

**IMPACT OF INTEGRATING ASSISTIVE TECHNOLOGIES IN LEARNING
MATHEMATICS AMONG THE VISUALLY IMPAIRED LEARNERS IN ST ODA
SCHOOL, IN SIAYA COUNTY KENYA**

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university/institution for consideration of any certification. This thesis has been complemented by referenced sources duly acknowledged. Where text, data (including spoken words), graphics, pictures or tables have been borrowed from other sources, including the internet, there is proper accreditation and citing using current APA 6th edition system in accordance with anti-plagiarism regulations. This research is my original work and has not been presented for a degree in any other university or any other award.

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DEDICATION

This work is dedicated to the Almighty God and to my late parents, Shem Onyancha and Wilkister Moraa, who encouraged me to take up a course of this level. Special thanks to my wife Stella and my lovely children Natalia, Adan, Joy and Allan.

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ABBREVIATIONS AND ACRONYMS

AFB	American Foundation for the Blind
AMS	American Mathematical Society
ATs	Assistive Technologies
BECTA	British Educational Communications and Technology Agency
CBE	Curriculum Based Establishment
CBM	Christophell Brinden Mission
EFA	Education For All
EFA-VI	Education For All children with Visual Impairment
ICEVI	International Council for Education of people with Visual Impairment
ICTs	Information and Communication Technologies
IDEA	Individuals with Disabilities Education Act.
INSET	In-Service Education and Training
KICD	Kenya Institute for Curriculum Development
KNEC	Kenya National Examinations Council
KSB	Kenya Society for the Blind
LDCs	Less developed countries
MDCs	More developed countries
NCST	National Council for Science and Technology
NCTD	National Centre for Tactile Diagrams
SANCB	South Africa National Council for the Blind
SNE	Special Needs Education
SPSS	Statistical Package for Social Sciences

UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
VIL	Visually Impaired Learners
WAFB	World Access for the Blind
WBU	World Blind Union
WHO	World Health Organization

ABSTRACT

Assistive Technologies (ATs) is defined as a piece of equipment or a product system or a hardware/ software or service used to increase, maintain or improve functional capabilities of learners with visual impairment. This study focused on how the ATs could support the learning of Mathematics for the Visually Impaired Learners in St. Oda School for the Blind in Kenya. The study was guided by four objectives: (a) to investigate available forms of ATs used to support the learning of Mathematics among the Visually Impaired Learners (b) to establish the challenges experienced by the Visually Impaired Learners in learning Mathematics using ATs in St. Oda School for the Visually Impaired Learners (c) to determine the level of integration of ATs in the teaching and learning of Mathematics for the Visually Impaired Learners in the school understudy and (d) to establish the impact of integrating ATs in learning Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners. The target population comprised of the Visually Impaired Learners in St. Oda School for the Visually Impaired in Kenya. The study used a descriptive survey design. A stratified random sampling technique was used to sample the learners according to class and gender, and the sample size was taken at 13.6 percent. The purposeful sampling technique was used to get the Mathematics teachers who gave the ATs facilities and services to the Visually Impaired Learners. The questionnaires, interview schedules, observation schedules and observation checklist were employed for data collection. In assessing the reliability and validity of the research instruments, piloting was done at Kibos School for the Blind and the data collected was coded and analyzed manually using descriptive statistics. The measures of central tendency, percentages, frequency distribution tables, and graphs were used. The study established that Assistive Technologies for the teaching and learning of Mathematics in the school were inadequate. The research indicated that the learners had challenges in utilizing ATs that supported learning of Mathematics like the abacus. The study also established that there were other challenges like the thirty-five- minute Mathematics lesson proved tedious. Based on the data collected, the level of integration and the impact of ATs in the learning of Mathematics ranged between average (50 percent) and zero. With these findings, the impact of ATs in the learning of Mathematics for the Visually Impaired Learners ranged between average (50 percent) and zero.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Disability is a condition characterized by physical, cognitive, psychological or social difficulty so severe that it negatively affects learning to full potential. In the Americans with Disabilities Act, disability is defined as a condition that limits a major life activity. Disability is any condition that makes it more difficult for a person to do certain activities or interact with the world effectively. Disability may be physical, psychiatric, intellectual, visual, hearing or neurological. The disabled learners may lack excellent educational opportunities hence Assistive Technologies (ATs) to aid their learning has become a global concern. The ATs from the World Health Organization (WHO) definition is a tool or equipment used to capture or improve the capabilities of disabled persons(WHO, 2007; Hersh & Johnson, 2010).

Visually Impaired Learners (VIL) are learners who have vision loss to such a degree as to qualify for additional support as the condition cannot be corrected by conventional means, such as refractive correction or medication. Educating the VIL poses challenges unlike the sighted ones. The VIL have trouble in eyesight. Eyesight obstacles cause them to have problems in day-to-day activities. Learning forms one of the most critical events in an individual's life and thus for learners with visual impairment, education is equally vital. It is through learning that self-knowledge is acquired (Senjam, 2019). According to the Universal Declaration of Human Rights by the United Nations, everyone has the right to education and professional assistance must be availed (Nations, 2015). The most significant reason for educating the VIL is to empower them and make them self-reliant. To accomplish the empowerment, the Assistive Technologies come in handy for their educational activities. The ATs for the VIL utilizes sight and other senses like touch, smell and sound (Senjam, 2019).

Mathematics is one of the challenging subjects to learn for VIL. The learners have problems learning the symbols and then carrying out calculations. Mathematics is one of the most crucial subjects for the daily running of activities (Daroni & Legowo, 2018). These activities include sales, the measurement of their purchases and many other activities that the VIL may engage in. To overcome the obstacle, the learners need to use ATs. Assistive Technologies in learning Mathematics is an essential effort. It has customized capabilities to the learners'

abilities to ease following during studies. Textual and audio supporting ATs such as the braille textbooks and talking calculators are useful. Others include the abacus, braille compass, braille ruler or protractor, the raised line graph and tactile geometrical kits (Senjam, 2019).

Daroni and Legowo (2018) did a literal study involving the collection of literature data, reading, recording and processing of materials from the library on the ATs in Mathematics learning for VIL in Indonesia. The study aimed at finding out the difficulties VIL face in learning Mathematics and the ATs developed to enable their learning. The opinions from the finding were the VIL have low cognitive ability because of little information delivery, they suffer low self-esteem, poor language skills, quickly get offended and have dependence from others. They noted from the data that the VIL had problems in understanding the mathematical symbols. They have difficulties in disequilibrium. They also face challenges in learning dimensional figures. The study established from other studies that the abacus and other audio-based mathematical tools could improve the learning of Mathematics (Daroni & Legowo, 2018).

A survey was done in Texas of 165 teachers of VIL examining the perception in the ATs. The study showed there was a deficit in knowledge in the 55 ATs that were surveyed on. 57.5 percent of them lacked confidence in teaching and elaborating the use of the ATs (Zhou, T, W, & Griffin-Shirley, 2011).

Eraj Nihal (2019) did a study from The University of Karachi on the impact of ATs on the education performance of VIL. The study objectives were to determine the use, benefits and the importance of using the ATs for academic improvement for the VIL. The study was a descriptive study with 10 VIL in the primary and secondary levels in Karachi. The study showed a positive impact on the use of ATs on performance; there was a shortage of ATs in the institutions. The study also showed that the VIL had the skills and knowledge required to put the ATs in use(Nihal, 2019).

Prof. Lazarus and Josephine (2018) carried out a study on the ATs for managing learners with the special needs in Makueni County, Kenya. The review was to find out how the teachers utilize the ATs and their availability in the county and the personalization of the lesson to influence the learner's skills. The study used a concurrent mixed design with purposeful selection. Quantitative and qualitative data was collected and analyzed through descriptive study. The target population was three hundred schools, county director of Education, head

teachers, teachers, learners and support staff totaling to 351 respondents. From the study, it was concluded that ATs equalizes the learners in the classroom. They empower the learners greatly on schoolwork and cognitive abilities. It also found that the ATs for learners' management is affected by lack of funds, negative attitudes, the staff and head teachers and the policy (Lazarus & Mbithe , 2018).

Chege et.al (2019) did a study in Kenya, on ATs for teaching VIL in special schools. The study used descriptive design; data was collected using the observational checklist and the classroom observational schedule for the schools selected. Purposive sampling was used for five deputy head teachers. The study results observed scarcity of the ATs in the special schools. The low technology ATs were more available than the mid and high technology ATs in Mathematics learning(Chege, Chomba, & Awori, 2019).

1.2 Statement of the problem

The Assistive Technologies (ATs)are used to enhance teacher and learner effectiveness in the process of teaching and learning of Mathematics among the VIL. As much as there is a concerted effort towards improving the learning of Mathematics by the VIL, little has been done towards integrating appropriate ATs in the teaching and learning of Mathematics to guarantee quality instruction for the VIL (Simalalo, 2011). Furthermore, the world is digitalized and most businesses today are transacted online. The ATs are revolutionizing learning, especially amongst those with disabilities by making it more accessible and flexible (Cooper, *ibid.*2008). The VIL needs appropriate ATs that would assist them due to their low vision to enable them to compete well with their sighted peers in the learning of Mathematics.

In Kenya, clear and well-focused policies are yet to be put in place to ensure a comprehensive system of education as a right to every child (Constitution of Kenya,2010). Failure to incorporate the VIL in the ATs-world of Mathematics would not only create a technology gap but also generate more dependents by compromising the independence and careers of VIL as well as access to information to this group of learners.

According to the Kenya Society for the Blind, only about 7000 out of 45000 visually impaired children of school-going age in Kenya are in school (KSB, 2013). This was already a problem as the education system was not accommodative to all VIL and it would be worse if those accommodated are side-lined in the digital world regarding Mathematics (Klingenberg, 2007). The focus of the study was to establish the impact of integrating ATs in

learning of Mathematics for the VIL in St. Oda School for the visually impaired. This may be one of the interventions towards improving the learning of Mathematics by the VIL at the school.

1.3 Purpose of the study

The purpose of this study was to establish the extent to which integrating ATs in the teaching and learning of Mathematics enables VIL to learn in Mathematics.

1.4 Study objectives

The following objectives guided the research:

To investigate available forms of ATs that are used to support the learning of Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners.

To establish the challenges faced by the Visually Impaired Learners in learning Mathematics using ATs in St. Oda School for the Visually Impaired Learners.

To determine the level of integration of ATs in the teaching and learning of Mathematics for the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners.

To establish the impact of integrating ATs in learning Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners.

1.5 Research questions

The research questions were based on the objectives that guided the focus of the study. They were as follows:-

What are the forms of ATs that are used to support the learning of Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners?

Which challenges do Visually Impaired Learners face in learning Mathematics using ATs in St. Oda School for the Visually Impaired Learners?

What is the level of integration of ATs in the teaching and learning of Mathematics for the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners?

What is the impact of integrating ATs in the learning of Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners?

1.6 Significance of the study

The findings would help policymakers to focus on training that would be tailored towards appropriate use of particular ATs for the VIL in Mathematics to meet their tremendous need for education and cope with the dynamic nature of technology in the teaching and learning of Mathematics. The study may serve as a reference point for the curriculum development officials. The study may also be used in formulating a universal learning design and enhance In-Service Education and Training (INSET) programs that focus on the blind and VIL. This study may also be used in the future as one of the reference points for those interested in ATs and Mathematics learning for the VIL in Kenya. Further, the study may open up avenues for progression path alternatives for career development for the VIL with Mathematics as a common denominator. Through the ATs in the teaching and learning of Mathematics, it will be possible for the VIL to become Mathematics teachers, engineers, musicians, analysts, programmers, quantity surveyors, bankers, cartographers, and nutritionists, just to mention a few.

1.7 Study delimitations

This study is delimited to the VIL in St. Oda School for the Visually Impaired, their Mathematics teachers and the school head teacher. The study involved a case of St. Oda School for the Visually Impaired, a public school in Siaya County in Kenya, as a random sample of the experiences of the entire Kenyan population of VIL. The focus, therefore, is only at one school and the findings may not be generalized for all schools for the Visually Impaired Learners. The research used questionnaires, interview schedules, observation guides and observation checklist as the only methods of data collection. Further, the study was delimited to investigate the level of use of ATs in studying Mathematics in St. Oda School for the Visually Impaired, the establishment of the challenges experienced in the use of ATs in learning Mathematics by VIL in the school and the impact of integrating ATs that enhance the teaching and learning of Mathematics in the selected primary school.

1.8 Study limitations

The aspect of time was a limitation as the study was conducted in a given period and the results were dependent on the ATs that were available during that time.

Financial constraints limited the study to a small group of Visually Impaired Learners in one school from where generalizations were made.

The study relied on the existing assistive technologies resources on the ground. Therefore, some of the latest ATs in the market were not captured. The effectiveness of the resources was pegged on the learning in Mathematics by the VIL.

1.9 Study assumptions

The study assumptions were as follows:-

That some forms of ATs are used in the teaching and learning of Mathematics in St. Oda School for the Visually Impaired

That the learners and teachers experienced challenges in the use of ATs in the learning of Mathematics

That the use of ATs has positive impact on the learning of Mathematics among the Visually Impaired Learners in St Oda School for the Visually Impaired

1.10 Theoretical framework

This study was based on two theories: Abraham Maslow's hierarchy of needs (1943) and Linda Harasim's Online Collaborative Learning Theory (2012). ATs are no longer a luxury, but a necessity. Naturally, human beings develop a need where there is value attached. Education has become so competitive that one feels doomed if he/she has failed in the education system. Education has become an essential need in our recent past and present. The VIL also have their needs in education which they regard so dearly-the the need for ATs in learning. This need for ATs will not only increase their independence but also support their aspirations. Therefore integrating ATs in the teaching of the VIL falls within the confines of Abraham Maslow's hierarchy of needs and is driving VIL towards high consumption of ATs in all spheres of life. According to Abraham Maslow, there are five levels of requirements for

any human being as shown in Fig 1.1. Maslow identified five levels of human needs in order of priority.

According to this theory, individuals strive to seek a higher need after the lower need has been fulfilled. Once a lower need is satisfied, it no longer serves as a source of motivation because needs are motivators only when they are unsatisfied. The following are needs as described by Maslow.

Physiological needs

These are needs that are the most basic for human survival, for example air, food and water. Learners and teachers cannot be motivated to use ATs unless these needs are met. For example, a hungry learner cannot be motivated to learn and the attention in class cannot be captured leave alone sustained. Similarly, a teacher cannot teach and deliver effectively using ATs while hungry. The classrooms should be well ventilated to have a good supply of fresh air. The school should ensure that there is an adequate supply of clean water for bathing, drinking, cooking and cleaning, then ATs for the teaching and learning in Mathematics would occur.

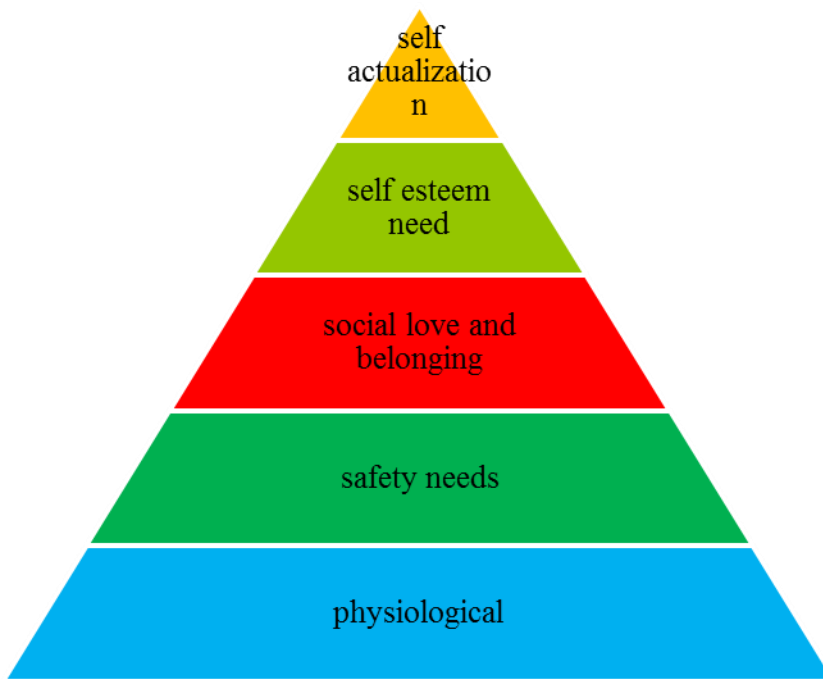


Figure 1.1: Maslow's hierarchy of needs

Source: Abraham Maslow (1943)

Safety needs

These are associated with people's needs for security. The VIL will feel insecure in the world of Mathematics without ATs. The safety needs entail personal security, health, well-being, stability and protection in the physical and interpersonal events of day to day life as well as safety against accidents. The VIL should feel safe for them to learn using ATs. Learning and teaching cannot take place in an insecure environment.

Moreover, the school should have a friendly ATs laboratory, a good fence, an environment free of barriers, humble operating rooms for the VIL, security lights and able care-takers and guards in the utilization of ATs. Safety precautions while using ATs in the learning of Mathematics should be spelled out to VIL. The ATs instructional materials should be free from danger for the VIL.

Social love and belonging needs

This is where people have to feel a sense of belonging and acceptance in relationships, families, schools and friendships. In a school situation, the extent to which the VIL are compensated for their loss of sight through ATs would determine how the VIL should feel respected, appreciated, and loved by the school and the community, hence develop a sense of

belonging. A teacher should change from being a disciplinarian to being a counselor and a friend as he/she engages the VIL with ATs in the learning of Mathematics. Teachers should encourage learners to work together in groups using ATs to develop interpersonal skills, conflict resolution, sharing and a sense of belonging to a peer group. The teacher should feel accepted by the learners to teach effectively using ATs.

Self-esteem needs

This is where the VIL would expect to be respected and to have self-respect as they interact with ATs in learning Mathematics. Achievement needs and respect for others are in this category. The VIL need to utilize ATs to exercise power and position over others in society, to direct and delegate responsibilities, which improve their self-esteem. Sentiments expressed by teachers in regard to ATs and the VIL can either lower or improve the learners' self-esteem in Mathematics. The teacher should avoid prejudiced comments based on culture, socio-economic class, disability or gender which might stigmatize the VIL and thereby limiting their potential in learning Mathematics using ATs.

Self-actualization

It is the highest level of needs that exist. This is when a person realizes his or her full potential by using ATs in Mathematics. Rarely is this level achieved. Learners aim at this level when they excel in their Mathematics examinations with the hope of realizing their dreams in life. The teachers would focus on this level when they feel that they are all round in interacting with ATs which enhances their teaching in Mathematics. This level propels the VIL to continue working hard in life.

The satisfaction of one need gives room for another need of a higher level. This research was grounded on this theory, given that this group of people have requirements for ATs, which can be met within Maslow's hierarchy of needs. As classes and textbooks move into the digital age, the VIL need to be absorbed in the dynamic system of education through the use of ATs. This theory partnered with Linda Harasim's Online Collaborative Learning Theory, where the learner would be expected to construct knowledge/cognition in the course of instruction and interaction with the teacher, fellow learners, and ATs in a given mathematical environment so as to grasp mathematical concepts.

According to Linda Harasim's theory of 2012, there are three levels of knowledge construction:

Idea generating / Brainstorming level where various views on ATs are gathered.

Idea organizing level where ideas are discussed, compared and then organized through ATs

Intellectual convergence level where there are synthesis and consensus using particular ATs after discussions, comparisons and organization

The VIL is part of the digital age and the role of the teacher would be to ensure that the core learning points are well integrated and are within the domain of the subject. This theory tends to create a link between the learning and interactions in the school set-up and the interactions out of school for all the youths of today including the VIL using ATs.

These levels are illustrated by the following figure:

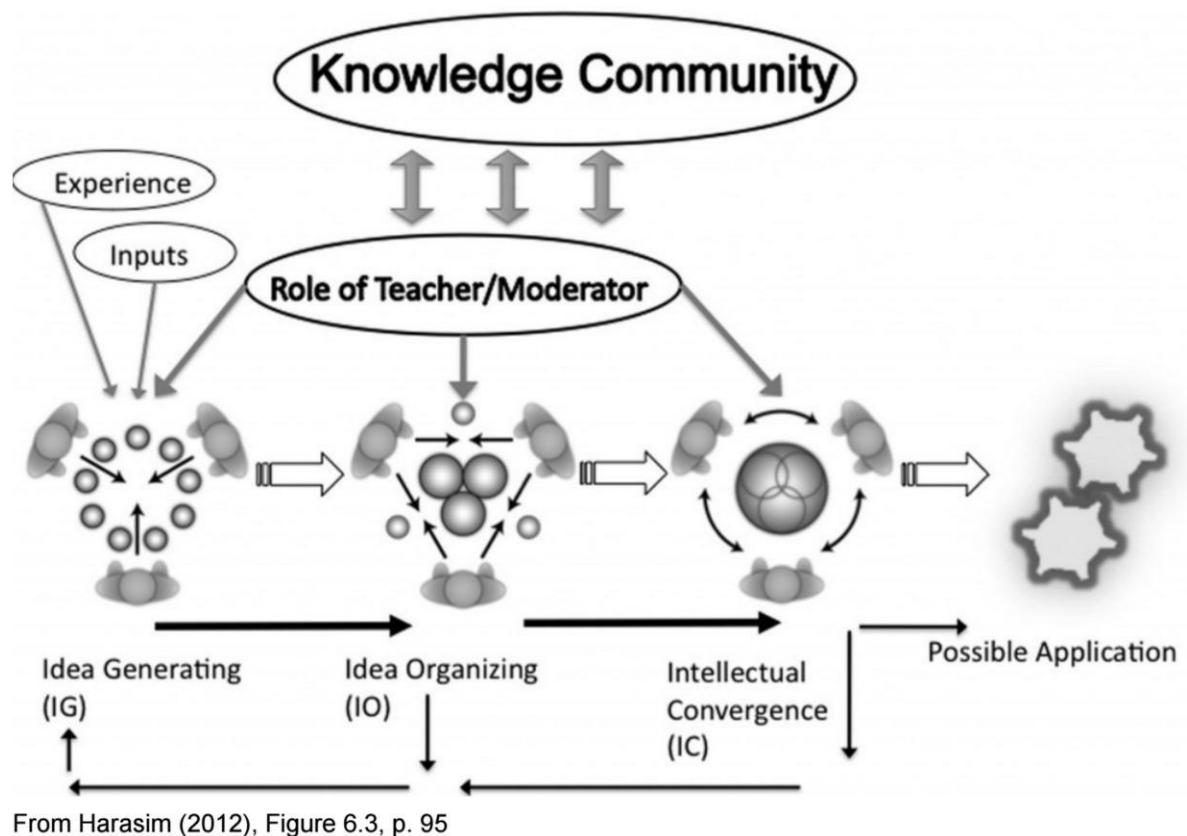
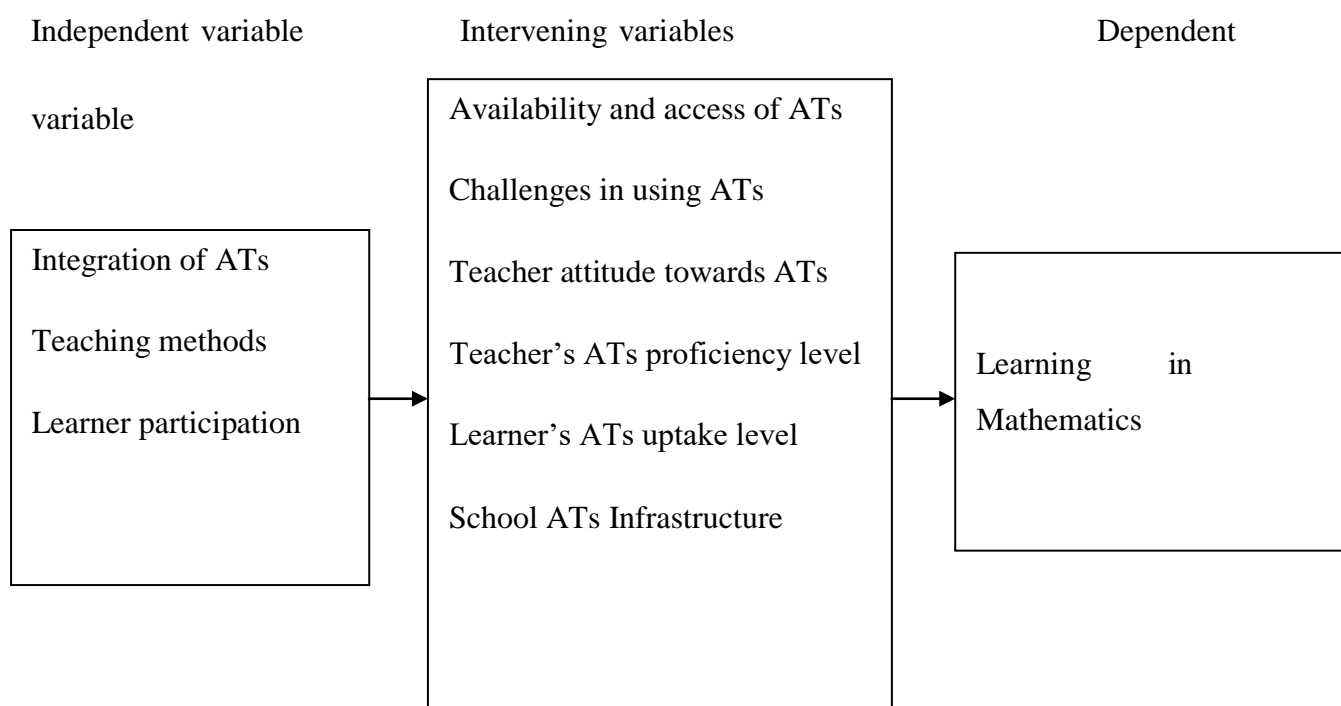


Figure 1.2: Online collaborative learning theory(Adopted from Linda Harasim) The Mathematics concepts learned in school should have a wide range of possible applications in and out of school for the VIL using ATs.

1.11 Conceptual framework

The focus of the research was to establish the influence that is created when there is the interaction between the variables that determine learning in Mathematics by the VII. The independent variables are the ones that cannot be manipulated by the researcher but when applied, their effect can be observed on the dependent variable. The intervening variables link the independent and dependent variables. Therefore the independent variable becomes the causal factor while the dependent variable becomes the observable effect. The intervening variable becomes the carrier of the result.

Figure 1.3: Conceptual framework



The above conceptual framework indicates that learning in Mathematics depends on the Challenges experienced in using ATs, teacher attitude towards ATs, availability and access, teacher's ATs proficiency level, learner's ATs uptake level and the ATs infrastructure in the school. These intervening variables depend on the independent variables i.e. the use of ATs in the school, the teaching methods and the learner participation.

The teaching and learning processes in Mathematics utilize the ATs in the school. The teaching method influences uptake of ATs by the learners thereby influencing learning. The

level of teacher training in the use of ATs influences the level of learner participation in the teaching and learning processes in Mathematics. The learners embrace ATs as an essential ingredient for their learning in Mathematics. The ATs infrastructure would determine the extent to which ATs will be integrated into the teaching and learning processes in Mathematics.

The impact will be witnessed in the way the learners learn Mathematics, which is the dependent variable. The techniques that teachers employ will vary instructional methods that use ATs in the classroom situation are vital as they will influence the ATs uptake level by the learners. Learner characteristics would focus on where they embrace ATs as an essential ingredient for their learning in Mathematics. All these factors would interact to determine the level of integration of ATs in the teaching and learning of Mathematics for the VIL hence the learning and achievement in Mathematics.

In answering the research questions, the existing ATs in school for learning Mathematics was established in the course of the interaction. The challenges faced by the VIL would have an impact on the learning and achievement in Mathematics. The ATs equipment, which the learners were aware of and comfortable to work with, was implied in the usage. The ATs available to the learners for learning Mathematics were therefore determined and as well as those which were accessible for pupils' use in class. Consequently, the quality of ATs that were used pointed to the quality of instruction which was witnessed in the learning and achievement in Mathematics by the VIL.

1.12 Operational definitions of terms

Assistive technologies: Assistive Technologies (ATs) is a piece of equipment, or a product system, or a hardware/software or service that is used to increase, maintain or improve functional capabilities of pupils with visual impairment.

Disability: Disability is a condition characterized by physical, cognitive, psychological, or social difficulty so severe that it negatively affects learning to full potential. In the Americans with Disabilities Act, disability is defined as a condition that limits a major life activity.

ATs Infrastructure: ATs Infrastructure is hardware and software which can enable a system to function

Impact: Impact is an observable effect on learning and behavior of the Visually Impaired Learners in an instructional process

Inclusive education: Inclusive education is the education system that accommodates all learners irrespective of disability or any form of impairment

Integration of ATs: Integration of ATs is the use of ATs in the teaching and learning of Mathematics to enhance mathematical concept formation.

Level: Level is the extent to which ATs were integrated in the school under study.

Nemeth code: Nemeth code is a Braille code for encoding mathematical symbols linearly using a standard six-dot Braille cell for tactile reading by the VIL.

Visually Impaired Learners: Visually impaired learners (VIL) are learners who have vision loss to such a degree as to qualify for additional support as the condition cannot be corrected by conventional means such as refractive correction or medication.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter gives the related literature and general overviews of what has been done globally in various countries to assist VIL to learn Mathematics better by integrating ATs. The section also outlines the history of blind mathematicians and that of ATs for teaching Mathematics. The regional state of affairs in selected African countries is outlined regarding VIL and Mathematics. The studies which have been conducted globally indicated a dire need by the VIL to learn Mathematics, just like sighted learners. Kiarie (2004) focused on Africa; Osterhaus (2012) detailed the USA case and the global leader in advocating for the education of the VIL, and UNESCO in 2010 highlighted the world trends regarding VIL (Altbach *et al.*, 2009). The socio-cultural and economic factors affecting the learning of Mathematics by the VIL have been highlighted. The review further highlights challenges faced by the VIL in the learning of Mathematics as well as the Mathematics resources for the blind.

2.2 History of Assistive Technologies integration in Mathematics for the Visually Impaired Learners

Assistive Technologies have been and are undergoing a revolution since the 30th March 1874 when the audiophone bone conduction amplifier was discovered; up to the latest technologies like the Apple products (iPad and iPod on 06th April, 2010); and the digitalized Braille (on 01st September, 2012) with efforts focused at bridging the gaps created by various disabilities.

Overbrook School for the Blind (USA) in 1998 and the Nippon Foundation (Japan) partnered to improve the Mathematics resources for the VIL in Cambodia, Indonesia, Malaysia, Laos, Vietnam, Thailand and Philippines. The main objective was to make the VIL more involved in the learning of Mathematics. This was to be achieved by coming up with new Assistive Technologies which can make Mathematics more-friendlier to the VIL and also be more accessible (National Center for Tactile Diagrams-NCTD, 2011).

In 2001, the partners established that instruction in Mathematics was weak for the VIL (ICEVI, 2005). The resources in Mathematics become one of the priorities to be addressed as it indicated that weak instruction in Mathematics was affecting careers negatively for the

VIL. A meeting held in Bangkok in 2003 resolved to focus on coming up with useful mathematical tools for instruction in the secondary school level for the VIL. A team was chosen and assigned the responsibility of designing and coming up with Mathematics packages for instruction that could improve ability in the teaching and learning of Mathematics in schools. The packages were to cover the methodology of teaching Mathematics, creative Mathematics, use of the abacus, use of the Nemeth Braille Code, and instructional strategies (ICEVI, 2005).

These efforts laid the foundation for the ATs that are integrated into the teaching and learning of Mathematics today (ICEVI, 2005). Assistive Technologies can significantly empower learners with vision problems to participate in Mathematics lessons, to communicate and learn more effectively (World Access For the Blind; WAFB, 2008). Access to information infrastructure would always determine the capacity of the country in question to meet the information needs of the VIL (Simalalo, 2011). The VIL, like other handicapped people, usually suffer social discrimination and cultural bias (McCarthy, 2002) that negatively impact on their information seeking needs and behavior (Eskay & Chima, 2013).

Assistive Technologies in Mathematics teaching and preparation is essential in today's education for the VIL as compared to the past (Lucky & Achebe, 2013) hence the need for research in ATs and the need for ever-growing instructional technology in hardware and software applications in Mathematics (Osterhaus, 2006). All learners therefore; sighted or not, should have equal access to learning with technology (Sinclair *et al.*, 2015). Stevens (2003) discovered a Mathematics talk in the University of York that solved difficulties in Mathematics in the learning of algebra by the blind learners. In the following year, 2004; Sanchez and Flores discovered the Audio Mathematics at the University of Chile. The pace at which inventions and innovations are taking place means that a new idea is generated which is most likely better than the one at hand (Smith, 2008). On this ground, the VIL equally should get access to the newly generated ATs for working out Mathematics (WAFB, 2008).

2.3 Global outlook of Visually Impaired Learners

According to Lighthouse International, through WHO (2014); there were 285 million people in the world who were visually impaired in 2011. UNESCO led the global Education for All (EFA) movement, aimed at meeting the learning needs of all children, by 2015. UNESCO promotes ATs with the ultimate goal of inclusive education, which it views as a means to ensure a quality education for all and to achieve broader social inclusion goals for all learners; sighted or not (UNESCO, 2010). The special needs for the VIL indeed should be turned into special opportunities for learning in Mathematics to occur (Osterhaus, 2005).

A case study conducted in the Texas School for the Blind and Visually Impaired Learners (USA), revealed that if the VIL are given the right materials, they are capable not only of learning Mathematics, but also doing it better (Osterhaus,2005). There is need for learners with vision loss to compete favorably in the modern world and enhance their independence and quality of life. Particular societies can achieve this by removing barriers, creating solutions or expanding possibilities for the VIL to realize their full potential (Caulton & Prine, 2010). In the USA education for the VIL has been growing and taking shape for the last 165 years which has witnessed tremendous growth in ATs that is meant to enhance learning in Mathematics (Jackson, 2009).

Singapore is a success story on how the VIL can be educated, trained and absorbed in the job market, where four secondary schools accommodate less than 150 VIL. The schools are equally well equipped with modern ATs, which is government-funded. These measures have eased the learning of Mathematics by the VIL. The number of VIL has been kept low because of the deliberate government interventions in time(Singapore Association for the Visually Handicapped, 2012 report).

In the UK, two students in every 1000 were visually impaired totaling up to 25000 VIL in 2008. The total numbers of people who were visually blind were estimated at 2000000 in 2008; and the trend was upwards as there were new cases each year, although 50 percent of the new cases were preventable. Whereas facilities were available for learning, the unemployment rate of the visually impaired was influencing learning negatively (Nations, 2015). 66 percent of the working-age people who are visually impaired were not in employment in the UK because they lacked the required skills and knowledge to match the tasks in employment.

In Australia, the staff from the South -Australian School for Vision Impaired are placed at Seaview. High School as both teachers and support officers. Support staff assist the learners to access the school curriculum, while teaching them the specialized skills required by a person with vision impairment (Babalola & Haliso, 2011). The support teacher works collaboratively with the classroom teacher, providing advice and assistance to ensure that materials and teaching practices are modified appropriately to accommodate each learner's vision needs to learn Mathematics. However, where adaptation was difficult, the learners skipped the content creating a gap in learning between the sighted and VIL in Mathematics (Tranter,2012). These cases reflected existence of VIL all over the world and indicated gaps in Mathematics instruction; which interfered with their employment and they ought to be taken care of in the fast-changing technology through ATs.

2.4 Education for Visually Impaired Learners in Africa

In Africa, some of the organizations that have played a critical role in ensuring the education of the VIL are Global Campaign on Education For All Children with Visual Impairment (EFA-VI),ICEVI, WBU, Nippon Foundation, Sight savers, Light of the world and the Perkins School for the Blind; among very many others, including those at country level to steward the education for the VIL. UNESCO takes the lead and co-ordinates the activities of these organizations. The countries that have benefited from their programs include Mali, Burkina Faso and Ghana in West Africa, Ethiopia to the North of Africa, Mozambique and Malawi to the south; and in East Africa Uganda, Rwanda and Kenya which were in the program by 2006 (UNESCO, 2010).

The mission of the EFA-VI Campaign is in three key areas which are (i) To harness the power of information and communications technology, enabling blind and partially sighted learners to participate in mainstream schools alongside their sighted peers and to acquire the specialist literacy skills they need to make their way in the world. (ii)To broker partnerships with relevant global education organizations, assisting them in putting VIL at the heart of their planning and delivery. (iii) ICEVI to maintain exemplary programs, assist with technical advice, and catalyze to help other agencies provide access to appropriate education for all visually impaired children and youth(ICEVI, 2005).

These three key areas are shaping the African perspective on VIL, who have been side-lined for a long time. A case study in Ghana showed VIL across the country, missing ICT exams in

the West African Senior High School Certificate Examination (WASSCE). The few schools that have units that take charge of the VIL did not have the basic ATs infrastructure to offer tuition to these learners. This is a form of discrimination that calls for urgent intervention to guarantee the brightness of the VIL(Maguvhe, 2006).

This situation puts the VIL in an awkward condition where they really feel discriminated against (Eskay&Chima, 2013). The VIL suffer when it comes to reading, writing, calculating, evaluating, constructing and observing; which are ordinary happenings in a Mathematics classroom (Kiarie, 2004). British Educational Communications and Technology Agency (BECTA) stresses the need for and the place for ATs for the VIL in the teaching and learning processes (Beachan, 2011). The VIL should be empowered to do what they dare to dream (Meek et al., 2009; Bandura, 1986; South Africa National Council for the Blind, 2010 report).

2.5 Mathematics ATs Infrastructure for the VIL

Teaching and learning ATs are very basic for active learning in Mathematics. The ATs infrastructure form the base on which the ATs will be built for integration in Mathematics.

The VILrequires resources/information that is made available in a variety of different formats (Osterhaus, 2005) to accommodate their diverse ways of understanding and therefore learning (EFA, 2010). These resources may include but not limited to Braille, abacus,large prints, Nemeth code, Taylor Frame, talking books, audio speeches, color-coding systems, magnification software/hardware, books on discs, audio calculators among others in a Mathematics study room (Rose & Meyer, 2002).

UNESCO promotes the development of inclusive schools; that is, schools that accommodate all children regardless of their physical, intellectual, emotional, social and linguistic or other conditions. It views inclusive education not as a synonym for special needs education or integration techniques but as an on-going process in an ever-evolving education system, focusing on those currently excluded from accessing education, as well as those who are in school but not learning with ATs, hence creating the connection in Mathematics for the VIL(UNESCO, 2010).

In developing countries, many educational systems struggle to provide quality education in mainstream schools and then favor the development of special needs schools. UNESCO stresses that the education system should be that which is all-inclusive in the same setting

where children with disabilities are fully accommodated in inclusive schools; the schools which it promotes as being more cost-effective and which lead to a more inclusive society (Tang, 2013)).

2.6 Challenges faced by the visually impaired learners in learning Mathematics

The VIL experiences a wide range of challenges while using ATs, which in most cases, thwart their efforts to learn Mathematics and make them give up on the way before their destination. Some of the challenges are (i)Poverty that is compounded by the high cost of ATs for the VIL(ii)Attitudes from the society regarding the VIL which can lead to low self-esteem(iii)Environmental factors like the stairs, recreational facilities, ablution systems and many other facilities(iv) Inaccessibility as there are few centers for learning. Mobility and distance discourage many from going to school.

(v)Mathematics curriculum especially 3-D and vector calculus(vi) Communication barriers especially written communication(vii) Limited and at times inadequate funding (UNESCO, 2010) (viii)Limited teacher training in special education(ix) High cost of the ATs for learning Mathematics(x)Assessment procedures which may be too demanding and weighing more on visual learning than tactile learning(xi)Keeping up with the pace of advancement of technology of mathematical tools for the sighted(xii)The language used in Mathematics relies much on the visual objects(xiii)Inadequacy of the ATs (Simalalo, 2011; Friend, 2009).

2.7 Level of ATs integration in Mathematics instruction for the VIL and the likely impact

The Mathematics instruction for the VIL was likely to take Seven phases in each of the Two levels as outlined below:

High Level: A likely situation where the ATs for the VIL is available, accessible and utilized;

Phase one: ATs available, accessible and utilized by the VIL

Phase Two: Enriched learning process for the VIL

Phase Three: Improved mathematical self-efficacy of the VIL

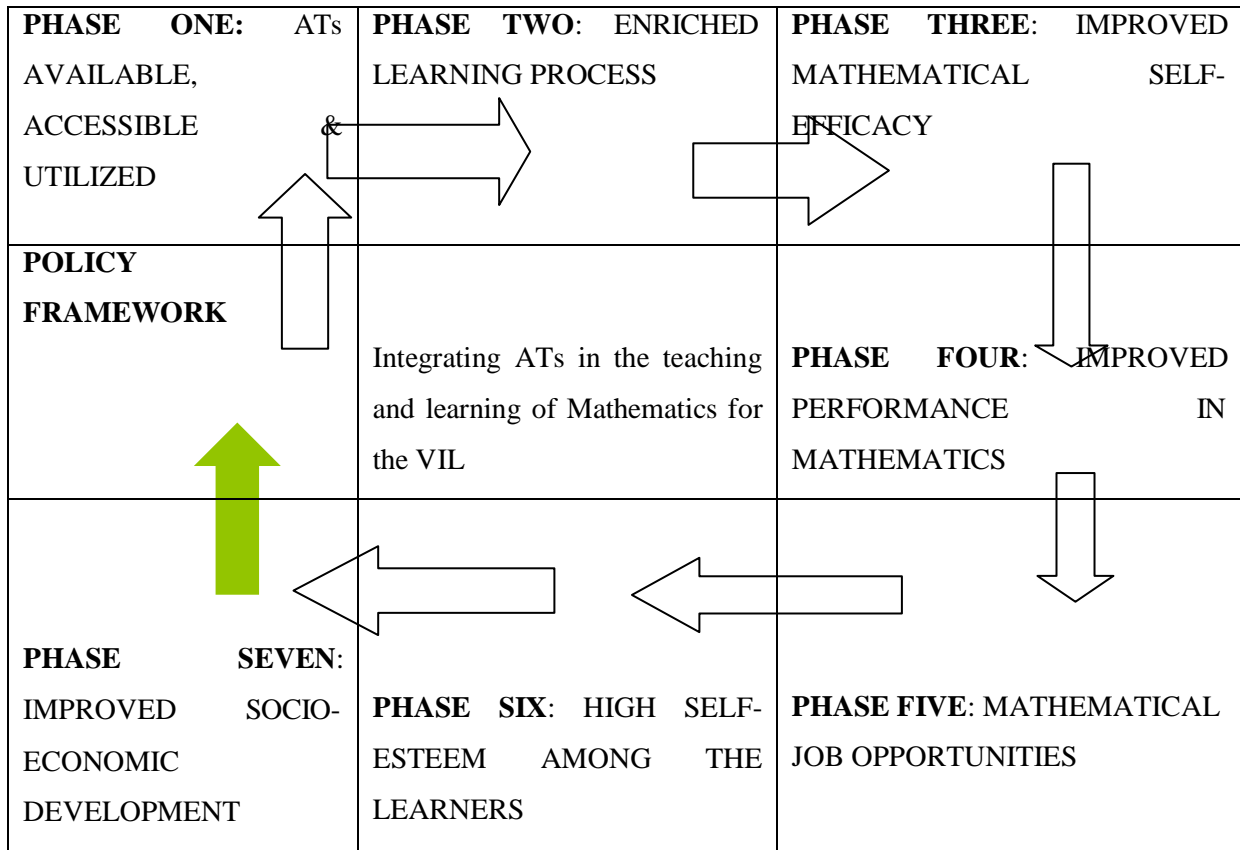
Phase Four: Improved performance in Mathematics by the VIL

Phase Five: Open job market opportunities for the VIL where Mathematics is a requirement

Phase Six: High self-esteem experienced by the VIL

Phase Seven: Improved Socio-economic development and independence.

Figure1.4: Availability, accessibility and utilization of ATs



Low Level: A likely situation for the VIL where the ATs are inadequate: - This situation was likely to give rise to seven phases, which would lead to a likely vicious cycle of mathematical destitution and poverty for the VIL.

Phase One: Access to ATs is inadequate/denied/ lacking

Phase Two: Limited learning

Phase Three: Limited mathematical self-efficacy

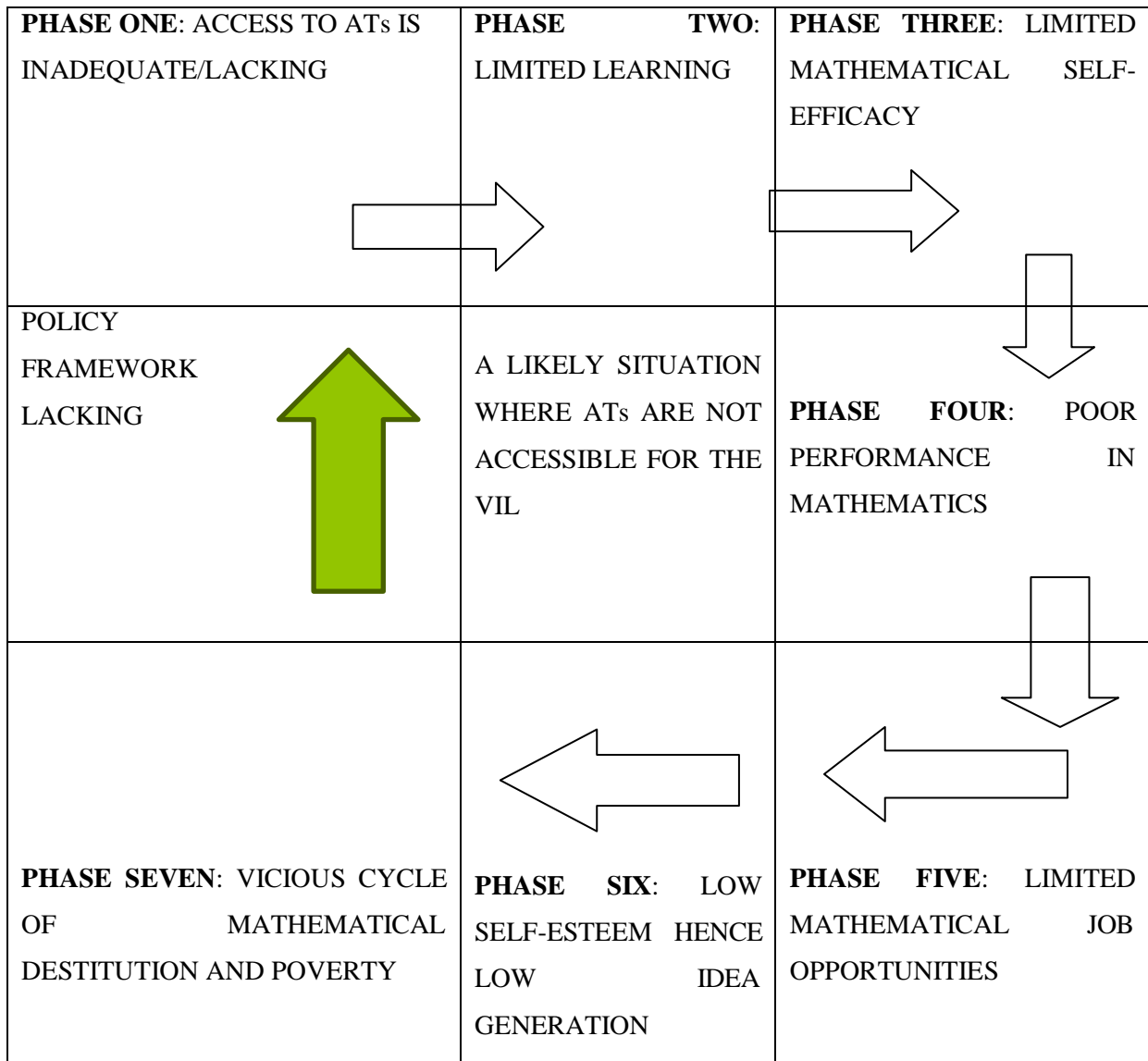
Phase Four: Below par performance in Mathematics by the VIL

Phase Five: Limited job market opportunities for the VIL where Mathematics is a requirement

Phase Six: Low self-esteem experienced by the VIL hence low idea generation

Phase Seven: Vicious cycle of mathematical destitution and poverty.

Figure 1.5 Inadequate availability/accessibility/utilization of ATs



Effective content delivery in Mathematics for the VIL requires that teachers should do among other things (i)Employ inclusive strategies by use of adapted and adopted instructional ATs to fill the gap left by textbooks for example tactile graphics(ii)Giving notes in Braille form on what has been covered(iii)For classroom testing; the VIL should be given at least twice the time the sighted learners are given(iv)Individual tutoring should be highly encouraged to address individual differences in learning(v)Source of the distraction that may break learning should be addressed thoroughly and quickly(vi)Include real-life mathematical situations

enjoyed by the VIL(vii)Give worksheets to be transcribed into Nemeth Code in advance.(ix)The VIL should read anew Mathematics problem, write it down, talk about it louder, listen to the problem, tactually explore it and then solve the problem with the help of ATs (Osterhaus, 2005; Friend, 2009)

2.8 Blind mathematicians and their contributions in Mathematics

History has clearly shown that VIL can do Mathematics to higher levels than they are doing now; and still teach the subject with the required competency given appropriate ATs that compensate for their loss of sight(AMS, 2002). The world has witnessed blind/visually impaired mathematicians over time. They include but not limited to Nicholas Saunderson (1682-1739) from England, the father of Bayesian statistics and Palpable arithmetic (outlined in his book; 'Elements of Algebra'). He also contributed in probability theory (American Mathematical Society-AMS, 2002).

Leonhard Euler (1707-1783), a Swiss mathematician, developed graph theory and infinitesimal calculus among others.Lev Semenovich Pontryagin (1908-1988), a Russian is the father of topology and homotopy theory. He also made great contributions in control theory in applied Mathematics. Vitushkin, A.G Still alive and Russian worked complex analysis. Louis Antoine (1888-1971), a French worked in 2-D and 3-D areas considered complicated even by the sighted.

Morin Bernard, French has contributed significantly in sphere eversion and singularity theory. Stephen Smale (French), in 1959 proved the theorem that all immersions of n-spheres into the Euclidean space are regularly homotopic. Emmanuel Giroux, in July 2001 made a very clear presentation on 'contact structures and open book decomposition' (his own work) in a Mathematics forum. Lawrence Baggett is another well-known American mathematician. He is a Professor Emeritus in Mathematics and has contributed in number theory, harmonic analysis among others.

Norbert Salinas (Argentine), is a renowned professor of Mathematics at the University of Kansas. He developed the GS8 Braille code together with Gardner, just an improvement on the Nemeth code; with 8-dots. Abraham Nemeth is a blind professor in Mathematics and computer science. He is the father of the popular Nemeth code. He retired from Detroit University.Zachary Battles is an American blind mathematician and also an expert in computer science. (AMS, 2002)

Clearly, from the above blind mathematicians and their contributions, the VIL can not only learn Mathematics to the highest level but also provide solutions to their limitations. Their way of Mathematics should be barrier-free through the integration of ATs, which will most likely bridge the gap that is created by their low vision.

2.9 Literature review summary and existing gaps

The literature review on ATs revolution, which started in 1874, has advanced to the Apple products, which are in existence today, and it clearly shows that the MDCs are much ahead than the LDCs. Therefore there is a need for the LDCs to embrace the new technologies in the teaching and learning process in Mathematics, which is employed in the MDCs. In Kenya, it is essential to find out whether the ATs that are in use are adequate and what can be done to improve.

Although from the literature review there are VIL in the MDCs who have gone through Mathematics to higher levels and have developed theories that have significantly contributed towards the learning of Mathematics; in Kenya, the VIL are yet to contribute significantly to the field of Mathematics indicating a need to investigate the cause of this exclusion.

The literature review has indicated that the resources which have been in use in the teaching and learning of Mathematics in most countries support rudimentary level Mathematics. It is also indicated that the VIL has limited options when learning Mathematics compared to their sighted peers. This situation limits conceptual learning in Mathematics making the pace of learning slower than it is in the sighted cases (Groenewegen, 2005; Simalalo, 2011). The use of Braille as a means of communication further reduces their speed of learning in Mathematics. Research review also reveals that teachers have inadequate knowledge on the use of ATs that can enable them to deal with the VIL effectively and constructively in the learning of Mathematics (Kiarie, 2004).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter will deal with the research design, study locale, target population, sampling techniques and methods of data collection; research instruments and data analysis techniques. The study was conducted at St. Oda School for the Visually Impaired Learners. The respondents were the teachers of Mathematics and the VIL in the school who were the critical ATs consumers.

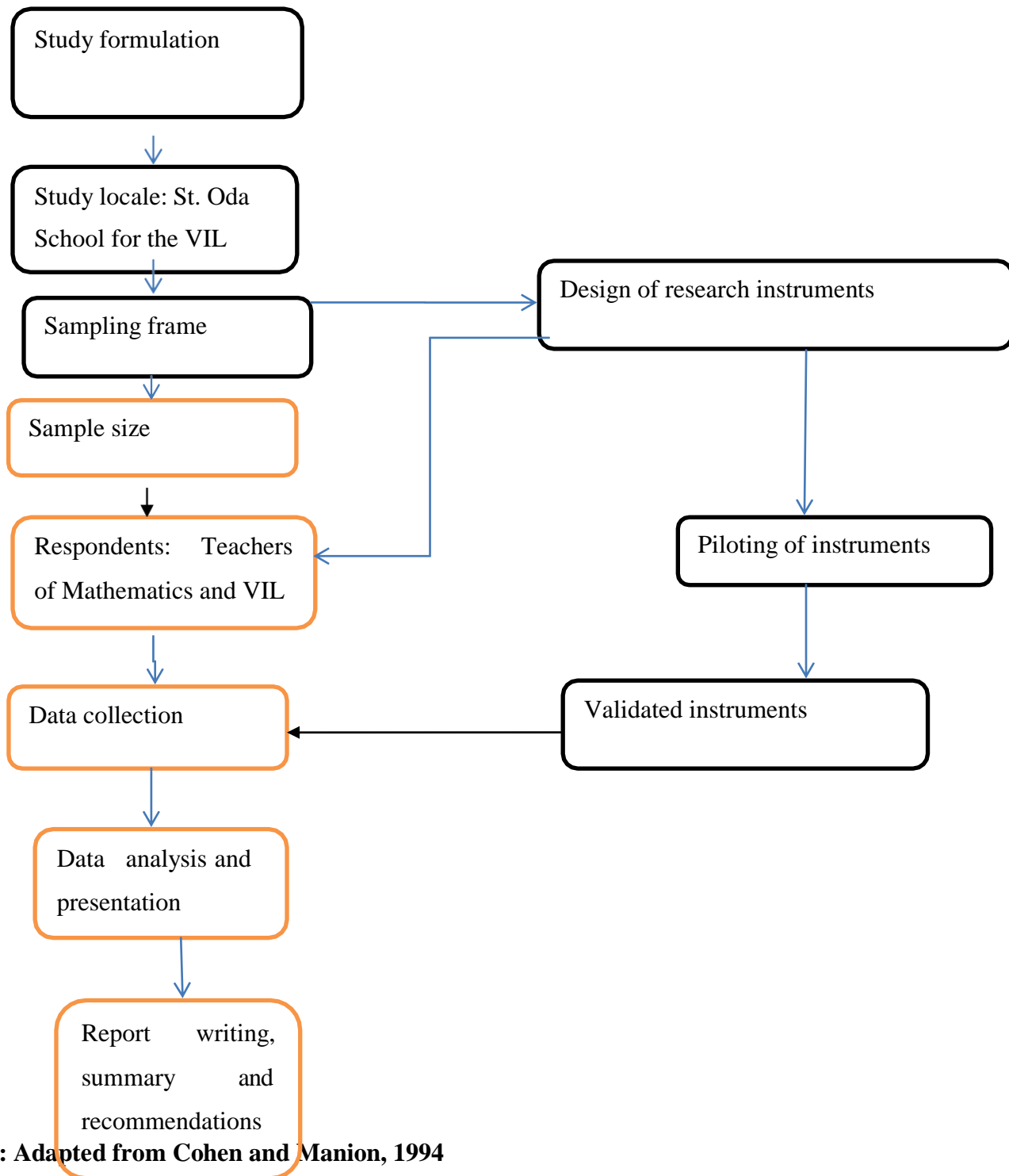
3.2 Research Design

The research followed a descriptive survey design that was applied to establish and determine how the ATs are integrated for the VIL to learn Mathematics in St. Oda School for the Visually Impaired Learners. The descriptive survey design aimed at describing the state of affairs as it existed (Kombo and Tromp, 2006), and the findings reported. The study adopted an exploratory approach through the use of the descriptive survey design which is usually used in educational research. The descriptive survey involved data collection through interviews, questionnaires, observation check list and observation schedules (Orodho, 2003).

The descriptive survey design had both qualitative and quantitative aspects of data collection, which complimented each other hence was preferred over a case study design as the focus was in the teaching and learning of Mathematics in the school under study. This two-prong approach was considered suitable for this study as it allowed for a full focus on the leaning of Mathematics and how it was influenced by integrating ATs in the instructional processes in the school.

The qualitative aspect provided detailed explanations of the teaching and learning processes in Mathematics when ATs are integrated. At the same time, the quantitative aspect provided facts in figures which reflected the real situation on the ground and hence achieved the required objectives. The research process followed five stages:- (i) Study formulation (ii) Design of research instruments (iii) Piloting of the instruments for data collection (iv) Data collection (v) Analysis and report writing. This information is summarized in the following Fig 3.1 that was adapted from Cohen and Manion, 1994.

Figure 3.1: Research flowchart



Source: Adapted from Cohen and Manion, 1994

3.3 Study Locale

The study was carried out in St Oda School for the Visually Impaired Learners in Siaya County in Kenya. The school was purposively selected as ideal for the research because it had learners who are visually impaired and taking Mathematics as one of the core subjects using ATs. The school was started in 1961 and had steadily enrolled pupils and as at 2018, the school had 220 pupils. The school had 26 TSC teachers (7 ladies and 19 males). The school also had gone into the ICT system where there were inABLE (an NGO) instructors in school. St. Oda School for the visually impaired is one of the schools that had embraced ATs hence the site choice for this study. Training of service providers to this group of pupils was also required alongside the ATs that were needed. The study focus was on the impact and level of integration of ATs in teaching and learning of Mathematics, challenges faced by the VIL on available mathematical ATs.

3.4 Target Population

The target population is the larger group on which generalizations of the findings will be made (Orodho, 2003). The target population for this study was the VIL enrolled in St Oda School for the visually impaired, who were learning Mathematics during the period of this study using ATs and comprised of 220 VIL (85 girls and 135 boys), 26 teachers (7 females and 19 males) and the head teacher.

Table 3.1: Respondent Statistics in St Oda School for the Blind, 2018

All members	Female	Male	Total
Mathematics teachers	7	19	26
Learners	85	135	220
Head teacher	1	-	1

SOURCE: St. Oda School for the visually impaired learners (2018)

3.5 Sample size and sampling procedure

A sample is a group from which information will be obtained. The sample size is the number of group entities. A sample size of above 10 per cent is considered good for research (Mugenda and Mugenda, 2003). For this study, the sample size was calculated at 13.6 percent of the target population. The sampling procedure is the technique or way of selecting individuals for the study. Random stratified sampling was employed where all VIL had an equal chance of participating in the research. Strata were formulated based on gender and grade of study. The stratified sampling was based on the understanding that the VIL in each stratum had undergone different experiences in regard to integrating ATs in the learning of Mathematics under similar background.

3.5.1 Sampling Procedures

Sampling was done based on the focus area as follows:

TABLE 3.2 Sampling Frame

S/NO	SAMPLING AREA	TOTAL POPULATION	SAMPLE SIZE	PERCENTAGE (%)
I	Total number of Mathematics teachers	7	7	100
Ii	Total number of pupils	220	30	13.6
Iii	Head teacher	1	1	100

SOURCE: St. Oda School for the Visually Impaired Learners (2018)

Table 3.3 Sampling of learners by Gender per Stratum

STANDARD/STRATUM	GIRLS	BOYS	TOTAL/STRATUM	PERCENTAGE
4	2	2	4	1.8%
5	3	3	6	2.7%
6	3	3	6	2.7%
7	3	3	6	2.7%
8	4	4	8	3.8%
TOTAL PUPILS PER GENDER	15	15	30	13.6%

SOURCE: St. Oda School for the Visually Impaired Learners (2018)

3.6 Research Instruments

The research instruments employed in this study are questionnaires, interview schedules, observation schedules and an observation checklist. The 4-point Likert scale was used to account for the variations.

3.6.1 The Questionnaires

Questionnaires were preferred here because of their ability to collect large amounts of data in a relatively shorter time and questions can easily be analyzed (Orodho, 2003). The questionnaires were suitable for this research because they gave the respondents flexibility and large room in registering their views, opinions and suggestions regarding the integration of ATs in the teaching and learning of Mathematics. Data collection was mainly based on the teachers' and learners' questionnaires, giving two sets of questionnaires that were close- examined to ascertain the perspective of teachers and learners on the integration of ATs. For this research, the questionnaires were divided into two: (i) Pupils questionnaire (ii) Mathematics teacher questionnaire. These Two questionnaires were used to complement each other for the success of this study. The two categories of questionnaires carried both open- ended and closed-ended questions. Part A for each category was designed to give the background information of the respondent. For the learners' questionnaire, part B was made to assess the self-efficacy and self-concept of the learners concerning the integration of ATs in the learning of Mathematics. The attitudes that pupils held towards integrating ATs in Mathematics were assessed here. The questionnaires were administered with the help of the Mathematics teachers in the school.

For the teacher's questionnaire (the most detailed), part B focused on job satisfaction and effectiveness. An unsatisfied person naturally cannot do a good job, especially when it comes to ATs which will impact on integration of ATs in the teaching- learning process. The last part for teachers' questionnaire contained open-ended, and some closed-ended questions regarding the integration of ATs in the teaching of Mathematics. The teachers' opinions were collected and analyzed.

Further, the impact of integrating ATs in the learning of Mathematics was examined using questionnaires. For teachers, part B had sections (i-iii). Section B (i) carried items on the working conditions. Section B (ii) contained items on teacher effectiveness, and section B(iii) had items which focused more on teacher challenges. Further, the teachers had a new section C, where they gave their opinions on the impact of integrating ATs on the teaching of Mathematics by integrating ATs, and how best other ATs can be utilized to make the learning of Mathematics by the VIL useful and more enriching. The school head teacher gave an overview of ATs infrastructure, sourcing and management in the learning of Mathematics in the school. The head teacher was also allowed to seek clarity on any unclear issue concerning the study. This was meant to create a good working relationship with the administration, which would extend down to teachers and learners.

The questionnaires were administered to the two groups: (i) The Seven teachers of Mathematics in the school; who are the implementers for ATs integration in the teaching and learning of Mathematics. The teachers' questionnaire was the most detailed as the teachers were the experts on the ground. The questionnaire covered the teachers' professional aspects. The teachers filled the questionnaire during the agreed time as per the booking. (ii) The 30 pupils who were sampled using the sampling procedure. Equally, the pupils filled the questionnaire during breaks and lunchtime to avoid interrupting the class programs.

3.6.2 Interview Schedules for the Head Teacher and Teachers

The interview schedule was organized with the school head teacher and the Mathematics teachers, where the scope of the study was elaborated. Given that this was a special school for the visually impaired learners, not all the learners as well as teachers were comfortable with the filling of the questionnaire. Interview schedules were organized to cover this limitation. Like the questionnaire, interview schedules carried items that were tied and tailored to the research objectives and research questions.

This instrument was employed to cater for learners and teachers who like giving answers orally than in written (Kerlinger, 1973). The interview schedule for teachers, like questionnaires, carried both closed and open-ended questions, which were tailored to the objectives. This was equally important for the study given that it was dealing with the VIL.

Further, there was a special interview schedule with the school head teacher, which focused on the management of the ATs in the school. It also targeted the current issues on the modern ATs for integration in the learning and teaching of Mathematics.

3.6.3 Observation Schedule

This instrument was used to assess the impact of integrating ATs in the teaching and learning of Mathematics in the school understudy for the VIL. The lesson observation schedules were organized with the help of the Mathematics teachers in the school. The teacher and learner behaviors and activities were observed by the researcher and recorded. The use of ATs was observed and the learning outcomes recorded by the researcher. Observation schedules were conducted in all the five classes (4-8).

The observation schedule was meant to get first-hand information. The researcher visited the research area and observed the critical areas for the study regarding VIL; the ATs infrastructure and use in learning Mathematics, the teaching and learning strategies, and the general interaction of VIL with ATs for learning Mathematics in a classroom situation. The teacher characteristics were also observed. The primary purpose of this instrument was to ensure that the required items in the questionnaire and interview schedule are done as per the objectives and the research questions. It summarized the data collected and indicated incomplete areas. This instrument was used to enable the researcher to observe the impact of integrating ATs in the teaching and learning of Mathematics in a classroom set-up. The observation schedule was planned with the respective teachers and learners through the head teacher.

3.6.4 Observation Checklist

An observation checklist was a list of ATs devices, software and hardware that were used in the instruction process during a Mathematics lesson. The list was derived from the internet, journals, and published books on ATs. At the school level, this list was used to establish the extent of availability and accessibility of the ATs for the learning of Mathematics. Using the checklist, one could quickly tell at a glance the extent of ATs integration in the teaching and learning of Mathematics by the VIL. The extent of access to ATs was ascertained and

indicated as either adequate or inadequate depending on availability and effective use in the teaching and learning of Mathematics.

3.7 Piloting of the Instruments

Orodho (2003) defines piloting as the pre-testing of research instruments to a chosen sample, which has the same characteristics as the actual sample to be studied; so as to establish the effectiveness of the instruments in the research. After getting the permit to conduct research from the relevant authorities the researcher started by conducting a piloting exercise. In determining the effectiveness of the instruments, piloting was done in Kibos School for the Visually Impaired Learners on ten learners comprising of two learners from each class 4-8; and two teachers who taught Mathematics to the VIL in the school. This was done to assess the strengths of the research instruments. Piloting also assisted in establishing the weaknesses of the instruments where some questions on the research instruments were adjusted. In piloting, validity and reliability of the instruments were gauged. The expert and professional views were sought for to make the study a success. The time allocation, the language used and the type of questions asked were evaluated at this stage and modifications were done.

3.1.1 Validity

Research validity is the degree to which results obtained represented the phenomenon under investigation (Orodho, 2003; Mugenda & Mugenda, 2003). The validity of the instruments was established through a pilot study in Kibos School for the Visually Impaired Learners in Kisumu County. Ten learners and two teachers participated in the pilot study where the data collected were analyzed to establish content validity. In analyzing data, consultations with my research supervisors and other experts in this area of study was done and content validity was ascertained. However the few questions which appeared general, were tied to the school under study.

3.7.2 Reliability

Reliability was the consistency at which the instrument produced similar results while focusing on the extent to which a particular procedure was administered in several trials (Orodho, 2003). It is the extent to which the instrument is stable and consistent across repeated measures. It is the degree to which a research instrument yields consistent results after repeated trials (Mugenda & Mugenda, 2003. p.95). Reliability was established through the split-half test method where all the ten pupils were given numbers 1-10, and then

separating odd and even numbers which gave two halves. The Pearson correlation coefficient formula was used to determine the correlation coefficient, which was used in determining reliability. The computer software SPSS version 21 was also handy in establishing reliability. The split-half test method was done by assigning numbers to all participants in a given stratum and then separating them into two halves i.e., odd and even numbers. The two teams' responses were then recorded (Appendix XI) and correlated, using the computer software spss version 21. The Pearson r coefficient of correlation was applied and the correlation between the two was determined at 0.8795 and hence used to establish reliability. The correlation coefficient of 0.8795 exhibited a high degree of reliability of the data collected.

3.8 Data Collection Procedures

The permission to conduct research was sought from Kenyatta University, the county director of education (Siaya County), the sub-county director of education, Siaya District and the school head teacher. Appointments were then booked with the head teacher St Oda School for the VIL; for formal introduction and on when the instruments will be administered. Data collection is the gathering of specific information that can be used to prove some facts as either correct or wrong (Kombo & Tromp, 2006). The process of data collection followed three phases: The first phase involved a visit to the school where the study was to be conducted to familiarize with the school environment, the head teacher, teachers, and the learners. The researcher utilized the opportunity and declared the intended research. The researcher further made adequate requests for cooperation and cleared appointments with the respondents. At this point, the researcher committed with the respondents that the information that they will give will be confidential and that it will only be for research purposes. The second phase entailed the delivery of the questionnaires to the respondents following the agreement in phase one. The questionnaires for the principal, teachers, and learners were left for filling for seven days and after that collected by the researcher. To avoid interference with the school programs, the learners filled the questionnaires during break time, lunchtime, and games time. The researcher kept on reminding the respondents on a daily interval from the day of delivery to keep the respondents on course in filling the questionnaires for a week.

Further, an appointment with the teachers and the head teacher were made at this phase for an interview schedule. Hence for the seven working days, the respondents had completed the filling of the questionnaires. In the third and final phase, the researcher collected the questionnaires from the teachers and learners. The researcher also used an observation

checklist to identify and record the use and adequacy of the ATs available for integration in the teaching and learning of Mathematics in the school. At this level, some preparations were made with teachers and learners for planned Mathematics lesson observations where the ATs were integrated. This phase was scheduled to last for ten working days, where a day was for a particular class, i.e., standards four to eight. The selection of the days was begged on the appointment with the head teacher such that the interview schedule with the head office was also conducted alongside lesson observations. This study made use of four instruments for data collection: (i)the questionnaire(ii)the interview schedule(iii)the observation guide and (iv) the observation checklist.

3.9 Methods of Data Analysis

The questionnaires, interview schedules, the observation schedule and the observation checklist were collected from the field and assembled. Then data cleaning was done to eliminate the errors that might have been committed by the respondents. The instruments generated both qualitative and quantitative data that were analyzed using descriptive statistics. These data were recorded, tallied, tabulated, coded, processed, and analyzed manually. The interpretations of the means, frequencies, and percentages were also used to draw the summary.

3.9.1 Analysis of data based on objectives

Table 3.4 Data collection procedure, type of data, instrument and method of data analysis

Objective	Data collection Procedure	Type of data	Instrument	Method of Analysis
Objective one: To investigate available forms of ATs those are used to support the learning of Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners.	Investigating AT sin the school by learners, teachers and researcher	Primary (qualitative and quantitative) Secondary (qualitative and quantitative)	Questionnaires Interview schedules Observation schedules Observation checklist	Descriptive statistics .Measures of central tendency .Frequency distribution table .Percentages
Objective two: To establish the challenges faced by the Visually Impaired Learners in learning Mathematics using ATs in St. Oda School for the Visually Impaired Learners.	Establishing challenges by learners, teachers and researcher	Primary (qualitative and quantitative) Secondary (qualitative and quantitative)	Questionnaires Interview schedules Observation schedules Observation checklist	Descriptive statistics .Frequency distribution table .Percentages .Graphs
Objective four: To establish the impact of integrating ATs in learning Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners	Establishing the impact of ATs on learner performance in Mathematics	Primary (qualitative and quantitative) Secondary (qualitative and quantitative)	Questionnaires Interview schedules Observation schedules Observation checklist	Descriptive statistics .Frequency table and graphs .Percentages .Graphs .Measures of central tendency

3.9.2 Analysis of data based on questionnaires

Data contained in the three questionnaires were assembled, organized, cleaned, and edited to assess errors of omission or commission to correct them for a reliable analysis. The data were then grouped in order of relationships in the item description in the research questions and

coded. In the analysis, the collected data were classified into two: quantitative and qualitative. The purpose of quantitative data was to show the extent to which the items in the research questions are in use. In contrast, the qualitative data had the objective of establishing the understanding and opinions held by the teachers and learners about resources, challenges, ATs and their level and impact of integration in the teaching and learning of Mathematics. Whereas the quantitative data would easily be analyzed using descriptive statistics and SPSS version 21, the qualitative data had to be first coded using numerals to take a quantitative form for analysis by the aid of descriptive statistics. Items were grouped as per the objectives for easy analysis. The purpose of analyzing qualitative data was to get the opinion on the way the integration of ATs in the learning of Mathematics was regarded, and it also revealed the level of preparedness for the same. Quantitative data was analyzed to determine availability, accessibility, level of use and the impact of ATs integration in the teaching and learning of Mathematics in the school.

The use of SPSS version 21 was applied, and the descriptive statistics were utilized to generate the means, the frequencies, the table, graphs and the percentages which were used to answer the research questions and gave a summary of the study. Therefore data on existing resources, challenges, ATs integration and level of use; and the impact of integrating ATs in the teaching and learning of Mathematics; which formed the study objectives, were analyzed using descriptive statistics and summarized using the means, frequencies, tables, graphs and percentages to answer the research questions.

3.9.3 Analysis of data on the interview schedule

The respondent responses in the interview schedule, which took a structured and orderly sequence, were grouped, ordered and coded. The qualitative responses were quantified and analyzed using descriptive statistics.

3.9.4 Analysis of data on classroom observation guide

The classroom observation guide mainly focused on collecting data from the classroom climate in a Mathematics lesson. The interaction between the resources, Mathematics knowledge, the learners, the integration of ATs and the teachers was observed. The learner activities and responses as well as the teacher activities were observed and recorded and formed the basis for analysis. The recorded observations, which were qualitative, were coded, categorized and grouped to apply descriptive statistics to analyze them where the means, frequencies and percentages were employed. Supplementary observations from the scheduled

ones were also analyzed qualitatively, which was then translated into quantitative data through coding and analyzed manually.

3.9.5 Analysis of data on observation checklist

The data on the record of all available Mathematics teaching/learning resources; and whether the ATs observed are either adequate or inadequate was made. The descriptive statistics were used to analyze this kind of data so as to answer the research question. The record of challenges faced by the VIL and the level of use of the ATs in the Mathematics instructional process were then grouped, quantified, and analyzed manually or by using descriptive statistics and by the SPSS version 21. The percentages were the best help in the summary level of the study.

3.10 Ethical considerations

The permission was sought from the school head-teacher for the study to be carried out.

The consent of the respondents was sought before the research was carried out.

Respondent identity was not revealed as they were not required to write their names or any other form of identification, and the information would be treated confidentially.

The rights of respondents to protection and privacy were guaranteed.

CHAPTER FOUR

REPORTING, INTERPRETATION AND DISCUSSION OF THE FINDINGS.

4.1 INTRODUCTION

This chapter presents the analysis, findings, presentations and discussions of the data that was collected from pupils and Mathematics teachers of St. Oda School for the Visually Impaired Learners in Siaya County in Kenya.

The data collected was analyzed and reports of the findings presented using descriptive statistics in the form of tables, frequencies and percentages. The findings of the study were discussed under the following research questions:

What are the ATs that can be used to support the teaching and learning of Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners?

Which challenges do Visually Impaired Learners face in learning Mathematics using ATs in St. Oda School for the Visually Impaired Learners?

What is the level of integration of ATs in the teaching and learning of Mathematics for the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners?

What is the impact of ATs on the learning in Mathematics of the visually impaired learners in St. Oda School for the Visually Impaired Learners?

The findings were presented based on the objectives and the research questions which guided this research.

4.2 Questionnaire response rate

A total of thirty (30) Visually Impaired Learners, seven (7) Mathematics teachers and the head teacher participated in this research. A total of 37 questionnaires were given out to 30 VIL and 7 teachers which were then filled, collected and returned making the turnout to be 100 percent. The respondents answered all the questions that they were required to respond to.

Table 4.2.1: Questionnaire Response Rate

Respondents	Questionnaires administered	Questionnaires received	Percentage (%)
Learners	30	30	100
Teachers	7	7	100
Total	37	37	100

4.3 Demographic characteristics of the respondents**Table 4.3.1: Age Distribution of Learners**

AGE IN YEARS	FREQUENCY	PERCENTAGE (%)	AVERAGE AGE
11	2	6.7	426/30 =14.2 ≈14 years
12	5	16.7	
13	3	10	
14	6	20	
15	6	20	
16	6	20	
17	1	3.3	
18	1	3.3	
TOTAL	30	100%	

The youngest learner was 11 years while the oldest was 18 years. There were no extremes in age gap that was witnessed. The 30 pupils who participated in the study represented 13.6 percent of the learner population in the school.

Table 4.3.2: Gender Distribution of the Learners

STANDARD	GIRLS	BOYS	TOTAL
4	2	2	4
5	3	3	6
6	3	3	6
7	3	3	6
8	4	4	8
TOTAL	15	15	30

Table 4.3.3: Age Distribution of Teachers

AGE GROUP(X)	FREQUENCY	PERCENTAGE (%)	AVERAGE AGE
20-29	0	00	$34.5 \times 2 + 44.5 \times 4 + 54.5$ $= 301.5$ $X = 301.5/7$ ≈ 43 years ≈ 43 Years.
30-39	2	28.6	
40-49	4	57.1	
Above 50	1	14.3	
TOTAL	7	100%	

A total of 7 teachers out of 26 in the school participated in this study; 5 males and 2 females. Among the teachers who participated two were visually impaired; a male and a female. The teachers were sampled in such a way that only those who taught Mathematics to VIL participated. This was the group that deemed suitable and likely conduits of information that would provide answers to the research questions. Among the sampled teachers, five were males and two females. This kind of sampling brought about a diversity of experiences in the teaching of Mathematics among the VIL.

Table 4.3.4: Teacher Qualification

TEACHER QUALIFICATION	FREQUENCY	PERCENTAGE (%)
Certificate	0	00
Diploma	1	14.3
Diploma in Special Educ.	3	42.9
Bachelor Degree	0	00
B.ED Degree in Special Educ.	3	42.9
Master's Degree	0	00
Others	0	00
TOTAL	7	100

Table 4.3.5: Teaching Experience of Teachers

TEACHING EXPERIENCE	FREQUENCY	PERCENTAGE (%)	AVERAGE YEARS
1-9 Years	1	14.3	$5X1+15X1+25X4+30X1$ $=150/7$ $=21.4$ ≈ 21 Years of teaching experience
10-19 Years	1	14.3	
20-29 Years	4	57.1	
Above 30 Years	1	14.3	
TOTAL	7	100	

4.4 Objective 1: To investigate available forms of ATs that are used to support the learning of Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners.

The first study objective was to investigate the available forms of ATs in the school that support learning in Mathematics. The VIL and their Mathematics teachers were asked to identify and name the existing ATs in the school that were used in a Mathematics lesson instructional process and therefore available in school. Following the ATs that were found in the school, there was need to keep up with the pace of advancement in technology of mathematical tools for the VIL; as the language used in Mathematics relied much on the visual objects (Osterhaus, 2012). According to Simalalo, 2011; and Friend, 2009; inadequacy level always affects learning in Mathematics.

Further, the existing ATs in the school were recorded by the researcher through observation schedule and the observation checklist. The learners disagreed 100 percent that there were enough ATs for teaching and learning Mathematics in the school. The teachers on their part were asked if there were ATs always for use in Mathematics. An above average percentage i.e 57.1 percent of the teachers reported ‘not at all’, 28.6 percent reported ‘rarely’ while 14.3 percent reported ‘often’.

The following ATs for teaching and learning of Mathematics were found in the school:

Table 4.4 ATs for the Teaching and Learning of Mathematics

Type of ATs	Frequency	Percentage(%)
Cubes	7	25.9%
Abacus	6	22.2%
Laptops	3	11.1%
Counters	3	11.1%
Cuboids	2	7.4%
Cuberithms	2	7.4%
Tactile graphs	2	7.4%
Talking calculators	1	3.7%
Braille geometrical instruments	1	3.7%
Total	27	100%

Generally, the study revealed that availability of ATs in the school was inadequate. However the cubes and abacus were the most available at 25.9 and 22.2 percent respectively. Braille geometrical instruments were the least available at 3.7 percent.

The study ascertained that the ATs in the school were inadequate and needed urgent attention for effective learning of Mathematics by the VIL. For instance the ratio of talking calculators to learners was 1:11; for the abacus and cubes the ratio was 1:5 in each case. For the Braille geometrical sets, the ratio was 3:10. This inadequacy greatly slowed down the pace of learning as the learners were compelled to share the few ATs that were available.

4.5 Objective 2: To establish the challenges faced by the Visually Impaired Learners in learning Mathematics using ATs in St. Oda School for the Visually Impaired Learners.

The second objective was to identify the challenges experienced by learners while learning Mathematics using ATs. The learners were asked whether they experienced challenges while

learning Mathematics using ATs. Apart from One learner (3.3 percent) who disagreed; 29 learners (96.7 percent) agreed that they experienced challenges in using ATs while learning Mathematics; with 15 out of 30 pupils strongly agreeing. The study revealed that assessment procedures were too demanding and weighed more on visual learning than tactile learning.

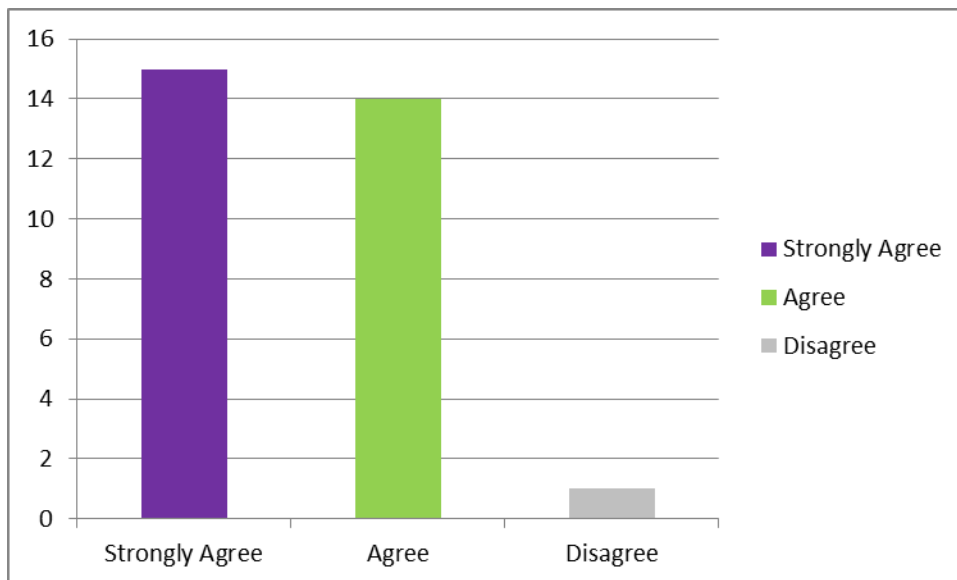


Figure 4.1: Challenges in using ATs while learning mathematics

This implied that 96.7 percent of the learners experienced challenges when using ATs while learning Mathematics. The learners stated the following as challenges encountered while learning Mathematics with ATs:

Inadequate time for Mathematics lessons (16.7 percent)

A lot of time taken to master the operations of the ATs particularly the abacus (23.3 percent)

Limited Braille textbooks for Mathematics (16.7 percent)

Sharing the scarce resources slowed conceptual learning by creating discontinuities in linear learning (6.7 percent)

General inadequacy of the Mathematics ATs in the school (26.7 percent)

Some topics lacked appropriate tools like measurement, graphs and construction of angles (10 percent)

The teachers also gave the frequency at which pupils experienced challenges in using ATs. 85.7 percent reported that ‘often’ the learners experienced challenges; with 14.3 percent reporting ‘rarely’. The 14.3 percent of the teachers agreed with Buhagiar & Tanti, 2011 who argued that the VIL could learn, do and achieve in Mathematics to advanced levels if given appropriate ATs. The 85.7 percent stressed on operational procedures particularly the abacus which proved difficult for most VIL. The study established that with proper orientation and induction of the VIL to ATs for learning Mathematics, the challenges could easily be minimized.

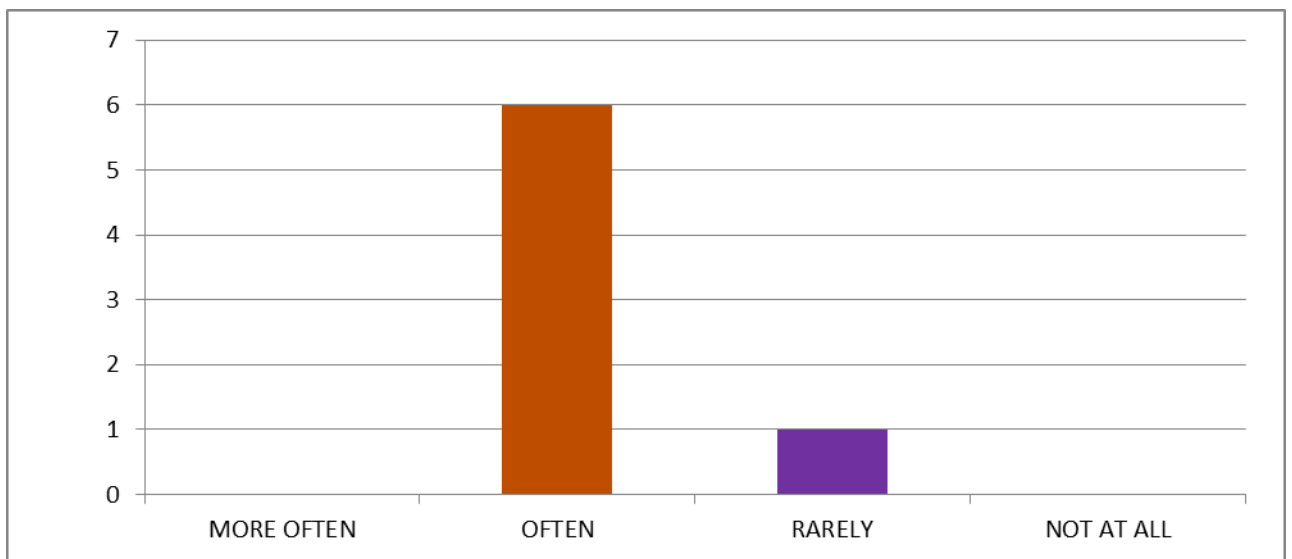


Figure 4.2: Teachers’ responses on frequency of learner challenges in using ATs

The teachers were asked to state the challenges experienced by the VIL when using ATs in learning Mathematics. This section was corroborated with section (III) on part C of the teachers’ questionnaire which required teachers to state the perceived barriers in the effective teaching and learning in Mathematics using ATs. The teachers gave the following as challenges:

Table 4.5: Challenges experienced by VIL in Learning Mathematics using ATs

CHALLENGE	FREQUENCY	PERCENTAGE(%) FREQUENCY
Needs a lot of time to integrate	2	7.4
Negative attitude of the learners towards Mathematics	6	22.2
Inadequacy of the ATs	7	25.9
Misuse by the learners	1	3.7
Takes time to train learners	5	18.5
Inadequate number of trained personnel	6	22.2
TOTAL	27	100

Inadequacy of the ATs was the most cited challenge at 25.9 percent. Negative attitude of the learners and an inadequate number of trained and qualified personnel followed at 22.2 percent in each case. The research indicated that the time the teachers took for training the learners on how to use ATs was a challenge on the path of the VIL towards excellence in Mathematics and was also confirmed by the respondents at 18.5 percent. The National Center for Tactile Diagrams-NCTD, 2011; noted that there was need to come up with new ATs to make Mathematics more-friendlier and also be more accessible for the VIL to learn with much ease otherwise teachers would always take time in training these learners on how to use ATs.

The study revealed that ATs were inadequate as compared to learner population. For instance, Standard seven, in a live lesson that was observed by the researcher, there were only four Braille geometrical sets against fifteen learners. The teachers also stated that they were taking a lot of time to train learners on the use of ATs like the abacus by developing specialized skills. In learning these specialized skills, the VIL needed unique strategies and an elaborate adaptation in mathematical concept formation and development (Adesina, 2007).

The observation guide comprised of data that was collected based on utilization of resources and ATs integration in a live classroom situation during a Mathematics lesson. The researcher requested and was given an opportunity to get first-hand information in regard to teaching and learning using ATs in a Mathematics classroom. The researcher while seated at the back of the class and observing lesson delivery by the teacher, observed the existing resources, the challenges faced by VIL in the course of learning Mathematics, the available and accessible

ATs for integration, the level of use and the impact created by the utilized ATs through which the research questions were answered.

The pupils' as well as the teacher' activities were recorded all through from lesson introduction, development and conclusion level. The interaction of the learners with the ATs during lesson delivery confirmed Linda Harasim's theory on online collaborative learning as the learners were able to generate ideas based on the content and the ATs link. The VIL need to be empowered to do what they dare to dream (Meek *et al.*, 2009; Bandura, 1986; South Africa National Council for the Blind, 2010 report). This would only be possible if there are adequate and dependable resources within their reach.

From the observation guide the following were observed by the researcher as challenges experienced by the VIL in learning Mathematics; in line with the second research question, which read 'Which challenges do VIL face in the teaching and learning process using ATs in St. Oda School for the Visually Impaired Learners?'

Inadequate time for effective lesson delivery

The 35-minutes lesson was too brief for this group of learners to effectively grasp Mathematics concepts and formulae.

Inadequacy of the ATs as there was sharing in the course of lesson delivery.

Class co-ordination was unique as the learners learnt at different paces and link-ups to the learning points were diverse based on learning experiences

Some learners were reluctant to move on with the teacher in conceptual and incidental learning pointing to their negative attitude towards the subject

The cubes and cuberithms were too small such that if misplaced or fell down, tracing took a lot of time or needed a sighted learner.

From the observation checklist, the researcher established that the ATs for the teaching and learning of Mathematics were inadequate in the school based on availability and accessibility vis-à-vis learner population. Apart from the Braille writing frame, where the ratio to learners was 7:10, all others had a ratio of 3:10 or less. Further, modern ATs for the teaching and learning of Mathematics like the Mathematics daisy were missing in the school under study.

The research review also revealed that teachers had inadequate knowledge on the use of ATs to enable them to effectively and constructively engage the VIL in the learning of Mathematics (Kiarie, 2004).

4.6 Objective 3: To determine the level of integration of ATs in the teaching and learning of Mathematics for the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners.

The third objective focused on determining the level of integration of ATs in the teaching and learning of Mathematics. The learners were asked whether they used ATs in every lesson in learning Mathematics. The learner responses were interesting as all of them, 100 percent disagreed. This implied that some lessons were taught without integrating ATs thus impacting negatively on the learning of Mathematics.

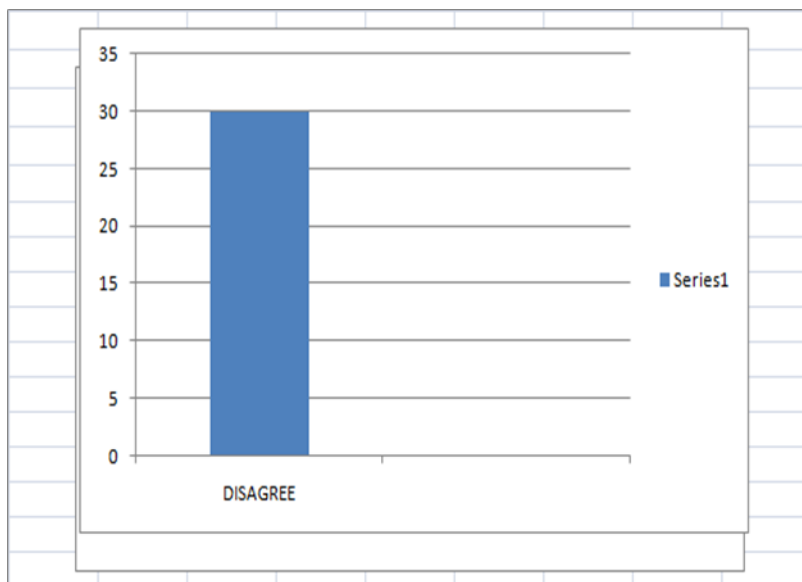


Figure 4.2: Every lesson use of ATs

The researcher asked the teachers to state their satisfaction rate regarding the level of integration of ATs in the teaching and learning of Mathematics. The teachers, 42.9 per cent, were 'satisfied', while 42.9 per cent were 'dissatisfied', and 14.3 per cent were 'highly dissatisfied.' According to UNESCO, 2010; inclusive education is not a synonym for special needs education or integration techniques but as an on-going process in an ever-evolving education system, focusing on those currently excluded from accessing education, as well as those who are in school but not learning with ATs, hence creating disconnection in Mathematics for the VIL (UNESCO, 2010). The dissatisfaction rate of over 57 per cent

clearly indicated that integration of ATs in the teaching of Mathematics in the school was inadequate.

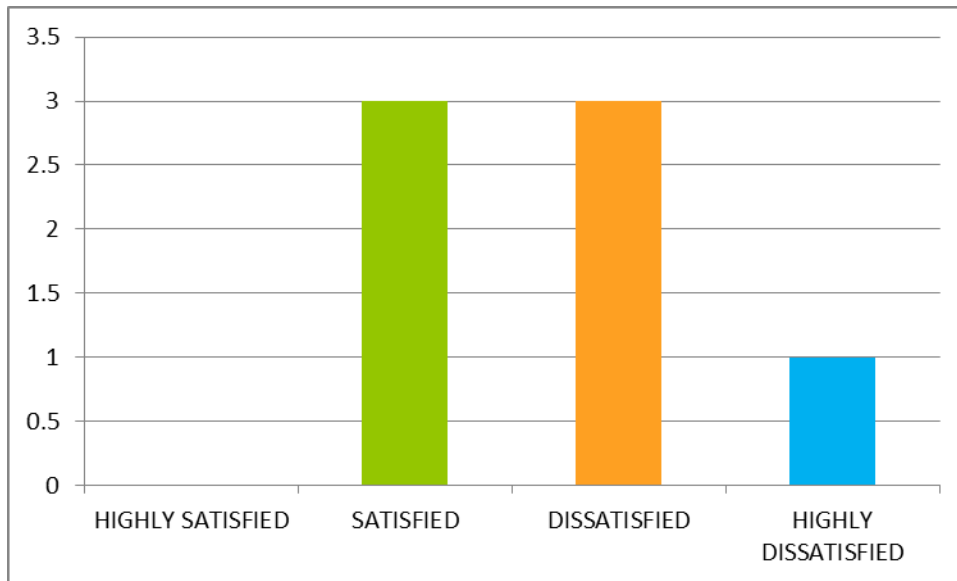


Figure 4.3: Teachers' satisfaction responses to the level of ATs integration

On the teachers' interview schedule, the teachers were asked to give the level to which ATs were integrated into the school for teaching and learning Mathematics. The teachers rated the level as; high (00 per cent), average (71.4 per cent), low (28.6 per cent) and no integration (00 per cent).

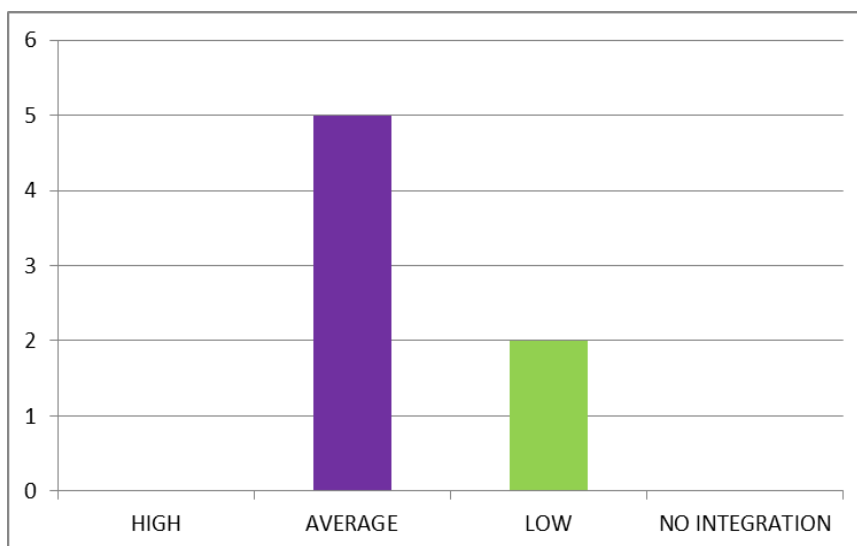


Figure 4.4: Teachers' responses to the level of integrating ATs

The teachers' rating on the level of ATs integration ranged between average (71.4 per cent) and low (28.5 per cent). Therefore the level of integration was less than 50 percent. These

responses correlated well with those of teacher satisfaction scale. The study established that the inadequacy of ATs in the school for the teaching and learning of Mathematics prompted a challenge in utilization and therefore integration ranged between average (50 percent) and zero. From the observation guide the study indicated an average level (50 percent) of integration.

4.7 Objective 4: To establish the impact of integrating ATs in learning Mathematics among the Visually Impaired Learners in St. Oda School for the Visually Impaired Learners

The focus of the study was to establish the impact of integrating ATs in the teaching and learning of Mathematics among the VIL in St. Oda School for the Visually Impaired. The learners were asked whether they learned Mathematics quickly when ATs were used. It was observed that 14 of the learners (46.7 per cent) agreed, one learner (3.3 per cent) strongly agreed while the other half (50 percent) disagreed. Those who disagreed gave ATs operational procedures as a reason why they were learning Mathematics slowly when ATs were used. At least half of the time meant for learning Mathematics was spent on learning the operations of the applicable ATs mostly for beginners or just in case of new ATs. The impact of ATs therefore depended on learners' uptake of the ATs.

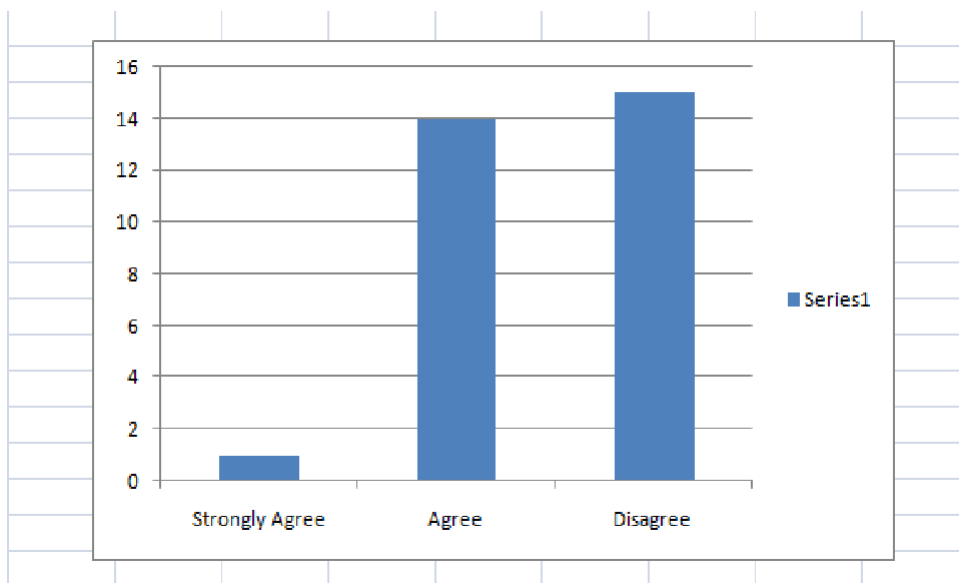


Figure 4.5: Impact of ATs on learning Mathematics according to learners

When the learners were asked if the ATs made Mathematics real hence easy to learn, 16 pupils (53.3 percent) agreed, one learner (3.3 per cent) strongly agreed while 13 learners (43.3 percent) disagreed. Those who disagreed gave operational procedures and the abstract nature of the subject in some areas of the syllabus like 3-Dimensional Geometry as the reasons.

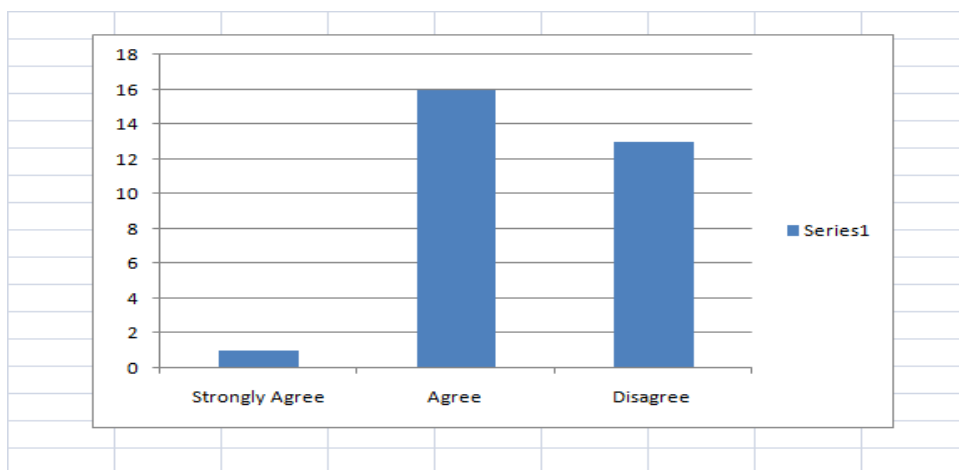


Figure 4.6: Reality of ATs on Mathematics according to learners

The teachers' questionnaire was used in establishing the impact of the ATs in the learning of Mathematics by the VIL.

The teachers were asked to state their satisfaction level regarding the impact of ATs on learner performance in Mathematics. It was observed that 28.6 percent of the teachers were satisfied while 71.4 percent were dissatisfied.

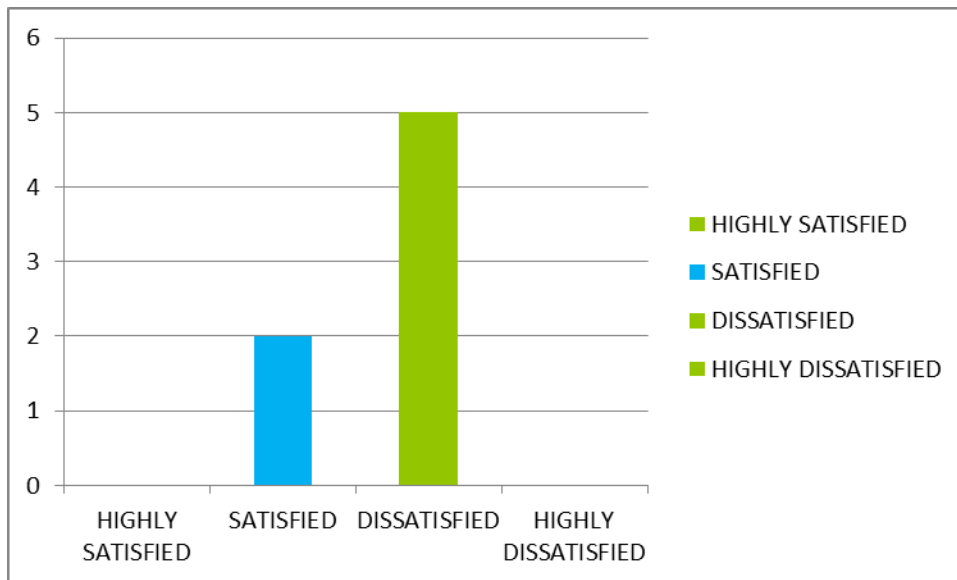


Figure 4.7: Teachers' responses on the impact of integrating ATs

The teachers were asked the rate of the pace of syllabus coverage given ATs. Three teachers (42.9 per cent) said that 'often' syllabus coverage was faster with ATs while four (57.1 per cent) said 'not at all.'

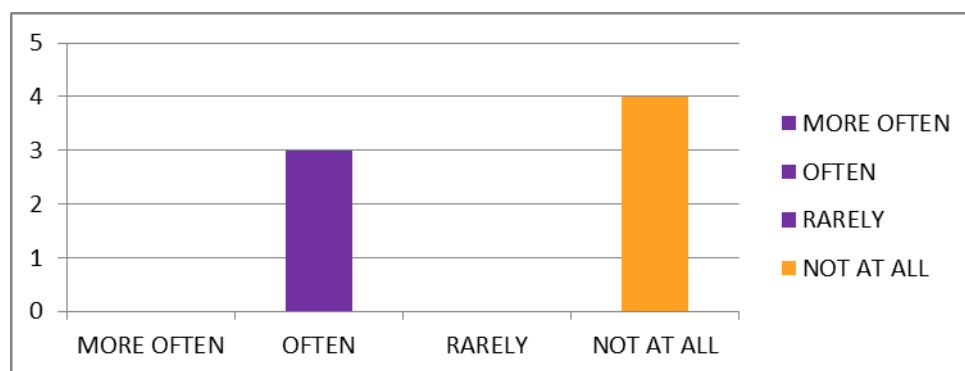


Figure 4.8: Teachers' responses on ATs and rate of syllabus coverage

The teachers were asked if ATs motivated learners. Three respondents (42.9 per cent) agreed that 'often' ATs motivated pupils to learn Mathematics, while Four (57.1 per cent) said 'not at all.'

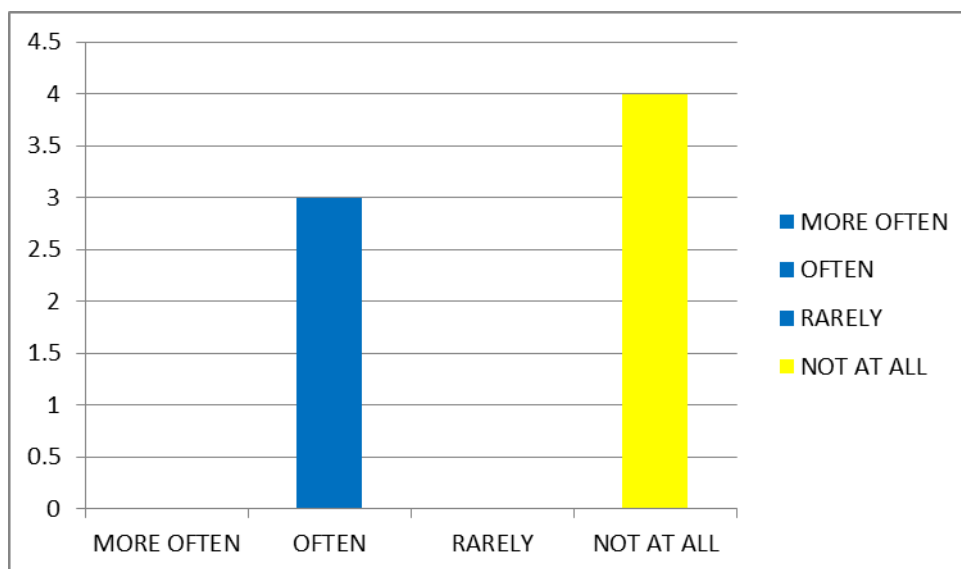


Figure 4.9: ATs and learner motivation in mathematics as per teachers

Further, the teachers were asked if ATs improved pupils' performance in Mathematics when used. Two teachers (28.6 percent) said 'often', three (42.9 percent) said 'rarely' while two (28.6 percent) said 'not at all'. Those who said 'not at all' gave inadequacy as the main factor.

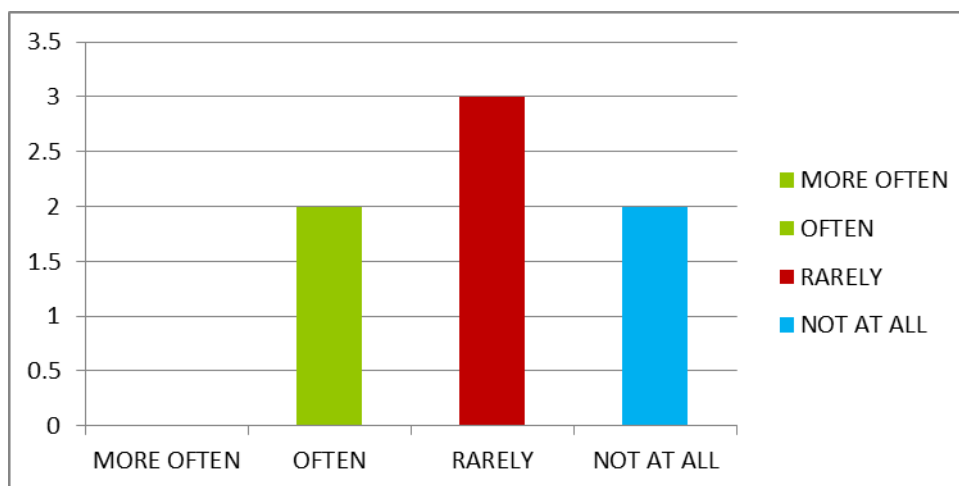


Figure 4.10: ATs and learner improvement in Mathematics

The teachers were also asked if the ATs enhanced the teaching of Mathematics. It was noted that three respondents (42.9 per cent) agreed that 'often' teaching Mathematics was enhanced

by ATs, Two (28.6 per cent) of the respondents said ‘rarely ‘and the other two (28.6 per cent) said ‘not at all’.

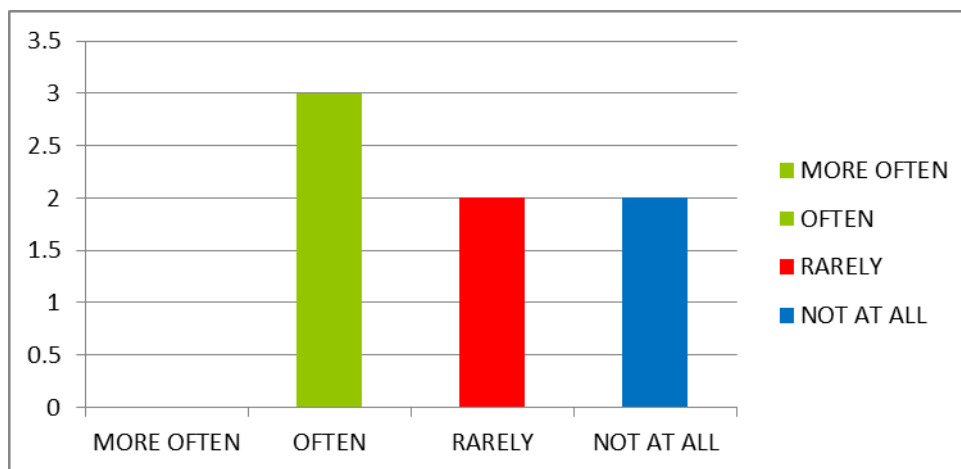


Figure 4.11: ATs and Mathematics enhancement

Regarding the performance of the learners in Mathematics, the teachers were asked if ATs enhanced pupil performance in Mathematics. It was observed that three teachers (42.9 percent) agreed, three (42.9 percent) disagreed while one (14.3 percent) strongly disagreed. There are three levels of knowledge construction: Idea generating/Brainstorming level; where various views on ATs are gathered, Idea organizing level; where ideas are discussed, compared and then organized through ATs and the intellectual convergence level; where synthesis and consensus are achieved using particular ATs after discussions, comparisons and organization(Harasim, 2012). The study established the need for the VIL to be given an opportunity for these three levels to be nurtured and realized for a barrier-free academic environment in their journey in Mathematics.

The teachers were asked to rate the impact of ATs on learner performance in Mathematics. Their responses were: high(00 percent), average(42.9 percent), minimal (42.9 per cent) and no impact(14.3 percent).

From the observation guide, the study established that the learners who had mastered the ATs operations grasped the concepts and mathematical formulae much faster than those who were learning ATs operational procedures at the same time learning Mathematics. The double burden for those learning operational procedures contributed to the learners’ negative attitude towards the subject and their self-esteem hence impacted negatively on the learning process.

The element of sharing also compounded the problem for the learners as it slowed down idea generation.

The study established a consistent trend which indicated that the impact of integrating ATs in the teaching and learning of Mathematics by the VIL ranged between average (50 percent) and zero. The research established that inadequacy of ATs in the school for the teaching and learning of Mathematics prompted a challenge in integration; and therefore an average (50 percent) to zero in integration; which further influenced the impact that ranged between average (50 percent) and below.

4.8: Findings from the head teacher

The purpose of this interview was to get information from the school head teacher, who is the manager of the ATs in the school. The head teacher was asked two questions by the researcher that focused on procurement and management of the ATs; and the in-service training for the teachers in the school. On procurement, the head teacher reported that the ATs were acquired through purchase, donations and gifts. On the management of the available ATs in the school, the head teacher reported that the ATs were stored in a designated room within the school from where they were obtained on demand by the concerned teacher. There was also an IT room that housed laptops with a qualified teacher assigned to take care.

On Mathematics teachers going for in-service training to cope with the emerging trends on ATs for the teaching and learning of Mathematics, the head teacher reported that it was a bit difficult as there was a tight learning schedule that limited this possibility. However, she was positive that going forward, in-servicing would be given a priority.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives a summary of the whole research, study findings, the conclusion based on the study, recommendations, and suggestions for further research. The research focused on the ATs available for the visually impaired learners for learning Mathematics in primary schools; the challenges experienced by the visually impaired learners while learning Mathematics; the level of integration of the ATs in the teaching and learning of Mathematics; and the impact created by these ATs in learning Mathematics among the Visually Impaired Learners of St. Oda Primary school for the Visually Impaired in Siaya County.

5.2 Summary of the main findings

The research focused on the ATs available for the Visually Impaired Learners for learning Mathematics in primary schools; the challenges experienced by the visually impaired learners while learning Mathematics; the level of integration of the ATs in the teaching and learning of Mathematics; and the impact created by these ATs in learning Mathematics. A total of 30 Visually Impaired Learners participated in this study and a total of 7 teachers who were teaching these learners Mathematics.

5.2.1 Assistive technologies available for the visually impaired learners

From the presentation of findings, interpretation and discussion in chapter Four; the forms of ATs in the school were inadequate, according to the learners (96.7 per cent) and teachers (57.1 per cent). From the ATs available in school, the research established that they were inadequate for the number of learners in the school. For instance the ratio of talking calculators to learners was 1:11; for the abacus and cubes for calculation, the ratio was 1:5 in each case. For every Ten learners there were Three Braille geometrical sets. This inadequacy greatly slowed down the pace of learning, as the learners were compelled to share the few ATs that were available. The most available forms of ATs for learning Mathematics were cubes (25.9 percent), abacus (22.2 percent), laptops (11.1 percent) and counters (11.1 percent).

5.2.2 Challenges experienced by the visually impaired learners

The main challenges experienced by the VIL while learning Mathematics were identified as:-

Inadequacy of the ATs was the most cited challenge at 25.9 percent.

The inadequate number of trained and qualified personnel at 22.2 percent.

The time the teachers took for training the learners on how to use ATs was also singled out as a challenge on the path of the VIL towards excellence in Mathematics, at 18.5 percent.

These challenges cumulatively covered 70.3% of the challenges experienced by the VIL.

The implication of these challenges is that the learning in Mathematics by the VIL will continue being below average until such a time that appropriate measures will be put in place.

5.2.3: Level of integration of ATs

The level of integration in the school was given by the teachers as 'Average' (71.4 per cent) and 'Low' (28.6 per cent). A significant percentage of the learners, 100% said they were not using ATs in every lesson of Mathematics in the school. The study showed that the inadequacy of the ATs in the school directly affected level of integration. From the observation guide the study indicated an average level (50 percent) of integration.

5.2.4: Impact of integrating ATs in the teaching and learning of Mathematics among the visually impaired learners

The study sought to establish the impact of ATs on the visually impaired learner performance in Mathematics in St. Oda School for the Visually Impaired Learners. According to the teachers and based on the ATs which were being used in the school, the impact was average (42.9 percent); minimal (42.3 percent), and 14.3 percent of the respondents said that there was no impact. The main reason that was given was the inadequacy of the ATs.

On the pace of learning, 14 of the learners (46.7 percent); agreed that they learned Mathematics quickly when ATs were used, with One learner (3.3 percent); strongly agreeing, while the other half (50 percent) disagreed. The 50 percent of the learners who disagreed gave ATs operational procedures as a reason why they were learning Mathematics slowly when ATs were used during Mathematics lessons. At least half of the time meant for learning Mathematics was spent on learning the operations of the applicable ATs. Further, a total of 53.3 per cent of the pupils agreed that ATs made Mathematics real hence easy to learn, with one learner (3.3 per cent) strongly agreeing. There were 13(43.3 per cent) learners who

disagreed, and they cited operational procedures of the ATs as a reason, and the abstract nature of the subject in some areas of the syllabus like algebra, graphing, and 3-Dimensional geometry; among others.

The study established a consistent trend which indicated that the impact of integrating ATs in the teaching and learning of Mathematics by the VIL ranged between average (50 percent) and zero. The research established further that inadequacy of ATs in the school for the teaching and learning of Mathematics prompted a challenge in integration; and therefore an average to low level in integration; which further influenced the impact that ranged between average (50 percent) and zero.

5.3 : Conclusions of the study

a) (i) Given the teacher responses on availability of ATs for all classes, 85.7 per cent said there were no enough ATs for all the classes. Only 14.3 per cent of the respondents agreed that the ATs in the school was enough for all classes. This means that the teachers were teaching without ATs, thereby disadvantaging the visually impaired learners, and hence the impact in integration ranged between average and zero.

(ii) The learners (96.7 per cent) equally said there were no enough ATs in the school.

It was interesting when 100 per cent of the learners said that there were no enough ATs for learning Mathematics in their school. Therefore this pointed to a likely acute shortage of ATs in the school, which needed urgent attention and intervention to guarantee this group's stake in Mathematics. This fact was also established through the observation guide and observation checklist.

b) The main challenges experienced by the VIL while learning Mathematics were:-

i Inadequacy of the ATs was the most cited challenge at 25.9 percent.

ii The inadequate number of trained and qualified personnel at 22.2 percent.

iii The time the teachers took for training the learners on how to use ATs was also singled out as a challenge on the path of the VIL towards excellence in Mathematics, at 18.5 percent.

The implication of these challenges is that the learning in Mathematics by the VIL will continue being below average until such a time that appropriate measures will be put in place.

c) The level of integration in the school was average (71.4 per cent) and low (28.6 per cent). This emanated from inadequacy of ATs and the trained personnel in the school. The net effect was that some lessons were taught without ATs, thereby disadvantaging the VIL

d) Given the inadequacy of the ATs in the school for the teaching and learning of Mathematics, the impact of integrating ATs in the teaching and learning of Mathematics among the visually impaired learners ranged between average (42.9 per cent); low (42.9 per cent) and no impact (14.3 per cent). The study established an average impact where about half of the learners were capable of handling the ATs and carry out calculations effectively. Low impact was established where, despite availability and access to ATs, a quarter of the learners were able to do Mathematics effectively using the ATs. No impact was established in a scenario where the learners were unable to handle and operate on the ATs in carrying out calculations in Mathematics; or where the ATs were not available and accessible.

The impact of integrating ATs in learners' performance in Mathematics therefore depended on how the VIL were inducted in the use of the ATs which determined their participation; the ATs integration of the ATs, and the teaching methods. The study established that with proper induction to VIL regarding ATs, their loss of sight will be substantially compensated and they can effectively learn Mathematics. Inadequacy of ATs in the school for the teaching and learning of Mathematics, prompted a challenge in integration and therefore an average to low level in integration; which further influenced the impact that ranged between average (50 percent) and zero.

5.4 Recommendations from the study

a) The ATs should be available and accessible to the teachers and VIL. This should go a long way in bridging the gap that is created by their loss of sight, and therefore connections in the learning of Mathematics will be enhanced. The respondents cited the inadequacy of the ATs as a severe barrier in effective teaching and learning of Mathematics by the VIL.

b) The teachers should be encouraged to improvise learning aids by use of locally available materials to mitigate on inadequacy of ATs for learning Mathematics

c) The time allocated for lesson attendance for the VIL should reasonably and adequately be increased. The 35 minutes lesson was not adequate for an effective Mathematics lesson delivery compounded by the problem of inadequacy of the ATs and the element of adoption and adaptation of these resources by the VIL.

5.5 Suggestions for further research

a) This research was conducted on only one school in Siaya County. The findings, therefore, are not representative of the whole country. Therefore, other similar studies should be conducted in other counties.

b) Research should be carried out on a modern and current universal design of ATs in the market that can accommodate the diverse nature of Visually Impaired Learners and enable learning outcomes to converge at a point in Mathematics.

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APPENDICES

APPENDIX I: Introductory letter

Dear sir/Madam,

My name is Fred Nyakwara Onyancha from Kenyatta University. I am conducting a research on integration of Assistive Technologies in the teaching and learning of Mathematics among the visually impaired learners in your school. The research will cover visually impaired learners in standards four to eight in the school. I therefore request for your cooperation and time in filling the questionnaire and responding to the scheduled interviews. Assurance is hereby given that the information given will be treated with utmost confidentiality; and will only be for this research.

Thank you for your anticipated cooperation and support

Yours Faithfully,



Fred Nyakwara Onyancha,

Masters of Education student, Department of Educational and Communication Technology,

Kenyatta University

Date.....

APPENDIX II: INFORMED CONSENT

My name is Fred Nyakwara Onyancha. I am a Master of education student from Kenyatta University. I am conducting a study on the **“IMPACT OF INTEGRATING ASSISTIVE TECHNOLOGIES IN LEARNING MATHEMATICS AMONG THE VISUALLY IMPAIRED LEARNERS IN ST ODA SCHOOL IN SIAYA COUNTY, KENYA”**. The information will be used by the ministries of education and ICT to improve access and quality of education in Mathematics that is offered to the visually impaired learners in Kenya

PROCEDURES TO BE FOLLOWED

Participation in this study will require that I ask you some questions through the tools for data collection which will include one or both of the following:

The questionnaire

The interview schedule

Data will also be collected through observation guide in a routine classroom lesson in Mathematics. The observation checklist will be used in ascertaining availability of the assistive technologies available. The data collected will then be recorded for analysis.

You have the right to refuse participation in this study. You will get the same care whether you agree to join the study or not and your decision will not change the attention you will get in the entire teaching and learning process in Mathematics.

Please remember the participation in this study is voluntary. You may ask questions related to the study at any time.

You may refuse to respond to any questions and you may stop an interview at any time. You may also stop being in the study at any time without any consequences to the teaching and learning process now or any other time in future

DISCOMFORTS AND RISKS

Some of the questions you will be asked may be embarrassing or make you uncomfortable. If this happens, you may refuse to answer these questions if you so choose. You may also stop the interview at any time.

BENEFITS

If you participate in this study you will help in advancing the quest for effective Assistive Technologies for the Visually Impaired Learners in the society which will enable them to realise their potential in Mathematics.

CONFIDENTIALITY

The interview will be conducted in a private setting within the school. Your name will not be recorded on the questionnaire. The questionnaires will be kept in a locked cabinet for safe keeping at Kenyatta University. Everything will be kept private.

CONTACT INFORMATION

If you have any questions you may contact Dr. Miheso on +254720853900 or Prof. Ondigi on +254721413037 or the Kenyatta University Ethical Review Committee Secretariat on kuerc.chairman@ku.ac.ke, secretary.kuerc@ku.ac.ke, secretariat.kuerc@ku.ac.ke

Address: P.O BOX 43844, NAIROBI, 00100

TEL: 8710901/12

PARTICIPANT'S STATEMENT

The above information regarding my participation in the study is clear to me. I have been given a chance to ask questions and my questions have been answered to my satisfaction. My participation in this study is entirely voluntary. I understand that my records will be kept private and that I can leave the study at any time. I understand that I can still get the same attention in the learning process whether I decide to leave the study or not and my decision will not change the care that I will receive in the teaching and learning process in Mathematics now or any other time in the future.

Name of

Participant:

Signature or Thumbprint

Date

INVESTIGATOR'S STATEMENT

I, the undersigned, have explained to the volunteer in a language s/he understands the procedures to be followed in the study and the risks and benefits involved.

Name

of

Investigator: Fred Nyakwara Onyancha.....

Signature or Thumbprint

Date

APPENDIX III: PUPIL QUESTIONNAIRE

The purpose of this questionnaire is to get information from you, as learners who are visually impaired and learning Mathematics. This questionnaire has two parts. Kindly complete each part as instructed. The information provided will be treated confidentially. You are not required to write your name or any other form of identification. Your sincere responses will be regarded highly. Your response is just your opinion so there is NO wrong answer.

PART A

BACKGROUND INFORMATION

(1) Gender: Male Female

(2) What is your Class?

(3) Give your age in years-----

PART B

MATHEMATICS AND ASSISTIVE TECHNOLOGIES QUESTIONNAIRE

Please use the scale given to respond to the given statements, after you have understood the statement clearly

PUPIL'S ATTITUDE FOCUS

Key:(1)Strongly Disagree (SD) (2)Disagree(D) (3)Agree(A) (4)Strongly Agree (SA)

{Just put a tick} in the column that suits you most)

TABLE 3.8: MATHEMATICS AND ASSISTIVE TECHNOLOGIES TABLE

S/NO	FOCUS AREA	SA	A	D	SD
1	In our school, there are many ATs				
2	In our school, we use ATs				
3	I experience challenges in using ATS while learning				
4	I experience challenges in learning Mathematics using ATs				
5	There are enough ATs for learning Mathematics				
6	We use ATS in every lesson in our school				
7	My understanding in Mathematics depends on the ATs used				
8	The ATs used in teaching Mathematics complicates learning				
9	I learn Mathematics quickly when ATs are used				
10	The ATs make Mathematics real hence easy to learn				

PART B (I)

The following is a list of factors that are related to your working conditions. You are requested to read them carefully and indicate a number that suits you most in the brackets.

Response scale

(1)Highly Dissatisfied (HD) (2) Dissatisfied (D) (3) Satisfied(S) (4) HighlySatisfied (HS)

What is your opinion on the following working conditions?

TABLE 3.9: TEACHERS AND ASSISTIVE TECHNOLOGIES

S/NO		HS	S	D	HD
1	Existing ATs in the school				
2	Ratio of ATs to the learners				
3	ATs for teaching Mathematics in the school				
4	The level of integration of ATs in the teaching and learning of Mathematics				
5	The impact of ATs on learner performance in Mathematics				

PART B (II)

TEACHING EFFECTIVENESS

The following are factors related to teacher effectiveness. Please use the response rating scale in every factor and put a tick in the column that suits you most in the table.

The response rating scale is:-

(4)More often (3) Often (2) Rarely (1) Not at all

Table 3.10: TEACHER EFFECTIVENESS TABLE

S/NO	Target area	More often	Often	Rarely	Not at all
1	ATs are available in school				
2	Pupils use ATs in school				
3	Pupils experience challenges in using ATs				
4	Mathematics has many areas of ATs integration				
5	Syllabus coverage is faster with ATs.				
6	ATs motivate pupils to learn Mathematics				
7	I integrate ATs in teaching Mathematics				
8	ATs improve pupils performance in Mathematics when used				
9	Teaching Mathematics is enhanced by ATs				
10	There are always ATs for use in Mathematics				

PART B(III)

TEACHER CHALLENGES

The following are factors related to teacher burnout in regard to ATs. Please use the response scale in every factor to show the one that suits you most.

Response scale:-

Key:(1)Strongly disagree(SD) (2)Disagree(D) (3)Agree(A) (4)Strongly agree(SA)

(Just put a tick in the column that suits you most)

TABLE 3.11: TEACHER CHALLENGES

C/NO	CHALLENGE AREA	SA	A	D	SD
1	There are so many types of ATs for integration in Mathematics teaching and learning in our school				
2	I spend a lot of time modifying ATs in math for VIL				
3	ATs create confusion when used to teach Mathematics				
4	In a school day I work better when there are adequate ATs for teaching Mathematics				
5	Adequate ATs shorten the Mathematics syllabus				
6	There is ATs integration in every Mathematics lesson				
7	ATs enhance pupil performance in Mathematics				
8	Dealing with pupils with visual impairment requires adequate ATs in learning Mathematics				
9	There are minimal ATs for teaching Mathematics in our school				
10	There are many challenges in integrating ATs in Mathematics lessons				

PART C

QUESTIONNAIRE: TEACHERS

(i) There is a wide variety of ATs that you can integrate in teaching Mathematics. List the ones that you are using in your school.....

APPENDIX V: INTERVIEW SCHEDULE FOR MATHEMATICS TEACHERS

The purpose of this interview is to get the information from teachers who implement the Mathematics curriculum to the visually impaired learners in the school.

Introduction to an interview

Hello. My name is Fred Onyancha. I request to interview you on five areas: ATs available in school for the visually impaired learners, the challenges experienced by the visually impaired learners in the course of learning Mathematics; the assistive technologies for the teaching and learning of Mathematics in the school; the level of integration of ATs in the teaching and learning of Mathematics for the visually impaired learners; and the impact of ATs on the learner performance in Mathematics.

(I) Which ATs are available in the school for the VIL?

(II) What are the challenges that are experienced by the VIL when using ATs in learning Mathematics?

(III) Which ATs are available in the school for the teaching and learning in Mathematics?

(IV) To what extent are ATs integrated in the school for the teaching and learning in Mathematics? (High, Average, Low)

(V) What is the impact of ATs on learner performance in Mathematics?

APPENDIX VI: INTERVIEW SCHEDULE FOR THE HEAD TEACHER

The purpose of this interview is to get information from the school head teacher who is the manager of the ATs in the school.

Introduction to an interview

Hello. My name is Fred Onyancha. I request to interview you on two areas:-

(i) How do you acquire and manage the ATs for the teaching and learning of Mathematics?

(ii) Do Mathematics teachers go for in-servicing so as to cope with the new ATs for the teaching and learning of Mathematics?

Thank you.

APPENDIX VII: OBSERVATION GUIDE

The observation guide will comprise of data that will be collected based on utilization of resources and AT integration in a live classroom situation during a Mathematics lesson. It will give an opportunity where first-hand information will be generated in regard to existing resources, the challenges faced by VIL in the course of learning Mathematics, the available and accessible ATs for integration; and also the level of use through which the research questions will be answered. The pupils activities as well as the teacher activities will be recorded all through from lesson introduction, development and conclusion level

CLASS..... TOPIC..... SUBTOPIC.....

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DURATION..... DATE..... NO. OF STUDENTS.....

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TABLE 3.13: OBSERVATION GUIDE

S/NO	TEACHER ACTIVITY	INTRODUCTION	DEVELOPMENT	CONCLUSION
I	Utilizing ATs			
Ii	Demonstrating with ATs			
Iii	Improvising			
Vi	Integrating ATs			
V	ATs adequacy level			
Vi	Engaging learners with ATs			
Vii	Other activities that are observable			

S/NO	LEARNER ACTIVITY	INTRODUCTION	DEVELOPMENT	CONCLUSION
I	Utilizing Resources			
Ii	Answering questions			
Iii	Interacting with ATs			
Iv	Calculating sums using ATs			
V	Grouping/Discussing			
Vi	Graphing/Drawing			
Vii	Other observable activities			

Lesson evaluation by researcher	Marks awarded	Grade awarded	Comments on the observation
On the teacher

Lesson evaluation by researcher on the VIL	Marks awarded	Grade awarded	Comments on the Observation

APPENDIX VIII: OBSERVATION CHECKLIST

The observation checklist will contain the list of ATs for use in a Mathematics instructional process. The checklist will be of use in determining the availability, accessibility and level of use of ATs in the school. The checklist will include all resources and ATs available in school whether in use or not; and this will determine their utilization. Some of the expected ATs for learning Mathematics are Screen magnifier, Accessible graphing calculator, Eye tracking, Talking word processor, Touch screens, Braille printer, Braille language converter, Maths Daisy, JAWS(screen reader software), Specialized keyboards, Nemeth code, Ipads and Ipods, CCTVs, Scanners, Tape recorders, Dolphin pen, Enhanced vision system cameras, Large print photocopier, Braille sense and the SMART/Interactive whiteboard. In case of more ATs in the school; the list will be added

KEY

=For available ; X = not available

CLASS.....SUBJECT.....

--

DATE OF RECORDING----- NUMBER OF STUDENTS-----

TABLE 3.14: AT Infrastructure and use

S/NO	AT TYPE	USE OF THE AT	Availability	Adequate number
I				
II				
III				
IV				
V				
VI				

VII				
VIII				
IX				
X				
XI				
XII				
XIII				
XIV				
XV				
XVI				
XVII				
XVIII				
XIX				
XX				

APPENDIX IX: WORKPLAN

January---April(2014)-----Concept Paper Writing
April –August(2015) -----Writing a Proposal
August(2015)- October(2015)-----Proposal corrections
November(2015)- 2017-----Submission of proposal
December (2017)- February(2018) -----Piloting/Data collection
March – August(2018)-----Analysis and Writing of the Thesis
January– May(2019) -----Submission of Thesis.

APPENDIX X: BUDGET

Fare/transport=====	Ksh.30000
Photocopying/Printing====	Ksh.20000
Typing=====	Ksh.7000
Stationery=====	Ksh.10000
Research permit=====	Ksh.1000
Miscellaneous=====	Ksh.16000
Internet=====	<u>Ksh.20000</u>
Total=====	<u>Ksh.104000</u>

APPENDIX XI: SPLIT-HALF RESPONSES FROM PUPILS(FOR RELIABILITY TEST):

SET A: ODD NUMBERS

S/NO.	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
1	0	0	15	0
2	0	15	0	0
3	8	6	1	0
4	8	6	1	0
5	0	0	15	0
6	0	0	15	0
7	3	2	10	0
8	8	6	1	0
9	1	6	8	0
10	1	8	6	0

SET B: EVEN NUMBERS

S/NO.	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
1	0	1	14	0
2	1	14	0	0
3	7	8	0	0
4	9	6	0	0
5	0	0	15	0
6	0	0	15	0
7	1	3	11	0
8	11	1	3	0
9	0	8	7	0
10	0	8	7	0

Using the Pearson r coefficient,

$r = \frac{\sum xy - (\sum x)(\sum y)/N}{\sqrt{\{(\sum x^2 - \Sigma(x)^2/N)\{ \sum y^2 - \Sigma(y)^2/N\}}}}$ which gave $r=0.8795$; using spss version 21.

$$\sqrt{\{(\sum x^2 - \Sigma(x)^2/N)\{ \sum y^2 - \Sigma(y)^2/N\}}}$$

APPENDIX XII: CITI COURSE RECORD

Bottom of Form

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Fred Nyakwara Onyancha

ID 5447012

Group 2 Social / Behavioral Research Investigators and Key Personnel

Georgia Institute of Technology

You completed the mandatory elements of this course on **16-Mar-2016** with a final reported average score of **85%**.

85%

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Required Modules

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Modules

Completed Score

Belmont Report and Its Principles (ID 1127)

14-Mar-2016 100%

Students in Research (ID 1321)

15-Mar-2016 60%

History and Ethical Principles - SBE (ID 490)

15-Mar-2016 100%

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Modules	Completed	Score
Defining Research with Human Subjects - SBE (ID 491)	15-Mar-2016	80%
The Federal Regulations - SBE (ID 502)	15-Mar-2016	100%
Assessing Risk - SBE (ID 503)	15-Mar-2016	80%
Informed Consent - SBE (ID 504)	15-Mar-2016	60%
Privacy and Confidentiality - SBE (ID 505)	15-Mar-2016	60%
Research with Children - SBE (ID 507)	15-Mar-2016	80%
Research in Public Elementary and Secondary Schools - SBE (ID 508)	15-Mar-2016	100%
International Research - SBE (ID 509)	16-Mar-2016	100%
International Studies (ID 971)	16-Mar-2016	100%
Internet-Based Research - SBE (ID 510)	16-Mar-2016	100%
Research and HIPAA Privacy Protections (ID 14)	16-Mar-2016	80%
Vulnerable Subjects - Research Involving Workers/Employees (ID 483)	16-Mar-2016	100%
Conflicts of Interest in Research Involving Human Subjects (ID 488)	16-Mar-2016	80%

APPENDIX XIII: THE MAP OF SIAYA COUNTY



APPENDIX XIV: COPY OF PERMIT TO CONDUCT RESEARCH

