher applied mixed qualitative and qualitative approaches to collect the raw data. The targeted population of that study was eighty (80) professionals who had been identified as AT specialists. The sample size was thirty nine (39) participants from five (5) geographical regions of Florida: Panhandle, North East, East Central, West Central and the South which represented rural and urban areas. The study instruments used were self-administered online surveys and phone interview guides. The survey that was employed contained multiple choice and open-ended questions totalling to one hundred items which took twenty (20) minutes to complete.

The researcher analyzed quantitative data using computer statistical software programmes and NVivo 10.0 software was used for the qualitative data. The result of the
Burgos (2015) study was that: AT specialists lacked competence in several areas where they were providing AT services. This study examined the competences of AT specialist in a developed country using self-administered online survey in regular schools focusing general teaching, but the current study examined the competencies of ToM in a developing country using face to face interview in special primary schools specifically on Mathematics.

Alkahtani (2013) from the department of Special Education, King Saud University carried out a study to investigate teachers’ knowledge and how they used AT to teach students with Special Educational Needs. The researcher adopted mainly quantitative approach which was supplemented with qualitative approach. The data was collected from one hundred and twenty seven (127) participants through questionnaires, surveys and phone interviews. All the one hundred and twenty seven (127) questionnaires were submitted by the participants electronically where some respondents had not answered all questions which explained the different sample size in the results. The quantitative data gathered from the questionnaires were analyzed using computer statistical software program, Statistical Package for Social Sciences (SPSS). The results of the study were that:

The lack of knowledge and skills of using assistive Technology is a critical issue, with over ninety-three of respondents reporting that they were poorly prepared or not at all prepared to provide Assistive Technology services for students with disabilities in their schools (Alkahtani, 2013, p. 14).
The sample size of Alkahtani study (2013) was one hundred and twenty seven general and special need education teachers and the raw data was collected using questionnaires which were supplemented with phone interviews focusing general teaching. However, the current study sample size was smaller (ten teachers of Mathematics) and the data was collected using face-to face interview focusing Mathematics.

Another study by Mwakyeja (2013) further carried out a case study in one of the secondary schools in Tanzania on teaching students with VI in an inclusive education. The study investigated on teacher competencies while teaching general subjects. The study revealed that: teachers teaching students with VI had little knowledge about inclusive education which included skills of teaching Mathematics. The researcher further noted that: despite teachers’ have had some little knowledge of teaching in inclusive settings; they were not using it due to: scarcity of the resources, rigid curriculum and lack of commitment of teachers. This study was carried out in a secondary school which adopted a case study research design to collect the raw data in an inclusive education for students with VI focusing on general teaching, but the current study was carried out in special primary schools for learners with VI adopting descriptive survey research design specifically focusing on Mathematics.

Chomba (2017) conducted a survey to investigate on teachers’ perceptions on their Braille proficiency using questionnaires for teachers in general teaching in five special primary schools for the Blind. Purposive and stratified random samplings were used to select the study sample size of the participants. The study revealed that almost 90% of the
participants did not know anything about Nemeth code. Proficiency in using slate and stylus was also reported to be one of the least skills acquired by teachers in special primary schools. The study further established that knowledge of Assistive aids was reported to have been acquired by thirty (30) out of fifty three (53) teachers in the selected schools. The study concluded:

A Braille teacher training curriculum that emphases Braille reading, writing and teaching methodology is necessary. There is also need to add Mathematics Braille … science Braille as a vital component in the Braille training curriculum for teachers, (Chomba, 2017, p. 162).

Chomba’s study of 2017 sampled eighty three teachers to investigated on perceptions of teachers of Early Childhood Development regarding their professional braille preparation in a developing country using questionnaires focusing on general teaching. However, the current study sampled ten teachers of Mathematics in order establish their professional preparations in special primary schools who taught learners with VI in classes seven and eight using face-to-face interviews.

Muhammed (1994) in the 20th century conducted a descriptive survey study to investigate the impact of pre-service training on teaching performance of teachers on social studies. The study focused teaching regular classroom learners. Questionnaires were used to collect the data. The study noted that all the participants including even those who had taken a two year pre-service course, reported inadequate in-service training of teachers
had hindered good performance in social studies. This study was carried out in the 20th century focusing regular learners on social studies using questionnaires, while the current study was carried out in the 21st century specifically focusing learners with VI on Mathematics using interviews.

Kiambati (2016) carried a local study at Kenyatta University Post Modern Information Centre exploring training skills of students with VI in accessing electronic information resources. The researcher population comprised of five (5) staff members and eighty (8) students with VI. The researcher used questionnaires and personal interviews to collect the data from the participants. The result of the study was that more than half of the students had not received any training/skills on how to access e-resources and finally the staffs who were serving these students with VI had average skills in Assistive Technology. Also the study revealed that most of the students with VI were not able to retrieve and use e-resources on their own. Thus, most of the students who were VI used their colleagues who were sighted to read for them. Kiambati (2016) study was conducted in a higher learning institution focusing students and staff on general teaching, but the current study was carried out in a lower learning institution (primary level) specifically focusing ToM in special schools.

In another study, Ngatia (2015) investigated preparedness on the use of information and communication Technology in teaching and learning in regular public secondary schools in Nyeri County. The data was collected using hand delivery questionnaires. The study employed purposive, stratified random sampling techniques to select a sample of fifteen
public secondary schools, fifteen (15) principals and one hundred and twenty (120) teachers. The author observed that teachers were not well adequately trained in the use of Technologies thus lowering the self-confidence of the teachers in the use of Technologies in teaching and learning. Ngatia study sampled one hundred and twenty five regular secondary school teachers and the data was collected using questionnaires in one county, but the current study sampled a smaller sample ten teachers of Mathematics from special primary schools where the data was collected through face to face interviews from five counties.

A comparative case study carried out by Mugo (2013) interviewed five (5) staff from Kenyatta University and three (3) staff from Syracuse University who provided services of AT to students with VI in general teaching. The study pointed out that although the three personnel from Syracuse University had masters degrees, neither of them had trained in the area of AT for the VI nor the field of Special Needs Education. Moreover, from Kenyatta University out of the five (5) personnel, only one who had been trained in the field of AT for students with VI though for a short course certificate. Moreover, it was also revealed that the provision of AT to the end user through educational institutions was a major challenge due to the high cost leading to serious scarcity of AT devices. Mugo’s study of 2013 adopted a comparative study focusing staff who were providing services of AT to students with VI in general teaching. However, the current study adopted a descriptive survey research design specifically focusing ToM in special primary schools in a developing country.
2.3.2 Attitudes of learners’ with VI towards learning Mathematics using Assistive Technology

Mwangi (2014) referred attitudes as the prevalence to respond favourably or unfavourably to a person, object or group of people or events. In the past, attitudes towards disability was associated with poverty, ignorance and religion, but today, we no longer have this excuse of poverty and ignorance as we are relatively well educated and prosperous society Tassoni of 2009 (as cited by Jackson, 2009). Pierce, Stacey and Barkatsas (2005) distinguished attitudes from beliefs in that, attitudes are moderate in duration, intensity and stability and have an emotional content while beliefs become stable and are not easily changed. Positive attitudes towards learning Mathematics are necessary ingredients in Mathematics education at all levels (Mutai, 2010). According to Bottom (1983), when students’ attitudes are negative towards a particular subject, all the stakeholders concerned should be examined.

Young (2008) from Wisconsin-Stout University investigated attitudes of learners before and after introduction of an AT (computer) into the learning using experimental research design. The study participants ranged from eleven (11) to thirteen (13) years. One class was taught Science using traditional methods which the teacher had used for the last ten years with a white board, a book, paper and pencil. The other four (4) classes were taught the same content incorporating AT devices into the classroom with interactive whiteboard, internet access, a projector, online testing and laptop computers. All the one hundred and fifty learners (150) were taught Science within two days using a block
schedule and the same amount of instructions time was the same. The study findings showed that interactive learning with the AT increased the learners’ participation and at the same time their attitudes towards learning improved. However, the learner’s attitudes did not improve while using AT to those learners where teacher centered learning was used. This study adopted an experimental research design focusing one hundred and fifty regular students in five classes on teaching Science in a developed country, but the current study adopted a descriptive survey research design which specifically focusing a smaller sample of twenty learners with VI in two classes on teaching Mathematics in a developing country.

Schifter and Simon (2007) conducted a descriptive survey study on students’ attitudes towards learning Mathematics in regular schools. The researchers collected data through surveys and standardized tests. Two tailed t-test was used to compare pre and post-programme of the survey responses. The two researchers found out that, attitudes scores for elementary learners in grade four (4) through six calculated from 171 pre-programme surveys and 179 post-programme surveys showed a high level of significant increase of 0.001. On specific items they found out that items which changed at a level of p<0.005 were; it was fun to do Mathematics problems, Mathematics was one of the students favourite subject, Mathematics arouse learners’ thinking and it was interesting to do words problems. Schifter and Simon (2007) sampled a large number of three hundred and fifty regular students from secondary in a developed country to investigate on student’s attitudes towards Mathematics, on the other hand, the current research sampled a smaller
sample of twenty learners with VI from special primary schools specifically to investigate their attitudes towards learning Mathematics using AT in a developing country.

A study from Australia by Pierce et al., (2005) investigated on a scale for assessing learners’ attitudes on Mathematics Technology and the learning of Mathematics with Technology. The three (3) researchers used five sub-scales which included: Mathematics confidence (MC), confidence with Technology (TC), attitudes to learning Mathematics with Technology (MT), affective engagement (AE) and behavioural engagement (BE). A sample of three hundred and fifty students (350) from six (6) secondary schools was used. The questionnaires they used had twenty (20) short items which allowed them to monitor five variables namely: Mathematics confidence, confidence in using Technology, attitudes to the use of Technology to learn Mathematics, affective engagement, behavioural engagement. The participants completed the questionnaires within ten to fifteen minutes. The result on gender difference revealed that boys had statistically significantly higher scores than girls for each sub-scale except on behavioral engagement.

The scores on confidence with Technology, affective engagement and behavioural engagement had similar medians at all schools and the students also had high and moderate high scores. Variations between the six (6) schools were observed on Mathematics confidence and attitudes to the use of Technology to learn Mathematics. In conclusion, attitude to learning Mathematics with Technology for boys correlated only with confidence in using Technology. The three researchers concluded, “This scale provides an instrument that can be used in classrooms by either teachers or researchers
interested in trailing teaching innovations which include the use of new Technology” (p. 298). In this study the raw data was collected from a large sample, three hundred and fifty regular students from six secondary regular schools using questionnaires in a developed country, while in the current study the data was collected from a smaller sample of twenty learners with VI in specifically focusing on special primary schools using face-to-face interview in a developing county.

Mutai (2010), in a local study investigated secondary schools students’ attitudes towards learning and performance in Mathematics. The study adopted descriptive survey design. Twenty four (24) teachers of Mathematics were purposively selected while three hundred and fifty nine (359) students were randomly selected. The study findings revealed that the major problems associated with attitudes in the learning of Mathematics in the secondary schools was lack of confidence in the subject, inadequate text books and learning resources and lack of interests.

Further, the study identified the opinions of secondary school students towards learning and performance in Mathematics. Students were provided with twelve items which measured their opinions towards the subject. The findings revealed that students strongly agreed with the following items: Mathematics was useful subject in life (70%), they enjoy learning Mathematics (56%), and they would like to continue doing Mathematics after secondary school (49%) and the best way to learn Mathematics is to discover a concept by yourself. Study participants strongly disagreed with: Mathematics lessons were not interesting (56%), to understand Mathematics is difficult (38%). The results
revealed that secondary school students had a positive attitude towards Mathematics as a subject. This study was conducted in regular secondary schools focusing three hundred and fifty nine students using questionnaires to investigate on their attitudes towards learning and performance in Mathematics, while the current study was conducted in special primary schools focusing twenty learners with VI selected through stratified simple random sampling to investigate on their attitudes towards learning Mathematics using AT.

2.3.3 The affordability of Assistive Technology

Kohanova (2006) conducted an experimental study in a developed country to investigate on teaching Mathematics to students with VI with specialization in solid geometry. The study revealed that some teachers of Mathematics who were not familiar with computers refused their usage as writing devices during examination time for learners with VI, thus students with VI had to pass exam verbally where their schoolmates who were sighted answered the exam questions in writing. Other challenges that the researcher noted included; lack of text books, study materials and limited Braille notation for Mathematics. Kohanova (2006) adopted an experimental research design in a developed country, while the current study adopted a descriptive survey design to collect the raw data in a developing country.

Muigai (2017) conducted a qualitative study in three counties: Nairobi City, Kiambu and Meru in order to trace the historical development of education for persons with VI in Kenya from 1945 and 2013. The researcher used one-on-one interviews and archival
materials (documents) to collect the data. The sample size of the participants that were interviewed was eleven. The study revealed that high cost of instructional materials and equipment and their maintenance was the main challenge to the education of learners with VI. Muigai (2017) further observed that thermoform machine by the time the researcher collected the data totalling ksh 300,000. Muigai (2017) interviewed the head teachers of the institutions for learners with VI from three counties focusing on general teaching, while this study interviewed teachers of Mathematics who were the implementers of the curriculum from five counties specifically focusing Mathematics.

Kochung (2003) conducted a survey to establish on unit cost of educating a learner with special needs. The study collected the data using questionnaires which were sent to special units, integrated programmes, government education offices, public universities and non-govermental Organizations for and of persons with disabilities. The study revealed that the government had allocated ksh 1000 per year for Assistive Technology to learner with special needs in a day pre-school, ksh 2020 per year in a day primary special unit and ksh 8000 per year for the boarders. The raw data was collected using questionnaires in this study focusing general teaching, but in the current study the data was collected using interviews specifically focusing Mathematics.

Kimotho (2017) studied on teachers’ information Technology affordability in classroom instruction in day schools in Murang’a County. The study participants in the study were day secondary school teachers who had attended Strengthening Mathematics and Science Education course. Stratified random sampling technique was used to sample 145 teachers
from the four departmental levels (Mathematics, languages, humanities and sciences). The study revealed that Information and Communication Technology was rarely used in classroom instruction due to the high cost, more of the Technology was used in administration in preparation of exams, time tables and typing of official letters. Kimotho’s (2017) study investigated on affordability on Technology used in regular day secondary schools teachers from one county on general teaching and the current study focused specifically on affordability of AT in teaching Mathematics to learners with VI in special primary schools for learners with VI from five counties.

2.4 Strategies employed by teachers when using Assistive Technology

It is important to know the teaching methods and instructional strategies that work best with learners with VI. This is because effective techniques can be shared with other teachers (Kautz, 2016). Teachers also need to know how to use AT in addressing the different needs of persons with disabilities which include learners with VI to learn (UNESCO, 2014).

Kautz (2016) while using descriptive observational study, identified strategies used by effective teacher of developmental Mathematics and to discover the learners’ perceptions they had about these strategies in higher institutions. The qualitative study involved observation of teachers of Mathematics classroom practice and triangulation via students’ questionnaires and interviews. Four study participants were selected through snowball sampling enrolment technique. Students who were eighteen years and above were observed and video recorded in the classes before, during and after the teaching of an
algebraic concept. The study focused on three (3) teaching methods and eleven (11) instructional strategies. The three (3) teaching methods were direct instruction, group work and constructivist while instructional strategies included: stating the objective, learner’s engagement, modeling, scaffolding, positive attitudes, use of manipulations, use of Technology, use of graphic organizer, use of humor and fun, real-world relevance and use of games.

The study findings revealed that all the four (4) instructors who were recorded on video used teaching method of direct instruction. Two (2) of the instructors used constructivist and none used group work. A direct instruction is also referred as lecture-based instruction which include tutorials, discussions, recitation, seminars, workshops and observation (Kautz, 2016). Group work is when learners work together as group or in partners. An example of a partner is Think-Pair-Share which involves sharing ideas with a partner enabling him/her to assess new ideas before presenting the ideas to a larger group. The author further stated that in group work, the teacher act as a manager who oversees the project that learners complete. According to Piaget (1967) constructivist teaching requires learners to do experiments and use the findings of those experiments to discover the rules of Mathematics, thus reaching to conclusions. In constructivist teaching the ToM allows his or her learner to manipulate blocks and let them come up with their own way of finding area of a circle, as opposed to giving learners the formula.

Regarding the instructional strategies, seven (7) out of eleven (11) were observed in the learning sessions stating the objectives at the beginning. Instructional strategies refers to,
“those experiences in teaching that make the attainment of knowledge and skills interesting, effective and appealing to students” (Kautz, 2016, p. 36). The instructional strategies included: stating the objective, learner’s engagement, modeling, scaffolding, positive attitudes, use of manipulations and use of games. Use of manipulates and use of games were not observed on the recorded video at all. Use of technology was observed on three instructors, use of graphics organizer and humor on two instructors while real-world relevance on one instructor. However, Kautz (2016) observed a very small sample of four regular learners focusing general teaching using snowball sampling techniques, while the current study observed a larger sample of nine classroom lessons using classroom schedules of thirty five minutes specifically focusing Mathematics using purposive sampling to collect the raw data.

Mugo (2007) investigated instructional methods that were most suitable for the use of instructional media in the facilitation of learning by learners with visual impairments in special primary schools and integrated programmes. The researcher adopted a descriptive survey design. Interview guides, observation schedules, checklists, questionnaires and focused group discussions were used to collect data from twelve (12) ToM in the six (6) special primary schools and two integrated programmes for learners with VI. The study findings were that ToM used combination of different instructional methods to achieve different types of objectives. Through the questionnaires, all the twelve (12) study participants mentioned the following strategies which they found to be most suitable in the facilitation of learning, assignments, arithmetic calculations, peer tutoring, question
and answer, self-exploratory exercise, shape identification and class discussions. Other methods that were noted included: competition games, brainstorming, group discussion, brainstorming and co-operative games.

Through observation, the researcher noted that, although the ToM selected various instructional strategies for teaching learners with VI, majority of those ToM were observed using lecture, class discussion, assignment and they sparingly used the instructional media. This study was carried out investigation teaching strategies in both special schools and integrated programmees for learners with VI ten years ago focusing general teaching in classes four to eight, while the current study investigated on teaching strategies specifically focusing only special primary schools classes seven and eight on Mathematics.

Wairimu (2013) further observed fourteen (14) classroom sessions in two integrated public primary schools in Nairobi County which enabled that researcher to obtain accurate data on how the ToM manipulated and used the instructional materials and devices which were actually available and used by learners and their ToM. The researcher used classroom observation checklists to observe the fourteen (14) sessions in integrated public primary schools in Nairobi County; classes four to eight which had learners with low vision. The qualitative data from the classroom observation checklist was summarized in narrative form. The researcher found out that in six out of the fourteen sessions, the teachers of Mathematics did not use any instructional materials while teaching Mathematics in integrated programmes.
In all the eight out of the fourteen sessions, ToM were observed employing demonstration method of teaching while teaching learners with VI. Other methods that were noted included were: lecture as well as question and answer. Further, the researcher revealed that majority of the sessions (5) observed, learners were not allowed to manipulate the materials while the remaining three sessions, the learners were allowed to manipulate the instructional materials throughout the lesson (Wairimu, 2013). The classroom observations of Wairimu’s study of 2013 revealed that, the majority of the ToM that were observed typically focused on the content of the task and spent very little time interacting with learners regarding individual attention and showing interest in the learners’ work. The researcher studied on the strategies that were employed by teachers when using instructional materials and devices to teach learners with low vision in classes four to eight in integrated programmes. However, the current study investigated on teaching strategies employed by ToM when teaching Mathematics specifically focusing learners with VI in classes seven and eight in special primary schools.

Mutai (2010) applied a descriptive survey to investigate on teaching strategies for teaching Mathematics in selected secondary schools in Buret District. The teaching methods that were observed included: lecture, small group discussion, question and answer, individualized teaching and student to student demonstration. When observed on instructional strategies, the following were observed: demonstrating usefulness of Mathematics, telling students the importance of Mathematics, organizing internal symposia and changing teaching methods. In this work, students seemed to like
Mathematics more when given individual attention by their ToM as well as in small group discussions to enable them to clearly understand the concepts. The locale of Mutai’s study was too small comprising of only one District for generalizing the results focusing regular secondary schools, but the current study was necessary as it locale was wider comprising five Counties specifically focusing special primary schools.

2.5 The role of Assistive Technology on teaching Mathematics

Stanley and Karshmer (2006) in the department of Information and Technology carried an experimental study on the importance of translating Mathematics Markup Language (MathML) into Nemeth Braille Code. The instruction of Mathematics was conducted with a spoken explanation. A note taker was recommended for a learner with VI. The researchers had the following example of the ambiguity intrinsic in the usual verbal rendering during a Mathematics lesson. “The square root of x plus 1 over y”. The square root of x plus 1 over y verbal rendering could be perceived in any of the following ways:

\[ \sqrt{x+1/y} \quad \sqrt{x+1/y} \quad \sqrt{x+1/y} \quad \sqrt{x+1/y} \]

According to the two researchers, all the four statements were correct. It was impossible to eliminate any of the formulas solely on the verbal statement. Clearly, a line of communication was needed between Mathematics instructors lacking experience with students with VI to learn Mathematics and their challenges. The two researchers provided an Assistive Technology software tool usable by anyone who can enter an equation into a MathML format into an unambiguous Braille representation. However, this study adopted
an experimental study in a more developed country, but the current study adopted a descriptive survey design in a developing country.

Flanagan (2008) from State university of New York carried out a study on importance of using graphing calculator in the teaching Mathematics to learners from urban middle schools on solving systems of equations by graphing in the 8th grade. The participants were nineteen (19): thirteen females and six males who ranged from thirteen to sixteen years. The learners were taught the unit on solving systems of equations using graphing for five days using pencils, rulers and graph papers in the month of March. The researcher tested the learners on the 5th day and recorded their results in the grade book. The researcher again taught the same learners the same unit using graphing calculator as a means of technology in the month of May. The learners were tested again using the assessment test that was used in March and their grades were entered in the grade book. The results showed that there was an indication of academic achievement due to introduction of graphing calculator in the classroom, which in turn added to learners’ interest in Mathematics lesson. This study adopted an experimental study in a developed country to investigate on importance of graphing calculator focusing regular learners, but the current study adopted a descriptive design in a developing country to investigate general role of AT for teaching Mathematics specifically focusing learners with VI.

Rowe (2014) researched on the impact of Technology on the teaching and learning of Science, Technology, Engineering and Mathematics (STEM) subjects for Persons with VI in the more developed countries. The researcher found out that the following
importance on the use of the Technology enable persons with VI to; scan and read mathematical equations, access and produce tactile representations of the most complex graphs and pictures, produce their own work in a variety of formats such as audio, Braille and Latex code and increased their learning capacities through sharing the knowledge. The researcher further noted that the Technology facilitated the crucial sharing of materials between the teacher and the learner; interaction increased learning potential and improved access to resources. Rowe (2014) carried out his study in a developed country, but the current study was conducted in a developing country.

Young (2008) from the University of Wisconsin –Stout conducted a descriptive survey study on the role of Technology tools in the public school classroom. The purpose of the study was to investigate whether integration of AT increased motivation, learners’ attendance and grades in the classroom by administering a survey to teachers and learners. Questionnaires were used to gather raw data from teachers and regular learners. One hundred and fifty 8th grade learners who ranged from eleven to thirteen years and shared the same science teachers were selected. Young (2008) found out that majority of teachers who participated in the study were in two stages with exception of four teachers who had reached stage four. Majority of teachers were in the first stage (entry stage) where they doubted about integrating Technology due to low use of Technology. Teachers were motivated to use the Technology when they first received the Technology; however, due to lack of proper training and adequate time to practice the new AT skills, motivation decreased quickly where teachers returned to the traditional teaching routines.
The author concluded that just as pencils do not replace crayons but rather, provide additional means of expression, AT should not replace other teaching methods but add to the devices available to learners to explore, create and communicate. The raw data in this study was collected using questionnaires focusing regular learners in a developed country, but in the current study the raw data was collected using face to face interview specifically focusing ToM in a developing country.

A study from Nigeria a developing country, (Adebisi, Liman & Longpoe, 2015) conducted a study to investigate on the role of AT to learners with learning disabilities on general teaching. The authors found out that AT assisted learners with learning disabilities to: increase independence in academic and employment tasks, participate in the classroom, gain access to the full variety of educational options, master academic tasks that they find difficult, work side by side with peers, secure high levels of independence learning and participate in community and recreational activities. The three authors investigated on the role of AT focusing learners with learning disabilities focusing general teaching, but the current study investigated on the role of AT specifically focusing ToM in special schools for learners with VI in Kenya specifically focusing Mathematics.

Virgile (2008), observed four (4) students who had learning disabilities. The purpose of the study was to investigate the role of AT as an educational tool in the areas of reading, writing and Mathematics for learners with learning difficulties in a developed country. The first student was a fifth grader who could not read the third grade reader. The second
student could not calculate Mathematics questions which were written on the board by the teacher. The third student was new in the school and he had left his class for washroom. Unfortunately, he was unable to return to his class as he could not read the English names on the door. Last but not the least, the fourth student arrived school late because she had to struggle to read the street signs as the mother could not take her to school that day.

The results of the study were that: in the area of reading, the use of AT improved students’ spelling abilities decoding, listening and oral skills. In the writing area, the following were the effects on the use of AT to learners with learning disabilities; enabled student to write neatly and legibly, write sentences that were grammatically correct. Finally, in the area of Mathematics the use of AT enabled students with learning disabilities to make proper calculations and computations. The researcher observed four learners with learning disability in a developed country focusing three areas i.e. reading, writing and Mathematics on importance of AT, but the current study interviewed fourteen participants specifically focusing only Mathematics in a developing country.

According to Toit (2015) AT increases awareness to persons with VI by informing them about the products and the services that increases their independence. AT also educates the community at large which bridges the gap that learners with LV contribute as members of society. Thus, this study focused on establishing factors that had influenced the use of AT in teaching Mathematics to learners with VI in special primary schools for learners with VI in Kenya. According to ICEVI (2014), if a learner has to master
Mathematics skills, he or she must practice continuously. This is achieved through provision of various appropriate devices and effective teaching methods. Learners with VI especially the Blind have difficulty accessing visual materials on the computer screen or in print form (Ahmad, 2015). For these learners to independently gain access to textbooks, syllabus and homework assignments, Ahmad (2015) highlighted examples of computer systems that they can easily work with. These computer systems include: Optical Braille Recognition Software, Refreshable Braille Displays, Scanner with Optical Character Recognition and Speech Output Systems.

Optical Braille Recognition Software enables a learner with VI to read a document written in Braille on a standard A4 scanner, scan the Braille document, analyze the dot pattern, translate the text and finally present the document on the computer screen. Refreshable Braille Displays Software allows a learner with VI to translate the screen text line-by-line into Braille which helps in detailed editing. Scanner with Optical Character Recognition Software enables a learner with VI to read printed material which is stored electronically on computers. The printed material is read using speech synthesis or it is printed using Braille Translation Software and Braille Printers. Speech Output Systems are used to read the screen text while Screen Readers or the text-to-speech software like Job Access with Speech helps the learner in adjusting the pitch, volume and speed of reading. The author (Ahmad) further noted that audio materials such as audio cassettes and talking books of recorded lessons may be used by learners with VI.
2.6 Summary of literature review

In summary, a comprehensive discussion has been done on the use of AT for teaching and learning Mathematics to learners with VI both within the developed and developing countries. It was evidently clear that, most of the studies were conducted in developed countries focusing AT in higher institutions on general teaching to regular learners. Limited research had been undertaken in the field of AT in the teaching and learning of Mathematics among learners with VI in the developing countries, Kenya being included (Rowe, 2014; Wairimu, 2013). The literature review of this study also showed that there was a lot of innovation in the accessibility of AT domain in the developed countries in the field of Mathematics. More so, this study was very necessary as it attempted to fill the gap noted in this literature review. Therefore, the current study specifically focused on types of AT for teaching and learning Mathematics, factors that had influenced the use of AT and teaching strategies employed by teachers when using AT in teaching Mathematics to learners with VI in special primary schools for learners with VI. Finally, the study investigated on the role of AT on teaching Mathematics among learners with VI in special primary schools for learners with VI in Kenya.
CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The chapter presents the research design, variables, locale of the study, target population, sampling techniques and sample size, research instruments, pilot study, data collection procedures, data analysis and logistical and ethical considerations.

3.2 Research design

This study adopted a descriptive survey research design to evaluate effectiveness of Assistive Technology (AT) on teaching Mathematics to learners with visual impairments (VI) using interviews and direct observation. According to Gay, Mills and Airasian (2006), descriptive surveys are concerned with assessing attitudes, opinions, preferences, demographics, practices and procedures. Further, descriptive survey design is concerned with ‘describing behaviours and gathering people’s opinions, attitudes, perceptions and beliefs about a current issue in education (Lodico, Spaulding and Voegtle, 2006)

Thus in this study, the descriptive survey design was appropriate because it helped in the collection of raw data based on the attitudes, opinions, preferences and the demographics of learners with VI, their teachers of Mathematics (ToM), as well as the deputy head teachers with regard to effectiveness of AT on teaching Mathematics to learners with VI in special primary schools in Kenya.
3.3 Variables of the study

The variables in this study were; Assistive Technology, teacher competency, learners’ attitudes, affordability of AT, teaching strategies and role of AT. The levels of measurement of all the six study variables were nominal or categorical. Categorical means that numbers assigned to each factor do not have meaningful values but are there to categorize.

3.4 Locale of the study

This study was conducted in the six out of the five special primary schools for learners with VI in Kenya (Appendix J). The selected five special primary schools for the study were Likoni (Mombasa County), St Lucy (Meru County), St Oda (Siaya County), Kibos (Kisumu County) and St Francis (West Pokot). The sixth school was selected for pilot study (3.7). First, these five special primary schools for learners with VI were identified as suitable locale of the study because they were the only special primary schools for learners with VI in the country, Kenya (Kochung, 2003), and thus, they provided the study’s data. Secondly, Wairimu (2013), in her study investigating the instructional materials and devices used to teach Mathematics to learners with low vision in integrated public primary schools in Nairobi City County, had recommended a further study to be carried out to investigate the use of AT in special primary schools for learners with VI in Kenya. In an attempt to fill this gap, the researcher selected the five (5) sites for the study to investigate AT used by learners with VI in special primary schools in Kenya. Thirdly, ToM who taught in these five selected special primary schools for the study were
specially trained to teach Mathematics to learners with VI and therefore they were in a position to provide relevant information required for the this study.

3.5 Target population

The study targeted special primary schools for learners with VI in Kenya. These schools were mixed boarding where three schools had single stream and the other two schools had double streams. The population from the five schools comprised of seventy-six (76) learners with VI in classes seven and eight, their ten ToM and five deputy head teachers. Class eight is an examination class and all learners sit for Kenya Certificate of Primary Education at the end of eighth year. The mode age of the learners was 16 years. Classes eight and seven learners were appropriate because it was assumed that they had possessed a wider knowledge as well as experience in learning Mathematics using AT for about seven years and also they responded well in English language. ToM teaching classes seven and eight were appropriate in the study because it was assumed that they had taught Mathematics for some years using AT and they were aware of the strengths and weaknesses using of AT in the subject by then.

3.5 Sampling techniques and sample size

The sample of this study involved the selected study participants and the selected study sites for investigation.
3.5.1 Sampling techniques

Purposive and stratified random sampling techniques were applied in the study to collect the raw data. Purposive sampling technique was applied to identify five special primary schools, ten ToM and five deputy head teachers. Purposive sampling allows the researcher to use cases that have the required information with respect to the objectives of the study (Mugenda, 2008). Hence, the five (5) special primary schools or the study sites were selected using purposive sampling due to the fact that they were the earliest to have been started in Kenya since 1945, had rich information for the study and the only special primary schools for learners with VI in Kenya (Kochung, 2003). ToM and deputy head teachers were selected purposively due to the fact that, the researcher believed that they had rich information (data) that the researcher had targeted for collection. They were the persons instructing learners with VI at the sites hence well informed regarding their academic characteristics.

Stratified random sampling technique was used to select twenty learners with VI based on the criteria of male and female status. From the different strata, random sampling technique was used to select one male and one female from each class ie standards seven and eight from the selected study sites. Stratified random sampling technique was appropriate for this study because it ensured that sub-groups that constitute the majority in the population were all represented proportionately (Mugenda, 2008). In addition, the researcher further used simple random sampling technique to select one male and one female from each of the classes 7 and 8 who totalled to four (4) learners with VI from
each of the five (5) special primary schools for learners with VI in Kenya. Two (2) out of the five special primary schools for learners with VI had double streams in both standards 7 and 8. This is how the researcher selected the sample from the two schools (sites). All the male learners with VI from the two standard 7 streams were put together. Then the researcher selected a single male learner from that group by simple random technique for investigation.

This grouping and use of the simple random sampling was also applied to the female learners in the same two standard 7 streams and also to the standard 8 two streams on both the males and females with VI. In the end, a sample of four (4), two males, one from class 7 and the other from 8 and two females each also sampled from classes 7 and 8 comprised a balanced study sample of both gender. Each study site (school) therefore, produced a sample of four (4) gender balanced participants and since there were five (5) such selected sites (schools), a total sample of twenty (20) participant learners with VI were selected for this study. This was necessitated by the fact that it ensured male and female participant learners in the population were represented in the sample in proportion to their number in the population (Kombo & Tromp, 2006).

3.5.2 Sample size

Table 3.1 represents distribution of the study’s sample population.
Table 3.1

Distribution of the study’s sample population

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<td>Blind Low Sighted</td>
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<tr>
<td>Deputy head Teacher</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Teachers of Mathematics</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>2</td>
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<tr>
<td>Learners</td>
<td>10</td>
<td>10</td>
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Table 3.1 represents a total sample size of thirty-five (35) study participants which consisted of: five (5) deputy head teachers, and ten (10) ToM who were selected purposively as well as twenty (20) stratified randomly selected learners with VI all of whom were obtained from the target population. Out of the five deputy head teachers, three (3) were males while two (2) were females and all were sighted. The ten ToM were made up of seven (7) males while three (3) were females. Again, of the seven male study participants, four (4) were visually impaired and three (3) were sighted. Of the three (3) female participants, two (2) were low vision and one was sighted. Further, Table 3.1 also indicate that in terms of gender, the number of learners with VI i.e. twenty (20) were equal in number namely; ten (10) males and ten (10) females. From the population, the researcher selected a sample made up of 25% of males (10) and 27% of females (10) of the targeted population to be the participant learners with VI.
3.6 Research instruments

The research instruments that were used to collect qualitative data on the effectiveness of AT on teaching Mathematics were interview guides, classroom observation schedules and observation checklists.

3.6.1 Interview guides

Structured and semi-structured interview guides were used to collect raw data from ToM and learners with VI. Structured interview guides allowed the qualitative researcher to ask all of the study participants the same series of questions (Gay et al., 2006). The face-to-face interview allowed collection of rich and more complete responses while the recorded audio was used during analysis which also enhanced validity and reliability.

Semi-structured interview guides gave the participants a greater freedom to express their ideas, opinions and suggestions where necessary (Fraenkel & Wallen, 2010) regarding the role of AT on teaching Mathematics to learners with VI in special primary schools for learners with VI in Kenya. Interviews were recorded by taking down notes and also through audio recording. Handwritten notes made a durable record of the interviews which necessarily focused the researcher's attention on the content of what interviewees said and much less on how they said (Lankshear & Knobel, 2011). Audio recording enabled the researcher to capture a good deal of the interviewees’ interaction, hesitations voice quality and self-correction.
Interview guides for teachers

Face to face interview guides for ToM was used to elicit information on teacher competence, affordability of AT and the role of AT on teaching Mathematics (Appendix A). In this study, section A of the interview guide for ToM contained demographic information of the ten (10) key participants. The demographic information that were chosen for this study included gender, education background (level of education and training level on AT) and teaching experience in teaching Mathematics in special primary schools for learners with VI in Kenya.

The Section B had four close-ended questions. The closed ended items for ToM enabled the researcher to obtain specific responses from the key participants (Orodho, 2009) with regard to the teachers’ competence in the use of AT, affordability of and AT and role of AT. The teacher competence on using AT was derived from a review of the literature carried out by Alkahtani (2013). To determine what an individual perceives, believes or feels about self, activities or situations, an attitude scale was used in this study (Gay et al., 2006). Section B question four of the interview guide had three statements which measured affordability of AT in teaching Mathematics to learners with VI in special primary schools. ToM were asked to give reasons why they did not integrate AT while teaching Mathematics. Section C had one open-ended question which investigated on the role of AT on teaching Mathematics to learners with VI in special primary schools for learners with VI in Kenya.
Interview guide for learners with visual impairments

The interview guide for learners with VI enabled the researcher to gather information on their attitudes towards learning Mathematics using AT. The interview guide for participant learners (Appendix B) was divided into two sections namely: section A for demographic information and section B (a five level likert-scale) with fifteen statements. The study adopted the Mathematics and Technology Attitudes Scale which had been derived from related literature (chapter two) carried out by Pierce et al., (2005) which had measured five sub-scales as follows: confidence level in learning Mathematics, confidence level in using the technology, behavioural engagement, affective engagement and attitudes towards use of technology for learning Mathematics.

The first three statements were to measure learners’ Mathematics confidence, three for confidence with technology, three statements for their attitudes towards the use of technology for learning Mathematics, three for affective engagement and the last three statements for behavioural engagement. Learners with VI were presented with twelve (12) items. They were asked to state the extent of their agreement levels on a five-point scale from strongly agree to strongly disagree which scored from 5 to 1. (Strongly agree = 5, Agreed = 4, Not sure = 3, Disagree = 2 and Strongly disagree = 1). The sub-scale of behavioural engagement (appendix II, items 13 to 15) had a different but similar responses set. The researcher used a five-point scale namely: nearly always, usually, about a half the time, occasionally and hardly ever which scored from 5 to 1. Learners with VI were required to indicate the frequency of occurrence of different behaviours.
3.6.2 Classroom observation schedule

Structured classroom observation schedule (Appendix D) was used to elicit information on strategies that were employed by teachers when using AT and the way teachers and learners manipulated AT. It was appropriate to this study because it enhanced possibilities for the researcher to make relatively straightforward and defensible comparisons across data sets constructed from different lessons and even from different classes together (Lankshear & Knobel, 2011).

The researcher used non-participant observation approach whereby, she sat at the back of the classroom, actively observed the lesson progress and at the same time, filled in the classroom observation checklist (Fraenkel & Wallen, 2010). Photographs (Appendix G) were taken which provided more detailed data since much setting for the events and activities captured on camera remained intact. Classroom observation checklists are mostly reliable when they are conducted over a period of time or more than one occasion so as to minimize the chances of such an observation lesson being atypical (Wilson, 2009). In this study, the researcher observed and filled nine classroom observation schedules where each teacher was observed once while teaching a thirty-five (35) minutes Mathematics lesson in either class seven or eight. The ToM who taught Mathematics in class eight were the same teachers who taught class seven in the special primary schools. Another indication was that there was shortage of teachers of Mathematics in special primary schools for learners with VI in Kenya. Five teachers of
Mathematics were observed from class seven while four ToM in class eight were observed.

The instrument had open-ended items numbered 1 to 4 on the classroom observation schedule which was tabulated at three levels namely; condition of vision of ToM, types of AT and lesson objectives. Items 5 – 10 were close-ended questions. The researcher and research assistant chose the appropriate responses by ticking on it as the Mathematics lessons progressed.

3.6.3 Observation checklist

Structured observation checklist was used to collect the data on types of AT that were available in the selected schools (Appendix C). The observation checklists from the five selected special primary schools were each 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 AT for teaching and learning Mathematics to learners with VI in special primary schools in Kenya. The filling of the data for each took about fifteen minutes. That data was analyzed at three levels namely: Low-Tech, Mid-Tech and High-Tech AT.

3.7 Piloting of the instruments

Pilot study was carried out prior to the actual study. The interview guides, procedures and planned analysis should be tried out with a small group identical to the population being studied (Gay et al., 2006). Therefore, in this study the researcher piloted the three study instruments with five (5) participants from Thika special primary school for learners with
VI in Kiambu County, Kenya who were identical to the study population. Thika special primary school for learners with VI was selected because the learners had the similar characteristics with the actual population, it was near the researcher’s place of work and the special primary school was not included in the actual survey study. During piloting, problems in the interview guide, classroom observation schedule and observation checklist were detected and they were remediated before the actual study, hence ascertained validity and reliability (Fraenkel et al., 2012). The selected participants for the piloting phase included: one ToM, one deputy head teacher and two learners; a male and a female with VI in classes seven and eight.

Several changes were made on the two interview guides and on observation checklist. On the interview guide for the teachers of Mathematics (Appendix A) a statement to clarify whether the teacher teaching Mathematics was low vision, visually impaired or sighted was included. Interview guide for learners with VI (Appendix B) had major changes: before piloting section B had eleven statements of responses which were intended to measure three variables namely: Mathematics confidence, confidence with Technology and attitude to learning Mathematics with Technology. But after piloting two variables were added namely: affective engagement and behavioural engagement. Affective and behavioural engagement were important variables to be measured as they involved examining how the learners with VI felt about Mathematics and how they behaved when learning Mathematics accordingly. Each variable had three (3) statements of responses thus totalling to fifteen (15) statements.
Observation checklist which was filled by the researcher in the library in the company of the deputy head teacher regarding availability and the quantity of AT for teaching and learning Mathematics had twenty AT. After the piloting of this observation checklist, two more AT were added. No review was done on classroom observation checklist as the researcher found it adequate regarding its contents. Piloting of these tools also helped the researcher to draw up coding frame work for the open-ended questions. This was done by looking at the answers to the questions and identifying those answers that commonly occurred (Orodho, 2009).

3.7.1 Validity of the instruments

To establish the content validity of the instruments in this study, the researcher enhanced it in two ways; triangulation and member checking. First, the researcher enhanced validity of the study through triangulating the instruments. The researcher used both a checklist and a classroom observation schedule to collect information on types of AT that were available in the selected sites. Secondly, to ensure the content validity, logical and format structure of the interview guides, classroom observation and checklist, the researcher simulated the instruments separately with the research assistant selected for pilot testing. At the end of each interview session or observation, both the researcher and research assistant involved in the pilot testing, separately went through the interview guides, observation schedule and observation checklist and reviewed each of the items through member checking, to assess their worth to elicit the needed data for the study.
3.7.2 Reliability of the instruments

Reliability of interview guides was achieved through audio tape recording the interview once by using a smart phone during piloting. In audio tape recording, the exact words of first-hand verbatim accounts of information is recorded as narrated by the participants selected to be pilot tested and who were knowledgeable in the area under study during piloting. Tape-recording verbatim information once disallowed the need to interview the participants twice, hence avoid information distortion. The recorded verbatim data became vital since the researcher re-played the record during analysis. The common term which is seen in qualitative research is dependability instead of reliability (Simon, 2011). In order to address the dependability issue more directly, the researcher has reported in detail the processes within the study which may enable a future researcher to replicate/repeat her work, if not necessarily to gain the same results (Shenton, 2004).

3.8 Data Collection Techniques

The study focused on the use of primary data which was collected through non-participant observations and face-to-face interviews. Pairing observation and interviewing provided valuable way to gather complementary data on evaluating effectiveness of AT on teaching Mathematics to learners with VI. Observation data collection technique was appropriate in the study because it enabled the researcher to understand the natural environment as lived by the participants without altering or manipulating it (Gay et al., 2006). More so, non-participant enabled the researcher to
observe the participants and record the data interacting with the life of the setting being studied.

Structured and semi-structured interviews were used to elicit the information from the participants. Structured interview helped the researcher to ask all the participants the same series of questions while the semi-structured interview gave the participants a greater freedom to express their ideas, opinions and suggestions where necessary (Fraenkel & Wallen, 2010). The researcher audio tape recording during interview provided the researcher with the original data for use at any time especially during analysis stage.

ToM were observed first while teaching learners with visual impairments in classes seven and eight. Each ToM was observed once while teaching Mathematics for a thirty-five minutes lesson. Thus a total of nine classroom observation lessons in the five schools were observed. During the classroom observation sessions, the researcher and research guide sat at the back of the classroom and keenly observed the progress of the lesson (Grosvernor & Rose, 2001).

The second instrument to be administered was the observation checklist for teaching and learning resources of which the researcher was assisted to fill by the deputy head teacher. Deputy head teachers were in-charge of inventories in their school stores. Thirdly, the researcher conducted interviews for teachers of Mathematics which were face-to-face interviews and audio recorded them verbatim. Audio recording enabled the researcher to
throughout retain an original data for use during the data analysis phase (Gay et al., 2006). The fourth and the last instrument to be administered were the face-to-face interviews with learners with visual impairments where the researcher was assisted by the class teachers of classes seven and eight in identifying those learners who had no other disabilities. The researcher and the research assistant first explained the importance of the research study to the learners and in each case proceeded to conduct the face-to-face individual interviews.

3.9 Data Analysis

Qualitative data was collected from twenty (20) learners with VI, their ten ToM and five deputy head teachers from five special primary schools in Kenya. Qualitative data analysis involves the identification, examination and interpretation of patterns and themes in textual data. Qualitative data consists of words and observations and not numbers (Taylor & Renner, 2003) and it determines how the patterns and themes help the researcher to answer the research questions at hand (Orodho, 2009).

The qualitative data collected in the semi-structured interview through open-ended questions was analyzed following six steps commonly used in qualitative studies manually (Lodico et al., 2006). First, the researcher prepared and organized the data. Verbatim transcriptions from the tape recording were performed which ensured the information from the interviews was valid. The researcher understood the qualitative data through reading, re-reading and examining the data in order to get overall sense of what was in the study participants’ minds. This made the researcher to figure out the volume of
data collected (Lodical et al., 2006). This as well, enabled the researcher to have a

general idea of the data by reading throughout all of the information.

Coding of the data manually where themes were developed which facilitated synthesis
was done. The researcher used codes to label the themes, ideas and behavior into
categories based on the four major study research objectives. Further, the researcher read,
re-read and re-examined again all the data and ensured it had been coded appropriately
inappropriately to the experiences of the study participants. The researcher combined data
from interviews, classroom observations and photographs which provided rich, in-depth
descriptions of the experiences, perspectives and physical settings represented in the data.
Finally, the actual writing of the research report and interpreting the data in a word
narrative manner was done. The researcher used the study participants’ own words to
build the reader’s confidence that accurately represented the reality of the participants
and situation studied.

Similarly, the qualitative data which was collected using structured interviews was
analyzed using Statistical Package for Social Sciences (SPSS Version 18) by frequencies,
percentages, means and standard deviations. Demographic information of the twenty
learners with VI and their ten ToM were analyzed by frequencies and percentages
manually.
3.10 Logistical and Ethical considerations

The researcher addressed the logistics and ethical issues as they related to different phases of inquiry. The phases were: prior to conducting the study, beginning of the study, during data collection and data analysis and in reporting, sharing and storing the data (Creswell, 2014).

Prior to conducting the study, the researcher obtained a research introductory letter from Dean, Graduate school studies, Kenyatta University before she embarked on the study. The introductory letter further facilitated the acquisition of a research permit from the Ministry of Education through the National Council for Science and Technology in Nairobi (Orodho, 2009). This was done on-line. After acquiring the research permit, all the six (6) County Education Directors and the County Commissioners of the Research locale were served with copies of the research authorization and permit letters. The counties included: Kiambu, Meru, Siaya, Kisumu, West Pokot and Mombasa. One of the Counties (Kiambu) out of the six was the site identified for the piloting phase of the study.

The study involved a wide spread of locale (Appendix J) and it was impossible for the researcher to collect all the data required in the research project alone. Therefore, to address this issue, the researcher recruited a good and reliable one post-graduate student and trained him on the use of the research instruments (Orodho, 2009). Budgeting was planned in advance which ensured the research process did not lag behind because of inadequate financial planning.
The researcher sought consent from the heads of the institutions (sites) through making calls by phone as the special primary schools were far apart (Appendix J). For the case of the learners, the researcher sought consent from the school administrators’ explaining the purpose and nature of the study (Appendix H).

According to Lankshear and Knobel (2011), study participants in qualitative research thesis need to give informed consent with regard to their participation in the study. The author further stated, “Since consent must be informed, the researcher developed two types of statement for seeking consent from the ToM (Appendix F) and an introduction letter (Appendix E). Secondly, appropriate/convenient dates with the head teachers of the actual site visits for the collection of the data were agreed upon again through the phone.

At the beginning of the study, the researcher disclosed the real purpose of the study to the participants. When collecting the consent form for the study, the researcher did not force the participants to sign the informed consent forms which had been presented to them by the researcher and or research assistant. It was voluntary. The respondents were assured of anonymity through a cover letter accompanying the interview guides that had described the purpose of the study. The researcher did not include respondents’ names on the data collecting instruments. Confidentiality was also assured to the respondents at the beginning of the study.

The researcher and research assistant ensured there was minimal disruption in the selected sites through proper arrangements with the administration. The participants were
provided with instructions by the researcher that reminded them about the purpose of the study which ensured they were active through the process. It is highly unethical for researcher to withhold important results or to cast the results in a favourable light to the participants or researchers inclinations when analyzing the data (Creswell, 2014). To address this, the researcher during the phase of data analysis reported the full range of the findings, including the findings that were contrary to the themes.

The researcher gave credit for the work of other researchers and quotations marks indicated the exact words claimed from other researchers’ work. The participants were assured that once the data would be analyzed it would be kept for about six years and the audio recorded will be destroyed which would be prevent it from falling into the hands of other researchers who might misappropriate the data. The researcher also ensured nobody linked the collected data to specific subjects (Orodho, 2009).
CHAPTER FOUR

PRESENTATION OF FINDINGS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents findings, interpretation and discussion according to the objectives.

The study findings were based on four research objectives restated below as follows:

i. To identify types of Assistive Technology used for teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

ii. To determine factors influencing the use of Assistive Technology in teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

   a) To determine teacher competencies required for teaching Mathematics to learners with visual impairments using Assistive Technology.

   b) To determine the attitudes of learners with visual impairments towards learning Mathematics using Assistive Technology in special primary schools for learners with VI in Kenya.

   c) To evaluate the affordability of Assistive Technology used for teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.
iii  To identify strategies employed by teachers when using Assistive Technology to teach Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

iv  To investigate the role of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya.

4.2 Demographic Information

This section describes demographic characteristics of the participants 20 learners with VI, their 10 teachers of Mathematics (ToM) and 5 deputy head teachers in the 5 selected special primary schools for learners with VI in Kenya.

4.2.1: Demographic information for learners with VI in classes 7 and 8

The study was interested in gender and age in years of learners with VI in special primary schools. Table 4.1 present the findings.
Table 4.1

Age in years and gender of participant learners with Visual Impairment

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Gender</th>
<th>Male Std 7</th>
<th>Male Std 8</th>
<th>Female Std 7</th>
<th>Female Std 8</th>
<th>Frequency (n)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>-</td>
<td></td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>1</td>
<td></td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>-</td>
<td>1</td>
<td>-</td>
<td></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

From Table 4.1, the mean age, median and mode was 15.8 years, 16 years and 16 years respectively. The youngest learner with VI was 13 years while the oldest was 21 years who was a female in class eight. Majority of the male learners’ ages in both classes lay between 16 years and 17 years. From this observation, it is evident that majority of the participants had begun nursery school at advanced ages. Late diagnosis of their disabilities may have contributed to that scenario.
4.2.2: Demographic information of teachers of Mathematics

The study was interested in gender, condition, years of experience, highest level of education, training experience and other examinable subjects taught by ToM in special primary schools. Table 4.2 presents the findings.

Table 4.2

Demographics information of teachers of Mathematics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (n)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>70</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Condition of the teacher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low vision</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Blind</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Sighted</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Years of Mathematics experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>11 to 15 years</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Highest level of education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KCSE/O level</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>A-Level</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Training experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1 certificate</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Diploma</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Bachelor degree</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Masters degree</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Other examinable subjects taught</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Christians Religious Education</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Social studies</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Kiswahili</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>English</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>
According to Table 4.2 demographic data on ToM revealed that about three quarters of ToM were males (7) and nearly a quarter (3) were females. All the participants’ highest level of education was Kenya Certificate of Secondary Education or O Level. Further, 3 out of the 10 participants held master’s degree, one held bachelor’s degree, five held diploma in Special Needs Education and one held a P1 certificate. This implies that, in addition to the entire ToM having attained O Level education, majority of them had furthered their studies.

Half of the ToM participants reported 6 to 11 years of teaching experience in Mathematics. A third (3) of the teacher participants had less than 5 years of teaching experience in Mathematics. A fifth of the participants reported that they had 11 to 15 years of teaching experience. The study finding regarding the 20 participant learners and the 10 ToM who formed the study’s population, indicate they represented reliable participants for the study. Also, according to the findings, majority of the ToM combined the Mathematics with other subjects that did not involve field and laboratory work. The subjects were: social studies, Kiswahili, English and Christian Religious Education. This finding of combination of subjects did not agree with Wairimu (2013) findings who found out that, majority of ToM who had taught learners with low vision in integrated public primary schools combined with science.
4.3 Types of Assistive Technology used for teaching Mathematics to learners with Visual Impairments in special primary schools for learners with Visual Impairments in Kenya

The first task of this study was to find out the types of AT used for teaching Mathematics to learners with VI in special primary schools for learners with VI in Kenya. The deputy head teacher was asked to tick the AT that was available in their special schools. The data was analyzed at three levels namely; Low-Tech, Mid-Tech and High-Tech and the results are indicated in Table 4.3.
Table 4.3

*Types of Assistive Technology used in teaching Mathematics*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequencies (n)</th>
<th>percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-Tech</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuberithm slate and cubes</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Braillon papers</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Braille books and papers</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Braille rulers and protractors</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Slate and stylus</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Crammer abacus</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Tactual diagrams</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Tylor frame and types</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>Tactual symbols and signs</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Tactile graphic kit</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Mid-Tech</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talking calculators</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Talking books</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Talking clocks and watches</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Talking compasses</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>High-tech</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermoforms</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Braille writers</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Adapted computer systems</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Braille transcribers</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>Electronic travel devices</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronic Braille note-takers</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronic Braille writers</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Embossers</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

This study revealed that majority of the low-Tech AT was available to all the five special primary schools. The Low-Tech AT that were available to all the five special primary schools were; cuberithm and cubes, slate and stylus (Plate A, Appendix G), braillon
papers, braille books and papers, braille rulers and protractors (Plate B and C, Appendix G). Four fifth of the special primary schools had crammer abacus and tactual diagrams (Plate D and E, Appendix G), while three fifth 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 AT. Two fifth of the special primary schools had talking calculators (Plate F, Appendix G) 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 AT, all the special primary schools in Kenya had thermoforms and braille writers (Plate H and G, Appendix G), 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 (Plate I, Appendix G).

Further, the study sought to establish the actual AT that were available in the classroom while learners with VI were learning Mathematics. The researcher and research assistant observed nine 35 minutes Mathematics lessons and the results are indicated in Table 4. 4.
Table 4.4

*The actual Assistive Technology available in the classroom while learners were learning Mathematics*

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

The results indicate that the majority of the classroom lesson observations, learners with VI were observed using Low-Tech AT. 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 AT was observed, while only a third of the observations a High-Tech AT was 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 AT observed in the classroom lesson observations, five of the AT available was Low-Tech AT and one was a High-Tech AT. 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 AT, few of the Mid-Tech AT as well as few of the High-Tech AT. The AT 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 AT is less expensive and they require less or no training, while High-Tech AT 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 AT.

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 AT were available, while Mid-Tech AT and High-Tech AT were few. Most of the special primary schools had Low-Tech AT than High-Tech AT. Alkahtani (2013) carried study in Saudi Arabia and revealed that about ninety four (94%) of the teachers did not use or request AT while teaching. However, majority (9%) of the available AT were low-tech, seven percent (7%) Mid-Tech and four percent (4%) High-Tech AT.
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 VI 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 VI. Plate 4.D (Appendix G) represents tactual diagrams for teaching a three-dimension mathematical concept on Pythagorean Theorem. Slightly above half of the special primary schools had Mid-Tech AT. 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 AT is easy to operate electronically with minimum training.

Regarding availability of High-Tech AT for teaching Mathematics to learners with VI 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., who revealed that majority of High-Tech
AT were available, few of Mid-Tech AT and none of Low-Tech AT 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. Plate 4.G (Appendix G) represents three manual Braille machines which had been donated by a non-governmental Organization called Kilimanjaro Blind Trust Africa. 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 VI to type the answers after computation while a thermoform (Plate 4. H, Appendix G) is a high-tech AT that is used for duplicating Mathematical examination Braille papers for learners with VI.

Adapted computer systems were available in four fifth 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 VI 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 VI on it basic use after lessons. Ahmed (2009) highlighted examples of useful computer systems that learners with VI 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 VI.

Electronic Braille note-taker, electronic Braille machine and an embosser (modern high-tech AT) 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 AT 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 AT for Mathematics teaching cultivate positive attitudes towards the subject to a learner with VI 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 AT though majority of the AT were Low-Tech AT. The author further argued that, the availability of the AT usually guides the choice of problem solving strategy.
4.4 Factors influencing the use of Assistive Technology in teaching Mathematics to learners with Visual Impairments in special primary schools for learners with Visual Impairments in Kenya.

The study investigated on three factors that had influenced the use of AT in teaching Mathematics to learners with VI in special primary schools for learners with VI in Kenya. The factors were: teacher competency when applying using AT, attitudes of learners with VI towards learning Mathematics and affordability of AT in teaching Mathematics.

4.4.1 Teacher competencies when applying Assistive Technology in teaching Mathematics to learners with Visual Impairments in special primary schools in Kenya.

The study was to determine the teacher competencies when applying AT in teaching Mathematics to learners with VI in special primary schools in Kenya. Teachers were provided with a five scale statements to measure their preparedness, level of knowledge and number of workshops or in-service trainings attended regarding AT in the teaching of Mathematics to learners with VI. The results are indicated in Table 4.5.
Regarding teachers’ preparation to provide learners with AT services majority of the respondents (four fifths) reported that they were adequately prepared to provide AT services to learners with VI in their special primary schools. Poorly prepared and somewhat were reported by one tenth of the respondents. From the results, there was no
respondent who was not at all prepared nor extremely well prepared to provide AT services to learners with VI in their special primary schools.

Further, regarding the level of knowledge and skills about AT for ToM in the teaching of Mathematics to learners with VI in classes 7 and 8, half (5) of the respondents reported they had good knowledge. Nearly a third (3) of the teachers of Mathematics reported they had some knowledge about AT in the teaching of Mathematics to learners with VI in their special primary schools. Little knowledge and extensive knowledge ratings were each reported by one tenth of the respondents. There was no teacher of Mathematics who had no knowledge at all about AT.

Half of the respondents reported that they had attended one to two workshops or in-service training pertaining AT for teaching Mathematics to learners with VI. Slightly above a third reported they had attended three to four such training workshops. From the findings, a tenth of the teachers of Mathematics had attended 5 or more workshops and none of the respondent had not attended workshop or in-service training.

**Discussion**

The results of the study revealed that majority of the ToM were adequately prepared to provide Low-Tech AT services to learners with VI. These results were in contradiction with the studies carried out by Alkahtani (2013) and Ngatia (2015). Alkahtani (2013) revealed that three quarters of the participants who had participated in the study were poorly/ill prepared to provide AT services for learners with disabilities in their schools.
Ngatia (2015) found out that teachers in the secondary schools were not well adequately trained and experienced in the use of teaching technologies. Lack of trained skills in the use of Technology usually lowers teachers’ self confidence in teaching learners especially those with VI.

It is important to provide professional development to ToM in order to help them choose the most appropriate AT and instructional strategies to meet their educational goals (Young, 2008). Byrom (1997) argued that training is time consuming, but when teachers are trained on how to operate the AT, they play a vital role in the classroom. This result support Young (2008) who verified that a positive increase in learner’s scores when the teacher of Science integrated AT into the curriculum with suitable planning and proper training. On a National study of Technology’s impact on achievement in Mathematics, Wenglinsky of 1998 (as cited by Young, 2008 p.12) verified that teachers who had been trained on computers during the last five years were more likely to use computers in effective way than those who had not been trained on the computer skills. Chomba (2017) revealed that Braille teacher training curriculum that emphasizes Braille reading and writing is necessary. He also highlighted the importance to add Mathematics Braille training curriculum for the training of ToM.

Regarding the level of knowledge and skills about AT, the study also revealed that half of the ToM had good knowledge and nearly a third had some knowledge. The results of this study, contradicted with that of Alkahtani (2013) which indicated that nearly three quarters of the participants had little knowledge about AT. This was an indication that
Kenya as a developing country was aware that teachers’ knowledge is essential for effective use of AT in the education of learners with VI in all the special primary schools. The teachers’ knowledge of Technology is the most crucial factor in determining the success of technology in the classroom. More so, technology training is needed for the teachers to apply technology as a curriculum tool.

Half (5) of the participants reported that they had attended one to two workshops or in-service training pertaining AT for teaching Mathematics to learners with VI. Slightly above a quarter (3) reported they had attended three to four such training workshops. Participant code 4 reported the following:

I have taught Mathematics for about three years in this school. And since am Blind, I use my own knowledge to teach Mathematics. Nobody has further trained me on Assistive Technology devices especially the computer for teaching Mathematics. I only use an abacus. (Interviewed on 15/5/2017).

The conclusion here was that ToM lacked AT training skills especially on the Mid-Tech AT and High-Tech AT which may have enabled them to be better in handling these learners. Petty (2012) noted that the level of expertise and training of the teachers regarding technology use was one of the major challenge in the efficient use of AT in inclusive Education. UNESCO (2014) further noted that the use of AT were rarely covered in teacher training programmes, thus teachers typically did not acquire the skills to support learners with disabilities while teaching the learners. AT is introduced in the classroom at all levels as a tool for teachers to help deliver teaching instructions to all
learners including those with VI to workout Mathematics problems (Akpan & Beard, 2014) and therefore, ToM need to be trained early enough before they start teaching. More so, integrating technology into teaching provides learners with knowledge and skills of using the required hardware and software that translated across the curriculum (Grabe & Grabe, 2003). Effective training and usage of AT in teaching is importance since poor or improper usage of AT in the classroom will result under performance in educational programmes (Toit, 2015).

4.4.2 The attitudes of learners with Visual Impairments towards learning Mathematics using AT in special primary schools for learners with Visual Impairments in Kenya.

The study was to determine the attitudes of learners with VI towards using AT in learning Mathematics in special primary schools for learners with VI in Kenya. The study used Mathematics and Technology Attitudes Scale (MTAS) to measure five sub-scales namely: Mathematics confidence (MC), confidence with Technology (TC), attitude to learning Mathematics with Technology (MT), affective engagement (AE) and behavioural engagement (BE) (Pierce, Stacey and Barkatsas, 2007). To achieve this objective, the researcher analyzed the data in three variations of MTAS to explore: overall attitudes of learners with visual impairments, schools and gender difference.
4.4.2.1 Using the Mathematics and Technology Attitudes Scale to explore overall learners’ attitudes variations

The study explored overall learners’ attitudes towards learning Mathematics using AT in their special primary schools. To explore the first four (4) sub-scales (MC, TC, MT and AE) the researcher used a five likert-type scoring format. Learners with VI were asked to state the extent of their agreement levels on a five-point scale from strongly agree to strongly disagree which scored from 5 to 1. (Strongly agree = 5, Agreed = 4, Not sure = 3, Disagree = 2 and Strongly disagree = 1). The sub-scale of BA had a different but similar responses set. The researcher used a five-point scale namely: nearly always, usually, about a half the time, occasionally and hardly ever which scored from 5 to 1. Learners with VI were required to indicate the frequency of occurrence of different behaviours and the results are presented in Table 4.6
Table 4.6

*Overall learners' attitudes mean towards learning Mathematics using Assistive Technology*

<table>
<thead>
<tr>
<th>Statements</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident with Mathematics</td>
<td>4.05</td>
<td>0.759</td>
</tr>
<tr>
<td>I have a Mathematical mind</td>
<td>3.75</td>
<td>1.209</td>
</tr>
<tr>
<td>I can get good results in Mathematics</td>
<td>3.95</td>
<td>0.826</td>
</tr>
<tr>
<td>I am good in using computers</td>
<td>3.85</td>
<td>1.309</td>
</tr>
<tr>
<td>I am good in mobile phones</td>
<td>3.95</td>
<td>1.317</td>
</tr>
<tr>
<td>I would be more confident of my school work with a computer to help me</td>
<td>4.00</td>
<td>1.124</td>
</tr>
<tr>
<td>I like using Abacus for Mathematics</td>
<td>3.75</td>
<td>1.251</td>
</tr>
<tr>
<td>I learn more when using an Abacus in Mathematics</td>
<td>3.85</td>
<td>1.309</td>
</tr>
<tr>
<td>Mathematics is more interesting when using Abacuses</td>
<td>3.70</td>
<td>1.261</td>
</tr>
<tr>
<td>In Mathematics you get rewards for your effort</td>
<td>3.55</td>
<td>0.887</td>
</tr>
<tr>
<td>Learning Mathematics is enjoyable</td>
<td>3.95</td>
<td>1.099</td>
</tr>
<tr>
<td>I am interested to learn new things in Mathematics</td>
<td>4.10</td>
<td>0.788</td>
</tr>
<tr>
<td>If I make a mistakes, I work until corrected them</td>
<td>3.90</td>
<td>1.021</td>
</tr>
<tr>
<td>If I can’t do a problem, I Keep trying different ideas</td>
<td>3.95</td>
<td>0.887</td>
</tr>
<tr>
<td>I try to answer questions the teacher ask</td>
<td>3.95</td>
<td>0.510</td>
</tr>
</tbody>
</table>
Table 4.7

**Overall percentages of learners’ attitudes**

<table>
<thead>
<tr>
<th>Statements</th>
<th>SA F</th>
<th>SA %</th>
<th>A F</th>
<th>A %</th>
<th>NS F</th>
<th>NS %</th>
<th>D F</th>
<th>D %</th>
<th>SD F</th>
<th>SD %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident with Mathematics</td>
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<td></td>
<td>5</td>
<td>25</td>
<td>12</td>
<td>60</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I have a Mathematical mind</td>
<td></td>
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<td>6</td>
<td>30</td>
<td>8</td>
<td>40</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>15</td>
<td>1</td>
<td>5</td>
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<td>I can get good results in Mathematics</td>
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<td></td>
<td>4</td>
<td>20</td>
<td>13</td>
<td>65</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I am good in using computers</td>
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<td>8</td>
<td>40</td>
<td>6</td>
<td>30</td>
<td>3</td>
<td>15</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>10</td>
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<tr>
<td>I am good in mobile phones</td>
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<td></td>
<td>9</td>
<td>45</td>
<td>6</td>
<td>30</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>10</td>
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<tr>
<td>I would be more confident working with a computer</td>
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<td>0</td>
<td>2</td>
<td>10</td>
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<tr>
<td>I like using Abacus for Mathematics</td>
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<td>0</td>
<td>2</td>
<td>10</td>
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<td>10</td>
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<tr>
<td>I learn more when using an Abacus</td>
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<td>2</td>
<td>10</td>
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<td>10</td>
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<tr>
<td>Mathematics is more interesting when using Abacuses</td>
<td></td>
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<td>10</td>
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<tr>
<td>In Mathematics you get rewards for your effort</td>
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<td>25</td>
<td>3</td>
<td>15</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Learning Mathematics is enjoyable</td>
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<td>6</td>
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<td>0</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>5</td>
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<tr>
<td>I am interested to learn new things in Mathematics</td>
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<td>6</td>
<td>30</td>
<td>11</td>
<td>55</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hardly</td>
<td>Occasionally</td>
<td>About half</td>
<td>Usually</td>
<td>Nearly always</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I make a mistakes, I work until corrected them</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>15</td>
<td>2</td>
<td>10</td>
<td>9</td>
<td>45</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>If I can’t do a problem, I keep trying different ideas</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>11</td>
<td>55</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>I try to answer questions</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>90</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Key: **SA** - Strongly agree  **A** - Agree  **NS** - Not Sure  **D** - Disagree  **SD** - Strongly Disagree
The study established that the mean scores obtained by learners with VI regarding their overall attitudes towards Technology and Mathematics ranged from mean scores of 4.10 to 3.55. The mid-point of the scale was score 3 in which mean scores above 3 denoted that most of the participants strongly agreed as well as agreed with the items (statements) while mean scores below 3 denoted that the participant learners strongly disagreed as well as disagreed with the items (statements). A score of 3 denoted that the learners were either not sure or were undecided.

Table 4.7 indicates that all the results from the fifteen (15) items (statements) obtained mean scores above 3. The three (3) items (statements) that had the highest mean scores of above 4 were: “I am interested to learn new things in Mathematics, I am confident with Mathematics and I would be more confident of my school work with a computer to help me” which attained mean scores of 4.10, 4.05 and 4.00 respectively.

In the three (3) items (statements) for measuring confidence with technology (TC), the majority of the learners with VI strongly agreed with the three items. Regarding the item: “I am good in using mobile phones” (TC), nearly half of the study participants strongly agreed with the item. The items (statements) that had the lowest mean score (3.55) was: “in Mathematics you get rewards for your effort.” The three items (statements) for the scale of BE (Appendix B) examined what learners with VI did in a Mathematics lesson in classes seven and eight in special primary schools in Kenya. The study further revealed that the three (3) items (statements) which measured BE of the learners with VI had high scores ranging between 3.90 and 3.95.
4.4.2.2 Variations of Mathematics and Technology Attitudes Scale scores amongst special schools

In this section the researcher evaluated report of the responses from the different special primary schools on the Mathematics and Technology Attitudes Scale sub-scales which had fifteen items (statements). Frequencies, mean scores and standard deviations for each sub-scale by schools are presented on Table 4.8.
Table 4.8

*Variations of Mathematics and Technology Attitudes Scale scores amongst special schools*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics confidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>10.25</td>
<td>1.258</td>
</tr>
<tr>
<td>School B</td>
<td>13.00</td>
<td>1.826</td>
</tr>
<tr>
<td>School C</td>
<td>11.50</td>
<td>0.577</td>
</tr>
<tr>
<td>School D</td>
<td>12.75</td>
<td>0.957</td>
</tr>
<tr>
<td>School E</td>
<td>11.25</td>
<td>3.304</td>
</tr>
<tr>
<td>Confidence with Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>7.75</td>
<td>5.500</td>
</tr>
<tr>
<td>School B</td>
<td>12.25</td>
<td>2.986</td>
</tr>
<tr>
<td>School C</td>
<td>13.75</td>
<td>1.258</td>
</tr>
<tr>
<td>School D</td>
<td>12.00</td>
<td>1.414</td>
</tr>
<tr>
<td>School E</td>
<td>13.25</td>
<td>1.258</td>
</tr>
<tr>
<td>Attitudes to learning Mathematics with Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>12.50</td>
<td>1.000</td>
</tr>
<tr>
<td>School B</td>
<td>8.50</td>
<td>4.933</td>
</tr>
<tr>
<td>School C</td>
<td>13.25</td>
<td>0.957</td>
</tr>
<tr>
<td>School D</td>
<td>10.00</td>
<td>4.690</td>
</tr>
<tr>
<td>School E</td>
<td>12.25</td>
<td>41.93</td>
</tr>
<tr>
<td>Affective engagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>11.50</td>
<td>3.109</td>
</tr>
<tr>
<td>School B</td>
<td>13.00</td>
<td>0.816</td>
</tr>
<tr>
<td>School C</td>
<td>11.25</td>
<td>0.500</td>
</tr>
<tr>
<td>School D</td>
<td>9.75</td>
<td>3.096</td>
</tr>
<tr>
<td>School E</td>
<td>12.50</td>
<td>1.732</td>
</tr>
<tr>
<td>Behavioural engagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>14.00</td>
<td>0.000</td>
</tr>
<tr>
<td>School B</td>
<td>12.00</td>
<td>0.816</td>
</tr>
<tr>
<td>School C</td>
<td>9.75</td>
<td>2.062</td>
</tr>
<tr>
<td>School D</td>
<td>11.50</td>
<td>12.91</td>
</tr>
<tr>
<td>School E</td>
<td>11.75</td>
<td>1.258</td>
</tr>
</tbody>
</table>
Table 4.8 revealed that the overall scores ranged from 14.00 to 7.75. In the first sub-scale; Mathematics confidence, all the learners with VI in the four schools had a positive attitude whose overall range of scores was 13.00 to 10.25. The three (3) items (statements) that measured Mathematics confidences in the current study were: “I am confident with Mathematics, I have a Mathematical mind and I can get good results in Mathematics”. However, learners with VI in school B were more positive with a mean score of 13.00 and standard deviation of 1.826 while learners in school A were less positive towards Mathematics confidence with a mean score of 10.25.

Regarding the second sub-scale on confidence with technology, the mean scores ranged from 13.75 to 7.75. The three (3) items (statements) that were used to measure attitudes to technology by learners with VI included: “I am good in using computers, I am good in using mobile phones and I would be more confident in my school work with a computer to help me”. School C had the highest score of 13.75 and standard deviation of 1.258 while school A had the lowest score of 7.75 and standard deviation of 5.500 on the sub-scale. Apart from school A all the learners from the other three schools had a positive attitude towards the confidence with Technology.

The third sub-scale of Mathematics and Technology Attitudes Scale analyzed attitudes towards the use of technology for learning Mathematics. The study revealed that the mean score range of this variable was from 13.25 to 8.50. The three items (statements) that were used to measure attitude towards the use of Technology for learning
Mathematics included: “I like using abacus for Mathematics, I learn more when using an abacus in Mathematics and Mathematics is more interesting when using abacus” (Appendix B). Table 4.8 indicates that in the three schools (C, A, E and D), the learners with VI in classes seven and eight had positive attitudes towards the use of Technology for learning Mathematics. Learners from school C were more positive as compared with the other three schools with a mean of 13.25 and standard deviation of 0.957. School C was noted to have most of the AT (Table 4.8) that were available in the selected study sites which may be had contributed to this result. Also school C had the ToM who had the highest teaching experience of between 11 and 15 years who was a low vision.

The fourth sub-scale of Mathematics and Technology Attitude Scale was affective engagement which examined how learners with VI felt about Mathematics. Three items (statements) that were used to measure affective engagement included: “In Mathematics you get rewards for your effort, learning Mathematics is enjoyable and I am interested to learn new things in Mathematics” (Appendix B). The range score was from 13.00 to 9.75. The findings of the study revealed that, all the learners with VI in the four selected schools had positive attitudes, but learners in school A were more positive as compared with learners from the other schools with a mean score of 14.00 and standard deviation of 0.000.

The last sub-scale was behavioural engagement which examined how learners with visual impairments in classes seven and eight behaved in the learning of Mathematics. The three items (statements) that measured behavioural engagement included: “If I make a mistake,
I work until I have corrected them; If I can’t do a problem I keep trying different ideas and I try to answer questions the teacher asks” (Appendix B). The mean scores for BE ranged from 14.00 to 9.75. The result regarding BE indicated that, all the learners with VI in the four selected schools had positive attitudes towards behavioural engagement. Learners from school A were more positive as compared with other schools with a mean of 14.00, while learners in school E had the least positive towards behavioural engagement.

4.4.2.3 Variations of Mathematics and Technology Attitudes Scale scores on gender difference

Mathematics differences in attitudes on gender have long been of interest as early as it was reported by Fennenma and Sherman (1976). Thus the question of the present study aimed at establishing whether the use of AT to learn Mathematics exacerbates difference in learners with VI in special primary schools in Kenya. Gender, mean scores and standard deviations are presented on Table 4.9 on the five sub-scales.
Table 4.9:

Variations of Mathematics and Technology Attitudes Scale scores on gender difference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics confidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12.60</td>
<td>1.713</td>
</tr>
<tr>
<td>Female</td>
<td>10.90</td>
<td>1.853</td>
</tr>
<tr>
<td>Confidence with Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12.70</td>
<td>3.234</td>
</tr>
<tr>
<td>Female</td>
<td>10.90</td>
<td>3.542</td>
</tr>
<tr>
<td>Attitudes to learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics with Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11.50</td>
<td>3.837</td>
</tr>
<tr>
<td>Female</td>
<td>11.10</td>
<td>3.755</td>
</tr>
<tr>
<td>Affective engagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12.60</td>
<td>1.350</td>
</tr>
<tr>
<td>Female</td>
<td>10.60</td>
<td>2.547</td>
</tr>
<tr>
<td>Behavioural engagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11.50</td>
<td>1.900</td>
</tr>
<tr>
<td>Female</td>
<td>12.10</td>
<td>1.729</td>
</tr>
</tbody>
</table>

The mean scores ranged from 12.70 to 10.60. The maximum score was 15 and the minimum score was 3. Mid-point was 9. This was an indication that; majority of the learners with VI overall (both males and females) had positive attitudes towards Mathematics and Technology. The mean scores by gender illustrated in Table 4.9 reveal that: despite both genders having a positive attitude towards Mathematics and
Technology, boys had higher mean scores than girls on the four items i.e: MC, TC, MT and AE. The greatest differences were items: TC, MC and AE with a mean score difference of 1.8, 1.0 and 1.7 respectively. The difference on MT was minimal on 0.4. The girls had higher mean score on BE than boys.

**Discussion**

Regarding overall attitudes mean score of learners with VI was between 3.55 and 4.10. The current study established that majority of the learners with VI in special primary schools had positive attitudes towards learning Mathematics because all the sub scales scores were above three. The three (3) items (statements) that had the highest mean scores of above 4 were: “I am interested to learn new things in Mathematics, I am confident with Mathematics and I would be more confident of my school work with a computer to help me” which attained mean scores of 4.10, 4.05 and 4.00 respectively.

This finding support Mutai (2010) who conducted a study to determine the opinions of secondary school students towards learning and performance in Mathematics which revealed concurrence results. His results indicated that secondary school students had a positive attitude towards Mathematics as a subject. When students are aware that Mathematics is an important subject and their attitudes which they acquire from their previous experiences in the subject, parents, peers and teachers usually influence their learning of the Mathematics. Mutai (2010) argued that unfavourable attitudes towards
learning Mathematics should be curtailed early enough before students give up in learning of the subject.

In the three (3) items for measuring confidence with technology (TC), the majority of the study participants strongly agreed with the three items. On the item, “I am good in using mobile phones” (TC), nearly half (9) of the study participants strongly agreed with the item.

Galbraith and Haines (1998) defines,

Technology confidence as evidence by students who feel self-assured in operating computers, believe they can master computer procedures required of them, are more sure of their answers when supported by a computer and in cases of mistakes in computer work are confident of resolving the problem themselves.

(Page: 278).

This was an indication that despite the fact that the study participants were Blind, they were aware and had interest on what was available for the digital era; use of computers and the mobile phones. The item that had the lowest score (3.55) was “in Mathematics you get reward for your effort.” This implies that, most of the time the study participants were not motivated during Mathematics lesson. Motivation is the key to learners increased ability to learn and promote academic achievement (Flanagan, 2008). In addition, this finding concurred with that of Gathwait and Weller (2005) who carried out a study to examine the effects of using laptops in the classroom. The study found out that
students were more willing to think through conceptual mistakes and made the requisite changes on their laptops.

The current study also established that the three items (statements) for the scale of BE which examined what learners with VI did in a Mathematics lesson in classes seven and eight in special primary schools in Kenya ranged between 3.90 and 3.95. This was an indication that learners had high attitude. Galbraith and Haines (1998) noted that a learner who scores highly on the scale of Mathematics engagement prefer to work through examples rather than learning the given materials by the teacher. Also, such a learner likes testing understanding through exercises in trying to link new knowledge to existing knowledge and reviews their work regularly. Therefore, in this note, it clear those learners with VI in special primary school in Kenya for learners with VI preferred to work out Mathematics problems through examples, and probably examples which are given in their Braille text books for Mathematics. To this extent, the researcher further explored the special primary schools for learners with VI in Kenya variations.

Comparing the demographic information of ToM who had been interviewed in the two schools (B and A) was that: in school B the two male ToM were VI, one was a holder of a Diploma in education and the other had a P1 certificate. Both had less than five years of teaching experience in Mathematics while in school A where learners’ positive attitude was least, the two ToM were: holders of a Master’s Degree, were sighted and low-vision sight. Their teaching experience of Mathematics was between six to ten years. This was
probably because ToM from school B with VI had counselled their learners with VI on the importance of learning Mathematics.

Moreover, learners from school B were noted to have a negative attitude towards the use of Technology for learning Mathematics while the same learners had more positive attitudes towards Mathematics confidence as compared with the other four selected schools. From the demographic information of the ToM, school B was the only school where the two ToM were VI (Appendix K) and probably this may be the reason for this result as the teachers had no readers who could have guided the learners with VI. This result did not support Kochung (2003) who pointed out that the government of Kenya through the Ministry of Education gives readers allowance of KSH 15,000 to teachers with VI.

The last sub-scale was on overall behavioural engagement which examined how learners with visual impairments in classes seven and eight behaved in the learning of Mathematics. The three items (statements) that measured behavioural engagement included: “If I make a mistake, I work until I have corrected them; If I can’t do a problem I keep trying different ideas and I try to answer questions the teacher asks” (Appendix B). The mean scores for BE ranged from 14.00 to 9.75. The result regarding BE indicated that, all the learners with VI in the four selected schools had positive attitudes towards behavioural engagement. But learners from school A were more positive as compared with other schools with a mean of 14.00. This was an indication that learners with VI in
all the five selected study sites (schools) preferred to work through the examples given by their ToM and also from the examples that were given in their primary Mathematics text books.

Regarding attitudes of learners with VI on gender, these results agreed with the findings of Pierce et al., (2005) who found out that, boys had higher scores than girls in four items which were: TC, MC, MT and AE, where the greatest differences occurred on TC and MC. The girls had higher scores on BE, the same with the current study. At the same time, the findings contrasted with (Wairimu, 2013 & Njoroge, 2011) as they are reviewed in the review of literature. Wairimu (2013) established that learners with low vision had negative attitudes towards Mathematics from integrated public primary schools in Nairobi City County. In addition, Njoroge (2011) also found out that learners in regular class six in Nairobi City County had a negative attitude towards Mathematics as a subject. More so, attitudes largely determine what the learners learn in which case, it may hinder or enhance the learning of the subject.

In the past, attitudes towards disability was associated with poverty, ignorance and religion, but today, we no longer have this excuse of poverty and ignorance as we are relatively well educated and prosperous society. Pierce et al., (2005) further distinguished attitudes from beliefs in that, attitudes are moderate in duration, intensity and stability and have an emotional content while beliefs become stable and are not easily changed. Positive attitudes towards learning Mathematics are necessary ingredients in Mathematics
education at all levels. Bottom (1983) pointed out that when learners’ attitudes are negative towards a particular subject, all the stakeholders concerned should be examined.

### 4.4.3 Affordability of Assistive Technology used for teaching Mathematics to learners with Visual Impairments

The study was to find out how affordable was AT in teaching Mathematics to learners with VI in special primary schools in Kenya. The ToM were asked to indicate possible reasons why teachers of Mathematics did not integrate AT while teaching the subject. The data was collected and the findings are presented on Table 4.10.

**Table 4.10**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of respondents</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cost of AT</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>No extra time on the time table to teach AT skills</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Costly maintenance</td>
<td>8</td>
<td>80</td>
</tr>
</tbody>
</table>

The study findings revealed that all the respondents reported high cost of AT and no extra time on the time table to teach AT skills as reasons for teachers of Mathematics not
integrating AT while teaching the subject. Costly maintenance of AT was reported by
four fifth of the respondents.

**Discussion**

This study finding on high cost of AT support Kochung (2003) and Muigai (2017).
Kochung (2003) found out that the average cost of educating a learner with VI in a
boarding special school was Ksh 32000 per year. Further, Kochung noted that learning
and teaching devices was allocated Ksh 6000. Recently, Muigai (2017) revealed that the
cost of one Braille machine cost Ksh 75,000 for an individual learner and a thermoform
Ksh 300,000. Thermoform is a high-tech machine that is used for duplicating Brailled
papers for use by learners who read through touch.

Plate 4.K (Appendix G) represents a pack of broken down thermoform and a perforating
machine which had broken down. Participant code 4 (Appendix G) pointed out the
following with regard costly maintenance of AT:

When devices such as the thermoform and braille typewriters broke down, their
spare parts are only available in the developed countries such as Britain, United
States of America. Fare to travel to these countries is very high and sometimes
there in nobody to send. Therefore, when they broke down they are kept in our
store.

Plate 4.L (Appendix G) represents a broken abacus that a learner with VI was using to
compute Mathematics skills. The teacher of Mathematics who was teaching a lesson by
the time of collecting this data was visually impaired and had no reader. Thus, the teacher was not aware that the learner had a broken down abacus. This study disagree with Kiambati (2016) who found out that most of students with VI used their colleagues who were sighted to read for them.

These results concurred with a study carried out by Muigai (2017) who investigated on the historical challenges that the education for learners with VI had faced between 1945 and 2013. The challenges that were revealed by Muigai (2017) that had greatly affected the education of learners with VI were high cost of instructional materials and costly maintenance. The cost of one thermoform by the time of collecting the data was Ksh 300,000 and a brailler type writer was Ksh 75,000. The higher the cost of the AT, the higher the cost of maintenance of the AT.

Participant code 1 with an experience of between eleven (11) and fifteen (15) years of teaching Mathematics pointed out the following with regard to inadequate Braille text books for Mathematics due to the high cost:

Today, the Braille text books for Mathematics are not enough. For example, in my class we have two (2) Braille text books for Mathematics which is shared among six (6) learners with VI. These learners with VI read Mathematics questions through touch, so sometimes am forced to read for them the questions in print. Other times, I do request their classmates with low vision to read for them. This
disadvantageous these learners especially during exams time because the learner must read, understand and calculate the problems independently. Last year, the Kenya Certificate of Primary Education (KCPE) mean score for Mathematics was thirty-nine (39) percent. This can be evident if one may request the deputy head teacher to allow the perusal of last year (2016) results for class eight and compare the results for the five examinable subjects. (Interviewed on 10/5/2017).

This sentiment clearly showed the kind of difficulties learners with VI faces when learning Mathematics in special primary schools in Kenya. This finding coincides with Kiambati (2016) who carried out a study at Kenyatta University Post Modern Information Centre exploring the challenges faced by students with VI in accessing electronic information resources. Kiambati (2016) revealed that most of the learners with VI were not able to retrieve and use e-resources on their own. Inadequate Braille text books for Mathematics were a challenge due to their high cost. Another participant code 2 also with an experience of between eleven (11) and fifteen (15) years in teaching Mathematics, reported the following narrative regarding inadequate Braille text books for Mathematics:

Learners, who are sighted, have an advantage as the ratio is 2:1 (i.e. two learners share one text book) which is the recommended government ratio. One print Mathematics text book for class 8 sighted learners’ costs Ksh 618, while one volume of Braille text book costs Ksh 500 and a learner who is Blind in class 8 requires 5 such volumes which amounts to Ksh 2,500 in order for such a learner to learn Mathematics in class eight (Interviewed on 10/5/2017).
The conclusion here was that learners with VI lack enough Mathematics braille text books in the classroom when learning Mathematics. A great contribution of this plight was lack of funds to purchase adequate braille text books. Moreover, this greatly affected the learning of learners with VI in special primary schools in Kenya. A sighted learner in class eight requires one print Mathematics text book while a learner with VI in the same class requires five (5) volumes of Braille Mathematics text books. Plate 4.M (Appendix G) represents the five volumes of Braille Mathematics text books for a learner with VI and a print Mathematics text book for a sighted learner.

After interviewing all the key participants at one of the study site, the researcher visited the deputy head teacher’s office for analysis of year 2016 KCPE results. Table 4.11 represents the KCPE results (mean scores) for the five examinable subjects as well as the total number of As, Bs, Cs, Ds and Es per subject.

**Table 4.11**

*The Kenya Certificate Primary Education 2016 results*

<table>
<thead>
<tr>
<th>Subject</th>
<th>As</th>
<th>Bs</th>
<th>Cs</th>
<th>Ds</th>
<th>Es</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>2</td>
<td>3</td>
<td>13</td>
<td>5</td>
<td>1</td>
<td>50.95</td>
</tr>
<tr>
<td>Kiswahili</td>
<td>4</td>
<td>11</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>60.38</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>15</td>
<td>0</td>
<td>38.5</td>
</tr>
<tr>
<td>Science</td>
<td>0</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>52.13</td>
</tr>
<tr>
<td>Social Studies</td>
<td>0</td>
<td>8</td>
<td>12</td>
<td>1</td>
<td>3</td>
<td>52.00</td>
</tr>
</tbody>
</table>
Table 4.11 is clear that in all the subjects, apart from Mathematics, attained fifty 50% mark and above. Majority (15) of the learners with VI in Mathematics scored below half mark, that is, fifty percent (50%) and none of the learners scored grade A. This means that, in addition to learners with visual impairments’ positive attitudes towards the use of AT, provision of adequate Braille text books for Mathematics is necessary for them to attain better grades in Mathematics. In addition, this was an indication that there were several factors that had contributed to the poor performance in Mathematics.

4.5 Strategies employed by teachers when using Assistive Technology to teach Mathematics to learners with Visual Impairments in special primary schools in Kenya.

The third task of this study aimed at finding out strategies that were employed by ToM when teaching Mathematics to learners with VI using AT in special primary schools in Kenya. The researcher observed the nine (9) ToM. Each teacher was observed once while teaching a thirty-five (35) minutes Mathematics lesson in classes seven and eight. Five teachers of Mathematics were observed from class seven while four ToM in class eight were observed. The findings were analyzed in two levels namely; teaching strategies and instructional strategies. The results on teaching strategies are presented on Table 4.12
Table 4.12

*Teaching methods for teaching Mathematics*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency (n)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question and answer</td>
<td>9</td>
<td>100.0</td>
</tr>
<tr>
<td>Discussion</td>
<td>9</td>
<td>100.0</td>
</tr>
<tr>
<td>Tutorials</td>
<td>8</td>
<td>88.8</td>
</tr>
<tr>
<td>Group work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer tutoring</td>
<td>1</td>
<td>11.1</td>
</tr>
<tr>
<td>Cooperative learning</td>
<td>0</td>
<td>00.0</td>
</tr>
<tr>
<td>Collaborating</td>
<td>0</td>
<td>00.0</td>
</tr>
<tr>
<td>Constructivist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstration</td>
<td>9</td>
<td>100.0</td>
</tr>
<tr>
<td>Experimental</td>
<td>0</td>
<td>00.0</td>
</tr>
</tbody>
</table>

Table 4.12 reveals that all the respondents were observed applying question and answer and discussion, while slightly above four fifth were observed using tutorials. One nineth was observed using peer tutoring and none of the respondents applied cooperative learning and collaborative teaching. All the respondents used demonstration teaching method and none used experimental teaching methods.

This study further investigated on strategies employed by ToM while teaching learners with VI using AT throughout the lesson. The results are presented on Table 4.13.
Table 4.13

*Instructional strategies for teaching Mathematics*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (n)</th>
<th>Percentages (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of technology</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>Stating objectives</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>Use of manipulations</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>Learner’s engagement</td>
<td>4</td>
<td>44.4</td>
</tr>
<tr>
<td>Use of humor and fun</td>
<td>3</td>
<td>33.3</td>
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<tr>
<td>Real-world relevance</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Games</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Content reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>22.2</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>77.3</td>
</tr>
</tbody>
</table>

Regarding instructional strategies, all the teachers of Mathematics were observed using technology, stating objectives at the beginning of the lesson and using manipulations. Nearly half of the ToM were observed engaging learners and a third used humor. Finally, none of the ToM was observed using Games and real-world relevance. Slightly above three quarter of the classroom observation learners were not allowed to refer to the content, while slightly below a quarter were allowed to refer to the content as the lesson was going on.
Discussion

The findings regarding teaching methods in this study revealed that ToM combined several teaching methods while teaching Mathematics to learners with VI. Teaching methods that were observed were; demonstration, question and answer, tutorials, demonstration and peer tutoring. These findings somehow concurred with Mugo (2007), Mutai (2010) and Wairimu (2013). This is why Alexander (2010) argued that the more teaching methods a ToM is able to employ, the more likely that they will be successful with the highest percentage of learners. Learners with VI need to be exposed to peers through symposiums/bench markings especially those from good performing institutions and learners (Adera, 2004). By so doing, learners with VI share new ideas and experiences which in turn develop positive attitudes towards Mathematics hence, improving the performance of the subject. Further, Mutai (2010) noted that students seemed to like Mathematics more when given individual attention by their ToM as well as in small group discussions to enable them to clearly understand concepts. Some methods of teaching are effective for showing gains in short-term where other methods of teaching are better for increasing and retaining gains in long-term Hiebert and Grouws (2003).

The finding of this study was in line with Kautz (2016) who categorized teaching methods into three groups namely: direct instructions, group work and constructivist. A direct instruction is also referred as lecture-based instruction which include tutorials, discussion, recitation, seminars, workshops and observation (Kautz, 2016). Group work
is when learners work together as a group or in partners. Group work involves partner work, cooperative learning and collaborative learning. An example of a partner work is Think-Pair-Share which involves sharing ideas with a partner enabling him/her to assess new ideas before presenting the ideas to a larger group (Azlina and Nik, 2010). In group work, the teacher acts as a manager who oversees the project that learners complete. In cooperative learning learners are grouped into small groups where they work together to accomplish the given task (Slavin, 1987). Cooperative teaching works effectively with computers and had a positive effect on Mathematics anxiety of low achieving learners (Mavarch, Silber & Fine 1991).

This study revealed that none of the teachers was observed using constructivist teaching which requires learners to do experiment and use the findings of those experiments to discover the rules of Mathematics, thus reaching to conclusions (Piaget, 1967). In constructivist teaching the ToM allows his/her learners to manipulate blocks and let them come up with their own way of finding area of a circle, as opposed to giving learners the formula. Alexander (2010) argued that constructivist teaching has a positive impact on Mathematics anxiety, autonomy and self-efficacy if the right environment and if the teachers are well trained about constructivism.

Regarding instructional strategies, in all the nine (9) classroom lesson observations, ToM were observed using AT while teaching Mathematics. This result concurred with Mugo (2007) who noted that learners with VI have no sight and since the eye is the most important gateway to the mind, AT is necessary for compensation of their sight. The
author further emphasized that, the visual impression is the one that can be easily interpreted and learners with VI lack the visual impressions and thus, more attention and efforts ought to be directed towards the provision of appropriate AT and availing of qualified personnel in and out of the classrooms. Further, Barghoutti (1973) argued that learners learn and remember more from what they see and they also get much more information about the subject through sight than through our ears, smell, taste and touch.

All the nine (9) teachers were observed introducing the topics by stating the objective and demonstrating to learners with VI on how to manipulate the AT. This finding concurred with Wairimu (2013) who revealed that majority of ToM were observed employing demonstration method of teaching while teaching learners with VI. Demonstration method of teaching engages multiple senses of the learner with VI and can help to ensure learning and understanding while the ToM emphasizes important points or concepts Tebo (2009). Tebo (2009) further pointed out that demonstrations are good for attracting attention of learners with VI.

In four classroom lesson observations, the four ToM were VI and they did not have readers. Thus, once they demonstrated on how to manipulate the AT, nobody confirmed that the learners with VI manipulated the AT correctly. Teachers of Mathematics should state objectives at the beginning of the lesson and not simply describe the upcoming learning activity (Perrott, 2014) as stating the objective at the beginning of a lesson make learners expectations clear Wong and Wong (2001).
In all the nine (9) classroom lesson observations, none of the ToM was observed visiting learners individually to demonstrate on how to manipulate available AT and also stating the objectives at the beginning of the lesson. Half of the teachers were observed using question and answer method while teaching learners. This was an indication that slightly above half of the learners with VI were engaged throughout the lesson. The findings did not concur with that of Kautz (2016) where all the four (4) instructors recorded on video engaged their students throughout the lesson by calling on students to answer mathematical questions and to work problems at the whiteboard. Hartman of 2001(as cited by Kauzt 2016) advocates on planning what will be taught, demonstrating to the learners and illustrating the techniques for modelling.

A game motivates learners enabling them to perceive a Mathematical task as fun and entertaining which was not observed in this study. Learners with VI observe items which are accessible to them through use of their remaining senses namely: by feeling, listening, tasting, smelling and using the remaining vision (Ndurumo, 1993). Use of games can be paper-based, manipulative-based, and technology-based or board games. A game motivates learners thus they perceive a Mathematical task as fun and entertaining (Kautz, 2016).

Teaching with manipulative refers to a technique that teachers of Mathematics use when teaching concepts that are more abstract to their learners (Moyer, 2001). Kautx (2016) stated that “using items such as geometric shapes, graphs and number lines to touch and manipulate helps learners to visualize representations and understand concepts in a more
concrete way” (p. 38). Further, the author observed that object concept for a learner with VI begins to emerge between three (3) years to five (5) years, while a learner who is sighted develops the concept of objects by two (2) years. This delay causes the learner with VI to be delayed in the acquisition of spatial concepts and their causality.

At the stage of manipulating the AT as the classroom observation sessions progressed, all the learners with VI were observed using the sense of touch while interacting with the AT. This is in agreement with Piaget (1967) who argued that learners including those with visual impairments learn best when they are actively interacting with the physical environment and seek solutions for themselves which could increase the rate of development because the opportunity to touch and manipulate objects help them to think in more ways that are complex.

This study also established that slightly above three quarter of the classroom observation sessions, learners with VI were not allowed to refer to the content in the Braille Mathematics text books. Instead, the learners with low vision were appointed by ToM to read Mathematics problems in print as the learners with VI listened. These results of learners with low vision reading on behalf of learners with VI concurred with that of Mugo (2013). Mugo (2013) carried out a study at Kenyatta University to investigate on how students with VI accessed the books and other reading materials in the postmodern library. Mugo’s study of 2013 noted that students with VI had to depend on their sighted readers to read the materials for them since it was in print”. In the remaining quarter of the classrooms observation sessions, learners with VI were allowed by ToM to refer to
the content themselves through touch. This is why Ndurumo (1993) noted that a learner with VI reads with one hand using the fingers to touch and moves from left to right the same as reading by sight. Braille reading refers to reading by touching the raised dots in the cells. This finding was in line with the Theory of Didactical situations which advocates on learning using combination of more than one senses.

4.6 The role of Assistive Technology on teaching Mathematics to learners with Visual Impairments in special primary schools for learners with Visual Impairments in Kenya.

The last task in this study was to establish the role of AT on teaching Mathematics to learners with VI in special primary schools in Kenya. Teachers were asked to indicate the role AT plays in teaching Mathematics. The data was collected and the findings are presented on Table 4.14.
### Table 4.14

*The role of Assistive Technology in teaching Mathematics*

<table>
<thead>
<tr>
<th>Role of Assistive Technology</th>
<th>Number of respondents</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve Mathematics performance</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>Make Mathematics real</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Increased participation of learners</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Increases speed of accuracy</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Enhance learner’s interests in developing information technology</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Exposed the learner to AT</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Develop learner’s confidence</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Develop learners’ self-interest</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

This study revealed that majority of the respondents (80%), four fifth reported that AT help to improve Mathematics performance and three fifth reported AT makes Mathematics real and increases learners’ participations. Fifth of the teachers of Mathematics reported AT increases speed of accuracy and it enhances learners interest in developing information technology. Out of the ten sampled teachers of Mathematics, one
tenth of them reported that AT exposes the learner with VI to AT services, AT help to develop learner’s confidence and self-interest.

**Discussion**

In the current study the entire ToM agreed that AT is useful in teaching Mathematics to learners with VI. Participant **code 12** (Appendix K) had this to report on the importance of AT in teaching Mathematics to learners with VI:

> Assistive Technology has highly improved both fast and slow learners with visual impairments since they handle both simple and complex Mathematical problems through on-line search *(Interviewed 19/5/17).*

The findings are consistent with other several studies revealed in the literature review of this study (Rowe, 2014; Flanagan, 2008; Virgile, 2008). Rowe was of the view that AT aided students with VI to: “scan and read mathematical equations, access and produce tactile representations of the most complex graphs and pictures, produce their own work in a variety of formats such as audio, Braille and Latex code and increase their learning capacities through sharing the knowledge. Rowe (2014) further noted that, the Technology facilitated the crucial sharing of materials between the teacher and the learner, interaction, increased learning potential and improved access to resources.

Majority of ToM in the current study were observed to be in the first two stages of AT integration in the classroom with exception of two ToM who had reached stage three (adaptation). The findings of this study concurred with (Young, 2008) from the
University of Wisconsin–Stout who conducted a study on using Technology tools in the public school classroom. The purpose of his study was to investigate whether integration of AT increased motivation, learners’ attendance and grades in the classroom by administering a survey to teachers and learners. In addition, the researcher of the current study observed that in all the nine lessons observed learners with VI were provided with AT and ToM stated the objective at the beginning of the lesson, demonstrated on how to manipulate the device which indicated that majority of ToM were in adoption stage (third stage). According to Young (2008) AT is not the teacher, rather it is a tool that’s used by the teacher to widen the learner’s with VI reach and should be complement and enhance what a teacher does naturally.

The current study was not in line with Dwyer (1994) who noted that educator typically experiences five stages in order to fully integrate AT in the classroom. The five stages include: entry, adoption, adaptation, appropriation and invention stage. Entry stage is the first stage which is characterized by ToM having doubts about AT as changes begin in their classrooms. The second stage is adoption which is identified by ToM using AT to support traditional text-based drill and practice. In adoption stage, when the ToM integrates AT effectively into the curriculum, learners’ attendance increases. Adaptation is the third stage where ToM thoroughly integrates AT into traditional classroom practice, learners produce more work faster, they are more actively engaged in learning and their productivity increases.
The fourth stage is appropriation where ToM and learners use appropriate AT. In this stage learners highly involve AT skills and they can learn on their own. Also ToM gains a perspective on how they can change the learning experience and finally learners work patterns and communication become collaborative rather than competitive. Invention is the last stage an educator experiences in order to integrate fully the AT. Invention stage ToM view knowledge as something learners construct rather than something that can be transferred and view learning as creative, an active and socially interactive process.

The Technology observation showed that both learners with VI and their ToM were motivated to use AT in the beginning. However, with lack of adequate time to practice and lack of readers to assist ToM who were VI to manipulate the device, learners with VI motivation decreased quickly and they went back to traditional routines of guess work. ToM complained on limited time to cover the Mathematics syllabus thus they did not have time for individualized attention. None of the ToM in this study reached the fifth stage (invention stage).

The current study finding concurred with that of Young (2008) who found out that majority of teachers who participated in his study were in two stages with exception of four teachers who had reached stage four. Majority of teachers were in the first stage (entry stage) where they doubted about integrating Technology due to low use of Technology. Teachers were motivated to use the Technology when they first received the Technology, however, due to lack of proper training and adequate time to practice the new AT skills, motivation decreased quickly where teachers returned to the traditional
teaching routines. The author concluded that just as pencils do not replace crayons but rather, provide additional means of expression, AT should not replace other teaching methods but add to the AT available to learners to explore, communicate and create.

Flanagan (2008) revealed that, the graphing calculator increased student achievement and interest in the solving equations. More so, Virgile (2008) established that, in the area of Mathematics, the use of AT enabled the learners with learning disabilities to make proper calculation and computations. AT provide children with disabilities with equal opportunities to participate in active environments with predictive activities that are aligned to their abilities (Alkahtani, 2013). AT provide learners with VI with equal opportunities to participate in active environments with predictive activities that are aligned to their abilities.

The finding of the study further corroborated with (Adebisi, Liman & Longpoe, 2015) from Nigeria a developing country who highlighted importance of AT to learners with learning disabilities. The three authors noted AT assisted learners with learning disabilities to: increase independence in academic and employment tasks, participate in the classroom, gain access to the full variety of educational options, master academic tasks that they find difficult, work side by side with peers, secure high levels of independence learning and participate in community and recreational activities. In addition, Scherer (2004) argued that availability of AT assist teachers in improving the functional capacities of their learners by increasing learners’ participation in learning opportunities and involvement in activities. Flanagan (2008) is in view that various forms
of Technology can be an enhancement to student learning but may also hinder a student’s knowledge of basic skills.
CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study was mainly conducted in order to evaluate effectiveness of Assistive Technology (AT) used for teaching Mathematics to learners with visual impairments (VI) in special primary schools for learners with VI in Kenya. This chapter presents the summary, the study’s conclusions and the recommendations based on the findings of the four (4) study objectives as well as suggestions for further related studies.

5.2 Summary of the main findings

On objective one of the study regarding the availability and the types of AT used for teaching Mathematics to learners with VI in special primary schools for learners with VI in Kenya, the study found out that the special primary schools had a scarcity of AT for teaching Mathematics. Most of the AT that were found out to be available in these schools were Low-Tech AT which were also not enough. The Low-tech AT that the researcher noted to be available in all the five schools included: Braille books, Braillon papers, Cuberithm boards and Cubes, Braille rulers, Braille protractor, Slate and Stylus. Tactile Graphic Kit was not available in any of the study sites.
The study further revealed that a third of the special schools had Mid-tech AT. The Mid-tech AT noted to have been particularly available but inadequate included: talking calculators, talking books, talking clocks and watches. No study site had a talking compass. Concerning the High-tech AT, the study findings were that all the five study sites had a Thermoform and Braille writers which were also inadequate. An Adapted computer system was available in all the four (4) of the study sites but ToM were not using them to teach Mathematics. None of the study sites had an electronic travel device, electronic Braille note-taker, electronic Braille writer or an embosser.

With regard to objective two that determined factors that had influenced the use of AT in teaching Mathematics to learners with VI, the findings as reported by study participants revealed that majority (four fifths) of the ToM were adequately prepared to provide Low-Tech AT services, half (5) of the study participants had good level of knowledge and skills about Low-Tech AT and nearly a third of the study participants (ToM) reported they had some knowledge about the use of AT. Little knowledge and extensive knowledge were each reported by one tenth of the respondents while none of the study participant reported lack of knowledge at all on the use of AT. Concerning the number of seminars and in-service courses the study participants had attended to acquire skills in low-tech AT, half (5) of the study participants reported having attended one to two times. A third reported attendance of three to four times while one participant reported attendance of more than five times.
Regarding the second factor on attitudes of learners with visual impairments in classes seven and eight on the use of AT, the findings indicated that on all the five sub-scales Mathematics confidence (MC), confidence with technology (TC), attitude to learning Mathematics with Technology (MT), behavioral engagement (BE) and affective engagement (AE)) the overall mean scores of which ranged between 3.55 and 4.10, the school variations ranged between 10.25 and 13.00 and the gender variations ranged between 10.6 and 12.70 which were indicative of positive attitudes toward learning Mathematics using AT. More so, on gender variation males were more positive in the four sub-scales (MC, MT, TC & AE), while the girls were more positive in one sub-scale (BE).

The third factor was to evaluate on affordability of AT used for teaching Mathematics to learners with VI. The study established that majority of the teachers reported that high cost of AT and no extra time on the time table to teach AT skills were the major reasons that hindered the use of AT by teachers of Mathematics. Costly maintenance was reported by four fifth of the teachers.

Regarding objective three that was to find out strategies employed by ToM when using AT to teach Mathematics to learners with VI in classes seven and eight, this study is of the view that in all Mathematics sessions (9), ToM were observed applying direct teaching methods ie question and answer, discussion and slightly above a fifth used tutorials. Ninth of the respondents were observed using group work and none using experimental teaching method. Further, regarding instructional strategies all the
respondents were observed using Technology, stating objectives at the beginning of the lesson and using manipulations. Nearly half engaged the learners throughout the lesson, a third used humor and fun and none of the respondents used games and real-world relevance. Slightly above three quarters of the teachers did not allow learners to refer to the content and slightly below a quarter allowed the learners to refer to the content during Mathematics lessons.

Based on fourth objectives of the study regarding the role of AT, majority of the respondents (four fifths) reported that AT help to improve Mathematics performance, three fifth reported AT makes Mathematics real and increases learners’ participations, while fifth of the teachers of Mathematics reported AT increases speed of accuracy and it enhances learners’ interest in developing information technology. Out of the ten sampled teachers of Mathematics, one tenth of them reported that AT exposes the learner with VI to AT services and AT help to develop learner’s confidence to learners with VI in special primary schools for learners with VI in classes seven and eight.

5.3 Conclusions

This study had the following main conclusions:

Based on this study’s findings which indicated that special primary schools had majority of Low-Tech AT, few of the Mid-Tech AT as well as few of the High-Tech AT, that again, were also conspicuously inadequate to cater for learners needs to use AT in learning Mathematics and especially availability of the modern High-Tech AT, it is
logical to conclude that inadequate use of AT for teaching Mathematics to learners with VI in special primary schools is real and this gap has contributed to lack interest in working out Mathematics problems by learners with VI leading to a decline of Mathematics performance as a subject among these learners.

Based on the findings that majority of the learners with VI who were practically observed in their classroom settings by the researcher were noted to be using low-tech (traditional) AT when learning Mathematics despite they were available in the school store, this study concludes that: ToM did not know the value of integrating Mid-Tech and High-Tech AT as well as they were not trained on the use of Mid-Tech AT (talking calculators) and High-Tech AT (computers) more so, these learners will continue to lack vital modern life skills they need to acquire and use in their pursuit of developing their lifelong careers.

From the findings regarding the teachers’ competencies when using AT to teach Mathematics to learners with VI in special primary schools in Kenya, this study concludes that there is a training gap among teachers on modern Mid-Tech and High-Tech AT skills to enable these teachers to be better in handling this category of learners.

Concerning this study’s findings that learners with VI had a positive attitude towards learning Mathematics through the use of AT; this study therefore; concludes that the need for an early application or supply of AT to learners with VI is a motivator in shaping the right attitudes towards learning
Due to study’s findings that there are factors affecting the use of AT in teaching Mathematics among learners with VI in special primary schools in Kenya, the study concludes that there is need to work out a formula to remove all learning barriers that can hinder the smooth running of educational programmes initiated for learners with VI to help them to be self-reliant.

Finally, based on the findings regarding the role of AT on teaching Mathematics to learners with VI, this study concludes that provision of adequate AT is necessary to learners in special schools for learners with VI in order to assist the acquisition of Mathematics problem solving skills for learners improved performance.

5.4: Recommendations

5.4.1: Policy-related recommendations

In view of the findings and conclusions that this study has concisely enumerated, the following recommendations were made in order to help improve the teaching and learning of Mathematics using AT to learners with VI in special primary schools in Kenya.

i. Firstly, based on objective one, this study recommends that the government through the Ministry of Education should allocate necessary funds for the acquisition and supply of much needed modern AT for teaching Mathematics to learners with VI to special primary schools such as Braille electronic note takers,
audio Mathematics text books which will widen access to Science, Technology, Engineering and Mathematics (STEM) to learners with VI.

ii. Secondly, since this study has established that the use of AT is an effective way to increase learners interest and achievement in acquiring Mathematics skills, this study recommends that the Ministry of Education should prioritize the provision of AT that learners with VI require for them to learn effectively in their classrooms.

iii. Thirdly, the study further recommends that special schools management boards be encouraged to source more funds for purchasing AT especially the modern Mid-Tech and High-Tech AT from the Non-governmental Organizations and the community.

iv. Fourthly, regarding the findings on the teacher competences, this study recommends that the government through the Ministry of Education to introduce a compulsory AT training course especially in Mathematics in teacher training colleges focusing on Mid-Tech AT and High-Tech AT. For those teachers of Mathematics who are already trained; the Ministry of Education to organize workshops, refresher and in-service courses for them at least twice a year.

v. Fifth, regarding the numerous factors this study has noted to have influenced the use of AT, the government should learn a lesson from sources of these factors and ensure they are rectified before they arise while similarly ensuring access to further education and jobs with numerical content without constraints by learners with VI.
vi. Lastly, regarding teaching strategies, this study recommends teachers of Mathematics to improve their teaching performances using combined methods when teaching the subject.

5.4.2: Recommendations for further research

Due to the limited scope of the present study, the researcher could not carry out an extensive research in the areas related to persons with VI and therefore, makes the following three recommendations for further research:

i. First, 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 VI and in the integrated programmes for learners with VI.

ii. A further similar study is required in the area of Science subjects in special primary and secondary schools and integrated programmes for learners with VI.

iii. There is need to investigate effectiveness of AT on teaching and learning Mathematics in other categories in Special Needs Education namely: hearing impaired, physically disabled, learning disabilities and autism.
REFERENCES


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Mutai, K. J. (2010). Attitudes towards learning and performance in Mathematics among students in selected secondary schools in Buret District. Kenyatta University: *Unpublished Master’s Thesis*


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APPENDICES

Appendix A: Interview guide for teachers of Mathematics

You have been purposively selected to participate in the study on effectiveness of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya. All the information given will be strictly used for the study and will be treated with utmost confidentiality. Your cooperation in answering the questions honestly will be appreciated.

Section A

1. i) Gender: Male [ ] Female [ ]
   ii) Is the teacher: Low Vision [ ] Blind [ ] Sighted [ ]

2. Education background

   a. The highest level of education attained

      KCSE/O Level [ ] A Level [ ] University [ ] Others: specify ________

   b. Training level

      P1 Certificate [ ] Diploma [ ] Degree [ ] Others: specify ____________

3. Your teaching experience in teaching Mathematics in a primary special school.

   Less than 5 years [ ] 6-10 years [ ] 11-15 years [ ] others specify ______

4. Besides teaching Mathematics which other subject(s) do you teach?

   Specify ______________________
Section B

1. Are you prepared to provide Assistive Technology services to your learners?

   Not at all prepared  -----  
   Poorly prepared      -----  
   Somewhat prepared    -----  
   Adequate prepared    -----  
   Extremely well prepared -----  

2. Estimate your level of knowledge about Assistive Technology in the teaching of Mathematics to learners with visual impairments in Classes 7 and 8.

   No knowledge          -------  
   Little knowledge      -------  
   Some knowledge        -------  
   Good knowledge        -------  
   Extensive knowledge   -------  

3. Estimate the number of workshops/in-services training pertaining specifically to Assistive Technology that you have attended in your career.

   None  -----  
   1 – 2  -----  
   3 – 4  -----  
   5 and more  -----  

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4. From the items given, indicate possible reason(s) why teachers of Mathematics do not integrate Assistive Technology. (Choose all that apply)

<table>
<thead>
<tr>
<th>Reasons for not integrating Assistive Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cost of AT</td>
</tr>
<tr>
<td>Costly maintenance</td>
</tr>
<tr>
<td>No specific time set on the time table to teach Assistive Technology skills</td>
</tr>
</tbody>
</table>

**Section C**

a. What are the roles of Assistive Technology on teaching Mathematics to learners with visual impairments in Classes 7 and 8 in special primary schools for learners with Visual Impairments in Kenya?
Appendix B: Interview guide schedule for learners with Visual Impairments

Instructions

This is not a test and therefore there are no wrong and right answers. The researcher will read the statement, give time to answer. The researcher will not write your name anywhere on this paper. You are free to change your mind at any time and to withdraw even after you have consented to participate. You may decline to answer any specific questions. The likert scale measures Mathematics confidence (MC), confidence with Technology (TC), attitude to learning Mathematics with Technology (MT), affective engagement (AE) and behavioural engagement (BE).

Section A

1. Class: STD 7 [ ]   STD 8 [ ]

2. Age in years: --------------

3. Gender: Male [ ]   Female [ ]

Section B

1. Appropriate statement of preference

   Key: Strongly disagree – SD  Disagree – D  Not sure - NS  Strongly agree – SA
   Agree – A
   Hardly ever – HE  Occasionally – Oc
   About half the time (Ha)
   Usually – U  Nearly always NA
<table>
<thead>
<tr>
<th>Statements of responses</th>
<th>SA</th>
<th>A</th>
<th>NS</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I am confident with Mathematics (MC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 I have a mathematical mind (MC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I can get good results in Mathematics (MC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 I am good in using computers (TC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 I am good in using mobile phones (TC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 I would be more confident of my school work with a computer to help me (TC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 I like using Abacus for Mathematics (MT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 I learn more when using an Abacus in Mathematics (MT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Mathematics is more interesting when using Abacuses (MT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 In Mathematics you get rewards for your effort (AE)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>11 Learning Mathematics is enjoyable (AE)</td>
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<tr>
<td>12 I am interested to learn new things in Mathematics (AE)</td>
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<tr>
<td>13 If I make a mistakes, I work until I have corrected them (BE)</td>
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<tr>
<td>14 If I can’t do a problem, I keep trying different ideas (BE)</td>
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<tr>
<td>15 I try to answer questions the teacher asks (BE)</td>
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</tbody>
</table>

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Appendix C: Observation checklist for Deputy Head teacher

Observation checklist to be filled by the researcher in the library/store in company of the deputy head teacher on availability and quantity of Assistive Technology for teaching/learning Mathematics to learners with visual impairments in special primary schools for learners with VI in Kenya

<table>
<thead>
<tr>
<th>Learning resources</th>
<th>Available</th>
<th>Not available</th>
<th>Enough</th>
<th>Not enough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crammer abacus</td>
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<td></td>
<td></td>
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<tr>
<td>Cuberithm slate and cubes</td>
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<tr>
<td>Braille ruler, compass, protractors, tapes</td>
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<tr>
<td>Tylor frame and types</td>
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<tr>
<td>Braille writers/ electronic Braille machines</td>
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<tr>
<td>Tactile graphic kit</td>
<td></td>
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<tr>
<td>Braille books/papers</td>
<td></td>
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<tr>
<td>Talking books</td>
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<tr>
<td>Braille transcriber</td>
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<tr>
<td>Braille and talking compasses</td>
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<tr>
<td>Slate and stylus</td>
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<tr>
<td>Electronic travel device</td>
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<tr>
<td>Adapted computer systems</td>
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<tr>
<td>Tactual diagrams</td>
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<tr>
<td>Tactual symbols and signs</td>
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<tr>
<td>Braille/electronic braille note-taker</td>
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<tr>
<td>Thermoform</td>
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<td></td>
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<tr>
<td>Talking calculators</td>
<td></td>
<td></td>
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<tr>
<td>Talking clocks/watches</td>
<td></td>
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</tbody>
</table>
Any other which is not mentioned above

________________________________________________________________________

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Appendix D: Classroom observation checklist for a Mathematics lesson

Name of the school: ______________________               Class:       ____________

Is the teacher: sighted ___________    Low vision _________  Blind ____________

No. of learners: Total ___________ Blind _______ Low vision _______ Sighted _________

Time:              ______________
Topic:             ______________________________________
Objectives:    ______________________________________

Teacher’s section

a. List down the Assistive Technology used
   i. ______________________
   ii. ______________________

b. General comments on point at which the Assistive Technology are used:
   i. Introduction _____                iii. End of the lesson      _____
   ii. As lesson progresses _____    iv. No aid materials used ______

c. Comment on how the learners are allowed to interact with the Assistive Technology in class;
   i. Teacher demonstrates for the class               [   ]
       ii. The instructional aid is passed round as the lesson progress [   ]
   iii The teacher visits each pupil and demonstrates to the learners using the Assistive Technology [   ]
   iv Others ________________________________

  d. Are learners with visual impairments at times asked to refer to the Braille content in their text Braille books themselves?       Yes [   ]       No [   ]

       If no, who reads for them the questions (exercises)? ______________________
e. Do learners with visual impairments use sense of touch while interacting with the Assistive Technology?  Yes [ ] No [ ]

f. If learners are using the Assistive Technology, does the teacher:
   i. Give general introduction before use?  Yes [ ] No [ ]
   ii. Move from individual/group to individual/group?  Yes [ ] No [ ]
   iii. Choose Assistive Technology related to what is being taught?  Yes [ ] No [ ]

g. After the Assistive Technology have been used during the lesson, does the teacher:
   i. Leave them in the class cupboard?  Yes [ ] No [ ]
      ii. Leave them with the class prefect/monitor?  Yes [ ] No [ ]
      iii. Take them away?  Yes [ ] No [ ]
         iv. Others ____________
Appendix E: Letter of introduction

My name is Chege Mary Wairimu. I am a Ph.D student from Kenyatta University. The purpose of this research interview guides is to help the researcher gather information on the effectiveness of Assistive Technology in teaching Mathematics in schools for learners with visual impairment in Kenya. Please, as you answer the questions from the interview guides, note that all information given shall be treated with utmost confidentiality. There are no known risks or benefits to you for assisting in the project and I will share with you a copy of my notes to ensure accuracy. Thank you for accepting to participate in this research.
Appendix F: Informed consent form for the teachers of Mathematics

My name is Chege Mary Wairimu, and I am currently enrolled as a Ph.D. student at Kenyatta University. Thank you for agreeing to participate in this study, which will take place in May and June, 2017. This form details the purpose of this study, a description of the involvement required and your rights as a study participant. I am studying on effectiveness of Assistive Technology on teaching Mathematics in special primary schools for learners with visual impairments in Kenya.

The information will be used by the Ministry of Education to improve access and quality of Mathematics performance for learners with visual impairments in special primary schools resulting from Effectiveness of Assistive Technology towards Mathematics. If you agree to participate in this study, you will be interviewed about Effectiveness of Assistive Technology on teaching Mathematics to learners with visual impairments in special schools. As you answer each question asked, the investigator will record the information you give using this equipment known as smart phone.

Please remember the participation in this study is voluntary. You may ask questions related to the study or raise concerns at any time about the nature of the study or the methods I am using.

My data collection consists of a 15-minutes interview that will be audio recording and observations to help me accurately capture your insights in your own words. The audio recordings will only be heard by me for the purpose of this study. The investigator will
not use your name or anything else that might identify you in my written work, publications or presentations. The only people who will have access to my work will be my research supervisors. If you feel uncomfortable with the audio recorder, you may ask that it be turned off at any time.

All information will be treated with utmost confidentiality. You also have the right to refuse to respond to any questions and you may stop the interview at any time. In the event you choose to withdraw from the study, all information you provide including tapes will be destroyed and omitted from the final dissertation. The investigator will destroy the audio recording after the paper has been presented and published which may take up to six years after the data has been collected.

If you wish to participate in this project, please sign in the space provided below.

Name of the participant: ___________________ Signature: ___________ Date: __________

Name of the Principal Investigator: ___________ Signature: ___________ Date: __________
Appendix G: Plates presenting Assistive Technology

Plate 4.A: Slates and stylus; cubarithm board and cubes

Plate 4.B: Braille set square, Braille divider and Braille ruler at site B

Plate 4.C: Represents a Braille set square, Braille ruler and cubarithm board and cubes
Plate 4.D: Tactual diagrams for teaching Pythagorean Theorem concept and area of triangles

Plate 4.E: Tactual diagrams: map of Africa and cylinder

Plate 4.F: Two talking calculators and two abacuses
Plate 4.G: Three manual Braille machines at site E

Plate 4.H: A thermoform machine

Plate 4.I: Two computer systems and two head phones
Plate 4.J: computer soft wares

Plate 4.K: A pack of broken down thermoform machine (on top) and a perforating machine below it

Plate 4.L: A broken abacus
Plate 4.M: Five volumes of Braille Mathematics text books used by class 8 learners with VI and a print Mathematics text book for sighted class eight learners

Plate 4.N: An abacus reading one thousand (1000) observed during a Mathematics lesson in class seven
Appendix H: Administrator consent form for participants under 18 years of age or dependent adults

Principal investigator: Mary Wairimu Chege

Study's Title: Effectiveness of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools in Kenya

Why is this study being done?

This study intends to determine the attitudes of learners with visual impairments towards learning Mathematics using Assistive Technology in special primary schools in Kenya.

What will happen while the learner is in the study?

If you agree to have the learner participate in this study, she/he will be interviewed about her/his attitudes towards learning Mathematics using Assistive Technology in the classroom. As the learner answer each question asked, the investigator will record the information she/he give using this equipment know as smart phone.

Length of study: The interview will take eleven (11) to fifteen (15) minutes.

Risks

There will be no anticipated personal risks because of the learner participating in this project. If she/he wants to stop, it will be okay and nobody will be angry or disappointed.

Benefits
There are no direct benefits to the learner’s participation; however her/his participation will allow teachers of Mathematics to better learners’ ability to work out Mathematics problems due to the presence of Assistive Technology. Teachers of Mathematics will be able to enhance their classroom in the future due to the information that prevails from this research.

**Who will know that the learner is in this study?**

The investigator will not use the learner’s name or anything else that might identify her/him in my written work, or presentations or publications. This information will remain confidential. All written work and electronic information will be stored in a secure, locked or pass worded location for the duration of the study. The audio recording will be destroyed after the paper has been presented and published which may take up to six years after the data has been collected.

**Does the learner have to be in the study?**

The learner does not have to be in this study. Her/his participation in this study is completely voluntary and she/he has the right to refuse participate or to withdraw from the study at any time without negative consequences.

**Do you have any questions about the learner’s right as a research participant?**

It is okay to use her/his data in other studies: Yes ____ No ____

I would like to get summary of this study: Yes: ______ No: __________
It is okay to audio record her/him while in this study: Yes ____ No _____

**Statement of consent**

I have read this form and decided that I agree to the learner’s participation in the project described above. I have read and understand the above statements. All the questions about the learner’s participation in this study have been answered to my satisfaction. If you choose to have the learner in this project, please sign in the space provided below.

Learner’s name: ____________________________

Name of the administrator: __________________Signature: ___________Date:

__________

Name of the Principal Investigator: ___________ Signature: ___________ Date:

__________
Appendix I: Assent form for participants under 18 years of age or dependent adults

Principal investigator: Mary Wairimu Chege

Study’s Title: Effectiveness of Assistive Technology on teaching Mathematics to learners with visual impairments in special primary schools in Kenya

Why is this study being done?

This study intends to determine the attitudes of learners with visual impairments towards learning Mathematics using Assistive Technology in special primary schools in Kenya.

What will happen while the learner is in the study?

If you agree to participate in this study, you will be interviewed about your attitudes towards learning Mathematics using Assistive Technology in the classroom. As you answer each question asked, the investigator will record the information you give using this equipment known as smart phone. You can feel it with your hands.

Length of study: The interview will take eleven (11) to fifteen (15) minutes.

Risks

There will be no anticipated personal risks because of you participating in this project. If you want to stop, it will be okay and nobody will be angry or disappointed.
Benefits

There are no direct benefits to participation; however the possible benefits from being in this study could be that information will be learned that would allow teachers of Mathematics to better learners’ ability to work out Mathematics problems due to the presence of Assistive Technology. Teachers of Mathematics will be able to enhance their classroom in the future due to the information that prevails from this research.

Who will know that you are in this study?

The investigator will not use your name or anything else that might identify you in my written work, or presentations or publications. This information will remain confidential. All written work and electronic information will be stored in a secure, locked or pass worded location for the duration of the study. The audio recording will be destroyed after the paper has been presented and published which may take up to six years after the data has been collected.

Do you have to be in the study?

You do not have to be in this study. Your participation in this study is completely voluntary. Remember, you can change your mind at any point and withdraw from the study at any time without negative consequences. You can refuse to participate even if your teacher gives permission for you to participate.
Do you have any questions about your right as a research participant?

It is okay to audio record her/him while in this study: Yes ____ No _____

Do you want to answer the interview questions? Remember, you can quit at any time.

Yes __________ No __________

Learner’s name: __________________________

Name of the Principal Investigator: __________ Signature: __________ Date: __________
Appendix J: Map of Kenya
Appendix K: Research Authorization

Mary Wairimu Chege
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on “Analysis of assistive technology on teaching mathematics to learners who are blind in special primary schools in Kenya.” I am pleased to inform you that you have been authorized to undertake research in Kiambu, Kisumu, Meru, Siaya and West Pokot Counties for the period ending 4th April, 2018.

You are advised to report to the County Commissioners and the County Directors of Education, selected Counties before embarking on the research project.

On completion of the research, you are expected to submit two hard copies and one soft copy in pdf of the research report/thesis to our office.

Boniface Wanyama
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioners
Selected Counties.

The County Directors of Education
Selected Counties.
Appendix L: Permit

APPENDIX XII

THIS IS TO CERTIFY THAT:
MS. MARY WAIRIMU CHEGE of KENYATTA UNIVERSITY, 250-1001 kalimoni - juja, has been permitted to conduct research in Kiambu, Kisumu, Meru, Slaya, Westpokot Counties on the topic: ANALYSIS OF ASSISTIVE TECHNOLOGY ON TEACHING MATHEMATICS TO LEARNERS WHO ARE BLIND IN SPECIAL PRIMARY SCHOOLS IN KENYA for the period ending: 4th April, 2018

Permit No: NACOSTI/P/17/28190/16571 Date Of Issue: 4th April, 2017 Fee Received: Ksh 2000

Director General

Signature

Applicant's

National Commission for Science, Technology & Innovation