

**ASSISTIVE TECHNOLOGY USE IN TEACHING MATHEMATICS TO
STUDENTS WITH VISUAL IMPAIRMENT IN TWO SELECTED
SECONDARY SCHOOLS IN EASTERN UGANDA**

BY

AKOL AGNES

21/U/GMSN/13998/PE

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DECLARATION

I, **Akol Agnes**, solemnly affirm that this dissertation is an outcome of my effort and has never been submitted for any award at any institution of learning or university.

Where a write-up by other authors has been used, I have dully acknowledged their word.

Signed: Date:

AKOL AGNES

21/U/GMSN/13998/PE

APPROVAL

I/we certify that this dissertation on the topic "Assistive Technology Use in Teaching Mathematics to Students with Visual Impairment in Two Selected Secondary Schools in Eastern Uganda" has been carried out by the student with my/our supervision and is now forwarded for submission.

Signed: Date:

Dr. Joseph Odeke-Nato

(Principal Supervisor)

Signed: Date:

Dr. Robinah Kalemeera Namuleme

(Second Supervisor)

DEDICATION

I dedicate this dissertation to my cherished family, especially my beloved spouse, David Omeke; children, John Francis, Elijah, Ezekiel, Elisha and Esther Colette; and my mother, for all the support and endurance of my absence at home.

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LIST OF ABBREVIATIONS AND ACRONYMS

AT	Assistive Technology
ATs	Assistive Technologies
CCTV	Closed Circuit Television
GoU	Government of Uganda
HAAT	Human Activity Assistive Technology
ICT	Information, Communication and Technology
JAWS	Job Access with Speech
LMICs	Low- and Middle-Income Countries
LwDs	Learners with Disabilities
MoES	Ministry of Education and Sports
MoICT	Ministry of Information, Communication and Technology
NGOs	Non-Government Organizations
OCR	Optical Character Recognition
PwD	Person with Disability
PwDs	Persons with Disabilities
PwVI	Persons with Visual Impairment
SwDs	Students with Disabilities
SwVI	Students with Visual Impairment
SwLV	Students with Low Vision
UBOS	Uganda Bureau of Statistics
USE	Universal Secondary Education
VI	Visual Impairment
WHO	World Health Organisation

ABSTRACT

Technology advancement has become inevitable in the teaching process world over. Educational institutions across the world have enormously invested in technology to enhance teaching. Despite such enormous investment, the majority of teachers are not using ATs for teaching. Moreover, there are limited studies that demonstrate the importance of ATs in teaching SwVI. Hence this study explored the use of ATs in teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda. It was guided by three objectives namely; (i) To establish the ATs available for teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda; (ii) To examine the training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda; and (iii) To explore how ATs are used to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda. It was hoped that the findings of the study would help various stakeholders recognize the necessity for using ATs in schools. Locating the study in Human Activity Assistive Technology (HAAT) as a theoretical framework to enhance an understanding of the use of ATs in teaching mathematics to SWLV, the researcher adopted a qualitative research approach and a case study design to execute the research. Qualitative data for the study was collected from a sample of eight that was purposively selected. Data was collected using two methods namely: semi-structured interviews and observations. The data collected was thematically analysed to derive meaning from them. The findings from the study revealed that Secondary Schools in Eastern Uganda had a few low-tech and high-tech ATs for teaching mathematics to SwVI, the teachers had general informal training with barely formal training which posed a major challenge on the use of ATs to teach mathematics to SwVI. There was use of ATs observed during the teaching of mathematics to SwVI to a lesser extent because of the informal training attained by teachers. The study concluded that secondary schools had inadequate ATs for teaching mathematics to SwVI; teachers were not adequately trained to use ATs as a pedagogical tool to teach mathematics to SwVI while the level of ATs use in teaching mathematics to SwVI remains wanting in Secondary Schools. The study recommended that more appropriate low-tech and high-tech ATs for teaching mathematics to SwVI be procured and supplied to secondary schools by the Ministry of Education and Sports (MoES), NGOs and other stakeholders. It further recommended that the government through MoES and school administrators should offer opportunities to teachers in Secondary Schools to go for in-service and pre-service training on the use of ATs to teach mathematics to SwVI. Additionally, MoES and school administrators should offer the opportunity for more in-service and preservice training for teachers on the use, repair and maintenance of ATs for teaching mathematics to SwVI.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Education is a human right that every individual is entitled to in order for them to lead a quality life (Zandy, 2019). Some persons with disabilities (PwDs), including those with visual impairment (VI), have been denied this right due to several reasons, such as inaccessibility to information (Eligi, 2017). Globally, technology has advanced quickly, making Assistive Technology (AT) important in service delivery, including teaching mathematics to Students with Visual Impairment (SwVI) (Rony, 2017). Rony notes that as the world rapidly transitions to digital media and information, AT plays an active role in classroom practices, including improving the capability of teachers to teach Mathematics to SwVI.

This study explored the use of assistive technology in teaching mathematics to SwVI in two selected secondary schools in Eastern Uganda. Eastern Uganda was chosen because two secondary schools enrol SwVI and have ATs used to teach them mathematics. This chapter, therefore, describes the background of the study, the statement of the problem, the purpose of the study, the study's objectives, the research questions, the scope, significance, and the theoretical framework of the study.

1.1.1 Historical background

The history of AT stems from the Foundation Period before 1900, when it was first revealed, and shortly followed by the empowerment era, which focused on

disability rights (Gatchalian, 2019). AT has been in use for a long time to support people's lives and education, even before technological advancement (Viner, 2020). In addition, Viner points out that Early ATs for Persons with visual impairment (PwVI) included the tree branches, which were used in the same way as modern white cane, handheld lenses and spectacles, which were introduced in the 13th century. Early in the 20th century, there was an evolution in the development of AT in terms of software and hardware. For example, Louis Braille invented braille, and Genensky created the first Closed Circuit Television (CCTV), Hocek created Optical Character Recognition (OCR), and Henter-Joyce created Job Access With Speech (JAWS), all of which were meant to make information more accessible and guarantee a standard of living for PwVI (Ali, 2021). The Individuals with Disabilities Act was established to compel all schools in Canada to offer aiding tools, services, and technologies to learners with disabilities (LwDs), including those with Visual Impairment (VI) (Sze, 2019). Sze reports that close to 1997, the American Individuals with Disabilities Education Act (IDEA) was reapproved to require the incorporation of assistive technologies into Individualized Education Programs (IEP). This led many countries to begin implementing AT use in schools to facilitate the teaching of SwVI.

Globally, Visual impairment (VI) is a significant disability currently affecting 1.1 billion people and is expected to affect over 1.8 billion people by 2050 (Chan & Congdon, 2021; World Health Organization [WHO], 2022). They also report that according to estimates, the prevalence of VI is four times higher in Low- and Middle-Income Countries (LMICs) than in High-Income Countries, which is

brought on by ageing and the rise in severe diseases. In Uganda, approximately 2.1 million PwVI are living in the country, according to the 2014 national population and housing census (Uganda National Bureau of Statistics [UBOS], 2016). This category includes SwVI, who struggle academically due to a lack of problem-solving abilities and an inability to think in the abstract when it comes to mathematics. This indicates that using AT is crucial for fulfilling their educational aspirations, especially their desire to perform well in mathematics (Mwakyēja, 2013).

The use of AT in teaching mathematics is hinged on many international policy frameworks, notably the Marrakesh treaty (2013), which emphasises that any copy of work should be made accessible for persons with visual impairment (Baguma & Wolters, 2021). The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) (2006) Articles 3 and 4 outline the responsibility of State parties to offer information that is accessible to persons with disabilities (PwDs), while Article 9 obliges State parties to take the necessary steps to guarantee that everyone has equitable access to information and communications both in urban and rural areas. These international instruments provide the foundation for using AT to revolutionise teaching for limited groups, including SwVI, in secondary schools (Smith et al., 2022).

Research shows that AT use, especially in teaching mathematics to SwVI, is crucial and rapidly growing since it draws from various disciplines and is mainly inspired by technological advancement; where Several mathematicians with visual impairment like Tim Cranmer, who invented the abacus, William Taylor who

developed the Taylor frame, Abraham Nemeth who initiated the Nemeth/standard Braille, Leonhard Euler who originated Braille manipulatives have made significant contributions to the development of ATs (Bhowmick & Hazarika, 2017; Ali, 2021). Therefore, AT is necessary for teaching Mathematics because it fosters a more profound understanding of mathematical concepts and enables SwVI to achieve greater independence.

Today, the use of AT is recognised to make Mathematics discoverable and exciting through the introduction of some programmes like the "Microworld programme", among others, which allow for in-depth studying of multiple areas of mathematics, cover a wide range of topics, develop particular constructivist environments and fixated on a limited range of Mathematical concepts (Asebriy et al., 2018; Klingenberg et al., 2020).

In the United Kingdom (UK), AT has recently developed into a crucial component of SwVI's daily mathematical experiences where AT tools like virtual learning libraries, internet programs like e-learning, and e-mail have become more prevalent in order to facilitate access to mathematics content with or without teacher support (Livingstone, 2012). This, therefore, fosters independent learning as teachers of SwVI guide them to look up mathematics information online and promote electronic communication tools for sending and receiving information between teachers and SwVI to improve their achievements in mathematics (Rony, 2017).

In South Africa, its National Council for the Blind (Ferree, 2010), in favour of AT, notes that ATs have been supplied to schools that enrol SwVI. This demonstrates

that South African schools have provided SwVI access to effective technologies that enable autonomous learning, where every learner can reach an age-appropriate level of Mathematics proficiency based on their abilities. However, learning via digital libraries and the internet presents more difficulties for SwVI, whose mathematical ability, creative thinking and potential for academic success may be concealed, making ATs crucial during the teaching of mathematics (Al-Dababneh et al., 2015; Ajuwon et al., 2016; Hassan & Salleh, 2017; Asebriy et al., 2018).

In Uganda, the Ministry of Education and Sports (MoES) has been creating digitally accessible learning materials and supporting LwDs, including those with VI in 20 model primary schools, with financing from the United Nations Children's Fund (UNICEF) through the United Nations Promotion of Rights of PwDs (UNPRPD) Fund then later from Norwegian Government. As mentioned above, the Ministry established a teacher's guide on assistive technology that the trained teachers would utilise to train other staff members locally on the utilisation, maintenance, and storing of AT devices. At least three teachers from each of the 20 schools, including the headteachers, received training in using digital tools to better the learning experience of young persons with Special Needs, including those with VI (Taremwa, 2022). The Government of Uganda is now establishing a national inclusive education policy that prioritises using AT for teaching all subject areas, including mathematics, equity, and quality education. The Ministry has already launched a similar initiative for secondary schools under the Uganda Secondary Education Expansion Project (World Bank, 2020). Therefore, using AT has become mandatory everywhere worldwide, including in Uganda.

1.1.2 Conceptual background

Assistive Technology (AT) stands for equipment, tools, apparatus, devices, products, systems, and services which are either custom-made or usually accessible, whose primary function is to maintain the functioning and independence of an individual with VI in carrying out academic tasks that would otherwise have been unattainable (Kim et al., 2016; Desmond et al., 2018). In this study, AT refers to any equipment and system, including hardware, software programmes and support systems that maintain functional abilities and improve accessibility to all academic opportunities, including teaching Mathematics to SwVI.

Visual impairment (VI) is a state of lessened visual capability that cannot be alleviated by refractive rectification, operation or medical means. This condition leads to functional restrictions on a person's visual structure when performing tasks of daily living, including reading, writing, and mathematics (Naipal & Rampersad, 2018). In this study, visual impairment is a condition that limits a person's visual abilities and includes low vision and blindness.

Low vision is defined as a vision impairment that persists despite treatment and standard refractive correction, presents a visual acuity of less than [20/60] to light perception, or a visual field less than 10 degrees from the point of fixation, and allows one to utilise or possibly able to utilise vision for organising and carrying out a task (Limburg et al., 2015).

Blindness refers to having a visual acuity of less than 3/60 or an equivalent loss of field of vision to no more than ten degrees in the better eye despite the best feasible correction (Kaiti, 2020).

Students with Visual Impairment are those who encounter hindrances in their ability to see (Daroni et al., 2018), bringing about challenges in daily tasks including learning mathematics, creating a need to ensure SwVI learn mathematics in a way that is appropriate and accessible. Among the various measures, the use of ATs is said to be superior worldwide (De Oliveira et al., 2017).

Teaching is an interactive and collaborative process between the teacher and the students to support learners' active construction and transmission of knowledge, skills, and values (Ramírez et al., 2015). In this study, teaching has been used to refer to the process in which teachers interact with SwVI to facilitate access to curricula activities, especially in Mathematics, both within and outside the classroom situation.

The use of AT in teaching SwVI has several benefits, including making the content simple for SwVI to comprehend during the initial period. If the SwVI can complete the stage, it is simpler for them to think through and solve Mathematical problems in the following stage. Additionally, AT can aid SwVI in learning some complex material, expand their conceptual understanding, and lessen their challenges when solving Mathematical tasks (Daroni & Legowo, 2018). It also improves access to education and increases participation and achievement for SwVI in Mathematics.

1.1.3 Contextual background

The Government of Uganda (GoU) has formulated several policies to ensure the provision and accessibility of ATs in schools to improve the education of SwVI. These policies include the Persons with Disability Act of (2020) as amended. Article 6 (5) states that an educational institute possessed or supported by the Government that enrolls a student with a disability has to offer educational and assistive resources appropriate for the student and as needed by the student for examinations. Article 15 (1b) obliges the Government to promote using information-assistive resources and technology. Meanwhile, the Information, Communication and Technology (ICT) policy of (2014), Article 5.2.3 (a, c & f) also emphasises the critique of syllabi at primary, secondary and tertiary levels to blend ICTs in the education procedure pedagogically, imparting teachers with required ICT skills to empower them to use ICTs in the education procedure; and initiating chances and offer support for the underprivileged, persons with special needs who include SwVI, women and the youth to obtain ICT expertise (MoICT, 2014). Although this study does not explicitly focus on ICT, some ICT devices and products are used as AT to support teaching mathematics to SwVI.

The 2014 national population and housing census reports roughly 2.1 million PwVI in Uganda (UBOS, 2016). This population includes SwVI enrolled in secondary schools, whose enrolment by 2017 was 4,020, representing 46% of all students with disabilities (SwDs) (MoES, 2017).

There are 2,995 secondary schools in Uganda; 1,487 are part of the Universal Secondary Education (USE) Program and 1,508 are non-USE. In Eastern Uganda, there are 734 secondary schools, of which 439 are USE and 295 are non-USE schools (MoES, 2017). There are currently ten secondary schools in Uganda (9-unit schools and one special school) enrolling SwVI, of which two of the ten schools are located in Eastern Uganda. However, some SwVI are studying in regular secondary school settings.

The GoU has taken the initiative in collaboration with other development partners, NGOs, and well-wishers like Cheshire Services Uganda, Sight Savers, UNICEF, and VISIO- All we see is a possibility project, among others, to procure and provide ATs in schools with SwVI. These ATs include computers with JAWS, Perkins brailers, slates and styluses, magnifiers, embossers, talking calculators, CCTVs, abacuses, and Taylor frames, among others, which are believed to improve access to education, increase participation and achievement in Mathematics among SwVI. The usability of AT is influenced by the management of the ATs as well as the user's training and the functionality of the technology itself (Morgado et al., 2019).

In Eastern Uganda, a limited number of ATs have been supplied to secondary schools, especially those that enrol SwVI, assuming that teachers can use them to facilitate teaching SwVI, including teaching Mathematics. Very few teachers in secondary schools are trained in Special Needs Education, which is supposed to provide them with the required skills in an assortment of areas, including the use of ATs and knowledge to teach SwDs, including teaching mathematics to SwVI (Nafula, 2023). This has left teachers, especially those who teach in secondary

schools, with no option other than to teach SwVI using the traditional approach (Teferra et al., 2018), which may be ascribed to inadequate ATs, teachers' deficiency of pre-requisite knowledge and skills on the utilisation of ATs to teach, guide SwVI on how to use the available and accessible ATs during the teaching process. Whereas ATs make a crucial contribution to facilitating the teaching of Mathematics to SwVI, as earlier mentioned, there is little known about its use to teach mathematics to SwVI by teachers in two selected secondary schools in Eastern Uganda. Therefore, this study was conducted to address this discrepancy.

1.2 Statement of the problem

A greater number of mathematics counts on visual lessons and therefore teaching mathematical ideas is a pronounced challenge to teachers who teach SwVI. Assistive technology is, however, recognised to be a vital measure towards eliminating the dependency life of persons with disabilities (PwDs), including SwVI in secondary schools, by providing them with opportunities to perform activities, including academics, with independence. Moreover, ATs facilitate teacher efficiency in teaching Mathematics to SwVI. In Uganda, Government and NGOs such as UNICEF, Sight Savers, Cheshire Services Uganda, VISIO- All we see is possibility project and others, have made an effort to provide ATs to schools with SwVI in Eastern Uganda although in a limited number. Different policies, such as the ICT Policy of 2014 and the Persons with Disabilities Act of 2020 (as amended), have been implemented to encourage information assistive devices and technology use appropriate for learners with disabilities and other special needs, including those with VI. Despite these efforts, more is yet to be known about using

ATs to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda, which may be due to lack of documentation regarding the use of ATs in schools. Given this, the study sought to explore how ATs were used to teach mathematics to SwVI in two selected secondary schools in Eastern Uganda in an effort to close the gap.

1.3 Purpose of the Study

The study aimed to explore the use of assistive technology in teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda.

1.4 Objectives of the study

The following objectives guided this study.

1. To establish the ATs available for teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda.
2. To examine the training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda.
3. To explore how ATs are used to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda.

1.5 Research questions

To obtain data, the following questions guided the study:

1. Which ATs are available for teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda?

2. What training have teachers undergone to enable them to use ATs to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda?
3. How are ATs used to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda?

1.6 Scope of the study

This section presents the content, geographical location, and time scope. The primary focus of this research was to explore the use of AT in teaching Mathematics to SwVI in secondary schools. The study was conducted in two selected secondary schools (one special school for blind students and one school with a unit for SwVI) in Eastern Uganda from November 2022 to September 2023.

1.7 The Significance of the Study

The following are some potential benefits of the study's findings;

- i. It may motivate teachers to use ATs to teach mathematics to SwVI since they may obtain information from the study about the ATs and how they are used.
- ii. Administrators may use the findings to recognise the necessity for using assistive technologies (ATs) in schools and, therefore, budget and lobby for them.

- iii. Policymakers may utilise the data to form contemporary AT policies and plans of action or modify prevailing ones better to meet the requirements of SwVI in secondary schools.

1.8 Theoretical Framework

The Human Activity Assistive Technology (HAAT) model, established by Albert Cook and Hussey 28 years ago, served as the framework for this study. HAAT was a modification of Bailey's Human Performance model of 1989, which was later examined by Albert M. Cook and Miller Janice Polgar in 2008 (Giesbrecht, 2013). This model was designed to aid with the selection, evaluation, and decision-making processes for designing, prescribing, and assessing the usefulness of an assistive technology (AT) system. Cook and Polgar contend that the completion of the AT system's outcome/result occurs when a PwD is carrying out an activity in a specific context. The model champions that; AT services must be focused on the PwD with the main aim of improving that person's performance(Cook & Polgar, 2008).

The HAAT model offers a theoretical framework that clarifies the fundamental factors that impact the utilisation of AT. The four primary critical components none of which works alone are used to determine if the AT is suitable (Cook & Polgar, 2008). The "Human" is the initial component, in control of a number of intrinsic factors (sensors, effectors, and central processing), as well as the capacities and skills that result in an outcome.

The second element is "activity," which describes the performance domains including self-care, daily living, academic, occupational, recreational, or goal to be

achieved by the AT, which may be influenced by intrinsic and extrinsic facilitators. This element is crucial for the individual and, in this example, the success of a SwVI in accessing knowledge during the teaching process as it represents the functional outcome of human performance. The third element is "AT," which is defined as extrinsic enablers like the devices a PwVI uses to participate in a particular activity. The last element is "context," which refers to the setting, social context, cultural context, and/or physical environment in which an individual lives. In the context of education, it refers to the location of the activity, and each of these factors is essential to determining whether the AT system would ultimately be effective or ineffective. For instance, social and cultural contexts describe important elements of interaction and acceptance of AT in a learning environment, such as school policies, teacher and peer attitudes toward a SwVI using AT, specialist teachers to provide services, the location of the school; and the physical context, which includes classroom arrangement, door dimensions, and postural support.

The relevance of the HAAT model to this study

This model is applicable to this study and focus will be on three elements namely: the Human, Activity and AT. In this model, the Human is the teacher, the activity is real teaching of mathematics whereas AT refers to the both low and high-tech equipment.

The model emphasises how the "Human," in this case, the teacher must link or interact with the "AT" accessible in the school setting to improve an "Activity" for

instance participation and/or involvement of SwVI during the teaching of Mathematics at school as the context from which he/she operates. The "ATs" used in this study may refer to both Low-tech and High-tech ATs, which are intended to serve as external facilitators that enable SwVI to access curriculum activities during the teaching of Mathematics. The “Human”, who is the teacher, must have knowledge of and proficiency with the ATs like computers with JAWS, Abacus, magnifiers, talking calculators among others in order to support the teaching of Mathematics. In this situation, the trainings undergone by teachers on AT use to teach Mathematics is crucial in determining how they adapt and utilise ATs in the teaching of Mathematics and also guide SwVI to improve their learning (Cook & Polgar, 2008). Teachers must be ready to utilise the available ATs in order to enhance their teaching in subjects like Mathematics.

Critic of the theory

The HAAT model is criticised on grounds that it has not undergone rigorous testing, particularly the connections between concepts or how they affect results (Lenker & Paquet, 2003; Bernd et al., 2009).

Application of the theory

A number of researchers have applied this model in the rehabilitation of people who have special needs in subsequent ways: HAAT model was used to explain the way the physical setting affects the development, creation, and procedures for using AT and services for PwDs in a study on "Assistive Technology in Occupational Therapy" conducted by Akyurek et al., (2017). They add that while utilising HAAT

model in education, it is crucial to identify and take into account the educational endeavors that the user is likely to participate in before developing the AT because these aspects might either aid or hinder their usage by the individual. This model was therefore utilised as a central framework to explore the use of AT in teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

The focal point of this chapter is doing a literature review on relevant materials by other authorities who have contributed new knowledge on the topic of study at hand. This is based on the research objectives in the earlier section (previous chapter). The objectives comprise available ATs for teaching Mathematics to SwVI, training teachers undergo to enable them to use ATs to teach Mathematics to SwVI and how ATs are utilised to teach Mathematics to SwVI.

2.2 The ATs available for teaching Mathematics to SwVI

The type and accessibility of ATs in secondary schools determine how easily teachers can utilise them to teach mathematics to SwVI. The development of AT software and programs has allowed for the support of teaching Mathematics to SwVI in schools (Daroni et al., 2018). As a result, this chapter reveals the findings of a literature review on empirical studies about the ATs teachers use to teach Mathematics to SwVI in schools.

Both high-tech and low-tech AT resources are available for SwVI (Kumar, 2013; Erdem, 2017). High-tech ATs are electronic and non-electronic technologies with related software and hardware that use complex, multifunction technologies. These include computers and related adapted software, like screen readers that convert electronic texts into speech, screen recognition software that enables data entry

using a voice rather than a mouse or keyboard, and screen magnifiers (zoom text) for displaying dilated monitor content. They include PowerPoint projectors, smartphones, mobile telephone software like Google Assistant, clear readers, and Optical Character Recognition software (OCR). Other high-tech ATs include huge monitors for enlarging view screens, large print, contrast-coloured keyboards (alternative keyboards), scanners for translating print media into computer files that can be transformed into other order to facilitate access, closed circuit televisions (CCTVs), and many others. ATs with low technology are electronic or non-electronic but lack incredibly advanced and complex components. They include table lamps, handheld electronic magnifiers, talking calculators with large print and keys, audio recorders, and audio players that SwVI can use throughout their education.

In a Tanzanian study, Wilfred (2017) reveals that less than 30% of the four schools he assessed had access to assistive technology tools such as styluses, white canes, computers, and eyeglasses. Additionally, less than 5% of people had access to tape recorders, thermoform, braille globes, talking computers, radio, embossers, block puzzles, braille alphabet puzzles, magnifiers, books on tape, talking watches, talking calculators, and handheld scanners, whereas 52.7% of Dodoma schools had Perkins Braille, 40.5% had Slates, and 54.9% had abacuses. While more than 64.9% of the Perkins braille machines in the sampled schools in Dar Es Salaam had slates, styluses, and white canes, only 36.1% of the schools had eyeglasses, and only 38.6% had the braille alphabet. The study demonstrates that only one of the examined schools had computers, while the rest had none. The results imply that

although some schools had few AT resources, others had one or needed more AT resources for teaching SwVI.

Erdem, (2017) in a study titled “Students with special educational needs and assistive technologies.” indicates that teaching mathematics to SwVI can be facilitated by Math manipulatives, Low tech ATs for example rulers, stamps, and modified manipulatives, like Abacus, adapted math papers such as enlarged worksheets, graph papers, and guideline papers, adapted math tools such as; talking calculators, adapted measuring devices, and adapted time tools, Math "Smart Charts", Math scripts, Digital access to math and Math toolbars (Equation editor). Using these distinct ATs in teaching mathematics to SwVI enables them to improve their mathematics skills. Similarly, Tebo, (2014), in the support guide to AT for SwVI, points out that Abacus, tactile manipulatives, refreshable braille, manual and electronic braille writers, talking money identifiers, tactile graphics, and specialised math software are some of the ATs used for teaching mathematics to SwVI.

Senjam et al., (2020) executed a study on ATs for SwVI and trainers at primary-level schools for blind students in Delhi. The findings of the study indicate that all schools have access to abacuses which would undoubtedly enable SwVI to learn the fundamentals of addition and subtraction; twelve schools had tactile geometric kits (54.5%), Braille rulers, talking calculators, braille protractors and compasses were available in 9 schools to enhance the teaching of Mathematics to SwVI. Evidence suggests using an abacus can support SwVI in learning mathematics (Daroni et al., 2018). The study also reveals a shortage of trained teachers of Special Needs Education who can use ATs and insufficient ATs, which was linked to

principals' and special teachers' lack of awareness, information and expertise on the use of AT to facilitate the teaching of mathematics to SwVI, inadequate funds to purchase enough ATs, particularly in developing nations.

The findings in the literature discussed above are correct in the context of India as a country because it is a middle-income country, and therefore, it was likely that all schools having SwVI were mostly supposed to have stocked such ATs. This situation may be different in the Ugandan context. Besides, the study was also carried out at an elementary level and had nothing to do with secondary schools on which this study focused. Therefore, this study is likely to unveil the prevailing situation at secondary school and in this developing country.

According to Daroni et al., (2018), in a similar study on "Assistive technology in mathematics learning for visually impaired students," Abacus, which is an instrument used for calculation that is made up of beads with different values, such as units, tens, hundreds, thousands, among others has been suggested to be an efficient instrument through modification for use by teachers to teach mathematics to SwVI more effectively. Similarly, Ali (2021) conducted a study on "Visually impaired student-teachers' knowledge and use of basic assistive technology tools for mathematics" and indicates that the Abacus, braille phones, braille calculators, math type systems, braille charts, and braille shapes are some of the ATs used to teach math to SwVI. According to the study's findings, several assistive technologies (ATs) are available for teaching mathematics to SwVI, but their awareness and utilisation are still deficient.

Bell and Silverman's study (2019) on access to math and scientific information for adolescents who are blind or visually impaired, including 49 participants, shows that the participants used a variety of strategies to determine how to perform math calculations. Talking calculators were the most widely used technology, although several other technologies were also mentioned. Several talking calculators, including talking scientific calculators, talking graphing calculators, talking calculators on Braille note-takers, and others, were used to enable teachers to guide students to work out mathematics concepts involving calculations in this study.

Similarly, Igba (2021) conducted a study on facilities, equipment, and personnel in education for PwVI. It indicates that the low-tech Assistive technologies for mathematics included Abacus, talking calculators, adaptive measurement tools, talking timepieces, talking money identifiers, Taylor frames, raised clock faces, geometric areas and volume aids, and braille rulers, among others. Igba continued, "Facilities, equipment, and personnel are essential to PwVI just as they are to every living being, so it is important to have improved facilities, equipment, and personnel to support PwVI education." This is very true because even with trained personnel, teaching SwVI can be challenging if facilities and equipment are unavailable.

According to a study by Brawand and Johnson (2016) on effective methods used to teach mathematics to SwVI, they report the Abacus, Nemeth Code for braille mathematics and science notation, tactile graphics, or graphics intended to be read primarily by touch rather than vision, manipulatives, and more as some of the ATs used by teachers of SwVI to teach them mathematics. They also emphasise how

advantageous it is to introduce mathematics to SwVI through a mix of the ATs, as mentioned earlier because SwVI exhibits resistance to learning mathematical codes when presented later in life. The study also noted the time constraints in personnel preparation programmes. It recommended that institutions make sure that prospective teachers of SwVI are at least aware of the varied AT supplies and existing methods that enable teaching mathematics to SwVI. The above recommendations resonate well with the teaching of mathematics using ATs. Indeed, teachers may need help to use ATs, which they are unaware of. Availability of ATs must go hand in hand with teachers' awareness of the same. In some Ugandan schools, these ATs may have been procured but not used because teachers may not be aware of their existence and how they are used.

Considering the number of students in secondary schools, it is not only evident from the reviewed literature above that the availability of ATs in a majority of schools does not meet the need to teach mathematics to SwVI but also that the available ATs are underutilised for various reasons which include; inadequate user training in addition to substandard infrastructure. The availability, enabling atmosphere and suitable knowledge and understanding among teachers in utilising the ATs to teach mathematics should therefore be sufficiently promoted, as this is essentially not done satisfactorily in Uganda. Also, most of the studies focused on low-tech ATs, and very few talked about high-tech ATs; thus, there is a need to fill this gap.

2.3 The training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI.

One of the main obstacles to the effective use of AT in teaching mathematics to SwVI is the degree of knowledge and preparation teachers undergo about utilising AT (Ali, 2021). This could be because AT use is seldom taught in teacher education programs, and therefore, for AT to be used effectively by teachers, they must receive high-quality training (Du Toit, 2015). In order to determine the training undergone by teachers on how to utilise AT to teach mathematics to SwVI in secondary schools, it is essential to define specific indicators as shown in the literature below:

In a study conducted by Burgos (2015) to look at the proficiency of AT specialists in K-12 public schools in Florida, it was discovered that AT specialists lack expertise in various areas which offer AT services because the majority of participants assert that they lack the time or managerial support for training, participants have diverse upbringing and professional preparation, and mostly, they lack pre-service education or certifications in the use of AT. Burgos recommends allocating training time and resources for school teachers who are not directly associated with AT to better support their learners in implementing the AT suggestions. Determine the training requirements for each provider based on their occupation and position within the AT team; deliver AT training in schools with a primary emphasis on group teaching and opportunities for hands-on experience; and so forth.

Alkahtani (2013) conducted a study at King Saud University's Department of Special Education to look into teachers' expertise and their usage of AT when teaching students with special educational needs. The study's findings show that over 93 per cent of respondents said they were either inadequately or entirely caught off guard in providing AT services to SwDs, including those with VI, in their schools. This suggests that a major problem is a dearth of skills and knowledge regarding the use of AT, and recommended professional growth approaches grounded on top practices and study as a starting point to transform what would encourage fruitful enforcement of the use of AT for SwDs, including those with VI. Findings from a study conducted by Msila (2015) show that many participants (teachers) felt unprepared to use AT, and without the right training, any attempt to use AT in teaching can shame and disclose their shortcomings in front of the learners. Msila goes on to explain that continuous professional development and attitudes are important components for the success of use and application of AT in teaching, hence drawing a conclusion that any innovation in education, including AT, requires teachers who are knowledgeable.

Ngatia (2015) conducted a study to determine whether ordinary public secondary schools in Nyeri County were ready to use AT for teaching and learning. The findings reveal that teachers lacked the necessary training in technology use, which affected attitude and confidence in using AT to its full potential to teach mathematics to SwVI. Ngatia suggests appropriate financing to enable schools to purchase the necessary assistive technology, as well as intensive training for

teachers to offer essential knowledge and expertise to them on use of ATs in their teaching.

Similar to other studies, different situations have an impact on how teachers use AT and therefore their knowledge and attitudes influence how they use ATs in the classroom (Buabeng-Andoh, 2020). The findings demonstrate that teachers' opinions on technology have an effect on whether and how it is used in the classroom. If teachers develop enthusiasm with regard to the use of ATs, the acceptance and integration of ATs into teaching of mathematics can be made easy. This signifies that most teachers possess undesirable attitude regarding the use of ATs hence making it difficult for them to teach mathematics to SwVI.

The literature above points out the fact that trainings undergone by teachers in the use of ATs to facilitate the teaching of mathematics to SwVI in Secondary Schools is of high value and therefore, efforts should be made to guarantee that teachers possess the required knowledge and skills, including the right professional attitude on the use of various AT to enable them use it to facilitate teaching of mathematics to SwVI. Whereas the studies have talked about the trainings and or level of proficiency by teachers in using AT resources in teaching, many of them fall short of being specific to addressing teachers' specific resourcefulness in adapting and integrating AT use to teach mathematics to SwVI and are generally encompassing all PwDs to some extent. Similarly, some of the literature talks about the training of staff in using AT to support SwVI in higher institutions of learning, meaning that little has been talked about concerning training of teachers on the use of AT to

facilitate teaching of mathematics to SwVI in secondary schools for which objective two focuses on in order to close this gap.

2.4 How the ATs are used to teach Mathematics to SwVI.

Academic standards are lower for SwVI (Samanta, 2017). Their capacity to comprehend mathematical symbols and carry out arithmetic operations found in mathematics, which are useful for undertakings such as sale, purchase, measurement, and others, are impacted. Therefore, SwVI need assistance in overcoming these challenges such that they can study on their own. One way to do this is through embracing the growth of the technology known as assistive technology (Daroni et al., 2018). Due to their importance in academic affairs, many scholars have argued for the utilisation of ATs in the teaching of mathematics to SwVI.

It is noted by Silman et al (2017) that teachers of SwVI have been using ATs like computers with the of internet to look for material on mathematical topics they are unfamiliar with. They continue by saying that teachers use ATs as essential tools to support SwVI learn to read mathematics documents on their own without the support from a second person. Similar to this, teachers teach SwVI using ATs by giving directions and further details over the phone.

Akpan and Beard;(2014), note that teachers utilise AT in the classroom at every stage as a means of supporting learners with different abilities, including those with VI, understand educational instructions and solve math problems. When technology is used in the classroom, the use of the essential hardware and software

is transferred across the curriculum, giving learners understanding of and hands-on experience with it.

Similarly, DePountis et al's., (2015) study on technologies used in the study of advanced mathematics by students who are visually impaired in classrooms notes that teachers utilise high-tech ATs to organise the lessons, notes, or resources before the teaching session actually takes place. They also mention how teachers of SwVI utilised ATs to facilitate writing of mathematics notes, practice, allowing both teachers and students to study, interact, or work on mathematical issues concurrently.

Senjam, (2019) illustrates in his study on assistive technology for students with VI and blindness that; teachers of SwVI use math manipulatives to present visual concepts to their students through hands-on experiences with the manipulatives. This helps their teaching in mathematical ideas like number sense, computation, graphing, and geometry that help SwVI develop their computing abilities. Additionally, they claim that teachers of SwVI use Braille translation software like Duxbury Braille Translator (DBT) to generate mathematics materials in Nemeth code Braille glyphs or convert Braille materials for sighted readers, particularly those who have Low Vision.

A study on the use of technology in lower secondary mathematics education by Hegedus et al., (2017); and Morgado et al., (2019) show that teachers have used AT to generate similar tasks automatically, create new types of activities like drag-and-drop objects. Teachers have also outsourced the selection and presentation of tasks

because tests can now more easily be modified to meet a wide range of abilities and respond to specific needs. These new technological capabilities have the potential to challenge the current assessment paradigm. As a result, teachers now find it less difficult to assess their students' conceptual knowledge, modeling skills, and problem-solving skills and abilities in mathematics using AT.

Nkiko et al.'s (2017) study in Nigeria indicate that teachers use a variety of tools to convert mathematics reading material using embossers, tape recorders, talking calculators, scanners, handheld magnifiers, computers with JAWS, dolphin pens, electronic Braille systems, optical characters recognition systems, synthetic speech software, Kurzweil reading machines, data technology, Braille 2000, CCTVs, and converters. The study also reveals that there is limited use of ATs for the conversion of reading materials into alternative formats and advised that Multi-National Corporations (MNCs) be encouraged to expand their Corporate Social Responsibility (CSR) activities to assist in the purchase of cutting-edge AT devices and software to augment transcription, as well as to increase stakeholders' knowledge of ATs, in addition to pertinent concerns by means of workshops, seminars, and training sessions.

Similar to the above, Ampratwum et al. (2016) conducted a study in Ghana on the challenges SwVI had when using computers with JAWS. The results show that a non-adaptive keyboard was a problem, which did not favour key conformation by the SwVI and the JAWS system uses sophisticated language software which gives difficulties to SwVI to make sense of it especially when reading mathematics content.

A study by Ali, (2021) on "Visually impaired student-teachers' knowledge and use of basic assistive technology tools for mathematics" reveals that teachers use the Braille abacus, Braille charts, and Braille shapes to teach counting, place value, addition, subtraction, area, and relationships between figures. Ali also pointed out that teachers use AT resources like computers with JAWS, braille graphic displays, and Audio Daisy to conduct mathematics assessments so that SwVI have access to speech, braille displays, and hearing. This is crucial because the AT resources make it possible for SwVI to hear questions read aloud and to touch braille displays to determine what they need to do on tests or exams. Similar to this, Chanana & Delhi, (2022) identifies the Abacus to be used for teaching Basic concepts of Mathematics, Geo-boards for teaching graphs, spatial relations, or shapes, Taylor frames and talking calculators for performing complex mathematical calculations, Tactile manipulatives for making sense of concepts like shape, texture, size, and other properties, and Geometric tangible manipulatives for teaching concepts like spatial relationships.

Particularly in the teaching of mathematics to SwVI, AT plays a significant role Tedla, (2012). Tedla also notes that a classroom becomes a play area where SwVI and teachers can interact, communicate, and collaborate during teaching, and this keeps students' interests and motivations intact and high in the process of teaching as it makes it fun. Teachers therefore find it simpler and spend less time when teaching mathematics to SwVI thanks to the use of ATs.

Contrarily, Cryer et al., (2013) note that many Science, Technology, Engineering, and Mathematics (STEM) subjects, such as mathematics, significantly rely on

visual aids that are unavailable to SwVI, such as graphs, diagrams, and charts. They go on to say that these symbolic issues are more challenging to give resources than other literary-based subjects. Cryer continues by saying that because audio is linear by nature, it is difficult to access elements like equations in that format. They further claim that it is challenging to obtain the entire equation at once while using large or enlarged print for SwLV. Therefore, it was determined that SwVI have difficulty not just accessing essential information like notes but also engaging in further reading regarding the subjects, particularly mathematics.

Similar to the above, Klingenberg et al. (2019) note that graphs, charts, diagrams, figures, and drawings are used as mathematical devices to convey enormous amounts of data or connections among parameters in a simplified and precise way. They go on to clarify that while it is an essential mathematical skill to acquire knowledge from such graphics and apply it to address difficulties, instructional graphic resources are visual in nature and subsequently several SwVI face significant difficulties.

In addition, Dalton H and Sarah E, (2020) in their study on Access to Assistive Technology among Students with Visual Impairment in Higher Education Institutions in Tanzania revealed some of the challenges to the use of ATs in institutions to include: Insufficient knowledge and skills regarding how to use ATs as a significant issue, shortage of ATs, lacking in specialists or technical support, lack of culture regarding the sustaining of ATs, and the fear of technology. They also offered additional solutions for overcoming these difficulties, such as sharing available ATs, making proper arrangements for supplying SwVI with ATs, such as

allocating specific equipment to first-year students only, disclosing to the administrators in order for them to apply a series of measures to help with the upkeep of such AT devices, and talking to SwVI on the use of freshly acquired ATs and the significance of doing so.

According to the literature mentioned above, many researchers have noted that teachers use ATs to organise, produce, present, convert, and process information that is used to teach mathematics to SwVI. They also understand that a number of issues, such as inadequate skills, inadequate AT, and difficulty accessing the right AT, hinder their ability to be used appropriately. This is very practical in Uganda because whereas ATs are supposed to be utilised as mentioned above, many teachers in secondary schools are inadequately skilled to use them, the ATs provided to institutes are insufficient because of the expenses involved in procuring them, making it very challenging for the teachers to use them to teach mathematics to SwVI. Many studies have talked about how ATs have been used in teaching generally and very few studies have talked about how they are used for teaching Mathematics to SwVI for which this study is meant to close this gap.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This study intended to explore the use of ATs in teaching mathematics to SwVI. It was guided by the objectives, which included establishing the ATs available for teaching mathematics to SwVI in two selected secondary schools in Eastern Uganda, examining the training undergone by teachers to enable them to use ATs to teach mathematics to SwVI in two selected secondary schools in Eastern Uganda; and to explore how ATs are used to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda. This chapter describes the methodology that guided the study on using ATs to teach SwVI mathematics in selected secondary schools. This being the practical heart of empirical research, the following vital components were described: research approach, research design, area of study, target population, study sample, sampling technique, methods and tools of data collection, procedure of data collection, data analysis, ethical considerations, and credibility in research.

3.2 Research approach

A research approach is an overall strategy for conducting social research (Bryman, 2016b). It can also refer to a strategy for conducting research that includes anything from general hypotheses to specific techniques for gathering, analysing, and interpreting data (Creswell, 2014). There are numerous methods for conducting research, including mixed, qualitative, and quantitative approaches (Creswell &

Creswell, 2017). In order to establish the utilisation of AT in teaching Mathematics to SwVI in secondary schools, this study used a qualitative research approach, which is a form of social action which emphasises how people interpret and make sense of their experiences in order to comprehend people's social realities (Bryman, 2016a). This approach was used because it permitted the researcher to get precise information, examine and develop comprehensive images, and in-depth opinions from the participants in a natural environment. In this instance, two secondary schools that enrol SwVI served as the natural setting.

3.3 Research Design

A research design is a plan for collecting and analysing information (Yin, 2014; Bryman, 2016). A case study design that involves the researcher understanding phenomena in real-life situations by collecting in-depth, thorough data was used (Yin, 2014; Karlsson, 2016). It was chosen for the reason that it would license the researcher to amass information about the research problem being examined from a real-life setting and aid in addressing the "how" and "why" questions, intended to provide participants with a chance to share more detailed information about an exciting phenomenon based on their knowledge and experience (Yin, 2014; Yazan & De Vasconcelos, 2016). Therefore, two secondary schools (one special and one inclusive) in Eastern Uganda served as the "case" in this study.

3.4 Area of study

The research took place in two purposively selected secondary schools in Eastern Uganda. These secondary schools included schools A and B (pseudonyms) in the

Eastern region, which were identified because they enrol SwVI and have ATs for teaching them.

3.5 Target population

Casteel and Bridier (2021) define a target population as a particular, conceptually defined set of likely participants who best represent the characteristics of the population of interest. Teachers and SwVI were the study's target populations. There were 193 potential participants for the study, 61 of whom were teachers and 132 SwVI from the two secondary schools where the sample was drawn. Secondary school A had 21 teachers and 102 SwVI, and secondary school B had 40 teachers and 30 SwVI. The teachers were singled out as possible participants in particular since they were directly taking part in using AT for teaching mathematics to SwVI and guiding the use of ATs during teaching, whilst the SwVI were the ones who benefited from the use of AT as a pedagogical instrument in the teaching of mathematics.

Table 1: Population of the Study.

School	Category of population	Total
Secondary school A	Teachers	21
	SwVI	102
Secondary school B	Teachers	40
	SwVI	30
Total		193

Source: Primary Data (2023).

3.6 Study sample

A sample is a collection of people, things, or items chosen for analysis from a vast population (Bhardwaj, 2019). It is a portion of a population that is representative of

the entire sizeable population. According to Casteel & Bridier, (2021), a sample size refers to the number of individuals needed to fully answer the study questions in a particular setting. This indicates that the size of the sample depended on the researcher's needs in light of the study's goal. Out of the overall population of 193, this study used a sample of eight (8) participants comprising four (4) teachers and four (4) SwVI from the two selected schools. Whereas the sample size is small, it is still relevant because it is advantageous in enabling the researcher to conduct an in-depth study. This corresponds with Creswell (2013), who states that a case study should involve few participants so that the researcher can get as much specific information as possible from each participant, which was thus considered in this study.

Table 2: Sample representative of the population

School	Category of population	Target population	Sample
Secondary school A	Teachers	21	2
	SwVI	102	2
Secondary school B	Teachers	40	2
	SwVI	30	2
Total		193	8

Source: Primary Data (2023).

3.7 Sampling technique

Sampling refers to pointing or searching out situations, contexts, and participants that furnish beneficial data concerning the subject matter of engrossment (Moser & Korstjens, 2018). Therefore, sampling technique refers to a strategy utilised by the

researcher to construct the sample while taking the required size into account (Casteel & Bridier, 2021).

Purposive sampling which is defined as a form of non-probability sampling where the researcher makes choices of the people to be involved in the sample considering the number of variables, such as their knowledge about the research topic, capability and willingness to take part in the study was utilised to choose the teachers and SwVI as participants for this study (Cohen et al., 2011; Rai & Thapa, 2015). Accordingly, the sample for this study was explicitly chosen based on the subsequent factors: SwVI from the lower secondary candidate class, who were the principal users of ATs and had been utilising ATs in their learning longer than those in other classes in lower secondary. The teachers chosen were those who had more experience teaching Mathematics to SwVI because they had used ATs for teaching Mathematics to SwVI for a long time, and teachers working in the resource room because they had interacted and guided on the use of most of the ATs including those used for teaching mathematics to SwVI.

3.8 Methods of Data Collection

An extensive range of data collection techniques were available for qualitative research. These included focus group discussions, interviews, document analysis, observation, archival records and artefacts (Creswell, 2014; Yin, 2014). Given the nature of this study, interviews and observation were used as the most appropriate data collection methods. These two techniques were utilised to combine the data gathered and verify the accuracy of the information provided.

3.8.1 Interview

An interview is a dialogue that involves two people (the interviewer and the interviewee) aiming to learn in-depth details about a particular subject or issue so that it can be understood in light of the meanings provided by the interviewee (Creswell, 2014; Brinkmann & Kvale, 2015; Bryman, 2016a). Bryman elaborates that three different sorts of interviews are used in qualitative research and they include: structured, semi-structured, and unstructured. In a structured interview, all participants give answers to questions that have already been predetermined; in a semi-structured interview, the interviewer makes a listing of questions to inquire about but has the freedom to tailor them to the interviewee's needs; and in an unstructured interview, a list of topics to cover is provided, but the questioning is informal. In order to gather comprehensive information about the use of ATs to teach mathematics to SwVI, this study used a semi-structured interview where the researcher developed an interview guide with predetermined inquiries that the participants were asked. Semi-structured interviews were optimal since they were thought to provide comprehensive information through dialogic interchange in which the researcher actively constructed knowledge in collaboration with the respondent who constructed replies (Kabir, 2016).

3.8.2 Observation

Observation is the act of recording an occurrence in a natural setting using one's five senses, including sight, smell, hearing, touch, and taste. It is frequently done using an instrument and recorded for scientific reasons (Creswell, 2013). The

researcher used non-participant observation; thus, the researcher went to the schools as an observer and watched how ATs were used in a social situation without participating in the activities and confirmed the ATs used to teach mathematics to SwVI (Bryman, 2016a). This approach was chosen because it would allow the researcher to gather firsthand facts from the natural environment that the participants could not supply. It would also allow the researcher to confirm what the participants said and non-verbal cues (Creswell, 2014; Kawulich, 2014). An observation guide was therefore developed to particularly address objective one of this study, which focuses on establishing the ATs available in the school used to teach Mathematics to SwVI, which enabled the researcher to confirm the verbal responses that were obtained from the participants and how the teachers utilised the ATs to teach mathematics.

3.9 Pilot study

A pilot study is a limited feasibility study aiming to appraise several aspects of the methods foreseen for a bigger, more exhaustive, or conclusive study (Lowe, 2019). The pilot study was conducted at another school in Central Uganda with similar conditions and was situated in Nakisunga sub-county, Mukono district, central Uganda. In particular, teachers of mathematics, teachers in charge of the resource room, and SwVI were chosen to test the dependability of the data collection tools for potential inconsistencies. Two data collection methods were used to confirm the trustworthiness of the pilot study's findings and ensure the viability of the interview and observation guides. The findings were used to modify the study methods and tools if certain discrepancies were found.

3.10 Data collection procedures

Before beginning the research in the proposed field, approval of the research proposal from the supervisors and the Directorate of Research and Graduate Training, Kyambogo University, was obtained. The Director, Directorate of Research and Graduate Training, Kyambogo University, granted the researcher permission to conduct the study by issuing an introductory letter. After gaining authorisation, the researcher designed a letter of request addressed to the participants and then went to the chosen study venues to meet the eligible participants. The researcher asked the school administration for permission to meet the population from whom the sample was derived. The researcher presented the intentions of the study and obtained informed consent from the participants regarding their expectations.

On agreement between the researcher and the participants, interviews were arranged and conducted with each participant. During the interview, permission was sought from the participants for the conversation to be audio-recorded. At the same time, the researcher took notes. Meanwhile, the researcher also observed and ascertained the nature of ATs used during the teaching of Mathematics to SwVI to confirm the narratives from the participants.

3.11 Data analysis

One of the most crucial phases of qualitative research is data analysis. This is because the data collected from the field is raw and does not have much meaning in its first state, and there is a need to describe and interpret it to derive its meaning and pattern (Mwakyēja, 2013). Qualitative research entails sorting through unstructured data to find relevant and usable information and transforming model-based information to serve as a basis for inference (Tracy, 2013; Yazan & De Vasconcelos, 2016). The data collected through recordings was transcribed to

English text and submitted to diriment coding forms, which included open coding in which the researcher sorted out different concepts and ideas related to the use of ATs, axial coding in which the researcher identified the core concepts as related to objectives, selective coding which helped the researcher to identify the central ideas from the transcript based on each objective. After coding, the data was subjected to the thematic analysis method. Thematic data analysis is a technique for locating patterns and themes of significance within a dataset concerning a research question to analyse data (Silverman, 2019). In line with this study, data was transcribed, coded, and categorised so the researcher could identify themes and sub-themes by extracting recurrent issues, similarities, and differences related to each research objective to ensure comprehensible logic regarding the data. Finally, to further emphasise the originality of the data, participant-recorded verbatim accounts from interviews were presented as recorded from participants to enhance the originality of the findings (Tracy, 2013).

3.12 Ethical consideration

People are involved in the research process; their primary function is to provide data. As a result, researchers must "guard the life, health, dignity, integrity, right to self-determination, and privacy of personal information of study participants" (Yip et al., 2016).

It is necessary to follow due procedure, which incorporates ethical considerations. An "ethical issue" refers to any circumstance that could directly or indirectly undermine the observance of at least one accepted and desirable value (Beauchemin et al., 2022). Therefore, ethical considerations are moral concepts and ideals that serve as a researcher's guideline when conducting a study, particularly on human beings (Mugenda & Mugenda, 2012). This study took ethical considerations into account to increase its credibility, transferability, dependability, and confirmability.

Numbers represented the participant's names, and their identity was kept secret, with a focus on anonymity and confidentiality. Participants also got information about the study before the data-collecting process, allowing them to decide whether to participate.

3.13 Trustworthiness of Findings

In this study, the trustworthiness of the findings was addressed in four ways: Credibility, Dependability, Confirmability and Transferability.

3.13.1 Credibility

Credibility refers to the qualities or standards used to assess how factual, convincing, dependable, and transferable the study findings are in the eyes of not just the researcher but also the study participants and readers (Mugenda & Mugenda, 2012; Yilmaz, 2013; Ong'ondo & Jwan, 2020). To increase the study's credibility, the researcher collected data using a triangulation of approaches, including interviews and observation, and a variety of participants, including teachers and SwVI, and two study areas, which included schools A and B (Ong'ondo & Jwan, 2020). Under the guidance of the supervisors, the interview and observation instruments were developed and approved. Pretesting of the instruments through a pilot study was also carried out.

3.13.2 Dependability

This alludes to the findings' consistency throughout time. It includes assessing the study's results, interpretation, and recommendations by the participants, all backed

up by the information obtained from the study's participants (Creswell, 2014). This was ensured through audit trials, data and method triangulation, and replication. The researcher used data and triangulation methods to ensure the study's dependability.

3.13.3 Confirmability

Confirmability is the degree to which others can verify or support the study's findings (Creswell, 2014). A researcher should collect and analyse data depending on what is precisely said by the participants and not put his or her own words. This helps the researcher to avoid bias. Therefore, in this study, the researcher collected and analysed data based on what was said by the participants and what was obtained through observation without adding any extra information. The researcher used data and method triangulation to ensure the confirmability of the study findings.

3.13.4 Transferability

It refers to the extent to which the study's findings can be applicable or transferred out of the project's boundaries. This means that the study's findings can apply to related situations or individuals (Mugenda & Mugenda, 2012). To ensure transferability, the researcher provided a thorough description of the phenomenon, including explaining the kind of participants engaged in the study, the place, the time, and the methods of data collection used.

3.14 Limitations and Delimitations

The following limitations were encountered while conducting this study:

The Eastern region of Uganda was the focus of this study, which was limited to two selected secondary schools. These schools were chosen for their uniqueness; one was a special school for SwVI, and the other had a unit or annex for students who are blind and SwLV, whose conditions might not be typical of other secondary schools nationwide. To allay this fear, measures were put in place to guarantee the credibility and reliability of the results, which included conducting a pilot study in another secondary school in a different part of the country (Central Uganda) under very similar circumstances, using various methods and participants to gather data, and protecting the privacy of participants to ensure accurate information was gathered.

Compared to the number of teachers and SwVI in secondary schools nationwide, the study's participants were also relatively few which may have affected the data saturation. A pilot study, triangulation of methods and participants was carried out to ensure that data was gathered from a range of participants using several methods to demystify this worry.

CHAPTER FOUR

PRESENTATION, INTERPRETATION AND DISCUSSION OF

FINDINGS

4.1 Introduction

This chapter presents, interprets and discusses the study's findings, which sought to explore the use of AT in teaching mathematics to SwVI in two selected secondary schools in Eastern Uganda. Data is presented in order of the research objectives, which include the ATs available for teaching Mathematics to SwVI, training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI, and how the ATs are utilised to teach Mathematics to SwVI.

In presenting data, verbatim statements from the participants were utilised to uphold the originality of the information collected. Each presentation begins with presenting the findings, the interpretation, and a discussion concerning the literature reviewed in chapter two. To maintain the participants' anonymity and confidentiality, the codes TR to mean teacher and SwVI to, mean Student with Visual Impairment have been used respectively to hide the identity of the participants. The data obtained from the participants using semi-structured interviews and observations have been presented and discussed in themes and sub-themes established from the data collected.

4.2 Demographic characteristics of the study participants

The study targeted teachers of mathematics, teachers in charge of the resource room, and SwVI in Secondary Schools. The total sample size of participants anticipated was eight, comprising four teachers and four SwVI, respectively. From the above, seven participants were reached and interviewed: two teachers of mathematics, one teacher in charge of the resource room, and four SwVI. This was possible due to the small number selected. More details are arrayed in the table below.

Table 3: Demographic Characteristics of Participants

Category	Gender		Total
	Male	Female	
Teachers of mathematics	2	0	2
Teachers in charge of the resource room	1	0	1
SwVI	2	2	4
Total	5	2	7

Source: Primary Data (2023).

4.2.1 Characteristics of Teachers

This study was interested in the teachers who teach mathematics to SwVI and those who are in charge of the resource room, and their characteristics are displayed in the table below:

Table 4: Characteristics of teachers

Participan ts	Ag e	Gende r	Qualificatio n	Experienc e	Classes taught	Subjects taught
TR ₁	50	Male	Graduate	20 years	S.2&S. 4	Mathemati cs
TR ₂	31	Male	Graduate	Five years	S.1- S.6	ICT & in charge resource room
TR ₃	61	Male	Diploma in Education, Certificate in English and Mathematic s braille.	21 years	S.1- S.4	Mathemati cs

Source: Primary data (2023).

4.2.2 Characteristics of Students with Visual Impairment

The study was interested in both students with low vision (SwLV) and students with blindness who were selected from the lower secondary candidate class, and their characteristics are indicated in the table beneath:

Table 5: Characteristics of Students with Visual Impairment

Participant	Class	Gender	Age	Category of VI
SwVI ₁	S.4	Male	19	Low vision
SwVI ₂	S.4	Male	22	Blind
SWVI ₃	S.4	Female	18	Blind

SWVI ₄	S.4	Female	17	Low vision
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Source: Primary data (2023).

4.3 ATs used for teaching mathematics to SwVI

The term "Assistive Technology" (AT) refers to a variety of products, systems, and services that are either specifically designed or generally available and whose primary purpose is to sustain the independence and functioning of a person with VI while they complete educational tasks that would ordinarily be impossible (Kim et al., 2016; Desmond et al., 2018). Its use is essential in teaching mathematics to SwVI because it makes the content simple for SwVI to comprehend during the initial period, improves access to mathematics content, and increases participation and achievement for SwVI in Mathematics subject (Daroni & Legowo, 2018).

In this section, the study sought to establish the available ATs for teaching mathematics to SwVI in Secondary Schools. This aspect was necessary because the available AT resources determine how they influence the teaching process. The emerging issues were the ATs available in the schools, low-tech, high-tech AT resources, and the low-tech and hi-tech AT resources used for teaching mathematics to SwVI in the schools.

4.3.1 ATs available in the school.

Participants were asked to mention ATs in their schools that aid the teaching of SwVI. The most available ATs in the schools identified by the participants were computers with JAWS, embossers, talking calculators, scanners, the Perkins braille machines, magnifiers, Taylor frames, scientific talking calculators, slates and

styluses, braille display devices like orbit readers, focus blue, digital audio solutions and text processing devices like victor readers, the abacus, the telescopes, braille mathematical instruments, a talking globe, braille processing software (DBT), white cane, alphabet cards and smartphones. Participants (n=7) mentioned the above as the ATs available in schools. One of the participants said:

Now, here in this school, we have computers, scientific talking calculators, and omni readers that we use, for example, to take a picture of the topic you will teach, and then it captures and reads. We also have a clear reader, which helps students with low vision (SwLV) to... magnify mathematical content and enable them to read the text. The analogue ones include cubes and frames, slates and stylus, and the Perkins braille machine, which helps them take notes and assignments. In addition, we have the phone, which is mainly used by the teacher and not the SwVI. (TR₁).

Another participant said:

Computers are here; we have talking calculators. I hear we also have a scientific calculator, though I have never seen one. Ahh, we have victor readers, clear readers, and orbits. We have the usual ones like brailers, cubes and cube frames, slates and styluses, braille rulers and other mathematical instruments (SwVI₂).

Another participant also had this to say:

Yeah, we have the magnifying CCTV and omni readers, which display the print and read the document aloud for students who are blind and those with low vision. We also have the clear reader, which works just like the omni reader, the talking calculators for carrying out mathematical calculations, computers with JAWS that can easily help those who are blind to improve their reading, and the embosser, which the teachers use to emboss mathematics questions (SwVI₄).

Other participants' (TR₂, TR₃, SwVI₁, SwVI₃) responses were equally the same in which they pointed out that their schools have ATs like the computers with JAWS,

CCTV magnifiers, clear readers, omni readers, abacus, cube frames and cubes among others.

The above study findings reveal that the schools have some ATs, namely, computers with JAWS, embossers, talking calculators, scanners, the Perkins braille machines, magnifiers, Taylor frames, scientific talking calculators, slates and styluses, braille display devices like orbit readers, focus blue, digital audio solutions and text processing devices like victor readers, the abacus, the telescopes, braille mathematical instruments, a talking globe, braille processing software (DBT), white cane, alphabet cards and smartphones.

When an onsite observation was made in both schools, it was discovered that the resource rooms had most of the ATs mentioned, though most were inadequate. These findings correspond with the narratives of the participants given above.

From the above statements, there are quite a variety of ATs in the schools, which have helped the teachers and the SwVI during the teaching process. Although the numbers are few, some ATs are not used. This is confirmed with the statement made by one SwVI, *"I hear we also have a scientific calculator though I have never seen it"* SwVI₂.

The findings also reveal that the government and other development partners have attempted to supply ATs to schools. However, the training on how they are used needs to be adequately given to the users, and they are too few compared to users. Therefore, they keep them the way they were brought.

The above findings can be linked to the third element of the HAAT model (AT), which elaborates that an AT should act as an external enabler (Cook & Polgar, 2008). The ATs include the computers with JAWS, the embossers, the talking calculators, and the Perkins braille machines, among others, available in the schools to be used by the teachers to guide SwVI to participate in the teaching and learning process actively. The findings, however, showed that whereas the ATs are available, they are not adequate in number, which deprives some users since they may require one-on-one correspondence.

These findings also correspond with Wilfred (2017), who conducted a study in Tanzania, and the results indicated that less than 30% of the schools assessed had access to AT tools such as styluses, white canes, computers, and eyeglasses. Additionally, less than 5% of people had access to tape recorders, thermoforms, braille globes, talking computers, radio, embossers, block puzzles, braille alphabet puzzles, magnifiers, books on tape, talking watches, talking calculators, and handheld scanners, whereas 52.7% of Dodoma schools had Perkins Braille, 40.5% had Slates, and 54.9% had abacuses. While more than 64.9% of the sampled schools in Dar Es Salaam had Perkins braille machines, slates, styluses, and white canes, only 36.1% had eyeglasses, and only 38.6% had the braille alphabet. The study demonstrates that only one of the examined schools had computers, while the rest had none. The results imply that although some schools had few AT resources, others had one or even needed to have the AT resources necessary for the teaching and learning of SwVI.

Equally, Kumar (2013) and Erdem (2017) note that ATs available for SwVI include computers and related adapted software, screen readers that convert electronic texts into speech, screen recognition software that enables data entry using a voice rather than a mouse or keyboard, and screen magnifiers (zoom text) for displaying dilated monitor content, PowerPoint projectors, smartphones, mobile telephone software like Google Assistant, clear readers, and Optical Character Recognition software (OCR), huge monitors for enlarging view screens, large print, contrast-coloured keyboards (alternative keyboards), scanners for translating print media into computer files that can be transformed into other order to facilitate access, closed circuit televisions (CCTVs), table lamps, handheld electronic magnifiers, talking calculators with large print and keys, audio recorders, and audio players that SwVI can use throughout their education including in mathematics.

The availability of ATs in schools must be appreciated as far as the findings and literature are concerned. However, this should be commensurate with the number of users (both teachers and SwVI) who demonstrate their effectiveness in teaching mathematics to SwVI. Therefore, responsible stakeholders must take further steps to ensure that more appropriate ATs for teaching mathematics are procured and supplied to schools.

4.3.2 Low-tech ATs available in the schools

Under this section, the researcher attempted to establish different low-tech ATs available in the school based on the expected availability, those that were functioning, and those that were missing.

Table 6. Low-tech ATs Available for SwVI in secondary schools A and B

Item expected	Available in school A	Functioning	Available in school B	Functioning
Perkins braille	80	54	50	36
Slates and styluses	20	20	10	10
Braille rulers	5	5	10	10
Abacus	10	5	2	2
Talking calculators	8	5	23	23
Talking money identifier	0	0	0	0
Braille protractors	5	5	10	10
Braille compasses	5	5	10	10
Tactile graphics	4	4	0	0
Taylor frames	3	3	10	0
Adaptive measurement tools	0	0	3	3
Adapted math paper	0	0	0	0
Audio recorders	8	5	5	5
Telescopes	0	0	0	0
Braille MTC textbooks	0	0	0	0
Tactile geometric kit	0	0	10	10
Talking clocks	0	0	0	0

Source: Primary data (2023)

Table 6 above shows the data composure from the teachers, SwVI and the researcher's observation. It shows that only twelve types of low-tech ATs, which included Perkins braille, slates and styluses, braille rulers, abacus, talking calculators, braille protractors, tactile graphics, Taylor frames, adaptive measurement tools, audio recorders, tactile geometric kits, were available in both

schools. It was also observed that Low-tech ATs like telescopes, braille mathematics textbooks, and talking clocks were not available in either school.

To confirm the findings from observation and what was provided by the teachers and SwVI, the Semi-structured interview carried out on each participant attests to similar findings:

When participants were asked to mention the low-tech ATs available in the schools, the major low-tech ATs mentioned were talking calculators, Perkins braille machines, slates and styluses, cube frames and cubes, Taylor frames, handheld magnifiers, telescopes, sets of mathematics instruments, abacus, the white cane and alphabet cards. Participants (n=7) responded by listing the above low-tech ATs as those that are available in the schools, and one of the participants said:

We have the lenses or telescopes, sets of mathematical instruments, handheld magnifiers, talking calculators, the Perkins brailers, slates and styluses usually used by people who are beginning to learn braille. The slates are used at the primary level and are in the category of low-technology ATs because they are simple to use, and our students come when they already know how to use them (TR₃).

Another participant said:

Yeah, like at, the brailier is low technology, then the abacus is low technology, then we have ah, even the lenses like these small ones, ah, the telescopes are low technology, yeah, I think those are the ones (SwVI₁).

Another participant also said: *"Ummm, those of low technology; I may talk about the braille machines, the hand frames, the Taylor frames and talking calculators as well"* (SwVI₃).

Other participants (TR₂, TR₁, SwVI₂, SwVI₄) equally had similar responses, noting the Perkins braille machines, slates and styluses, the white cane, the cubes and

frames, the braille alphabet cards, among others, as low-tech ATs available in their schools.

The study findings revealed that schools have low-tech ATs, namely talking calculators, Perkins braille machines, slates and styluses, cube frames and cubes, Taylor frames, handheld magnifiers, telescopes, sets of mathematics instruments, abacus, the white cane and alphabet cards as some of the low-tech ATs used for teaching SwVI in secondary schools.

From the observations, the researcher ascertained that most of the low-tech ATs mentioned by the participants were available in these schools. These included the talking calculators, the Perkins braille machines, and the Taylor frames, among others. Some of the mentioned low-tech ATs, like the talking calculators, were few compared to the number of SwVI in these schools. This, therefore, suggests that the teachers have to give SwVI to use the few AT resources in turns, and this causes time wastage and makes the teachers' work challenging as they have to go through the work over and over to involve all SwVI.

The findings are in line with Kumar (2013), Wong and Cohen (2016), and Erdem (2017), who note that low-tech ATs are electronic or non-electronic technologies but lack highly advanced and complex components. They include table lamps, handheld electronic magnifiers, talking calculators with large print and keys, audio recorders, Perkins braille machines, slates and styluses, Taylor frames, and audio players that SwVI can use throughout their education.

Similarly, Senjam et al. (2020), in a study carried out on Assistive technologies for visual impairment and trainers at primary-level schools for blind students in Delhi, indicated that all schools have access to low-tech ATs like abacuses, tactile geometric kits, Braille ruler and talking calculators, braille protractors and compasses were available in 9 schools to enhance the teaching of Mathematics to SwVI.

It is significant to note that various low-tech ATs used for teaching SwVI are available in the schools, although they are few, considering the findings and the literature. These available ATs have facilitated access to mathematics content, improved participation, and limited dependence on SwVI during teaching. The inadequacy of these ATs poses a challenge to the teacher regarding how to distribute them to the SwVI, especially during teaching, yet it necessitates that each SwVI works with an AT. Consequently, the government and other development partners ought to ensure that necessary steps are taken to secure more low-tech ATs for schools with SwVI.

4.3.3 High-tech ATs available in the school

Under this sub-theme, the researcher aimed to establish different High-Tech ATs available in secondary schools. To attain this information, the researcher carried out case observation with the help of observation guides, and the expected, available, and functionality was rated in the table below;

Table 7. High-tech ATs available for teaching SwVI in secondary schools A and B.

Item expected	Available in school A	Functioning	Available in school B	Functioning
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Braille embossers	1	1	1	1
Closed-circuit television (CCTV)	4	4	5	5
Scanners	1	1	1	1
Optical character recognition (OCR) software	1	1	1	1
Computers with screen magnifiers	29	29	3	3
Projectors	0	0	0	0
Screen readers	29	29	1	1
Computers with JAWs	29	29	5	5
Duxbury Braille Translator	2	2	1	1
Scientific talking calculators	1	1	1	0
Printers	1	1	1	1

Source: Primary data (2023)

Table 7 above shows the study findings, which are the results of case observation. It shows that the secondary schools have only nine kinds of high-tech ATs, which include braille embossers, closed circuit televisions, scanners, optical character recognition software, computers with screen magnifiers, screen readers, computers with JAWs, Duxbury Braille Translators, scientific talking calculators and printers. The findings also revealed that neither school had any projectors, but one of them had a non-functioning scientific calculator.

To counter-check these findings, the researcher interviewed the participants by posing a question and prompting them to mention the high-tech ATs available in their schools and the major high-tech ATs noted by participants to be available in the schools were; computers with JAWS, scanners with Optical Character Recognition (OCR), the omni readers and the clear readers, the embossers and the braille display devices like the orbit readers, and focus blue, Scientific calculator, victor readers, and screen magnifiers. Participants (n=7) responded by listing the above high-tech ATs, and one participant said:

Our high-tech ATs include software like JAWS and tactile view, among others. Then we have victor readers, orbit readers; ah, the focused blue, the omni readers, the clear readers, the computers themselves installed with the assistive software and the embossers (TR₂).

Another participant said: *“Computers with JAWS, the orbit (meaning orbit readers), the victor readers, ahh I think even the clear reader, and this scientific calculator I hear of, ahhha ahha those ones”* (SwVI₂).

Another participant also said: *“The omni readers, the clear readers, the computers with JAWS, and the magnifying CCTV”* (SwVI₄).

Other participants (TR₁, TR₃, SwVI₁, and SwVI₃) equally had similar responses, noting the omni readers and the clear readers, the embossers and the braille display devices like the orbit readers, and focus blue, scientific calculator, victor readers, and screen magnifiers among others as high-tech ATs available in their schools.

The statements above disclose that teachers and SwLV in these schools have access to some of the high-tech ATs like computers with JAWS, scanners with Optical Character Recognition (OCR), omni readers and clear readers, embossers and braille display devices like the orbit readers, and focus blue, Scientific calculator, victor readers, and screen magnifiers. These ATs offer teachers access to any content and have made teaching SwVI relatively easy because they can type work using computers, which they can print in braille format for students with blindness using the embossers and produce large print for SwLV.

When the observations were made in the schools to confirm the high-tech AT resources available, they matched with what the participants had previously

revealed during the interviews. It was noted that the high-tech ATs available included computers with JAWS, embossers, and scanners like Omni and Clear readers, among others. The findings and observation results indicated that there were more low-tech ATs compared to high-tech ATs. This implies that high-tech AT resources have recently been introduced to schools. One participant's statement *confirms this: "And this scientific calculator which I hear of"* (SwVI₂), meaning that such AT is new and has not yet been exposed to the SwVI.

This indicates that an effort has been made to supply high-tech ATs to schools, which must be appreciated and encouraged. Nevertheless, they must be adequate regarding the number of SwVI in these schools (Appendix iii).

The findings are in line with what Kumar (2013) and Erdem (2017) observed that high-tech resources typically comprise a computer and related software and use complex, multifunction technologies which include computers and related adapted software, like screen readers that convert electronic texts into speech, screen recognition software that enables data entry using a voice rather than a mouse or keyboard, and screen magnifiers (zoom text) for displaying dilated monitor content. They include PowerPoint projectors, smartphones, mobile telephone software like Google Assistant, clear readers, and Optical Character Recognition software (OCR). Other devices include huge monitors for enlarging view screens, large print, contrast-coloured keyboards (alternative keyboards), scanners for translating print media into computer files that can be transformed into other order to facilitate access, closed circuit televisions (CCTVs), and many others.

Regarding the findings and literature, an attempt has been made to have high-tech ATs in schools, which should be commended. Nonetheless, there is a need to increase the number of available high-tech ATs in these schools so that SwVI have a more significant opportunity to interact with the ATs one-on-one during the teaching process.

4.3.4 Low-tech ATs used for teaching mathematics to SwVI

The participants were asked to mention the low-tech ATs used for teaching mathematics to SwVI, and the major low-tech ATs that were mentioned to be used for teaching mathematics to SwVI included talking calculators, cube frames and cubes, Taylor frames, the abacus, the Perkins braille machines, a set of mathematical instruments, drawing wheels and telescopes. Participants (n=7) responded by listing the above low-tech ATs, and one of the participants said:

Majorly, our teachers use talking calculators to teach us mathematics. These talking calculators can be used by students who cannot see anything and those with low vision (SwVI₄).

Another participant said:

Mainly, we use the cube frames and cubes; we usually use them in lower classes like S.1 and S.2. So, when one is teaching topics like bases, that one makes it easy, addition and subtraction, say decimals, fractions, the Taylor frame and cubes can also be used (TR₁).

Another participant also said:

The ones that we use for teaching mathematics are mostly the abacus, cubes, cube frames, then ahhh, the Taylor frames, which is a kind of an old technology though we do not commonly use them because currently, few teachers know how to use them (TR₂).

The other participants (TR₃, SwVI₁, SwVI₂, SwVI₃) equally mentioned the use of talking calculators as the major ATs, cube frames and cubes, Taylor frames, the abacus, the Perkins braille machine, a set of mathematical instruments that includes braille rulers, protractors, pair of compasses among others, drawing wheels and telescopes as the low-tech ATs used for teaching mathematics to SwVI.

From the above statements, all the participants cited the talking calculators as the major low-tech ATs used for teaching mathematics. I agree with this because the talking calculators are essential in teaching mathematics to SwVI since they enable the teachers to guide SwVI on how to work out numbers that deal with calculations, notably when dealing with the operation of numbers. These talking calculators have speech output that makes it easy for SwVI to follow as the teacher demonstrates using examples, and they also have large buttons and screens that enable SwLV to use when following during the teaching of mathematics. The findings also reveal that many participants mentioned the Taylor frames, the cube frames and cubes, and the abacus as some of the low-tech AT resources used for teaching mathematics. These low-tech AT resources mentioned are not commonly used, following the statements of some participants, for example, TR₂.

The above statement reveals that the low-tech ATs used for teaching mathematics to SwVI include talking calculators as the major ATs, cube frames and cubes, Taylor frames, the abacus, the Perkins braille machine, a set of mathematical instruments that include braille rulers, protractors, pair of compasses among others, drawing wheels and telescopes.

Although some low-tech ATs exist, teachers do not commonly use them because they need knowledge and skills to use them when teaching mathematics to SwVI. This statement was confirmed when the researcher carried out an observation to ascertain if what the participants had said was true because the low-tech ATs like the abacus, Taylor frames, cube frames and cubes were packed and were also dusty, hence revealing that they were rarely used for teaching because currently, few teachers know how to use them.

The above indications/revelations are contrary to the second element of the HAAT model (The Human), in this case, is the teacher who must link or interact with the low-tech ATs accessible in the school setting to improve participation of SwVI during the teaching of Mathematics at school as the context from which the teacher operates. If the teacher does not use the low-tech ATs for the above reason, teaching mathematics without ATs may not yield results. It should be recorded that using ATs in teaching mathematics to SwVI can improve access to mathematics content, make students independent and even improve performance.

The above findings are in line with Senjam et al. (2020), who, in their study findings, noted that all schools had access to abacuses, which undoubtedly enabled SwVI to learn the fundamentals of addition and subtraction, twelve schools had tactile geometric kit (54.5%), and Braille ruler and talking calculators, braille protractors and compasses were available in 9 schools to enhance the teaching of Mathematics to SwVI. Similarly, Igba (2021) observes that the low-tech Assistive technologies for mathematics include abacus, talking calculators, adaptive measurement tools, talking timepieces, talking money identifiers, Taylor frames,

raised clock faces, geometric areas and volume aids, and braille rulers, among others. Erdem (2017) similarly says that Low-tech ATs include rulers, stamps, and adapted manipulatives like an abacus; adapted math papers such as enlarged worksheets, graph papers, and guideline papers; adapted math tools such as talking calculators; adapted measuring devices, and adapted time tools, Math "Smart Charts", Math scripts, Digital access to math and Math toolbars (Equation editor).

The availability of some low-tech ATs in schools, as shown by the findings and literature, is worth acknowledging. The available low-tech ATs do not match the number of SwVI in the schools, and teachers need to learn how to use some of the devices. The availability of various low-tech ATs, as pointed out in the literature, can be attributed to the context where the study was carried out compared to a Ugandan economic growth status. There must be a need to do something to ensure that more low-tech ATs for teaching mathematics are procured and supplied to schools that enrol SwVI and that user training is carried out.

4.3.5 High-tech ATs used for teaching mathematics to SwVI

When the participants were asked about the high-tech ATs used for teaching mathematics to SwVI, the major high-tech ATs mentioned to be used for teaching mathematics to SwVI included computers with JAWs, embossers, orbit readers, scientific talking calculators, victor readers, magnifiers, and the CCTVs.

Participants (n=7) responded, and one of the participants said:

Actually ehhe, I use the computer. I use the computer to type and later produce mathematics content in large print with the help of a printer, especially for SwLV to be able to read. I also use the

embosser to print questions for discussion and examination in braille, especially for the students who are blind. (TR₃).

Another participant said:

Yeah, ahh, computers can be used to teach mathematics. For example, excel deals with mathematical expressions that simplify calculations that involve adding and subtracting, among others. Our teachers also use the orbit readers to save mathematics notes that SwVI can use for future reference by replaying and listening to the recordings. The teachers also use victor readers, embossers, scientific talking calculators and talking calculators to teach mathematics (SwVI₁).

Another participant also said:

For mathematics, they usually use digital calculators (meaning talking calculators) to calculate numbers. Let us say our teachers use the embosser to emboss questions if he is giving a test or exam, but they do not use it most of the time because sometimes he reads the questions for us and we just type (SwVI₃).

Other participants (TR₁, TR₂, SwVI₂, and SwVI₄) also mentioned the embosser, the computers with JAWS and the scientific calculators as some of the hi-tech ATs used for teaching mathematics to SwVI in schools. A few participants listed the orbit readers, clear readers, victor readers, CCTV magnifiers and tactile view software as other high-tech ATs used for teaching mathematics to SwVI in secondary schools.

The findings of the study revealed the braille embosser, the computers with JAWS, the scientific calculators, and a few of them mentioned the orbit readers, clear readers, victor readers, magnifiers like the CCTV, and tactile view software as the high-tech ATs used for teaching mathematics to SwVI.

When the researcher made on-the-spot observations in the schools to establish the high-tech ATs used for teaching mathematics to SwVI, it was revealed that there is

one embosser in each school, some computers with JAWS, one scientific talking calculator in each school for which one school had not started using it because the teachers of mathematics did not know how to use it, and the other school was also not using theirs because it was spoilt. There were also a few CCTV magnifiers, orbit readers, clear readers, victor readers, and tactile view software in the schools. This information is equally related to the above statements from the participants.

These findings indicate that an effort has been made towards using the high-tech ATs for teaching mathematics to SwVI, which is a good thing and should be uplifted. The statements above reveal that teachers who teach mathematics to SwVI have access to a few high-tech AT resources which enable teachers to produce braille content of mathematics for students who are blind, large print content of mathematics for SwLV and audio content of mathematics for both students who are blind and SwLV.

These findings are in line with (Kumar, 2013; Erdem, 2017), who note that the high-tech resources used for teaching mathematics typically comprise a computer and related software, screen readers that convert electronic texts into speech, screen recognition software that enables data entry using a voice rather than a mouse or keyboard, and screen magnifiers (zoom text) for displaying dilated monitor content. They include PowerPoint projectors, smartphones, mobile telephone software like Google Assistant, clear readers, and Optical Character Recognition software (OCR). Other devices include huge monitors for enlarging view screens, large print, contrast-coloured keyboards, scanners for translating print media into computer

files that can be transformed into other order to facilitate access, closed circuit televisions (CCTVs), and many others.

Even though there is a similarity in the examples of high-tech AT resources for teaching mathematics in the literature and what is available in the schools, it is necessary to note that what exists in these Secondary Schools is just a minimum (appendix 3) as compared to the variety of High-tech AT resources highlighted in the literature and the number of SwVI. This indicates that the use of high-tech ATs to teach mathematics to SwVI is limited in one way or another since they need various resources to choose from during teaching. This stems from the fact that mathematics content in secondary schools requires the use of a scientific calculator by both the teachers of mathematics and the SwVI, which is different in these schools. This is premised on the findings that revealed that each school has one scientific talking calculator, for which one school had yet to start using it because the teachers of mathematics did not know how to use it, while the other school had theirs spoilt. This, therefore, calls for urgent intervention from stakeholders in education to ensure that a variety of these high-tech AT resources are availed to schools to provide a higher advantage to teachers and SwVI to equally participate in the teaching process of mathematics compared to the current situation.

4.4 Training undergone by teachers to enable them to use ATs to teach mathematics to SwVI

This section examined the training teachers underwent to enable them to use ATs to teach Mathematics to SwVI in two selected secondary schools in Eastern

Uganda. This aspect was vital because knowledge and skills enable teachers to manipulate and operate AT resources and support SwVI in using them while teaching mathematics. The emerging issues included informal training, formal training, how skills from training have been applied, and teachers' experiences in using ATs to teach mathematics to SwVI. These subthemes have, therefore, been presented as follows:

4.4.1 Informal training that teachers have in using ATs to teach mathematics to SwVI

Participants were asked about the kind of informal training the teachers have had in using ATs to teach mathematics to SwVI. The emerging issue was that most teachers of mathematics had undergone some informal training on the use of ATs.

Participants (n=7) responded as above, and one of them said:

Now, regarding the informal training that I have gone through, I had the opportunity to attend a workshop organised by the Department of Special Needs Education-MoES in Mityana PTC in 2020. This training took one week, and it was on introduction to ATs, which was more general. Then we had another one-week workshop last year (May 2022) in Arua by Visio Kyambogo, where we learnt how to record; say, you can read the text, then you have it recorded in your phone or recorders, then you can play. (TR₁).

Another participant said:

Our teachers have gone for such training because I remember last year, that is 2022, around the second term, June, they went to Arua and spent almost two weeks there, and they came back telling us they were learning braille and also mathematics braille (SwVI₂).

Another participant also said:

Informal training! Ok, our teachers have sometimes gone for workshops for two or three days, a few weeks, and they are trained on the use of ATs, especially our only teacher of mathematics. Last year, some of our teachers went to Kabale for training on teaching mathematics to SwVI. I hear they sometimes even go for training in Kyambogo because, during Covid, a training was organised by Visio, and our teachers were taught how to use these gadgets, mostly the talking calculator and drawing devices (SwVI₄).

Other participants (TR₂, TR₃, SwVI₁, SwVI₃) also said that teachers had informal training from workshops that lasted for a few days or weeks.

On the other hand, some participants (n=4) responded to their informal training on using ATs for teaching mathematics, noting that they have learnt from each other and the SwVI. One participant said:

They also learn from each other and the SwVI themselves. For example, some teachers here are learning from our mathematics teacher, who has undergone several trainings on using ATs for teaching mathematics (SwVI₃).

Another participant also said:

We have also been using these very students because they are equipped with some knowledge on how to use some ATs which we do not have. They, therefore, informally guide and teach us what to do. I have learnt from SwVI, who came saying, ahh sir, this is how we do this, and this is how we do this locally and in small bits. (TR₃).

Another participant also said:

Then they also learn from one another, especially from our teacher who is in charge of the resource room because he seems to have much knowledge on the use of these ATs, but they also sometimes learn from us, the students, because we are always using some of these ATs (SwVI₁).

The participant (SwVI₄) also said something similar to what the above participants said, noting that teachers have had informal training by learning from the SwVI

themselves and their friends who know how to use the ATs to teach mathematics to SwVI.

The pronouncement from the findings above indicate that teachers have undergone some informal training through workshops and seminars organised; they have also learnt how to use the ATs for teaching mathematics from friends and SwVI themselves, who furnish them with the requisite knowledge and skills that have enabled them to teach SwVI using some of the ATs to a lesser extent. Although teachers have undergone informal training on ATs, the training looks generic. Very little is discussed regarding training in using most ATs for teaching mathematics and the fact that teachers use a few ATs while teaching mathematics. The informal training may have yet to fully prepare teachers, especially those who teach mathematics, to effectively use the available ATs to teach mathematics to SwVI in secondary schools.

These findings contradict the HAAT model, suggesting that the "Human" is the initial component in controlling several intrinsic factors (sensors, effectors, and central processing) and the capacities and skills resulting in an outcome. In this case, a teacher of mathematics ought to have knowledge and skills to ably use the ATs at his or her disposal to deliver mathematics content or support SwVI by training them to manipulate the same devices to access the content of mathematics being taught during the teaching process.

The findings align with Ngatia (2015), who notes that teachers lacked the necessary training in technology use, which affected attitude and confidence in using AT to

its full potential to teach mathematics to SwVI. Ngatia suggests that there must be appropriate financing to enable schools to purchase the necessary assistive technology and intensive training for teachers to offer them essential knowledge and skills on using ATs in their teaching. Similarly, Alkahtani (2013) notes that teachers are either inadequately trained or entirely caught off guard in providing AT services to SwDs, including those with VI, in their schools. This suggests that the major problem is a lack of skills and knowledge on the use of AT and recommends professional growth approaches grounded on top practices and study as a starting point to transform what will encourage fruitful enforcement of the use of AT for teaching SwDs, including those with VI.

Although the findings and literature indicate that informal training that teachers have undergone is on the use of general ATs, it is a milestone that the government and some NGOs must be commended for because teachers have been able to acquire some skills to enable them to use some of the ATs to teach. Nevertheless, the training should focus on the ATs used for teaching mathematics, and not only the general ones, as stated by the findings, to enable teachers to have adequate knowledge and skills in using AT for teaching mathematics to SwVI in secondary schools. It is an appeal that the government and other well-wishers take up to organise specific training, especially on the use of ATs for teaching mathematics to SwVI in secondary school, because mathematics is one of the critical subjects in the country.

4.4.2 Formal training that teachers have in using ATs to teach mathematics to SwVI

Participants were asked which formal training the teachers have had in using ATs for teaching mathematics to SwVI, and the major emerging issue was that teachers still needed to attain formal training on using ATs to teach mathematics to SwVI. Participants (n=4) gave the above response, and one of them said: *“There is no formal training yet that I have attained in the use of ATs to teach mathematics to SwVI”* (TR₁). Another participant said:

Actually, for the formal one, I have yet to hear them talk about it. I only believe the other one of Iganga because the teachers went; ahh, it was for two weeks, and I believe they learnt a lot (SwVI₁).

Another participant also said:

Since I came to this school, I have never heard of or seen such a happening that our teachers have gone for formal training. I only know of their training for weeks and days (SwVI₂).

The other participant (TR₂) also mentioned the same thing, noting that he has yet to take a serious course on AT for mathematics for SwVI.

The above findings of the study disclosed that teachers have yet to have an opportunity to have formal training on the use of ATs to teach mathematics to SwVI. The findings also suggest that there needs to be more such teachers can do about using ATs to teach mathematics to SwVI in secondary schools.

The statements above align with Msila (2015), who conducted a study that showed that many participants (teachers) felt unprepared to use ATs. Without the proper training, any attempt to use the ATs in teaching can shame and disclose their

shortcomings in front of learners. Msila explains that continuous professional development and attitudes are essential components for the successful use of AT in teaching, especially mathematics to SwVI, concluding that any innovation in education, including AT, requires knowledgeable teachers.

This implies that formal training to prepare teachers to use AT to teach mathematics to SwVI is vital. Therefore, teachers of mathematics ought to be exposed or given opportunities to receive special training in using ATs to teach mathematics to SwVI to enrich their resourcefulness in using the ATs as pedagogical tools for teaching mathematics to SwVI in secondary schools.

On the other hand, some participants (n=3) had a slightly different view, as indicated in the statements below. One participant said:

I got that one directly from Kyambogo University's UNISE department. The award was a certificate in English and Mathematics braille, which this school sponsored. This training took only three consecutive months (TR₃).

Another participant said:

Well, one of them has gone for formal training because using ATs to teach SwVI mathematics is not easy. What I am sure about is that our only teacher of mathematics has a certificate in braille mathematics. He has the knowledge and skills from formal training and is using it to operate these devices when teaching mathematics to us (SwVI₃).

Another participant said:

As a student, I am aware that our only teacher of mathematics has a certificate in braille mathematics and is one of the best teachers of mathematics for SwVI in this country because he talks about it. Even other teachers tell us we are lucky to have one of the country's best teachers trained to teach braille mathematics (SwVI₄).

The above findings of the study reveal that teachers have had some formal training in using ATs to teach mathematics to SwVI. The training is general because it focused on braille mathematics and was not specific to using ATs to teach mathematics to SwVI. This implies that teachers have had limited opportunity to attain sufficient knowledge and skills in using some of the ATs to teach mathematics because, from the observation, a few ATs, like talking calculators and the Perkins braille machines, were used while teaching mathematics. Therefore, the majority of teachers who have never had an opportunity to go for formal training on the use of ATs to teach mathematics to SwVI are finding it very hard to use the ATs, hence sticking to the traditional methods of teaching, for instance, talk and chalk that does not benefit SwVI at all.

These findings do not agree with the HAAT model, which contends that a human being, in this case, the teacher, who is supposed to use the AT to teach mathematics, should possess knowledge and skills to enable effective use during an activity (teaching).

The findings contend with Burgos (2015), who observes that AT specialists lack expertise in various areas which offer AT services because the majority of participants assert they lack the time or managerial support for training, participants have diverse upbringing and professional preparation, and mostly, they lack pre-service education or certifications in the use of AT. He recommended allocating training time and resources for school teachers who are not directly associated with AT to better support their learners in implementing the use of ATs. Determine the

training requirements for each provider based on their occupation and position within the AT team; deliver AT training in schools with a primary emphasis on group teaching and opportunities for hands-on experience; and so forth.

In this era of technological advancement, having a few teachers in a school knowledgeable in using ATs for teaching mathematics to SwVI is not enough. This implies that specific pedagogical training (pre-service and in-service) is necessary to prepare teachers to use ATs to teach mathematics. This would enrich their knowledge and skills in using ATs to teach mathematics to SwVI in secondary schools in Uganda.

4.4.3 Teachers' experiences in using ATs to teach mathematics to SwVI

When participants were asked about teachers' experiences using ATs to teach mathematics to SwVI, the major emerging issue was that ATs have simplified work. All participants (n=7) responded noting the above, and one participant had this to say:

It is easier to make someone understand and follow what you are doing when using assistive devices rather than failing to use one. It is easier and has certainly simplified work (TR₁).

Another participant said:

These ATs are simplifying the work of our teachers because I hear that in some schools, including ours, the SwVI now type their work using computers, save it, and attempt those mathematics questions. They print the work automatically in the print version, which most teachers understand. Teachers are, therefore, relaxed with marking braille work, which most of them need to learn, making their work easy (SwVI₁).

Another participant also said:

They have a good experience using these devices because they make their work easier. For example, cube frames, the Taylor frames, and digital calculators simplify work involving mathematics calculations; computers and embossers simplify typing and production of mathematics questions in braille and large print during exams. This saves their time, though; on the other hand, they need training on operating some of these ATs (SwVI₃).

Other participants (TR₂, TR₃, SwVI₂, SwVI₄) had something similar, noting that using ATs to teach mathematics to SwVI has made teachers' work easy and saved them time.

The findings from the study reveal that teachers are encountering a good experience when using ATs to teach mathematics to SwVI because ATs have made their work simpler and saved time, something that should be appreciated.

These findings are in line with Hegedus et al. (2017) and Morgado et al. (2019), who found that teachers have used AT to generate similar tasks automatically or to enable the creation of new types of activities like drag-and-drop objects or the analysis of dynamic situations. Teachers have also outsourced the selection and presentation of tasks because tests can now more easily be modified to meet a wide range of abilities and respond to specific needs. These new technological capabilities have the potential to challenge the current assessment paradigm. As a result, teachers now find it easier to assess their students' conceptual knowledge, modelling skills, problem-solving skills, and abilities in mathematics using AT.

I agree with the findings and discussion above because ATs were introduced to make it easier for teachers to teach, especially mathematics, which is assumed to be challenging to teach to SwVI because of the many abstract concepts and guides in the access of content, especially that of mathematics by SwVI who have diverse needs in their education. These ATs have, therefore, eliminated the dependence syndrome among SwVI, who would always rely on assistance from other sighted students when AT use had not been introduced. However, very few teachers have the knowledge and skills to use the ATs to teach mathematics to SwVI. Therefore, teachers must be trained in using most of the ATs available for teaching mathematics.

4.5 How ATs are used to teach mathematics to SwVI

In this section, the study explored how ATs are used to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda. This was very important because the academic standards were lower for SwVI. They, therefore, need assistance in overcoming these challenges so that they can study on their own. One way is to embrace the evolution of technology known as ATs by using them to teach mathematics to SwVI. The emerging issues here included how teachers use ATs to teach mathematics to SwVI, how SwVI make use of ATs to learn mathematics, areas in mathematics that teachers find difficulties using ATs during teaching, the difficulties faced when using ATs to teach mathematics to SwVI, how the difficulties mentioned have been overcome, and what can be done to improve

the use of ATs to teach mathematics to SwVI. These emerging issues have, therefore, been analysed as follows:

4.5.1 How teachers use ATs to teach mathematics to SwVI

Participants were asked how teachers use ATs to teach mathematics to SwVI in secondary schools. The significant findings were to prepare and produce mathematics notes in an accessible format, teach and guide SwVI to carry out mathematics calculations, do research on mathematics content, teach counting and simple operations, magnify mathematics content, guide SwVI to read mathematics content from the textbooks, drawing and guiding SwVI to write mathematics notes.

Below are statements from the participants:

4.5.1.1 Preparing and producing mathematics notes in accessible formats

One of the emerging issues regarding teachers using ATs to teach mathematics to SwVI was that teachers use ATs to prepare and produce mathematics notes in accessible formats. Responses from participants (n=7) are shown below. One participant said:

The embosser is the one I use to emboss work. I type the information on mathematics I want to print using a computer; I put it in a flash, transfer it to a computer with DBT installed, and then manipulate the computer and emboss the work using the embosser (TR₃).

Another participant said: *“Yeah, even the computer. Teachers specifically use the computer to organise and produce mathematics notes and questions for the students”* (SwVI₁). Another participant said:

Our teachers use the embosser to emboss (meaning produce) braille questions and exams in mathematics so that from print form, it is changed to braille form so that I can also read. Then, the teacher uses these computers to type and print out some mathematics work for SwLV in large print so that they can read (SwVI₃).

Other participants (TR₁, TR₃, SwVI₂, SwVI₄) said that teachers use ATs to prepare and produce mathematics content for the SwVI in accessible formats, for example, braille format for students who are blind and large print for SwLV.

The study findings reveal that preparing and producing mathematics content in an accessible format is one common way teachers use ATs like computers and embossers to teach mathematics to SwVI in secondary schools. These ATs enable teachers to organise the content that they teach and produce it in different accessible formats to enable them to carry out effective teaching of mathematics to SwVI. Also, from the observations, only a few teachers, especially those in charge of the resource room, can manipulate these ATs, like computers, to produce mathematics work in different formats, including large print, to cater for SwLV. This indicates that not all teachers have the knowledge and skills to operate the ATs available in the school; otherwise, preparing and producing mathematics content in different formats for SwVI is one of the appropriate ways mathematics contents can be delivered to SwVI during the teaching of mathematics. Teachers should be encouraged to learn and use it.

These findings correspond with the second element of the HAAT model (activity), which describes the performance domains, including academics (teaching mathematics). The activity will be achieved using the AT, which intrinsic and

extrinsic facilitators may influence. It is, therefore, crucial for the teacher to use the available ATs to teach mathematics to SwVI. These activities, therefore, include producing mathematics content in accessible formats, carrying out research, and writing mathematics content, among others. This will ease SwVI's access to mathematics content and active participation during the teaching of mathematics, representing human performance's functional outcome.

This is in line with Senjam (2019), who found in his study that teachers of SwVI use Braille translation software like Duxbury Braille Translator (DBT) to generate mathematics materials in Nemeth code Braille characters or convert Braille materials for sighted readers, particularly those with Low Vision. That is to say, digits and mathematical notations can be translated from visual math codes in digital form (such as those written in Scientific Notebook by MacKichan Software or MS Word by Microsoft) to Nemeth code Braille characters (such as those produced by DBT or Megadots by Duxbury Systems) and then reproduced with Braille embossers to aid accessibility

I agree with the above findings because SwVI, especially those who are blind, need to access mathematics content in the accessible format, which is none other than the braille format. This can only be possible with the use of ATs like the computers with DBT software that are used to type and convert the mathematics content from print to braille format, and the embosser, with braille paper, that is now used to produce the mathematics content in braille. At the same time, SwLV need

accessible mathematics content in large print, which the use of computers and printers can produce.

4.5.1.2 Teaching Mathematics Calculations

The second emerging issue on how teachers use ATs to teach mathematics to SwVI in secondary schools was using ATs to teach mathematics calculations. Responses from participants (n=6) are shown below. One participant said:

Now, the calculator itself, of course, is used for teaching mathematics content that involves calculations. It has buttons numbered 0 up to 9, a key for switching on, equal sign, subtraction, division, and multiplication. When the SwVI is manipulating it, you begin by switching it on, then you type, say, $54 + 22 =$ and the answer is seen on the screen but also mentioned by the calculator itself. This enables the students with low vision and those who are blind to see and hear the mentioned answer. This helps to simplify the teaching and learning of mathematics, which involves calculations (TR3).

Another participant said:

Ah, haaaa, a teacher uses a calculator to guide us in carrying out mathematics calculations. For example, a teacher may read a number from the textbook or chalkboard and press that number on a calculator. You know these calculators can talk, so the teacher will press the number 14 times 5 equals, and it will automatically show the answer on the screen for SwLV and read it aloud for both students who are blind and those who have low vision (SwVI₂).

Another participant also had this to say:

Now, like the talking calculators, if our teacher is telling us to calculate something in mathematics, he guides us to press the numbers in the calculator as he mentions them. You calculate and say the answer you have got (SwVI₄).

Other participants (TR₁, SwVI₁, SwVI₃) also said something similar by explaining that talking calculators are used by teachers to teach and guide SwVI to work out mathematics calculations while teaching mathematics.

The above findings of the study reveal that teachers also use ATs like talking calculators to guide SwVI in working out mathematics concepts that deal with calculations during teaching. This was confirmed when an observation was made, and talking calculators were seen being used by teachers to guide SwVI in working out mathematics calculations. It was also noted that although the talking calculators were used during the teaching process, they needed to be more because some SwVI did not have them.

This is similar to what Bell and Silverman (2019) noted: the most widely used AT for teaching mathematics to SwVI was talking calculators, although several other technologies were also mentioned. Several talking calculators, including talking scientific calculators, talking graphing calculators, talking calculators on Braille note-takers, and others, were used to enable teachers to guide students to work out mathematics concepts involving calculations.

I approve of the above findings for the reason that mathematics is a subject that deals primarily with calculations, and this can only be possible with the use of ATs like the talking calculators that the teachers can use to guide SwVI to manipulate and use to work out mathematics concepts that deal with calculations.

4.5.1.3 Researching Mathematics Content

The third emerging issue on how teachers use ATs to teach mathematics to SwVI is that ATs are used to research mathematics content. Participants (n=4) gave this response, and one of the participants said:

If mathematics content requires students to research, you only prepare the questions and bring them to the computer lab, which also doubles as a resource room. They do the research themselves, and they take note of what the question is requesting them to do (TR₁).

Another participant said: *“Teachers use the computers for researching some content in mathematics that they teach us”* (SwVI₁).

Other participants (SwVI₂ and SwVI₄) also responded similarly, noting that teachers use ATs like computers for research, especially on mathematics content they teach to SwVI.

The study findings above state that teachers use ATs like computers to guide SwVI in research, especially on mathematics content that they may find challenging. This was also confirmed through an observation whereby SwVI were seen using computers to research mathematics content with the teacher's guidance.

The statements contend with what Silman et al. (2017) note, that teachers of SwVI have been using ATs like computers, with the help of the internet, to look for material on mathematical topics they are unfamiliar with.

I agree with the above statements because research is necessary in any field, including teaching mathematics to SwVI. Therefore, teachers who teach

mathematics to SwVI ought to conduct research, especially on mathematics topics that they find challenging to teach to SwVI and guide SwVI in researching any mathematics content whenever they are faced with a challenge.

4.5.1.4 Magnifying Mathematics Content

The fourth emerging issue on how teachers use ATs to teach mathematics to SwVI was that teachers use ATs to magnify mathematics content. Responses from participants (n=3) are shown below, and one participant said:

Now, I use the magnifier to make the text bigger so that when the mathematics work is placed under it, a SwLV will look at the screen, not the original work. This work will be captured, and the magnifier will enlarge it, and the student will comfortably be able to read from the screen, so it is very effective (TR₃).

Another participant said:

Then, this CCTV magnifier guides those with low vision to use it to magnify what is in the mathematics textbook such that a SwLV can read (SwVI₄).

The other participant (SwVI₃) said that teachers use ATs like CCTV magnifiers to guide SwLV in magnifying mathematics text so that they can read the enlarged text. Teachers use the ATs to teach mathematics to SwVI by magnifying mathematics content. One participant said:

The above statements suggest that teachers use ATs like magnifiers to guide SwLV in magnifying mathematics content to ease their reading. They explained that content in mathematics textbooks is magnified by ATs such as CCTVs, handheld and stand magnifiers or projectors to ease access to mathematics content by SwLV,

which I agree with. SwLV typically find reading any standard text with their bare eyes very difficult.

The findings concur with Erdem (2017), who noted that teachers use ATs like screen magnifiers (zoom text) and closed circuit televisions (CCTV) magnifiers to display enlarged screen content and also enlarge text from textbooks for easy access by SwLV.

Students ought to be encouraged to access information using the remaining vision at all times. Therefore, teachers must use ATs like CCTV magnifiers to enable and guide SwLV in accessing mathematics content in the textbooks. These magnifiers have provisions for adjusting the amount of light, enlarging text to a font one can read, and choosing the best colour contrast, among others, to enable access to mathematics content by SwLV without straining their eyes.

4.5.1.5 Teach counting and simple operations of numbers

The fifth emerging issue on how teachers use ATs to teach mathematics to SwVI was that teachers use ATs to teach counting and simple operations of numbers.

Participants (n=3) gave this response, and one participant said:

Yes, the abacus is used mainly in those lower classes like S.1 and S.2 for counting numbers. This simplifies teaching counting to a SwVI who cannot see a number that a teacher is trying to explain. For example, a teacher may say that one bead represents a hundred thousand, and if we have five beads, what do they represent? You find that the SwVI quickly understands by counting the beads and multiplying them, hence getting the answer (SwVI₁).

Another participant said:

Hah ha haaaa! Ahhhh! Let me begin with the abacus, which only requires a few skills. Our teachers use the abacus to teach us how to count and do simple operations of addition, subtraction and others. The teacher brings the abacus, puts it on the table in front of a SwVI, then guides them to put beads, count how many there are and then guide SwVI to add or multiply numbers (SwVI₂).

The other participant (TR₁) said the same thing. Some ATs, like the abacus, are used to teach counting and working out simple mathematics operations like addition and subtraction, among others.

The above finding suggests that the abacus can be used to teach counting and simple mathematics operations, which are very basic to teach and understand mathematics.

The findings concur with what Ali (2021) and Chanana & Delhi (2022) state, that teachers use ATs like the Braille abacus, Braille charts, and Braille shapes to teach counting, basic concepts in mathematics like place value, addition, subtraction, area, and relationships between figures.

I agree with the findings and literature above because complex mathematics concepts can only be introduced to SwVI if they know how to count and work out simple mathematics operations. It is therefore necessary to introduce counting and simple mathematics operations using the abacus, especially to students who have a visual impairment at a later stage, for example, when they have already passed through the primary cycle.

4.5.1.6 Reading Mathematics Content

The sixth emerging issue of how teachers use ATs to teach mathematics to SwVI is that they use ATs to guide SwVI in reading mathematics content. Participants (n=2) gave this response, and one of them said:

Teachers use a victor reader to guide SwVI to read mathematics content and a clear reader to guide students to read aloud the content in the scanned mathematics textbooks (SwVI₂).

The other participant said:

Then, there are magnifiers like clear readers; the teacher uses them in class, and we have some work to do in the textbook. SwLV can be helped by using magnifiers to magnify the text so that they can also read the enlarged text clearly and understand it (SwVI₃).

The statements from the study findings above indicate that teachers also use ATs like clear readers, victor readers, and magnifiers to guide SwVI in reading mathematics content from physical mathematics textbooks and online.

The statements are in line with Silman et al. (2017), who note that teachers of SwVI have been using ATs like victor readers, clear readers, and magnifiers to support SwVI in learning to read mathematics documents on their own without support from a second person. Some of these ATs, like the victor readers, read the mathematics text aloud, which benefits all SwVI, whereas the magnifiers enlarge text, which benefits SwLV. I agree with the above finding because the primary access to mathematics content is through the textbooks of mathematics, which is only possible for SwVI by use of ATs, of which they need to be guided by the

teacher of mathematics on how to use to access mathematics content, especially from mathematics textbooks.

4.5.1.7 Writing Mathematics Work

The final emerging issue on how teachers use ATs to teach mathematics to SwVI was that teachers use ATs to guide SwVI in writing mathematics work. Participants (n=2) gave this response, and one participant said:

Come to the Perkins brailers; I allow the SwVI to get the paper, open the JAWS of the Perkins brailers, insert the paper there, roll the roller and allow the paper to be fixed in the machine; then the person begins to write his or her mathematics using the Perkins brailers (TR₃).

Another participant also said:

Teachers use a victor reader to guide SwVI to read mathematics content and a clear reader to guide students to read for them aloud the content in the scanned mathematics textbooks (SwVI₂).

The study findings above indicate that some ATs, like slates and styluses, Perkins braille machines, and orbit readers, among others, are very useful in ensuring that information is written and kept for future reference by the SwVI. During the observation, SwVI, especially those who are blind, were seen using ATs like the Perkins braille machine during the teaching of mathematics to write their mathematics notes.

These findings are similar to what DePountis et al. (2015) observed in their study that teachers of SwVI used ATs to facilitate writing mathematics content and practice, allowing both teachers and students to study, interact, or work on mathematical problems concurrently.

I consent to the findings and literature in that SwVI need to write down their mathematics work such that they can refer to it in future, for example, when revising. Having access to the mathematics content they have learnt and written down will make it easy for them to read and remember what they learnt, for instance, a specific topic, way back.

4.5.2 Areas in mathematics that teachers find difficult to teach using ATs

Participants were asked to mention the areas in mathematics in which teachers find difficulties teaching using ATs. The major emerging issues included areas that involve drawing and abstract concepts. Statements from the participants are shown below:

4.5.2.1 Areas that involve drawing

One of the emerging issues in the areas of mathematics that teachers find difficult to teach using ATs is the areas that involve drawing. Participants (n=7) gave the above response, and one of the participants said:

Mmmhhh, I think anything that involves drawing because interpreting is complicated. In most cases, since this is based on touch, the SwVI may need help to interpret some of the diagrams or shapes as the teacher is trying to teach (TR₂).

Another participant said:

Mostly these numbers which have diagrams like drawing the histogram, drawing the graphs, there is no way, like it seems complicated. Our teachers find it difficult to draw those graphs, so they often explain or skip that topic (SwVI₄).

Another participant said, *"Then another area that I know is dealing with diagrams. We cannot draw mathematics diagrams using a braille, and teachers have found it challenging"* (SwVI₁).

Other participants (TR₁, TR₃, SwVI₂, and SwVI₃) also said something similar by noting that teachers find it challenging to teach diagrams to SwVI using ATs. They said that teaching drawing, for example, Venn diagrams, graphs, and mathematics tables, among others, is very challenging, even with the use of ATs.

4.5.2.2 Areas with abstract concepts

The following emerging issue in the areas of mathematics that teachers find challenging to teach using ATs was the areas with abstract concepts. The above response was given by participants (n=4), and one of them said:

There are many areas because mathematics itself is very demanding. We have too many abstract areas like vectors, matrices, and linear programming, which are challenging to teach to SwVI, especially to the Blind. For example, writing work on vectors is lengthy. It confuses students who use Perkins braille, forcing us to end at column vectors and magnitude of vectors, ignoring other aspects of vectors like proving that three points are collinear, which is supposed to be known by the student at O'level (TR₃).

Another participant said: *"Haaaa where there is a huge problem, if you talk about indices, then you talk about haaaa, logarithms, and then matrices ahhh now there, chaos comes in"* (SwVI₂).

Other participants (SwVI₁ and SwVI₄) also concurred with the above statements, noting that areas that teachers find difficulties using ATs to teach mathematics to

SwVI include areas that have abstract mathematics content, for instance, logarithms and matrices, because they deal with big brackets that cannot be written using these ATs like the Perkins braille machine and are also full of theory hence making it difficult for the teachers to teach to SwVI especially those who are blind.

The study findings above reveal that topics involving drawing, abstract concepts like logarithms, indices, and matrices, among others, and three dimensions are areas in mathematics where teachers find difficulties using ATs for teaching.

The above findings are similar to what Klingenberg et al. (2019) point out: graphs, charts, diagrams, figures, and drawings are used as mathematical content to convey enormous amounts of data or connections among parameters in a simplified and precise way. They go on to clarify that while it is an essential mathematical skill to acquire knowledge from such graphics and apply it to address difficulties, instructional graphic resources are visual. Subsequently, many SwVI need help. Equally, Cryer et al. (2013) assert that many Science, Technology, Engineering, and Mathematics (STEM) subjects, such as mathematics, significantly rely on visual aids like graphs, diagrams and charts unavailable to SwVI. They say these symbolic issues in mathematics are more challenging to provide ATs for than other literary-based subjects. Cryer continues by saying that because audio is naturally linear, it is difficult to access elements like equations in that format. They further claim that obtaining the entire equation at once is challenging while using large or enlarged prints for SwLV. Therefore, it was determined that SwVI need support accessing essential information like notes and engaging in further reading regarding

the subjects, particularly mathematics, causing a need to continue exploring how best ATs can be adapted to accommodate these areas of teaching in mathematics.

I agree with the above statements from the findings and the literature because I cannot imagine how difficult it can be to teach abstract concepts and those that involve drawing to SwVI. The concepts of drawing, for example, need one to be able to see what he or she has been asked to draw before he or she embarks on the actual activity of drawing and the abstract concepts, for example, writing the big brackets when dealing with matrices may tend to be challenging because the number of keys that produce dots in the Perkins braille machine is limited to only six dots which makes it difficult to teach some concepts beyond that, as some brackets like the round brackets, curly brackets can be written using the keys available in the ATs, compared to the big brackets talked about in the matrices.

4.5.3 Challenges faced in an attempt to use ATs during the teaching of mathematics to SwVI

When participants were asked about the challenges they face in an attempt to use ATs during the teaching of mathematics to SwVI, the major emerging issues included Inadequate knowledge and skills by both teachers and SwVI on the use of ATs, inadequate ATs used during the teaching of mathematics, absence of technicians to repair the ATs that get spoilt, technophobia, ATs being sophisticated and a problematic accent, especially on ATs that read text.

4.5.3.1 Inadequate knowledge and skills on the use of ATs

The first emerging issue regarding the challenges faced in an attempt to use ATs while teaching mathematics to SwVI was inadequate knowledge and skills in the use of ATs. Participants (n=7) gave the above response, and one of the participants said:

All teachers are still struggling with how to use ATs. We are learning since most ATs, especially those in high technology, have just come on board. We need adequate knowledge of using these ATs to teach mathematics to SwVI (TR₁).

Another participant said:

Well, another thing I may say is that there are these topics in mathematics where we find things complicated, and our teacher fails to interpret them well, and we feel left out as we move on to another topic. This makes me feel that the teacher may need to gain adequate knowledge in that area and may need help (SwVI₃).

Another participant also said:

Indeed, most of our teachers need more knowledge and skills to use all the ATs available because most of these teachers have not undergone serious training on using ATs for teaching mathematics. Sometimes, they keep asking us how we use these ATs (SwVI₁).

In similar responses, other participants (TR₂, TR₃, SwVI₂, and SwVI₄) also reported that the challenges faced when ATs are used while teaching mathematics included the inadequate skills to use the ATs during mathematics.

The above study findings suggest that the main challenge faced in an attempt to use ATs to teach mathematics to SwVI is that both teachers and SwVI are not adequately trained on the use of the ATs that are used for the teaching of

mathematics to SwVI in secondary schools which I agree with because, during the observation, a few ATs were seen being used during the teaching of mathematics and on an inquiry about why some ATs like the orbit readers were not being used, one teacher said:

Then the other one is the orbit reader. So far, we have not dealt much with it in terms of mathematics. It is a new AT that has been introduced, and we are also first making SwVI to learn how to use it. So, if they master it, it will also be good that we shall be in a position to put the content of mathematics in the orbit reader to make it easy for SwVI to study (TR₁).

The findings concur with Alkahtani (2013), who in a study at King Saud University's Department of Special Education, revealed that over 93 per cent of respondents were either inadequately or entirely caught off guard in providing AT services to SwDs, including those with VI, in their schools which suggests a significant problem is a lack of skills and knowledge about the use of AT.

Similarly, Msila (2015) shows that many participants (teachers) felt unprepared to use AT. Without the proper training, any attempt to use AT in teaching can embarrass and expose their shortcomings in front of learners. Msila explains that continuous professional development and attitudes are essential components for the success of the use and application of AT in teaching, hence concluding that any innovation in education, including AT, requires qualified teachers.

The inadequate knowledge and skills in using ATs to teach mathematics to SwVI have made teachers stick to traditional teaching methods. For example, talk and chalk due to fear of making mistakes in front of SwVI in an attempt to use the available ATs to teach mathematics. It is, therefore, crucial that avenues are created

for teachers and SwVI to be equipped with the knowledge and skills through training on the use of the ATs to be able to use them during the teaching and learning process of mathematics.

4.5.3.2 Inadequate ATs for teaching mathematics

Another emerging issue on the challenges faced in an attempt to use ATs during teaching mathematics to SwVI was inadequate ATs for teaching mathematics. All participants (n=7) gave the above response. One participant said:

The other challenge is looking at the materials; as I have told you, we have classes of 20, 23 and 28 students, but we have only one scientific calculator, which cannot be used by the whole class individually, and that causes an enormous challenge because the only way they can use is now to rotate and finishing say 28 SwVI takes days (SwVI₂).

Another participant said:

The other difficulty we face is that there are few AT gadgets compared to the number of students who need to use them. This makes it very difficult to use; we used to have only one scientific talking calculator, which has even spoiled (SwVI₄).

Another participant equally said:

There are few ATs, especially scientific calculators and talking calculators, among others, which is why you see some of us come with personal ones. If you have not acquired it for yourself, you may face some challenges (SwVI₂).

Other participants (TR₁, TR₃, SwVI₁, and SwVI₃) similarly said that inadequate ATs are one of the significant challenges to the use of ATs during the teaching of mathematics. Some of these inadequate ATs included the computers with JAWS, the scientific talking calculators, the talking calculators, the clear readers, orbit readers, and victor readers, among others, as confirmed by the observation made.

The study findings above indicate the inadequacy of the ATs in secondary schools, which is another significant challenge faced in an attempt to use ATs while teaching mathematics to SwVI. Participants noted that there are very few ATs compared to the number of SwVI in schools, hence making it difficult for them to use the few available during the teaching of mathematics to SwVI.

4.5.3.3 Breakdown of ATs

The following emerging issue on the challenges faced in an attempt to use ATs during teaching mathematics to SwVI was the breakdown of ATs. Participants (n=4) noted the above as another challenge, and one of them said:

The biggest challenge is the breakage of the AT devices. When they break down, we need almost a permanent repairer here because the moment they break down, they stay there for some time without being repaired. Later, someone comes to repair them, but after a long time, there is a lag (TR₃).

Another participant similarly said:

These AT devices breakdown and there are no people who are available all the time to repair them, and we find difficulty not only in mathematics but even other subjects but more so in mathematics when we are discussing we have to write, and this becomes difficult when the writing machine is down. (SwVI₃).

Other participants (SwVI₂ and SwVI₄) said that the other challenge faced when ATs are used to teach mathematics to SwVI is the breaking down of the ATs.

The above findings of the study suggest that the ATs used during the teaching of mathematics to SwVI sometimes break down, and because there are no technicians readily available to repair them, this poses a serious obstacle towards their use to teach mathematics to SwVI. It was also surprising to observe that schools have

various non-functioning ATs because they broke down, yet it would be relatively cheaper to repair them than to buy brand-new ones.

4.5.3.4 Technophobia (Fear) for ATs.

The other emerging issue on the challenges faced in an attempt to use ATs during the teaching of mathematics to SwVI was technophobia for ATs. Participants (n=2) responded by noting the above challenge, and one of them said:

Some of us have no interest in mathematics because many people talk about mathematics as a complex subject, and people talk about these ATs negatively. For example, people say that some are brought with bad intentions, and some assume that these ATs may behave like X-ray machines that affect people. So, students have developed a negative attitude (SwVI₁).

The other participant similarly said:

Uummmh, some people are rigid. For example, we had a boy who only wanted a slate and refused to use a Perkins braille. This became very challenging, and we had to let him use the slate. Then, others could not take up the use of the AT devices at all. We had a student who failed to cope with any AT, and that student was finally removed from the school (TR₃).

The above findings indicate that some SwVI fear the ATs due to assumptions or myths. For instance, some ATs behave like X-ray machines that affect people, some ATs are brought with bad intentions, and some SwVI have a negative attitude towards using the ATs. The findings also imply that some SwVI doubt their ability to perform when using ATs and hence suggest that they either have limited knowledge of the use of ATs or have poor self-efficacy. These have all made it challenging for these ATs to be used while teaching mathematics to SwVI.

All the above findings are also in line with Dalton & Sarah (2020), who also indicated that Insufficient knowledge and skills regarding how to use ATs is a significant issue, shortage of ATs, lack of specialists or technical support, lack of culture regarding the sustaining of ATs, and the fear of technology as challenges faced in an attempt to use ATs for teaching mathematics.

I agree with these findings because for ATs to be used efficiently by SwVI, each SwVI should be given an AT to ease manipulation and use during the teaching of mathematics and therefore, SwVI will find it challenging to use ATs effectively during mathematics lessons if they have limited access to crucial ATs for mathematics such as scientific talking calculators, computers with JAWS among others. It is also good to note that if an AT breaks down during the lesson, it means that the SwVI who was using it is at a disadvantage. Given that these ATs are few, there will be no room for replacement, for example, by giving another one which is functioning. Therefore, the participation of a SwVI during the lesson comes to a halt, which is also a very challenging situation. Some SwVI fear ATs because most of these ATs are delivered to schools, and not much sensitisation about the ATs has been carried out, let alone training on how they are used. Therefore, it is necessary to inculcate a culture of repair and maintenance among educational authorities with a particular budget set aside for that and train SwVI in using available ATs.

4.5.3.5 Challenge in pronunciation

The final emerging issue on the challenges faced in an attempt to use ATs during the teaching of mathematics to SwVI was the challenge in pronunciation.

Participants (n=1) also noted the above as another challenge and had this to say:

Sometimes, like most computers with JAWS, you do not hear what it has said because the accent may be complicated, so sometimes the computer reads something, and you find us writing something else (SwVI₄).

The above study findings indicate that SwVI face a challenge when reading mathematics content with the help of ATs like computers with JAWS and other screen readers. This is because the software that supports speech pronounces words in the text being read in quite a complicated way, hence confusing the SwVI, who are not used to such accents.

The findings are in agreement with Ampratwum et al. (2016), who conducted a study in Ghana on the challenges SwVI had when using computers with JAWS, and the results show that a non-adaptive keyboard was a problem, which did not favour critical conformation by the SwVI. The JAWS system uses sophisticated language software, which makes it difficult for SwVI to make sense of it, especially when reading mathematics content.

I concur with the statement because the accent used to pronounce the words in the mathematics content being read with the help of the ATs is quite different from the accent and pronunciation the SwVI are familiar with. This may need clarification among SwVI during their lessons in mathematics, especially when they are reading

mathematics content, for instance, online, hence making it a challenging situation for them.

4.5.4 How challenges mentioned have been overcome

Participants were asked to state how they have been overcoming the challenges they face while using ATs during the teaching process of mathematics in their schools. The major emerging issues were lobbying for more ATs, training other teachers on using ATs, asking for assistance from teachers and other students, scheduling mathematics lessons at different intervals to avoid colliding, and involving parents through sensitisation on the need to support SwVI, among others.

4.5.4.1 Lobby for more ATs

The first emerging issue on how challenges faced when using ATs to teach mathematics have been overcome was lobbying for more ATs. Participants (n=3) revealed the above as one way to overcome the challenges of inadequate ATs. One participant said:

We have been lobbying people of goodwill who have come in to support us in acquiring more ATs in order to solve the challenge of inadequate ATs. For an organisation that came, we shared with them that we have given our numbers of ATs and requested that they help us acquire more ATs (TR₁).

Another participant revealed that:

We have been talking to our administrators about these ATs not being enough, and they have also been trying their level best to lobby from well-wishers to see to it that more ATs are acquired (SwVI₃).

The other participant (TR₃) also said the same thing, noting that they have been trying to lobby for more ATs used for teaching mathematics so that each SwVI can have an AT to use during the teaching of mathematics.

The findings above suggest that schools have tried to overcome the challenge of inadequate ATs for teaching mathematics to SwVI by lobbying for more ATs from NGOs like Cheshire Services Uganda and VISIO- All we see is the possibility of the project and other well-wishers. I acknowledge it because for SwVI to participate during the teaching of mathematics actively, each SwVI should have an AT that he or she manipulates and uses during the teaching of mathematics.

4.5.4.2 Training Other Teachers

The second emerging issue on how challenges faced when using ATs to teach mathematics have been overcome was by training other teachers on using ATs for teaching mathematics to SwVI. Participants (n=2) raised the above solution to overcome the challenge of inadequate knowledge and skills among teachers and SwVI. One participant from school B said:

I have passed the knowledge and skills on using ATs to teach mathematics to SwVI to some teachers, especially those who show interest. I have also just informed the administrators about the need for training more teachers, but they always say, where is the money? We do not have money for the training of these teachers (TR₃).

The other participant from school A similarly said:

We have arranged for internal training here at school to equip ourselves with skills and knowledge to use the ATs to teach

mathematics to SwVI, though this has not yet been implemented (TR₁).

The study findings above reveal that there has been an attempt, at a lesser extent, to pass on skills to other teachers through organising internal training on the use of ATs for teaching mathematics to SwVI, noting that teachers who have undergone some informal training on the use of ATs have tried to train other teachers, including SwVI on how to use the ATs available.

This is commendable though to a greater extent; it has not been achieved due to several reasons, for instance, lack of interest from some teachers, no time to conduct the training as many teachers seem too busy due to the big workload they have at school and no funds to organise for such training among others.

4.5.4.3 Assistance from teachers and friends

The third emerging issue on how challenges faced when using ATs to teach mathematics have been overcome was getting assistance from teachers and friends. Participants (n=3) pointed out the above as one way of overcoming the pronunciation challenge, especially when using ATs like the computers with JAWS. One participant said: *“Sometimes we ask the teacher if he is near or our friends to clarify for us the words that are read by these computers with JAWS”* (SwVI₄). Another participant said:

We have been talking to our teachers to encourage our friends to continue helping us. For example, when we do not understand the mathematics concepts we listen to from the computers with JAWS, we form discussion groups, and our friends who have understood those concepts explain them to us (SwVI₃).

The other participant (TR₂) said the same, noting that they give SwVI time to interact with the teachers who explain the concepts they may struggle with when reading mathematics content using the ATs.

The statements above indicate that teachers, as well as other students, show concern for SwVI when they face challenges while using the ATs during the teaching of mathematics by giving the necessary support they need, for example, by clarifying for them the words they find difficult to understand because of the unfamiliar accent and pronunciation from the ATs like computers with JAWS.

4.5.4.4 Sensitisation on the use of ATs

The last emerging issue on how challenges faced when using ATs to teach mathematics have been overcome was through sensitisation on the use of ATs. Participants (n=1) stated the above solution as a way of overcoming the challenge of technophobia for ATs. One participant said:

Sometimes, our teachers talk to us, especially at the beginning of each year, taking us through the importance of using ATs and also training us on how to use some of the ATs, hence making us used to them, which reduces our challenge of fear towards the ATs (SwVI₃).

The study's findings reveal that sensitisation on the importance of the use of ATs by teachers and SwVI has, to some extent, been carried out in schools to overcome the challenge of technophobia while teaching mathematics to SwVI in secondary schools. I concur with this because SwVI, who are reluctant to use particular ATs, either have limited knowledge of ATs or need to be more confident in their ability to use the ATs. In this regard, the teachers in charge of the resource room and unit

have tried to make special arrangements to create awareness through training to promote the use of ATs among SwVI and expose them to different ATs available to minimise the challenge of technophobia.

All the above strategies for overcoming the challenges faced when using ATs during the teaching of mathematics are in line with Dalton and Sarah (2020), who offered strategies for overcoming the difficulties in using ATs during the teaching of mathematics, which included sharing available ATs, making proper arrangements for supplying SwVI with ATs, such as allocating specific equipment to first-year students only, reporting to the administrators so that they could enforce the programme that could help with the upkeep of such AT devices, and talking to SwVI on the use of freshly acquired ATs and the significance of doing so.

I concur with all the above findings and literature because there is a need to lobby for more ATs since the ones in schools are few so that SwVI have one-on-one opportunities to interact with the ATs and training of teachers because teachers who have some knowledge of the use of ATs to teach mathematics to SwVI seem very few, encourage teachers and other students to assist SwVI and also carry out sensitisation on the use of ATs for teaching mathematics so that SwVI have increased access to using ATs and an equal opportunity to compete with other students in mathematics favourably since the barriers will be overcome.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The study sought to explore the use of assistive technology in teaching Mathematics to SwVI in two selected secondary schools in Eastern Uganda and was guided by the objectives, which included establishing the ATs available for teaching mathematics to SwVI; examining the training undergone by teachers to enable them to use ATs to teach mathematics to SwVI; and to explore how ATs are used to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda. The presentation in this chapter is therefore made according to the above objectives. The summary, conclusion, and recommendations are submitted, and areas for further research are suggested.

5.2 Summary of the findings

The study's findings revealed that low-tech ATs used for teaching mathematics to SwVI in secondary schools are scarcely available, and even from the available, most of them were inadequate. Out of several low-tech ATs on the market, only talking calculators, cube frames, and cubes, Taylor frames, abacus, and Perkins braille machines were available for use by teachers and SwVI during the teaching of mathematics. The study also revealed that high-tech ATs are available in the resource rooms but very few in number and assortment. Each school had only one braille embosser, printer, scientific calculator, orbit reader, and a few computers

adapted to the needs of SwVI, clear readers, victor readers, and CCTV magnifiers, while projectors were not available for use by teachers and SwVI during the teaching of mathematics.

The study found that teachers have had informal training on the general use of ATs, which cannot enable them to effectively use ATs for teaching mathematics to SwVI. The findings of the study additionally disclosed that teachers have barely undergone formal training on the use of ATs for teaching mathematics to SwVI, apart from one teacher who had a certificate with general training in mathematics and English braille, which was not specific to the use of ATs for teaching mathematics to SwVI. The study also divulged that, with the little knowledge and skills attained from the informal training, teachers have used ATs to simplify their work while teaching mathematics to SwVI.

The study revealed that most of the teachers who teach mathematics to SwVI rarely use ATs for teaching mathematics to SwVI in Secondary Schools by minimally using them to carry out research, produce mathematics work in accessible formats, magnify work and guide SwVI to read and write mathematics content during the teaching of mathematics. This has increased the opportunity for SwVI to access information while teaching mathematics. The study additionally revealed that topics that deal with drawing and abstract concepts are the areas mathematics teachers find difficult using ATs when teaching mathematics to SwVI in secondary schools.

5.3 Conclusion

The study has put forward that ATs are resources that enable access to mathematics content and promote dependency among SwVI during the teaching of mathematics. Nonetheless, it has evolved that teachers in the two selected secondary schools in Eastern Uganda need access to most ATs required for teaching mathematics to SwVI. This is because the secondary schools have few low-tech and high-tech ATs as opposed to the number of SwVI in the schools, which may pose a challenge in the effective use by teachers to improve the teaching of mathematics to SwVI.

Teachers in these secondary schools do not have adequate knowledge and skills to use ATs for teaching mathematics to SwVI because they have not had formal training on using ATs for teaching mathematics to SwVI.

The use of ATs in teaching mathematics to SwVI in secondary schools is minimal, but it has, to a greater extent, enabled research by teachers and SwVI on mathematics concepts that seem challenging, production of mathematics content in accessible formats for SwVI, reading and writing of mathematics content even though the ATs are inadequate.

5.4 Recommendations and Implications

The use of ATs for teaching mathematics to SwVI in secondary schools necessitates the availability of adequate ATs, adequately trained teachers, technicians to do repairs, and proper budget allocation. Considering the findings of this study, it is therefore recommended that:

The government, through MoES, NGOs and other stakeholders, need to combine efforts to ensure that low-tech and high-tech ATs for teaching mathematics to SwVI are procured and supplied to secondary schools, considering the number of SwVI in the schools. This implies that there is a need for the government through MoES to assign a budget to ensure procurement and supply of ATs to secondary schools because the study findings from the interview conducted, as well as the observations made, revealed inadequacy of both low-tech and high-tech ATs used for teaching mathematics to SwVI in the secondary schools. These findings are also supported by the findings from the study of (Daroni et al., 2018), who also note the inadequacy of ATs, especially in developing countries, due to inadequate funds to purchase enough ATs.

Through MoES and school administrators, the government ought to offer opportunities to teachers in Secondary Schools to go for in-service and pre-service training on the use of ATs to teach mathematics to SwVI. This implies that administrators and teachers ought to have a straightforward staff development programme and identify potential training institutions where teachers can be trained in using ATs. This is because the study findings revealed that teachers do not have formal training in using ATs to teach mathematics to SwVI. The findings also contend with Burgos (2015), who observes that AT specialists (teachers) need more expertise in various areas that offer AT services because of a lack of time or managerial support for training and a lack of pre-service education or certifications in using AT. Burgos recommended allocating training time and resources for

teachers. This will enable them to acquire the necessary knowledge and skills to use ATs to teach SwVI, especially mathematics, in secondary schools.

There is an urgent need for the government, through the Public Service Commission, to identify, recruit, and post teachers with the knowledge and skills to use ATs to teach SwVI in secondary schools that enrol such students. This implies that the Public Service Commission ought to collaborate with secondary school administrators to know the teachers' requirements and the needs of the students so that advertisements for personnel needed are intentional. This arose because the study findings revealed that ATs are minimally used to teach SwVI mathematics. After all, the secondary schools with SwVI need more teachers trained to use the necessary ATs to teach SwVI. These study findings are also supported by Msila (2015), who conducted a study that revealed that many teachers felt unprepared to use ATs because they did not have proper training, and therefore recommended continuous professional development as an essential component for the success of use and application of AT in teaching especially mathematics to SwVI, hence concluding that any innovation in education, including AT use, requires knowledgeable teachers.

Different stakeholders need to advocate for and ensure the training of some teachers, especially those who use the ATs for teaching SwVI, on the maintenance and repair of these ATs. This will help reduce the challenges caused by delayed repair and maintenance of the available ATs in the schools, which were revealed in the study findings.

5.5 Suggestions for further research

With regard to the study findings, I therefore suggest that studies should be carried out in the following areas to improve the use of ATs in teaching mathematics to SwVI in secondary schools:

To examine the status of maintenance and repair of various ATs used for teaching mathematics to SwVI in secondary schools in Uganda. This is because, from the findings of the study, it has been noted that there are scarcely any teachers in schools to carry out maintenance and repair of the ATs that have been procured and supplied in secondary schools that enrol SwVI.

To explore how best ATs can be used in teaching all Science subjects to SwVI in Secondary Schools in Uganda because the achievement of SwVI in mathematics and other STEM subjects generally seems low in Ugandan secondary schools.

To establish the use of Assistive Technology in teaching abstract mathematics concepts to Students with Visual Impairment in secondary schools in Uganda. The study findings revealed that teachers struggle to teach abstract mathematical concepts to w Source: Uganda Bureau of Statistics, SwVI in secondary schools.

REFERENCES

- Ajuwon, P. M., Meeks, M. K., Griffin-Shirley, N., & Okungu, P. A. (2016). Ajuwon. *Journal of Visual Impairment & Blindness*, 110(2)(Reflections of teachers of visually impaired students on their assistive technology competencies), 126–134.
- Akpan, J. P., & Beard, L. A. (2014). Assistive Technology and Mathematics Education. *Universal Journal of Educational Research*, 2(3), 219–222. <https://doi.org/10.13189/ujer.2014.020303>
- Akyurek, G., Kars, S., Celik, Z., Koc, C., & Cesim, Ö. B. (2017). Assistive Technology in Occupational Therapy. *Occupational Therapy - Occupation Focused Holistic Practice in Rehabilitation*. <https://doi.org/10.5772/intechopen.68471>
- Al-Dababneh, K. A., Al-Masa'deh, M. T. M., & Oliemat, E. M. (2015). *The effect of a training programme in creativity on developing the creative abilities among children with visual impairment. Early Child Development and Care*. 185(1), 1–27.
- Ali, C. A. (2021). Visually impaired student-teachers' knowledge and use of basic assistive technology tools for mathematics. *African Educational Research Journal*, 9(4), 945–955. <https://doi.org/10.30918/aerj.94.21.151>
- Alkahtani, K. D. F. (2013). Teachers' Knowledge and Use of Assistive Technology for Students with Special Educational Needs. *Journal of Studies in Education*, 3(2), 65–86. <https://doi.org/10.5296/jse.v3i2.3424>
- Ampratwum, J., Offei, Y. N., & Ntoaduro, A. (2016). Barriers to the Use of Computer Assistive Technology among Students with Visual Impairment in Ghana: The Case of Akropong School for the Blind. *Journal of Education and Practice*, 7(2222-1735), 58–61. www.iiste.org

- Asebriy, Z., Raghay, S., & Bencharef, O. (2018). An assistive technology for braille users to support mathematical learning: A semantic retrieval system. *Symmetry*, *10*(11). <https://doi.org/10.3390/sym10110547>
- Baguma, R., & Wolters, M. K. (2021). Making Virtual Learning Environments Accessible to People with Disabilities in Universities in Uganda. *Frontiers in Computer Science*, *3*(June), 1–14. <https://doi.org/10.3389/fcomp.2021.638275>
- Beauchemin, É., Côté, L. P., Drolet, M. J., & Williams-Jones, B. (2022). Conceptualising Ethical Issues in the Conduct of Research: Results from a Critical and Systematic Literature Review. *Journal of Academic Ethics*, *20*(3), 335–358. <https://doi.org/10.1007/s10805-021-09411-7>
- Bell, E. C., & Silverman, A. M. (2019). Access to Math and Science Content for Youth Who Are Blind or Visually Impaired. *Journal of Blindness Innovation and Research*, *9*(1). <https://doi.org/10.5241/9-152>
- Bernd, T., Van Der Pijl, D., & De Witte, L. P. (2009). Existing models and instruments for the selection of assistive technology in rehabilitation practice. *Scandinavian Journal of Occupational Therapy*, *16*(3). <https://doi.org/10.1080/11038120802449362>
- Bhardwaj, P. (2019). Types of sampling in research. *Journal of the Practice of Cardiovascular Sciences*, *5* (3), 157.
- Bhowmick, A., & Hazarika, S. M. (2017). An insight into assistive technology for the visually impaired and blind people: state-of-the-art and future trends. *Journal on Multimodal User Interfaces*, *11*(2), 149–172. <https://doi.org/10.1007/s12193-016-0235-6>
- Brawand, A. C., & Johnson, N. M. (2016). Effective Methods for Delivering Mathematics Instruction to Students with Visual Impairments. *Journal of Blindness Innovation and Research*, *6*(1). <https://doi.org/10.5241/6-86>

- Brinkmann, S., & Kvale, S. (2015). Interviews: Learning the craft of qualitative research interviewing . *Sage Publications*.
- Bryman, A. (2016a). Research Methods. Oxford: Oxford University Press
- Bulent, C., & Punar, Karaoglan Bahar, Ki. T. (2009). A Study on Science Teachers' Attitudes Toward Information. *The Turkish Online Journal of Educational Technology*, 8(2), 20–32.
- Bryman, A. (2016b). *Social research methods*. Oxford university press.
- Buabeng-Andoh, C. (2020). An Exploration of Teachers' Skills, Perceptions and Practices of ICT in Teaching and Learning in the Ghanaian Second-Cycle Schools. *Contemporary Educational Technology*, 3(1).
<https://doi.org/10.30935/cedtech/6066>
- Burgos, B. B. (2015). A Study of Assistive Technology Competencies of Specialists in Public Schools. *ProQuest Dissertations and Theses*, 60, 132.
https://nsuworks.nova.edu/gscis_etd
- Casteel, A., & Bridier, N. L. (2021). Describing populations and samples in doctoral student research. *International Journal of Doctoral Studies*, 16.
<https://doi.org/10.28945/4766>
- Chan, V. F., & Congdon, N. (2021). (More) Action on Vision, Now! *Asia-Pacific Journal of Ophthalmology (Philadelphia, Pa.)*, 10(5), 421–422.
<https://doi.org/10.1097/APO.0000000000000428>
- Chanana, A. B., & Delhi, N. (2022). *Enabling Education of Children with Visual Impairment in Schools through Assistive Technology*. 13(6), 1676–1682.
<https://doi.org/10.47750/pnr.2022.13.S06.220>
- Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education (7th ed.)*. Routledge. 2011.

- Cook, A. M., & Polgar, J. M. (2008). *Cook & Hussey's. Assistive technology principles and practice (3rd ed.)*. St. Louis, MO: Mosby . 2008.
- Creswell, J. W. (2013). *Qualitative Research Inquiry Design: choosing among five approaches*. London: *Sage Publications*, 2013.
- Creswell, J. W. (2014). *Research Design, Qualitative, Quantitative and Mixed Approaches*, Fourth edition,. *SAGE Publication, London-United Kingdom*.
- Creswell, J. W., & Creswell, J. D. (2017). (2017). *Research design: Qualitative, quantitative, and mixed methods approaches* . *Sage Publications.*, 2017.
- Cryer, H., Home, S., Wilkins, S. M., Cliffe, E., & Rowe, S. (2013). *Teaching STEM subjects to blind and partially sighted students: Literature Review and Resources*. *RNIB Centre for Accessible Information (CAI), Birmingham* .
- Dalton H, K., & Sarah E, K. (2020). *Access to assistive technology among students with visual impairment in higher education institutions in Tanzania*. *University of Dar Es Salaam Library Journal*, 15(2), 137–151. <https://search.ebscohost.com/login.aspx?direct=true&db=awn&AN=jol-3894-1&site=ehost-live&scope=site>
- Daroni, G. A., Gunarhadi, G., & Legowo, E. (2018). *Assistive Technology in Mathematics Learning for Visually Impaired Students*. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 3(1), 1. <https://doi.org/10.24042/tadris.v3i1.2406>
- Daroni, G. A., & Legowo, G. E. (2018). *Assistive Technology in Mathematics Learning for Visually Impaired*. *Journal of education and teacher training*. 3, 1–9.
- De Oliveira, F. S., Do Nascimento, A. S., & Bianconi, M. L. (2017). *Teaching Enzyme Activity to the Visual Impaired and Blind Students*. *Technologies*, 5, 52. <https://doi.org/10.3390/technologies5 030052>

- DePountis, V. M., Pogrud, R. L., Griffin-Shirley, N., & Lan, W. Y. (2015). Technologies used in the study of advanced mathematics by students who are visually impaired in classrooms: Teachers' perspectives. *Journal of Visual Impairment and Blindness*, *109*(4), 265–278. <https://doi.org/10.1177/0145482x1510900403>
- Desmond, D., Layton, N., Bentley, J., Boot, F. H., Borg, J., Dhungana, B. M., Gallagher, P., Gitlow, L., Gowran, R. J., Groce, N., Mavrou, K., Mackeogh, T., McDonald, R., Pettersson, C., & Scherer, M. J. (2018). Assistive technology and people: a position paper from the first global research, innovation and education on assistive technology (GREAT) summit. *Disability and Rehabilitation: Assistive Technology*, *13*(5), 437–444. <https://doi.org/10.1080/17483107.2018.1471169>
- Du Toit, J. (2015). *Teacher training and usage of ict in education. New directions for the UIS global data collection in the post-2015 context. September.* [http://www.uis.unesco.org/StatisticalCapacityBuilding/WorkshopDocuments/Communication workshop dox/Paris 2014/ICT-teacher training-use_EN.pdf](http://www.uis.unesco.org/StatisticalCapacityBuilding/WorkshopDocuments/Communication%20workshop%20dox/Paris%202014/ICT-teacher%20training-use_EN.pdf)
- Eligi, I. (2017). ICT accessibility and usability to support learning of visually-impaired students in Tanzania. *International Journal of Education and Development Using Information and Communication Technology*, *13*(2), 87–102.
- Erdem, R. (2017). Students with special educational needs and assistive technologies: A literature review. *Turkish Online Journal of Educational Technology*, *16*(1), 128–146.
- Ferree, K. E. (2010). *Framing the race in South Africa: The political origins of racial census elections*. Cambridge University Press.

- Gatchalian, C. (2019). Assistive Technologies in the 21st Century – Technology and the Curriculum: Summer 2019. *Pressbooks*, 2019. <https://techandcurr2019.pressbooks.com/chapter/21st-century-assistive-tech/>
- Giesbrecht, E. (2013). Application of the human activity assistive technology model for occupational therapy research. *Australian Occupational Therapy Journal*, 60(4), 230–240. <https://doi.org/10.1111/1440-1630.12054>
- Hassan, N. J., & Salleh, N. M. (2017). Development and assessment of the usability of mathematical teaching module for visually impaired fourth year students. *International Journal of Education, Psychology ...*, 54–69. <http://www.ijepc.com/PDF/IJEPc-2017-05-09-05.pdf>
- Hegedus, S., Laborde, C., Brady, C., Dalton, S., Siller, H.-S., Tabach, M., Trgalova, J., & Moreno-Armella, L. (2017). *Uses of Technology in Upper Secondary Mathematics Education*. https://doi.org/10.1007/978-3-319-42611-2_1
- Igba, I. (2021). Facilities, Equipment and Personnel in Education of Persons with Visual Impairment. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3840986>
- Kabir, S. (2016). Basic Guideline for research CHAPTER-9 METHODS OF DATA COLLECTION. *Basic Guideline for Research*, 201–276. https://www.academia.edu/41606874/CHAPTER_9_METHODS_OF_DATA_COLLECTION_Topics_Covered
- Kaiti, R. (2020). Visual Impairment and its Rehabilitation: A Review. *Trends in Ophthalmology Open Access Journal*, 3(1), 208–212. <https://doi.org/10.32474/tooaj.2020.03.000152>
- Karlsson, M. (2016). *What is a case study? Academy of Business. Engineering and Science, Halmstad University, Halmstad, Halland, Sweden* . 2016.
- Kawulich, B. (2014). Collecting Data Through Observation. *Katalog BPS*, XXXIII(2), 81–87.

- Kim, H. K., Han, S. H., Park, J., & Park, J. (2016). The interaction experiences of visually impaired people with assistive technology: A case study of smartphones. *International Journal of Industrial Ergonomics*, 55. <https://doi.org/10.1016/j.ergon.2016.07.002>
- Klingenberg, O. G., Holkesvik, A. H., & Augestad, L. B. (2020). Digital learning in mathematics for students with severe visual impairment: A systematic review. *British Journal of Visual Impairment*, 38(1), 38–57. <https://doi.org/10.1177/0264619619876975>
- Klingenberg, O. G., Holkesvik, A. H., Augestad, L. B., & Erdem, E. (2019). Research evidence for mathematics education for students with visual impairment: A systematic review. *Cogent Education*, 6(1). <https://doi.org/10.1080/2331186X.2019.1626322>
- Kumar, P. (2013). Assistive Technology competencies: Need, outlook, and prospects (with reference to special educators for children with visual impairment). *Researchgate.Net*, 1(8), 2268–2280. <https://www.researchgate.net/publication/259781160>
- Lenker, J. A., & Paquet, V. L. (2003). A Review of Conceptual Models for Assistive Technology Outcomes Research and Practice. *Assistive Technology*, 15(1). <https://doi.org/10.1080/10400435.2003.10131885>
- Limburg, H., Espinoza, R., Lansingh, V. C., & Silva, J. C. (2015). Functional low vision in adults from Latin America: Findings from population-based surveys in 15 countries. *Revista Panamericana de Salud Publica/Pan American Journal of Public Health*, 37(6), 371–378.
- Livingstone, S. (2012). *Critical reflections on the benefits of ICT in education*. 38. <https://doi.org/10.1080/03054985.2011.577938>

- Lowe, N. K. (2019). What Is a Pilot Study? In *JOGNN - Journal of Obstetric, Gynecologic, and Neonatal Nursing* (Vol. 48, Issue 2). <https://doi.org/10.1016/j.jogn.2019.01.005>
- Ministry of Education and Sports. (2017). *Education Abstract 2017. April*.
- MoICT. (2014). National Information and Communications Technology Policy for Uganda. *National Information and Communications Technology Policy for Uganda*, October. https://www.google.com/search?safe=active&sxsrf=ALeKk03IVCH_f1LROxWBx5rcVxDoBXPkEg:1584012410555&ei=ehxqXvjAicWWaa6-hLgK&q=uganda+national+ict+policy+framework.pdf&oq=uganda+national+ict+policy+framework.pdf&gs_l=psy-ab.3...3173.4240..5108...0.2..0.655
- Morgado, D. Z., Holloway, C., & Austin, V. P. (2019). *Report on the Usability of Assistive Technology in Ugandan Schools with Children with Visual and / or Hearing Disabilities*. May. <https://doi.org/10.5281/zenodo.3746526>
- Moser, A., & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. *European Journal of General Practice*, 24(1), 9–18. <https://doi.org/10.1080/13814788.2017.1375091>
- Msila, V. (2015). Teacher Readiness and Information and Communications Technology (ICT) Use in Classrooms: A South African Case Study. *Creative Education*, 06(18). <https://doi.org/10.4236/ce.2015.618202>
- Msoni, R. (2021). (2021). *Academic experiences of blind students in two colleges of education in Zambia (Doctoral dissertation, The University of Zambia)*. 2021.
- Mugenda, A. G., & Mugenda, O. M. (2012). *Research methods dictionary*. Applied Research & Training Services: Nairobi, Kenya.

- Mwakyeya, B. M. (2013). *Teaching Students with Visual Impairments in Inclusive Classrooms: A Case Study of One Secondary School in Tanzania*. 1–99. <https://www.duo.uio.no/bitstream/handle/10852/36642/MasterxsxThesis.pdf?sequence=1>
- Nafula, J. (2023). “Experts Blame special Needs Poor Grades on Few Teachers .” *Daily Monitor, Friday, February, 10, 41, 3*.
- Naipal, S., & Rampersad, N. (2018). A review of visual impairment. *African Vision and Eye Health*, 77(1), 1–4. <https://doi.org/10.4102/aveh.v77i1.393>
- Ngatia, P. K. (2015). Preparedness of Public Secondary Schools on the Use of Information Communication Technology in Teaching and Learning in Mukurweini, Nyeri County-Kenya Paul Kamau Ngatia a Research Project Submitted To the School of Education in Partial Fulfillment of the. *Ir-Library.Ku.Ac.Ke, December*. [http://ir-library.ku.ac.ke/bitstream/handle/123456789/14446/Preparedness of public secondary schools.....pdf;sequence=1](http://ir-library.ku.ac.ke/bitstream/handle/123456789/14446/Preparedness%20of%20public%20secondary%20schools.....pdf;sequence=1)
- Nkiko, C., Atinmo, M. I., Michael-Onuoha, H. C., Ilogho, J. E., Fagbohun, M. O., Ifeakachuku, O., Adetomiwa, B., & Usman, K. O. (2017). Information Technology and Transcription of Reading Materials for the Visually Impaired Persons in Nigeria. *Journal of Education and Learning*, 7(1), 42. <https://doi.org/10.5539/jel.v7n1p42>
- Ong’ondo, C. O., & Jwan, J. . (2020). Qualitative Research Process: From Conceptualization to Examination. *Jomo Kenyatta Foundation: Nairobi* .
- Rai, N., & Thapa, B. (2015). A study on purposive sampling method in research. *Kathmandu:Kathmandu School of Law*, 1–12. <http://stattrek.com/survey-research/sampling-methods.aspx?Tutorial=AP>,

- Ramírez, H., Mendoza, E., Mendoza, M., & González, E. (2015). Application of Augmented Reality in Statistical Process Control, to Increment the Productivity in Manufacture. *Procedia Computer Science*, 75(Vare), 213–220. <https://doi.org/10.1016/j.procs.2015.12.240>
- Rony, M. R. (2017). *Information Communication Technology To support and include Blind students in a school for all An Empirical study of teachers ' and students ' . 1–107.*
- Samanta, B. (2017). *Effectiveness of Technology in Learning*. 16567–16573. <https://doi.org/10.15680/IJIRSET.2017.0608263>
- Senjam, S. (2019). Assistive technology for students with visual disability: Classification matters. *Kerala Journal of Ophthalmology*, 31(2). https://doi.org/10.4103/kjo.kjo_36_19
- Senjam, S. S., Foster, A., & Bascaran, C. (2020). Assistive Technology for Visual Impairment and Trainers at Schools for the Blind in Delhi Assistive Technology Assistive technology for visual impairment and trainers at schools for the blind in Delhi. *Assistive Technology*, 00(00), 1–5. <https://doi.org/10.1080/10400435.2020.1839144>
- Silman, F., Yaratan, H., & Karanfiller, T. (2017). Use of assistive technology for teaching-learning and administrative processes for the visually impaired people. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(8), 4805–4813. <https://doi.org/10.12973/eurasia.2017.00945a>
- Silverman, D. (2019). *Interpreting qualitative data. Interpreting Qualitative Data* (pp. 1–568).

- Smith, E. M., Huff, S., Wescott, H., Daniel, R., Ebuenyi, I. D., O'Donnell, J., Maalim, M., Zhang, W., Khasnabis, C., & MacLachlan, M. (2022). Assistive technologies are central to the realization of the Convention on the Rights of Persons with Disabilities. *Disability and Rehabilitation: Assistive Technology*, 0(0), 1–6. <https://doi.org/10.1080/17483107.2022.2099987>
- Sze, S. (2019). *An Investigation of Various Types of Assistive Technology (AT)*. [Web page]. Retrieved from <https://files.eric.ed.gov/fulltext/ED490347.pdf>. 490347.
- Taremwa, A. (2022). *They may have lost sight, but digital assistive learning technologies have given learners a vision.* 2022. <https://www.unicef.org/uganda/stories/they-may-have-lost-sight-digital-assistive-learning-technologies-have-given-learners-vision>
- Tebo, L. (2014). Resource Guide To Assistive Technology for Students With Visual Impairment. *Dissertation of Graduate at Bowling Green State University*. http://indicators.knowbility.org/docs/resourcebank/TEBO_VI_Resource_Guide.pdf
- Tedla, B. A. (2012). Understanding the importance, impacts and barriers of ICT on Teaching and Learning in East African Countries. *International Journal for E-Learning Security*, 2(2), 199–207. <https://doi.org/10.20533/ijels.2046.4568.2012.0025>
- Teferra, T., Asgedom, A., Oumer, J., Dalelo, A., & ... (2018). Ethiopian education development roadmap (2018-30). *An Integrated Executive ...*, July, 1–101. <https://5y1.org/download/f80344e9046fa0346fc402c29dd76288.pdf>
- Tracy, S. J. (2013). (2013). *Qualitative research METHODS*. Blackwell Publishing. A John Wiley & Sons, Ltd., Publication. 2013.

- Uganda National Bureau of Statistics (UBOS). (2016). *The National Population and Housing census 2014 Main report*. Kampala: UBOS.
- UNICEF. (2014). *Situational Analysis on the Rights of Children with Disabilities in Uganda*. Kampala: UNICEF.
- Viner, M. (2020). *Assistive Technology to Help Students With Disabilities*. September. <https://doi.org/10.4018/978-1-7998-1431-3.ch012>
- Wilfred, J. (2017). Influence of assistive technology utilization on academic performance of pupils with disabilities In Tanzania s primary school. *Thesis*, 1–235. <http://repository.udom.ac.tz>
- World Bank. (2020). Uganda Secondary Education Expansion Project (Useep). *Shire Valley Transformation Program-1 Report No: PAD2241, 102(SUPPL. 1)*.<https://documents1.worldbank.org/curated/en/406361595815248191/pdf/Uganda-Secondary-Education-Expansion-Project.pdf>
- World Health Organization. (2022). *Summary report on the regional consultation on the WHO- UNICEF global report on assistive technology (GReAT), virtual meeting, 4 October 2021 (No. WHO-EM/HLP/131/E)*. World Health Organization. Regional Office for the Eastern Mediterranean. 2021(October 2021).
- Yazan, B., & De Vasconcelos, I. C. O. (2016). Three approaches to case study methods in education: Yin, Merriam, and Stake. *Meta: Avaliacao*, 8(22), 149–182. <https://doi.org/10.22347/2175-2753v8i22.1038>
- Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions: Epistemological, theoretical, and methodological differences. *European Journal of Education*, 48(2), 311–325. <https://doi.org/10.1111/ejed.12014>
- Yin, K. R. (2014). *Case Study Research Design and Methods*. SAGE Publications.

Yip, C., Han, N. L. R., & Sng, B. L. (2016). Legal and ethical issues in research. In *Indian Journal of Anaesthesia* (Vol. 60, Issue 9). <https://doi.org/10.4103/0019-5049.190627>

Zandy, J. (2019). Universal declaration of human rights. *Radical Teacher*, 113(December), 54–55. <https://doi.org/10.5195/rt.2019.591>

APPENDICES:

Appendix I: Interview Guide for Teachers

I am Akol Agnes, a student at Kyambogo University, pursuing a Master of Special Needs Education. To complete my studies, I am supposed to carry out research. As a result, I am conducting a research study on; "Assistive Technology Use For Teaching Mathematics to Students with Visual Impairment (SwVI) in Two Selected Secondary Schools". To complete my research, I am conducting an interview. The interview will focus on ATs available for teaching Mathematics to SwVI, Training teachers undergo to enable them to use ATs to teach Mathematics to SwVI and how ATs are used to teach Mathematics to SwVI in secondary schools. The findings were used for this study, and confidentiality was observed.

A. Background information of interviewees.

- (a) Gender:
- (b) Age:
- (c) Qualification:
- (d) Classes taught:
- (e) How long have you taught SwVI:

B. AT resources available for teaching mathematics to SwVI in secondary schools

- i. Mention the ATs that you have in your school.
- ii. From the ATs you have mentioned,
 - which ones are Low-tech?
 - which ones are High-Tech?
- iii. Out of the Low-Tech ATs you have mentioned, which ones do you use to teach mathematics to SwVI?

- iv. Which of the high-tech ATs you mentioned do you use to teach mathematics to SwVI?

C. Training undergone by teachers in using AT resources to teach mathematics to SwVI.

- i. What informal training do you have on using ATs to teach mathematics to SwVI?
- ii. Which formal training have you attained in adapting ATs to teach mathematics to SwVI?
- iii. What are your experiences using the ATs mentioned to teach mathematics to SwVI?

D. How AT is used to teach mathematics to SwVI in secondary schools.

- i. In which ways have you been using AT resources to teach mathematics to SwVI?
- ii. In what ways do your SwVI use AT resources when you are teaching mathematics to them?
- iii. In which areas of mathematics do you find difficulties using AT resources during teaching?
- iv. Based on your experience, what challenges do you face in an attempt to utilize ATs to teach mathematics to SwVI in this school?
- v. How have you been overcoming the challenges you have mentioned above?
- vi. What can be done to improve the use of AT to teach mathematics to SwVI in your school?

THANK YOU FOR YOUR COOPERATION.

Appendix II: Interview Guide for SwVI

I am Akol Agnes, a student at Kyambogo University, pursuing a Master of Special Needs Education. To complete my studies, I am supposed to carry out research. As a result, I am conducting a research study on; "Assistive Technology Use in Teaching Mathematics to Students with Visual Impairment (SwVI) in two selected secondary schools". To complete my research, I am conducting an interview. The interview will focus on ATs available for teaching Mathematics to SwVI, training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI and how ATs are used to teach Mathematics to SwVI in secondary schools. The findings were used for this study, and confidentiality was observed.

A. Background information of interviewees.

- (a) Class:
- (b) Gender:
- (c) Age:
- (d) Category of visual impairment, i.e., low vision or blind:

B. Available AT resources used to teach mathematics to SwVI in secondary schools.

- i. Mention the ATs that you have in your school.
- ii. From the ATs you have mentioned,
 - which ones are Low-tech?
 - which ones are High-Tech?
- iii. Out of the Low-Tech ATs you have mentioned, which ones do your teachers use to teach mathematics to SwVI?
- iv. Which of the high-tech ATs you mentioned do your teachers use to teach mathematics to SwVI?

C. Training undergone by teachers to enable them to use ATs to teach mathematics to SwVI

- i. What informal training do you think your teachers have in using ATs to teach mathematics to SwVI?
- ii. What formal training do you think your teachers have in using ATs to teach mathematics to SwVI?
- iii. What are your teachers' experiences using the ATs mentioned to teach mathematics to SwVI?

D. How ATs are used to teach mathematics to SwVI

- i. How do your teachers use AT to teach mathematics to SwVI in this school?
- ii. How do you usually use ATs to learn mathematics in this school?
- iii. In which areas of mathematics do your teachers find difficulties using AT resources during teaching?
- iv. What difficulties do you face when teachers use AT to teach mathematics?
- v. How have you been overcoming the difficulties you have mentioned above?
- vi. What can be done to improve the use of AT to teach mathematics to SwVI in your school?

THANK YOU FOR YOUR COOPERATION

Appendix III: Observation Guides

Observation Guide, School A

Aspect to observe	Resources expected	Resources available	Comment
Assistive technology resources available	AT resource room	Available	-Doubles as lab, -Averagely equipped
	High-Tech AT resources		
	Braille embossers	1	Working
	Closed Circuit Television (CCTV)	4	Working but few
	Scanners	1	Working but few
	Optical Character Recognition (OCR) software	1	Working but more needed
	Computers with screen magnifiers	29	Working
	Projectors	0	Needed
	Screen readers	29	Working
	Computers with Job Access with Speech (JAWS),	29	Working

	Duxbury Braille Translator (DBT)	2	Working
	Scientific talking calculator	1	Not enough
Low-Tech AT resources			
	Perkins brailers	80	54 working
	Slates and styluses	20	Working
	Braille rulers	5	Working
	Abacus	10	Working
	Talking calculators	8	5 working
	Talking money identifier	None	None
	Braille protractors	5	Working
	Braille compasses	5	Working
	Tactile graphics	Available	Few
	Talking clocks	None	Not available
	Taylor frame	3	Few
	Adaptive measurement tools	None	None

	Adapted math papers, i.e. enlarged worksheets, graph papers,	None	None
	Audio recorders	Available	Very few
	Telescopes	None	None
	Braille mathematics textbooks	None	Needed
	Tactile geometric kit	Available	Few

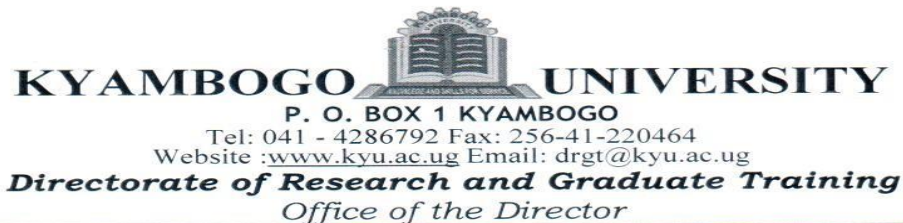
Observation Guide, School B

Aspect to observe	Resources expected	Resources available	Comment
Assistive technology resources available	AT resource room	Available	Only one
	High-Tech AT resources		
	Braille embossers	1	Need more
	Closed Circuit Television (CCTV)	5	Few
	Scanners	1	For official use
	Optical Character Recognition (OCR) software	1	More needed
	Computers with screen magnifiers	3	Functioning but more needed
	Projectors	None	No projector
	Screen readers	1	Limited
	Computers with Job Access with Speech (JAWS),	5	Few
	Duxbury Braille Translator (DBT)	1	Few
Scientific talking calculators	1	Spoilt	

Low-Tech AT resources		
Perkins brailers	50	36 working
Slates and styluses	10	Enough
Braille rulers	10	Working
Abacus	2	Working
Talking calculators	23	Working
Talking money identifier	None	None
Braille protractors	10	Working
Braille compasses	10	Working
Tactile graphics	None	None
Talking clocks	None	None
Taylor frame	10	Working
Adaptive measurement tools	3	Tape measures but not enough
Adapted math papers, i.e. enlarged worksheets, graph papers,	None	None

	Audio recorders	5	Working but not enough
	Telescopes	None	Individuals have
	Braille mathematics textbooks	None	Needed
	Tactile geometric kit	10	Working

Appendix IV: Introductory Letter



APPENDIX 8

Date: 25/07/2023

TO WHOM IT MAY CONCERN

RE: AKOL AGNES

Dear Sir/Madam,

This is to introduce to you the above named student Reg: No **21/U/GMSN/13998/PE** Pursuing Masters in Special Needs Education, Department of Visual Impairment Studies, Kyambogo University. She intends to carry out research on **Assistive Technology: Its use in Teaching Mathematics to Students with Visual Impairment in Secondary Schools in Eastern Uganda** in partial fulfillment of the requirements of the award of Masters in Special Needs Education

The purpose of this letter therefore is to request you to grant her permission to carry out her study in your institution.

Any assistance rendered to her will be highly appreciated.

Yours sincerely,


Prof. Bosco Bua
AG. DIRECTOR



Appendix V: Consent Form for Interview

Dear Participant,

I am Akol Agnes, a student pursuing a Master of Special Needs Education at Kyambogo University. I am conducting a Research study on "Assistive Technology Use in Teaching Mathematics to Students with Visual Impairment in two selected schools in Eastern Uganda." It is hoped that the findings of the study will enable teachers to obtain information on accessible and inaccessible ATs and be motivated to utilise them to teach Mathematics to SwVI, administrators to recognise the necessity for using assistive technologies (ATs) in schools and, therefore, budget and lobby for them and policymakers to form contemporary AT policies and plans of action or modify prevailing ones better to meet the requirements of SwVI in secondary schools.

You have been identified as one who can inform the study through an interview. The interview will focus on ATs available for teaching Mathematics to SwVI, training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI, and how ATs are utilised to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda, and it is likely to last 25 minutes. Please participate in the study. Whatever information you provide will be used for the study and kept confidential.

Thank you very much for your support and co-operation

Yours faithfully,

Akol Agnes.

Confirmation of acceptance

I understand the purpose of the study, and as a result of this consent to participate.

Signature: Date:

Appendix VI: Consent Form for Audio Recording

Dear Participant,

I am Akol Agnes, a student pursuing a Master of Special Needs Education at Kyambogo University. I am conducting a Research study on "Assistive Technology Use in Teaching Mathematics to Students with Visual Impairment in two selected schools in Eastern Uganda." It is hoped that the findings of the study will enable teachers to obtain information on accessible and inaccessible ATs and be motivated to utilise them to teach Mathematics to SwVI, administrators to recognise the necessity for using assistive technologies (ATs) in schools and, therefore, budget and lobby for them and policymakers to form contemporary AT policies and plans of action or modify prevailing ones better to meet the requirements of SwVI in secondary schools.

You have been identified as one who can inform the study through an interview. The interview will focus on ATs available for teaching Mathematics to SwVI, training undergone by teachers to enable them to use ATs to teach Mathematics to SwVI, and how ATs are utilised to teach Mathematics to SwVI in two selected secondary schools in Eastern Uganda, and it is likely to last 25 minutes. Please participate in the study. Whatever information you provide will be used for the study and kept confidential.

Thank you very much for your support and co-operation.

Yours faithfully,

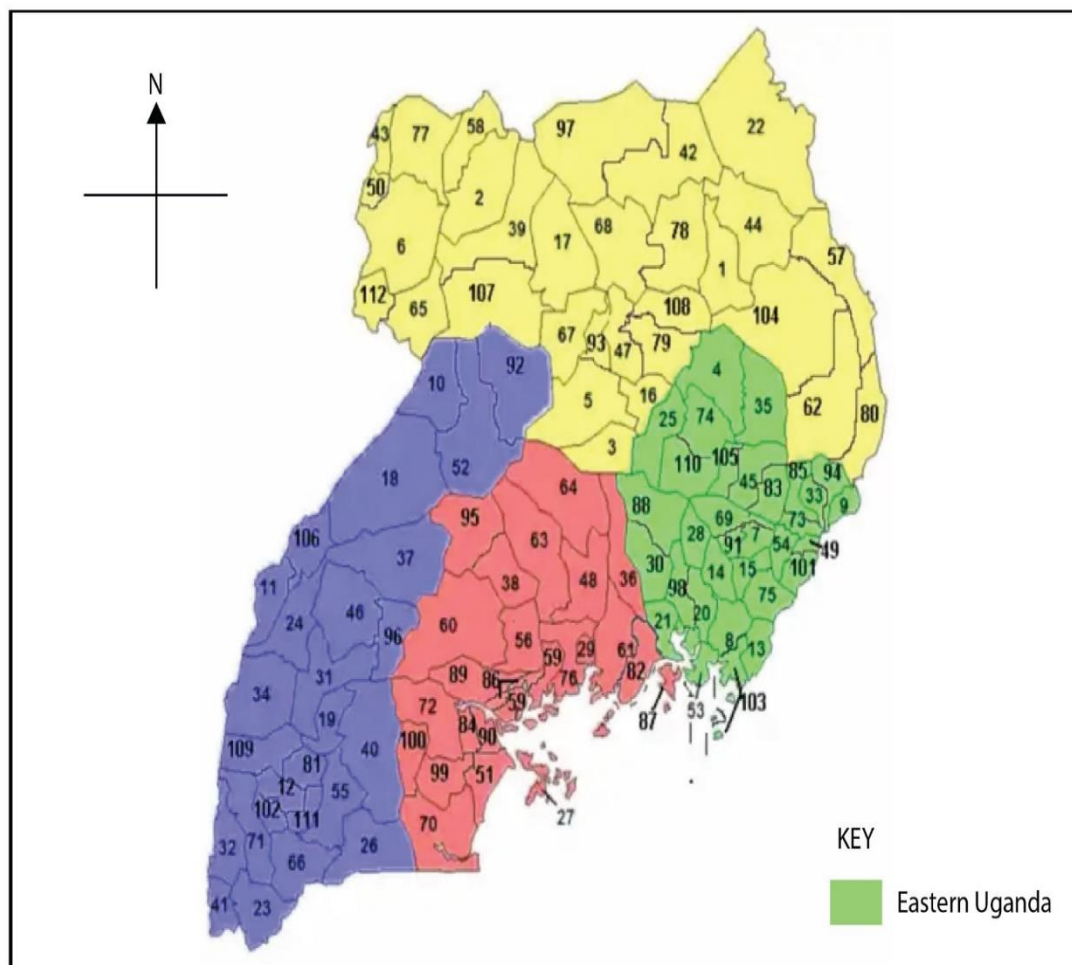
Akol Agnes.

Confirmation of acceptance

I understand the purpose of the study and, as a result of this consent to audio recording, whatever information is provided.

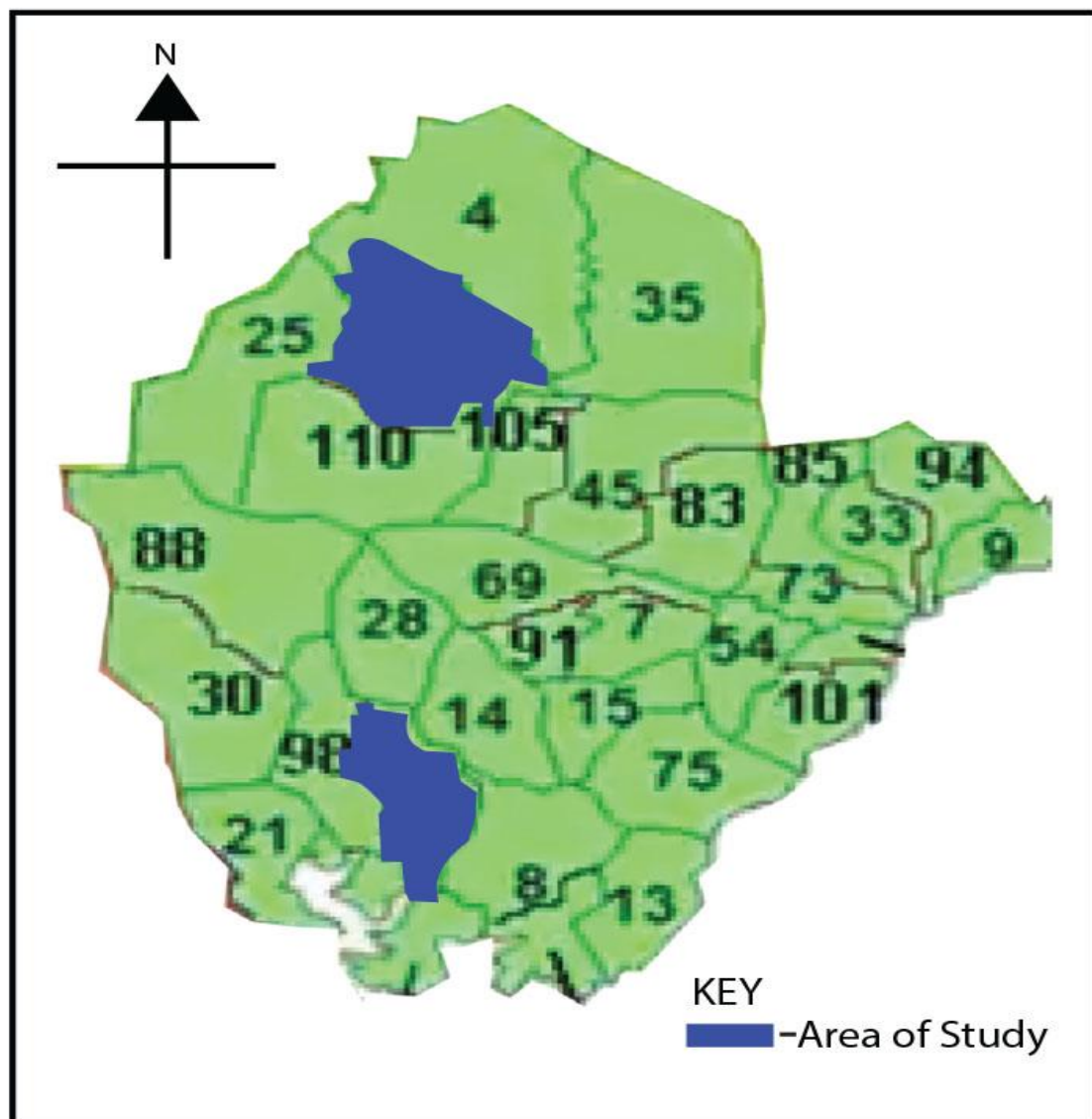
Signature: Date:

Appendix VII: Map of Uganda Showing Eastern Uganda.



Source: https://en.wikipedia.org/wiki/Districts_of_Uganda

Appendix VIII: Map of Eastern Uganda Showing Areas of the Study.



Source: https://en.wikipedia.org/wiki/Districts_of_Uganda



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ASSISTIVE TECHNOLOGY USE IN TEACHING MATHEMATICS TO
STUDENTS WITH VISUAL IMPAIRMENT IN TWO SELECTED
SECONDARY SCHOOLS IN EASTERN UGANDA

BY
AKOL AGNES
21/U/GMSN/13998/PE

A DISSERTATION SUBMITTED TO THE DIRECTORATE OF
RESEARCH AND GRADUATE TRAINING IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE
AWARD OF A MASTERS DEGREE IN
SPECIAL NEEDS EDUCATION OF
KYAMBOGO UNIVERSITY

JUNE, 2024

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