2021

Accessibility of mathematics examinations to students with hearing impairment: a case study of a school for the deaf in Nyeri County-Kenya

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ACCESSIBILITY OF MATHEMATICS EXAMINATIONS TO STUDENTS WITH HEARING IMPAIRMENT: A CASE STUDY OF A SCHOOL FOR THE DEAF IN NYERI COUNTY-KENYA

BY

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A research project submitted to the Institute for Educational Development, East Africa in partial fulfilment for the requirements for the degree of Master in Education

(**Assessment, Measurement and Evaluation**)

Dar es Salaam, Tanzania

NOVEMBER 2021

APPROVAL PAGE

THE AGA KHAN UNIVERSITY

Institute for Educational Development East Africa

Peter Mwangi Kabethi

I hereby give my permission for the research project of the above-named student, for whom I have been acting as supervisor, to proceed to examination.

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(Research Project Supervisor)

Date: 22nd May 2022

The members of the Research Project Evaluation Committee appointed to examine the research project of the above-named student find it satisfactory and recommended that it be accepted.

_________ _________

(Internal Examiner)

Date: ____8Th June 2022___

Dedication

I dedicate this work to my precious and beautiful wife Hellen Ruguru for her unwavering support, prayers, encouragement, and tireless struggle of raising our children whilst I was away.

To my two adorable sons who kept calling me asking how my studies were going.

To my beloved parents Mr. & Mrs Kabethi for your prayers, encouragement, indefatigable effort of upbringing, and educating me.

With the greatest appreciation to the Almighty God.

Abstract

The objective of this study was to establish the extent to which mathematics examinations are accessible to students with HI. The study adopted a qualitative approach via a case study design. The participants included the principal, Head of the mathematics department, teachers, and students from Clifftop school for the deaf. Purposive sampling was used to select the 5 students with HI and 3 mathematics teachers.

Data was collected through focus group discussion (FGD) with students and teachers separately and classroom observation. In addition, the principal and the head of the mathematics department were interviewed to ascertain the general accessibility of mathematics examinations to students with HI and identify strategies that can be employed to enhance the accessibility of mathematics examinations to students with HI. Furthermore, documents such as students' mathematics examinations answer sheets, standard examination test papers, and KCSE results were analysed for corroboration of data collected from interviews and FGD.

Although the students stated that they could access some mathematics concepts, the findings showed that mathematics examinations are highly inaccessible to students with HI. At the end of the study, the teachers and students indicated that mathematics needs to be adapted to increase access to mathematics examinations. The study suggests that providing necessary accommodations in testing should be done with caution to avoid affecting the validity of the test scores.

Acknowledgement

First, I extend my sincere gratitude to the Almighty God whom without I could not be able to execute this research project.

Secondly, to my supervisor, Dr Mweru Mwingi, I heartily appreciate your relentless effort, mentorship, and excellent guidance with a lot of expertise throughout the entire process. Your faith in me, despite being a student with special educational needs and faith in my research area gave me the strength to work. Moreover, I am grateful to my academic supervisor, Mr Joachim Tamba, who gave me invaluable advice and ensured my needs were met by providing me with an interpreter and other technological support I needed as a student with hearing impairment.

I further extend my appreciation to Aga Khan University for providing me with a partial scholarship to pursue my studies and the entire faculty and staff for equipping me with knowledge and skills to improve our pedagogical practice.

To my employer the Teachers Service Commission, I extend my sincere gratitude for granting me study leave with pay that ensured that I was able to meet most of my financial needs while still studying.

Not forgetting my interpreter, Samson Rotich, whose support throughout the entire course was selfless and endless, pushing me until the end of this study.

I also wish to extend my sincere appreciation to the principal, teachers, and students with HI for taking part in this research. My life has been transformed through you.

Lastly, special appreciation to my fellow course participants who walked with me throughout this journey and ensured I did not fall behind.

Thank you and God bless you.

Declaration of originality

I, Peter Mwangi Kabethi, hereby declare "*Accessibility of Mathematics examinations to Students with HI: A Case Study of a School for the Deaf in Nyeri County-Kenya*" to be my work. It represents my original ideas, efforts and has not been taken whole or in part from any source without acknowledging the author or where the information was retrieved from.

Signature ____________ Date: ***30th November 2021***

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List of Abbreviation

AKU	Aga Khan University
FGD	Focus Group Discussion
HI	Hearing Impaired
KCSE	Kenya Certificate of Secondary Education
KNEC	Kenya National Examination Council
KSL	Kenyan Sign Language

CHAPTER ONE

1.0 Introduction

This study examined the extent to which a mathematics examination should be modified to make it accessible to students with hearing impairment (HI) in one of the schools for the deaf in Nyeri county, Kenya. The objective was to establish whether mathematics examinations are accessible to students with HI. The study assumed that mathematics examinations are modified and are therefore accessible to students with HI.

This chapter presents the research background, the statement of the problem, the purpose and rationale of the study. Further, it presents the significance of the study, the research questions, the definition of key terms and lastly outlines the layout of the study.

1.1 Background to the study

Mathematics is extremely vital in this world; everyone requires it since it allows us to think rationally. According to Leighton (2017), mathematics is used practically everywhere in our daily lives since it fosters certain abilities such as reasoning, creativity, problem-solving and even communication skills. Furthermore, mathematics is used in all facets of life, including everyday tasks such as timekeeping, driving, cooking, and professions like accounting, finance, banking, engineering, and software development. Mathematics is linked to other sciences such as physics, chemistry, biology, and geography.

In addition, mathematics is used in a variety of industries, including engineering, medicine, statistics, space research, and technology, to name a few hence offering the door to more advanced courses in science and other related fields (Gegbe et al., 2015). As a result, mathematics is a compulsory subject in many nations, including Kenya. Hence low competence in mathematics can result in penalties such as disqualification from mathematics courses, for learners, including those with hearing impairment.

To measure a student’s performance in mathematics, an assessment is conducted. Assessment results have constantly been used as a basis for determining students’ ability whose result has a very considerable impact on students' educational progression. Assessment has various definitions for instance, assessment is a process that encompasses gathering information about a student for the intent of making decisions Bennett (2011). Alternatively, Conderman and Hedin (2012) describe assessment as a process involving the collection of information on the strengths of a student and needs in all areas of concern. From these definitions of assessment, it can be concluded that assessing students including those with hearing impairments can affect their future life and extreme attention should therefore be given to assessment.

Nevertheless, all students can participate in an assessment, but students may not participate meaningfully and validly if the assessment design limits them to demonstrate knowledge and skills according to the national standards in the evaluation design. Admittedly, ensuring access to students with diverse needs and abilities has been a major concern in the quest for developing inclusive assessment tests (Beddow et al., 2013). In this regard, Thurlow et al. (2011) affirm that accessible assessments allow participation and ensure valid performance interpretations for all the test-takers in the assessment. Further, accessible tests help to measure the performance of students with diverse abilities allowing opportunities to manifest competence on the same content.

In Kenya, the government has made efforts to ensure that assessments in national examinations are accessible to students with HI through the adaption of English and chemistry practical examinations and introduction of Kenyan Sign Language (KSL) as an examinable subject to replace Kiswahili that proved challenging to students with HI. However, the same is yet to be replicated in mathematics despite being a compulsory subject whose performance has been dismal for the last three years. Yet, mathematics pervades every aspect of our lives and hence it is extremely very vital and offers door to courses in sciences and other related fields (Gegbe et al., 2015). This has considerably affected the performance of students with HI in mathematics.

The poor performance in mathematics examinations by students with HI has been attributed to a lack of accessibility. This has been depicted by the comparison of performance in Mathematics to English and Kenya Sign Language by students with HI for the last three consecutive years in the Kenya Certificate of Secondary Education (KCSE), wherein 2018, 2019, and 2020 examinations, secondary schools for the deaf recorded national mean of 1.24, 1.45, and 1.5 respectively in mathematics. While the English examination results were 3.10, 3.14 and 3.67 for 2018, 2019 and 2020 respectively and 9.33, 7.63 and 8.95 for Kenya Sign Language in the same years. This points out accessibility as a bridge to improved performance in English and KSL and lack of it as an impediment to better performance in mathematics by students with HI.

Against this backdrop, I conducted a study that would gather information on the extent to which mathematics examinations are accessible and why they should be modified to make them accessible to students with HI without affecting the validity and reliability of the tests.

1.2 Statement of the problem

National evaluations which include the assessment of learning using tests are often used for countrywide accountability and for promoting students to the next level of education. Therefore, the test instruments in testing a specific population must be valid and reliable for all test takers. However, according to Kavanaugh (2017), repeatedly these tests have failed in accessibility, which in no doubt impact the validity for students with special needs. Tests intended for the special population should therefore be made accessible, a concern addressed by Salend (2012) who argues that adaptations to examinations are designed to make students with special needs access and make progress in assessment. Therefore, tests modification helps students with HI to be able to access the examination.

In Kenya, the KCSE mathematics examination is not modified making it inaccessible to students with HI thus denying them an opportunity to compete equally with their hearing peers. Consequently, it limits their chances of transitioning to the next level of education and diminishes their career choices. This calls for adaptations in mathematics examinations to increase accessibility and provide a level playground to students with HI.

With the paucity of literature and no empirical research studies on adaptations of mathematics examinations in the Kenyan context, this study, therefore, sought to find out the extent to which mathematics examinations are accessible to students with HI and strategies used in tests modifications to ease access for students with HI.

1.3 Rationale

From my experience as a teacher of students with HI the poor performance in KCSE mathematics by students with HI has greatly affected their educational progression especially to tertiary institutions. For instance, despite scoring the minimum aggregate grade (C-) required to join teachers training colleges many students with HI scores below the requisite C- grade in mathematics which has caused them to be disqualified from admission.

This phenomenon is playing to the disadvantage of students with HI and has motivated me to investigate whether mathematics examinations are accessible to students with HI.

1.4 Significance of the study

The study highlights the difficulties students with HI experience while trying to access mathematics examinations. The study is significant because it will first, provide new teachers and test developers with information regarding modification of mathematics examinations to make them accessible to students with HI. Secondly, the study will also inform the KNEC on the need for modifying mathematics examinations and finally, the study will help the Kenya Institute of Curriculum Development to design and make more references to content adaptations to suit the assessment needs of students with HI. Furthermore, the findings of this study might inform the ministry to conduct more intensive training on accessibility in the assessment of students with HI.

1.5 Research questions

This research intends to answer the following questions

1.5.1 Main Question

To what extent is mathematics examination accessible to students with HI?

1.5.2 Subsidiary questions

1. How do students with hearing impairment access mathematics examinations?
2. Which aspects of mathematics examination are accessible to students with hearing impairment?
3. How do teachers ensure accessibility to mathematics examinations to students with hearing impairment?

1.6 Definition of the key items

Accessibility: the degree to which a test and its constituent item set permit the test taker to demonstrate his or her knowledge of the target construct.

Accommodation: this is a reasonable adjustment of the typical assessment techniques or practices to enable the students with special needs to learn the same material with the 'normal' peers but in a more accessible format.

Examination: In education, an examination is a test to show the knowledge and ability of a student.

Test- A bunch of questions, exercises or practical work to determine someone's skill, ability or knowledge. Both test and examination can be used interchangeably.

Modification: Changes in testing techniques or formats that give students with disabilities an equal chance to engage in test situations and demonstrate their knowledge and abilities.

1.7 Organization of the dissertation.

The content of each chapter is briefly summarized in this section. This report is divided into five sections.

The first chapter provides context for the research and identifies the research problem. It also identifies the study rationale and significance, as well as the research questions and operational definitions of important terminology utilized in the study.

The second chapter contains a review of the literature on evaluation, accessibility, and mathematics learning, as well as the learning experiences of students with HI.

The research approach used in this study is highlighted in Chapter 3. The study design, sampling, data collection processes, constraints, rigour, and trustworthiness are all included.

The fourth chapter summarizes the research findings and is organized by research questions.

The fifth chapter discusses the findings, draws conclusions, identifies lessons learned, and makes recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews literature around the concept of assessment, accessibility in assessment and individuals with hearing impairment and its effect on mathematics performance to provide basic knowledge and context on which the accessibility of mathematics examinations is evaluated against the research questions.

2.1 The concept of assessment

Assessment is a broad term and is defined differently by scholars. According to Dann (2014), assessment is the process of gathering student's data to get insight and a wide understanding of the student's knowledge level, how they can utilize the knowledge they possess and their perception about learning to enrich the teaching and learning process. Meanwhile, Gao et al. (2021) define assessment as the process of collecting data and using this data to decide on the student's curriculum, school programs and educational policies.

Currently, the role of assessment in educational settings has undergone significant changes, from assessment singly used to rank students based on their academic abilities to assessment intended to improve learning. This has been explicated by Fisher and Frey (2014), who assert that assessment currently has taken different forms and purposes which has increased dramatically. From this definition, we can conclude that assessment plays a significant role in student's academic and life including for students with HI.

In this study, it is important to understand that assessment falls under two distinct categories: summative and formative assessment. Summative assessment is the provision of evidence of a student's achievement to form a judgment about the student's competency or program effectiveness. Further summative assessment is used to document what students comprehend, know, and are capable of doing (Chappuis et al., 2012). Formative assessment, on the other hand, is a sort of assessment that occurs during the teaching and learning process and allows for the giving of relevant feedback while learning is formed, concepts and knowledge bases are continuously developed (Fisher & Frey, 2014). Formative evaluation for students with special needs essentially provides feedback to students directly so that they can monitor and control their learning (Flórez & Sammons, 2013). In this study, the focus is biased towards standardized summative mathematics assessment tests and students with HI. This is because summative assessments are set following guidelines recommended for standard tests, unlike formative tests which hardly meet the standard guidelines for testing further it has been argued that the problem of using such formative assessment for evaluation is that the teacher-made tests themselves are often severely flawed (Kinyua & Okunya, 2014).

Assessing students' knowledge in the mathematics classroom serves several functions, including testing students' understanding and use of the subject, collecting instructional feedback, grading, and monitoring improvement in mathematical achievement. Given these various aims, teachers must make several considerations regarding the form, timing, rigorousness, and usability of assessment (Suurtamm et al., 2016).

Additionally, assessment is a vital tool for analysing the knowledge that students are building, the meaning that they are attributing to mathematical ideas, and their progress toward acquiring mathematical power. Although using well-designed standardized tests with solid evidence of reliability and validity can improve assessment decision making, it does not result in optimal measurement for all students. Some students may be unable to demonstrate target knowledge and skills due to the way a test is conducted under standardized conditions. From the foregoing, it is only imperative that assessments are made accessible to all the test takers including those with HI which is the subject matter of this study.

2.2 Assessment accessibility

Prior to the introduction of accessibility in assessment, students with special needs were instructed and assessed just like other students which had a negative effect on their overall performance (Thurlow et al., 2012). To eliminate unfairness in testing, the concept of access to assessment was introduced. There is some ambiguity about the definition of access in assessment; the concept of offering access through a test or other type of assessment is complicated (Thurlow & Kopriva, 2015). The view above triggers the import of succinctly conceptualizing the term accessibility concerning this study. Thus, in an educational context, accessibility is defined as the extent to which a test and its constituent item are set to permit the test taker to demonstrate his or her knowledge of the target construct (Beddow et al., 2011). In summary, testing necessitates a combination of abilities, some of which represent the construct of interest and others which indicate auxiliary processes involved in material interaction. Multiple-choice mathematics assessments, for example, need reading abilities in order to obtain the material and answer the problems. As a result, the construct being examined (mathematics) becomes entangled with non-measureable access abilities (reading), potentially leading in construct-irrelevant variation in student scores. Students with access skills impairments may be unable to demonstrate their knowledge and talents in the topic being examined.

One solution is to create suitable tests at the onet is by removing barriers such as reading skills in assessments and providing users with tailored exams depending on their specific needs.

Test access and accessibility for all students including those with special needs can be applied in both standardized and non-standardized classroom assessments. Moreover, accessibility does not only benefit the special population but it has been found to benefit students without special needs (Beddow et al., 2013). However, accessibility affects the test performance of students with special needs to a greater extent than their hearing peers. This view has been echoed by Larson et al. (2020), who affirms that providing accessibility and accommodation for students with special needs is an important method for improving access to education or assessments.

Access in academic testing is a complicated topic, requiring various design, development, implementation, scoring, and analytic components to give students adequate access to item requirements and the capacity to educate people receiving the results about what the students know and consequently making an assessment or test accessible is an arduous task (Thurlow & Kopriva, 2015). In a similar viewpoint, Kettler (2012) and asserts that accessibility is not a constant characteristic of the test but the interaction of test features and characteristics that either allow or impede student responses to a particular measurement content. This complexity of considering accessibility in testing is compounded because each subject requires a unique form of accessibility provision. For instance, the accommodations placed on English cannot be employed in mathematics since the two subjects are distinct. In the current Kenyan context, the KCSE English examination has been adapted by simplifying vocabularies and eliminating elements of sound. Simplifying the vocabulary is applicable to mathematics, however, elimination of elements of sound cannot be executed since mathematics does not test sound concepts. This scenario depicts the complexity of accessibility.

Most of the available literature on the accessibility of assessment focuses on linguistic minorities otherwise known as second language learners or non-native speakers while very few focus on general accessibility of assessments to students with HI. Accessibility of mathematics examinations to students with HI is therefore understudied. The few available studies (Cawthon & Leppo, 2013; Qi & Mitchell, 2012; Reesman et al., 2014) focus on providing accommodations to students with HI in a general while (Bull et al., 2018; Kidd et al., 1993; Pagliaro & Kritzer, 2013) focus on mathematics difficulties encountered by students with HI. There is hardly any extant literature focusing on improving accessibility in mathematics examinations for students with HI per se. With the paucity of literature on the accessibility of mathematics examinations to students with HI, this study will be a prelude to future research.

2.2.1 Principles that underpin accessible assessments

2.2.2 Universal Design of Assessment (UDA)

The concepts of universal design can be applied to assessment to improve accessibility and promote appropriate testing for all students. When a test is originally established, it is important to consider the needs of all individuals who may need to take part in it. Universal design concepts and ideas can be used by test developers to make assessments as accessible as possible without compromising educational goals. Examining the characteristics of the exam itself – whether it is a paper-and-pencil or a technology-based test – is an additional technique for increasing assessment accessibility. To guide the design of large-scale assessments, Thomas and Collier (2002) developed Elements of Universally Designed Assessments, which include: (a) an inclusive assessment population, (b) precisely defined constructs, (c) accessible, non-biased items, (d) items that can be accommodated, (e) simple, clear, and intuitive instructions, (f) comprehensible language, and (g) maximum legibility.

These characteristics have been applied to classroom evaluations and assignments in education, according to Acrey et al. (2005), as referenced in Smith et al. (2014), and can easily be incorporated in the promotion of accessible secondary school mathematics tests in Kenya. Accurately describing the construct to be investigated, for example, is one of the most important tasks in the construction of any assessment. A construct might be used to assess a specific criterion, or it can reflect a wide variety of abilities. In either case, explicitly describing the construct to be tested is crucial to reducing construct-irrelevant behaviours (Haladyna & Downing, 2004) cited in (Haladyna & Rodriguez, 2013).

For example, a mathematics assessment examination may place a high value on reading ability rather than mathematical comprehension. This means that when a student is given a verbally dense mathematical item, due to the interaction between his or her reading skills and the item's language, he or she is unable to respond effectively. The combination of personality factors and item qualities impedes accurate measurement of the student's mathematical knowledge and skills because reading fluency and understanding are not part of the intended mathematics construct. To put it another way, accessible assessment practice suggests that designers discriminate between the domains they want to test and any non-construct domains that could act as a barrier to students (Cohen et al., 2017; Liu et al., 2008).

Another step in creating tests that adhere to Universal Design principles is to reduce test bias. Systematic errors in performance are caused by test bias, which is dependent on student characteristics. Emphasizing verbal responses, for example, when a student with hearing impairment is among the test takers, contributes to prejudice based on individual characteristics and should be avoided at all costs. Teachers and test developers can improve the validity and accessibility of their measures' interpretations by evaluating and eliminating any bias that may exist.

Thurlow et al. (2011) also discuss how assessments can be adjusted to allow for modifications if they are needed. Although it is widely acknowledged that universal design will never eliminate the need for accommodations, one of the most important aspects of the universal design process is ensuring that students who use accommodations receive tests that are comparable to those who take tests under standard conditions. As a result, changes in the venue, timing, presentation, response style, or equipment should have no bearing on the intended constructs. Teachers may wish to seek guidelines on designing and implementing accommodations that make the test no more or less difficult than the original format to ensure the test's integrity. Accommodations are intended to level the playing field for students with disabilities by changing the test's accessibility, not by changing the test's difficulty.

Another universal design process guideline is to include clear, transparent, and intuitive instructions and administrative procedures. As a result, an accessible evaluation meets high content standards while remaining simple to use. Assessments that give students clear directions and follow straightforward procedures are more likely to help teachers figure out what students know and do not know.

Further, if the language used in items and activities is understandable, an assessment may become more accessible. Rakow and Gee (1987) cited by (Kopriva, 2011) describe “comprehensible language” within the context of learning activities and assessments. Comprehensible language does not automatically imply simplified language, as an assessment's intended objective may be to deconstruct original (and perhaps difficult) content.

Lastly, Collins-Thompson (2014) emphasize the importance of designing tests that are as legible as possible based on these principles. Certain formatting specifications, according to vision and reading researchers, improve comprehension for most readers. In terms of font size, people with excellent vision can read 10- to 12-point print with little difficulty. Students with low vision require an 18-point print (Smallfield et al., 2013). In addition to the size of the print, more space between letters and lines also may increase accessibility (Grainger et al., 2016). Text that is justified to the left but has ragged right edges keeps the same amount of space between characters and reduces hyphenation, improving legibility. Although this is intended to improve access for students with low vision, it also assists children who have a combination of hearing loss and low vision.

Assessments created using universal design approaches, in theory, are more accessible to both students with disabilities and students without disabilities. The theory of UDA allows the application of its principle to provide accommodations in assessment tests for students with HI. The principles allow students with HI to present their responses in sign language for example during oral examinations, provision of extended time as it is common during the administration of KCSE English papers 2 and 3 where students with HI are allocated 30 minutes above standard examination timing and the simplification of vocabularies in English comprehension examination and elimination of any elements that require perceiving sound in all assessment tests.

The universal design principles are important in this study because they guide us on what it takes to design accessible mathematics examinations that can benefit learners with hearing impairments. However, making tests accessible must go through several trials until it is certified to be working appropriately without altering the validity and reliability of tests.

2.3 Strategies for promoting accessibility

In many countries, Kenya included national examinations are used to make decisions on students' promotion to the next level and placement to tertiary education, there is, therefore, a greater need to ensure that tests are accessible to students with disabilities to maintain equitable and fair assessment for all students including those with hearing impairment.

Researchers such as (Beddow et al., 2013; Kettler, 2012; Phillips et al., 2012) have put forth several strategies for making tests accessible to a special population which include testing accommodation and modifications/adaptations. The literature surrounding accommodation in assessment is immense and passionate. The term 'accommodation' is used interchangeably with the term 'modification (Darrow, 2008; Thurlow et al., 2011). This shows there is some contestation between the two terms. This implies that the definition depends on individual scholars. In this study, the two terms will be treated independently for clarity purposes. To understand the appropriate selection of accommodations for this population, we need to understand the implication of being hearing impaired (HI) and how it affects performance in mathematics and education in general.

2.3. The learning experiences of students with HI

According to Lipkin and Okamoto (2015) hearing impairment is a condition that limits a child to process linguistic information through hearing even when using amplification. In Kenya, according to the Kenya National Bureau of Statistics (2009 census report) out of a total population of 38.7 million people, 600,000 are hearing impaired. Of these, an estimated 30.7% are students at all levels of education from primary to tertiary level.

Hearing loss is determined by a person's perception of sound and is measured in Decibels (dB) and according to the American Speech-Language- Hearing-Association (ASHA, 2020), hearing loss ranges from slight hearing loss (16dB) to profound hearing loss (above 91dB). The severity of hearing impairment is measured by the amount of sound that can be heard using one's better ear.

Reviews by Richburg and Hill (2014) and Moeller and Tomblin (2015) found that even minimal hearing loss, which is as small as 15 dB (decibels), can significantly affect academic achievement. Although studies have shown that students with HI possess the same capability of normal intelligence and some possess even greater capacity and are considered intellectually gifted (Powers, 2011). Hearing loss greatly affects language development and consequently affects their academic performance.

Despite encouraging advancements in the education of students with HI, their achievement continues to lag that of their hearing classmates, and many do not attain the knowledge and skills required to realize their full potential (Qi & Mitchell, 2012). There are various explanations for this disturbing and long-standing underachievement. Many students with HI arrive at school without fluency in either a signed or spoken language and service providers frequently struggle to adequately structure language environments and provide access and opportunities for students with HI to learn (Marschark & Knoors, 2012; Marschark et al., 2013; Singleton et al., 2015; Watson et al., 2013). There is also a shortage of competent teachers of the hearing impaired, as well as research-based teaching approaches and instructional resources for hearing impaired students (Kelly et al., 2003; Marschark et al., 2011; Pagliaro & Ansell, 2012).

In Kenya, special residential, integrated schools, and special units connected to conventional schools provide education for students with HI (Kimani, 2012). Special residential education is offered to students with HI from preschool to class eight and form one to form four in primary and at the secondary level respectively. In an integrated school, students with HI study the same subjects as hearing students, but in different classes, though they are exposed to the same curriculum and participate in the same activities (Adoyo & Maina, 2019). Furthermore, special units are classrooms where students with HI learn alongside hearing students in the same classes with the assistance of a specialist or curriculum modifications that lower the learning expectations to their level (Adoyo & Odeny, 2015). The fundamental problem in educating students with HI, regardless of the school environment, is satisfying their communication needs.

High school education for students with HI is intended to provide them with the necessary academic skills to prepare them for higher education. However, these students who are receiving academic skills face a significant language challenge. Students with HI communicate using sign language, which is quite different from verbal language. Furthermore, they have difficulty expressing themselves and/or perceiving and comprehending some critical educational concepts. This is because the hearing loss has a significant impact on the language and speech development of students with HI, as well as their academic achievement, social and emotional interaction, and cognitive milestones (Moores, 2010).

As a result, the curriculum that is availed to them is either adopted or adapted. The accepted curriculum preserves the entirety of the standard curriculum rather than altering it. While on the other hand adapted curriculum refers to a curriculum that has been modified and improved to meet the needs of students with HI. In secondary schools in Kenya, the only subject which has an adapted curriculum in KSL, which has been put in place to replace Kiswahili that has been evidenced to be too abstract to be learnt by students with HI due to confusion revolving which signing system to use (Obidike & Enemuo, 2013). The rest of the subjects such as mathematics, geography, physics, agriculture, business studies, chemistry, biology just to mention a few uses adopted curriculum which is meant for regular learners and is rigid and overloaded. In addition, the content of the regular curriculum does not provide for individualized instruction to cater for the varied needs of students with HI. For instance, despite the curriculum being written in English language students with HI are instructed in KSL which is the official language of instruction in schools for the hearing impaired. Consequently, because of the complexities of the language of teaching against the language of the curriculum, teachers struggle to present curriculum content in the allotted time without putting enough attention on the learners' grasp of the content, reducing the quality of the classroom content.

However, in a bid to enhance understanding the teachers employ skills such as the philosophy of total communication which entails speech reading, cued speech reading, writing, sign language and gestures among others, these strategies have however not helped in academic performance of students with HI as the assessment is thought to be inaccessible. The national examinations are designed for the general hearing population and not appropriate for students with HI. Moreover, very little is done to help them prepare adequately for the examinations and understand what is required of them. Research has revealed hearing impaired and hearing pupils have cognitive distinctions that necessitate the use of various pedagogical strategies, instructional materials, and assessment accommodations (Leppo et al., 2014; Qi & Mitchell, 2012). These revelations are particularly important to this study as they point out extant problems in teaching, learning and assessment which calls for modifications not only in instructional strategies but also assessment methods for students with HI.

2.3.1 The learning of mathematics for students with HI.

Mathematics is an extremely vital subject since it is used in almost all facets of life. In Kenya mathematics is a compulsory subject in schools and a prerequisite requirement for pursuing science-related courses in colleges and universities. This means that if a student does not pass in mathematics his or her chances of pursuing science or mathematics-related course are diminished or obscured. This scenario is common with the students with HI whose performance in mathematics have been repeatedly found to be below average. Mathematical knowledge and ability are important in the successes of our social life Ritchie and Bates (2013), but most students with HI struggle to learn arithmetical skills even if they have the roughly same level of non-verbal intelligence as hearing peers (Braden et al., 1994; Nunes & Moreno, 2002; Powers, 2011).

According to research, difficulty understanding mathematics in deaf children begins before they reach school age (Pagliaro & Kritzer, 2013). Regardless of how mathematics ability is measured, students with HI continue to perform at a level that is significantly lower than that of their hearing peers. Researchers have noted low levels of achievement have been noted in tasks involving reasoning, logical thinking, test scores and problem-solving (Allen, 1995; Ansell & Pagliaro, 2006; Ray, 2015; Traxler, 2000; Wood et al., 1986). Furthermore, individuals with hearing impairment have been found to perform worse than hearing individuals on several tasks related to the verbal system, for example, arithmetic word problems that require reading (Hyde et al., 2003), fractions (Bull et al., 2018) and multiplication (Noorian et al., 2013).

Further studies have been conducted to find out the achievement of students with HI in mathematics. For instance, (Hallahan & Kauffman, 1994) as cited in (Noorian et al. (2013) concluded that students with HI have significant performance differences in mathematics compared to their hearing peers. Similarly, (Shaira, 2007) found out that the level of mathematical literacy in students with HI is not more than sixth grade. These findings are extremely important to this study since they acknowledge that students with HI indeed experience challenges in mathematics both during learning and assessment.

Several factors have been attributed to the low achievement of students with HI in mathematics. For instance, Oommen and Mathai (2021) point out insufficient vocabulary as one factor. They observe that insufficient vocabularies result in difficulties learning mathematics concepts by students with HI. In addition, they affirm that communication in students with HI is difficult therefore if a child is unable to communicate with peers the child cannot develop logic and consequently will have challenges solving mathematical problems. Simply put language affects the performance of students with HI in mathematics due to the reduced language abilities Li et al. (2013). Huber et al. (2014); (Vitova et al., 2014) concurs by pointing out that students who are hearing impaired are disadvantaged in the interdependent language process such as problem-solving, concepts in number, operations, measurements.

In addition to that, several differences in the way students with HI responded to test items were discovered in a study that sought to investigate the reasons for the underachievement demonstrated by 14-year-olds in the United Kingdom. These differences were classified into four major categories: language issues, as manifested in a limited understanding of mathematical vocabulary and/or difficulties with linguistic structure; work habits, as evidenced by limited use of mental calculation; responses in written English that were incomplete or lacked the element of justification; and a general lack of knowledge of content for test items that focused on concepts deemed 'difficult to teach' (Swanwick et al., 2005). These findings are important to this study as they will help in the analysis of the challenges that the students with HI are encountering and subsequently help in identifying the most appropriate accommodation strategy.

Furthermore, Gregory (1998) as cited in Knoors and Marschark (2014), revealed that lack of mathematical language can explain the cause of deaf children's difficulties in two ways: first mathematics has its vocabulary, for example, Chord, denominator, fraction, isosceles vocabulary that must be learned. The second reason is that, unlike a normal conversation, some vocabularies like different, similarity and distinction have multiple meanings in mathematics. He also claimed that children with hearing impairment lose their ability to communicate about mathematics from birth and as result, they lack informal knowledge and experience in the subject.

Ngota (2012) similarly states that the language of instruction is the language in which the learner is examined. On the contrary, this is not the practice for students with HI who are instructed in KSL and must sit the KCSE in English. In line with this notion, Kimani (2012) claims that utilizing just the English language in the design of test items causes students with HI to perform poorly in mathematics as they struggle with the level of language and vocabulary employed. These perspectives are particularly significant to this study as they helped in analysing the factors that impede access to mathematics examinations for students with HI and consequently help us in suggesting the optimal accommodations or modifications.

2.3.1 Accommodations

According to different scholars, the term accommodation has a plethora of definitions. For instance, Hallahan et al. (2020) define accommodations as changes in materials and procedures that provide students with access to instruction and assessments while enhancing the authenticity of assessment results for students. Thurlow et al. (2011), on the other hand, describe accommodation as adjustments in test materials or methods that do not affect the target construct. Meanwhile, according to Frey and Gillispie (2018), accommodation in assessment encompasses accommodations that permit the special populations to participate in tests by compensating for the challenges brought about by their disability. From the above definitions and for the purpose of this research we shall use the term accommodation as removing access barriers that may prohibit a learner with special needs from demonstrating his or her ability in a test. Extant literature outlines numerous ways in which accommodation can be provided to students with HI. For instance, Christensen et al. (2011) outline the four types of accommodations which includes a) presentation format, which allows test takers to access information in a manner that meets their needs. For example, repeat instructions, read aloud and signing written assessment tasks to test takers who are hearing impaired; b) response formats which allow test takers the opportunity to complete tasks in different ways such as marking answers in answer books, pointing to answers, or signing to test administrators; c) setting; which can include special room, special writing or special lighting and d) timing or scheduling provisions such as extended time, frequent breaks, multiple days given to complete a test. Additional accommodations tailored to the language characteristics of students with HI include (a) having an interpreter translate test directions, reading passages, or test items into sign language, a signed system, or a read-aloud approach; and (b) allowing students to respond in sign language and having their responses recorded by a scribe who back-translates their responses into English. These scholars' insights into the various methods of accommodating students with special needs, particularly those with hearing impairment, are critical to this study because they direct us to the types of accommodations, we are likely to encounter when examining the extent of mathematics test accessibility to students with HI. However, it is worth noting that accommodations are neither the same nor do they have similar aspects and the teachers and experts in the field should consider the most appropriate form of accommodation to utilize based on an individual student's needs. This is reinforced by Cawthon et al. (2013), who cautions that communication tactics must be well-designed and implemented to avoid changing the basic features of item adaptations across groups. This perspective is particularly relevant in this study because it aided in determining whether the accommodations provided to students with HI in mathematics are within the recommended level and do not alter the standard test's intended design.

2.3.2 Modifications

Changes in test materials or procedures that affect the content being measured are referred to as assessment modifications (Thurlow & Kopriva, 2015). From this definition, questions abound on the accuracy of the results to represent the test takers knowledge and skills since the assessments have been altered. Moreover, it has been assumed that modification undermines the comparability of the results between the students taking the modified test and those under standard conditions (Elliott et al., 2010). However, Beddow et al. (2013) contradicted this assumption by conducting research in which they applied the principles of universal design, cognitive load theory, and test item research to modify a grade 8 multiple-choice items formative assessment test and discovered that they could successfully modify many items without changing the grade-level construct being measured. Furthermore, the researchers also discovered that the changes did not affect the range of knowledge or the readability of the items.

Consequently, several modification strategies have been identified to improve item accessibility, which includes simplifying and decreasing the length of item stimuli and stems, eliminating unnecessary visuals, and reducing the spread of information required for responding to the items across pages, shortening and/or simplifying the text of item stimuli and stems to clarify the question or directive, eliminating unnecessary or implausible distractors, and attending to balance (*ibid*).

Most of these measures are recommended for mathematics examination items especially shortening of the stem, eliminating unnecessary visuals, or clarifying directives was significantly reported to improve the scores in mathematics for students with disabilities (Kettler, 2012)

However, decisions about which modifications facilitate more accurate measurement for a particular test and about which students should receive the associated adaptations can be exceedingly difficult. As a result, if evidence indicates that task materials are not being understood as intended by survey and test developers, modifications to question wording and answers can be made to guarantee that the correct interpretation is optimized (Leighton, 2017).

Furthermore, according to Frey and Gillispie (2018), test developers should be familiar with and competent in providing the access measures required to ensure fair and appropriate assessment of students with HI, as well as familiar with the intended construct to avoid altering the validity of the assessment task.

2.4 Factors that impede access to the assessment.

Research has pointed out several factors that can impede accessibility of assessment, for instance, it has been pointed out that depending on the assessment purpose, limited accessibility can jeopardize validity score interpretation in a variety of ways, such as a lack of proficiency in the target skill. The test taker will need to go through an extended or adapted learning process in such a case.

Secondly, according to Sireci et al. (2005) cited in (Ercikan & Lyons-Thomas, 2013), there is a plethora of evidence that lack of physical access capabilities is a cause of access problems. When a student possesses some handicap or disorder then processing task information or responding to the task becomes a challenge. For example, test takers with disabilities such as visual, auditory, motor disorder, attention deficit, autistic and dyslexia lack the necessary capabilities to access test items. As a result, the validity of inference is compromised for these test takers when they are unable to access the items and tasks assigned to them and with which they are required to interact. Modifications of test items is an example of ways of lowering barriers and increasing accessibility for students with HI by having a student respond to test items in sign language.

The third source of limited ability is lack of access skills that can be developed through education but are controversial whether they belong to the target skill or competency (Kettler, 2012). For example, assessment tests for mathematics may place a high emphasis on reading ability, resulting in access issues. This raises the question of whether it is the students' fault they lack the necessary skill or whether they lack access skills to reading comprehension skills. This view is particularly important in this study because it aids in determining whether the construct tested is related to the target skill or competence in mathematics and whether it affects access to test for students with HI. This can be rectified by explicitly defining the expected skill of the assessment goal in the target construct.

Lastly, flaws in task presentation limit accessibility to some or even to all the learners. Design flaws, according to Roelofs (2019), are inconsistencies, errors and omissions in the test or in response options that cause extra processing load for students, such as when more information is presented than is strictly necessary for the assessment task, the test taker cannot get a complete problem representation and when the task presents redundant information that causes an extra memory load. For example, the extra information presented in lengthy mathematics word problems increases extra memory load to test-takers with hearing impairment.

Limitations in access to test do not only affect validity but also affects the overall learners' performance in assessment. Learners with special needs are the most affected and as such they require assessment strategies that increase their capability to access tests.

2.5 Conceptual framework.

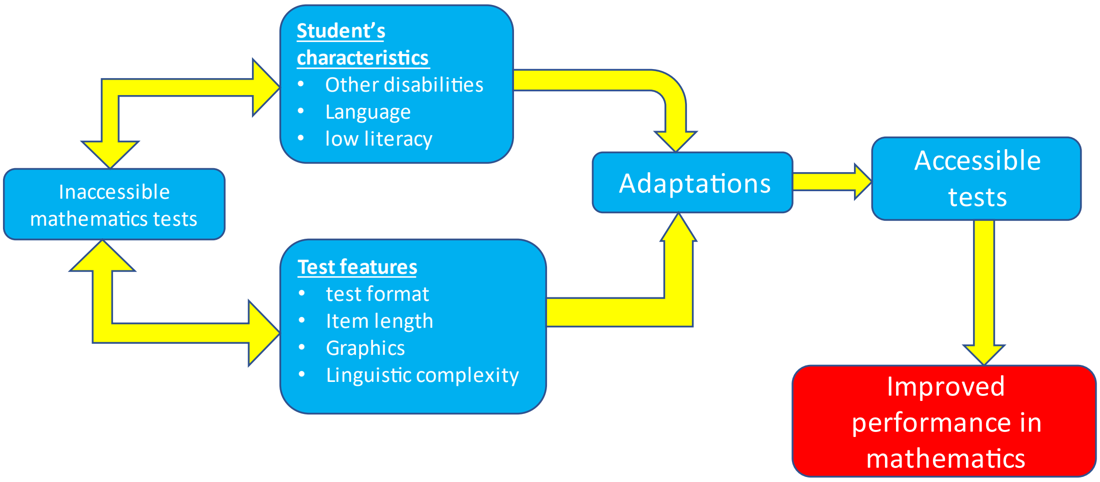

Figure 1: Conceptual framework

(Source: author)

This conceptual framework is based on the interrelationship between access to tests and improved performance in mathematics examinations. The Independent variable is inaccessible mathematics examination while the dependent variable is improved performance in mathematics examinations. Two broad factors affect the accessibility of tests such as student's characteristics and tests features. These factors can be overcome through adaptations and accommodations in testing which leads to making tests accessible to students with HI and consequently improved performance.

2.6 Summary

This chapter has presented an analysis of accessibility of assessment, principles of universal design of assessment, strategies used in the provision of access to tests, learning experiences of students with HI and mathematics achievement and concluded by highlighting the factors that may impede access in assessment. From the review of literature, several findings are revealed. For instance, making tests and other assessments accessible does not only benefits students with HI and other disabilities but also benefits the regular students. Secondly, accommodations in assessment level the playing field for students with HI in mathematics. In addition, language is one of the major impediments to access mathematics examinations especially to students with HI.

However, some methods of making tests accessible reduce the standards of the tests and therefore caution should be taken to ensure the appropriate strategies are employed to ensure that only construct irrelevant varieties are eliminated to ensure that the tests remain valid.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The main concern of this study was to examine the extent to which mathematics examinations are accessible to students with HI with the purpose to find out how mathematics can be made accessible to students with HI. To collect data for this study, I used a qualitative approach to gather data for this study, which included analysing examination papers and results, observing classrooms during the administration examinations, conducting one-on-one semi-structured interviews with the principal and Head of the Mathematics Department, and holding focus group discussions (FGD) with teachers and students.

The research concept and approach, the research site, the sample and sampling techniques, data collection procedures, and data analysis methodologies are all outlined in this chapter. The ethical considerations that were explored, the constraints that were encountered, and the rigour and dependability of the results are also discussed in this chapter.

3.1 Research design

The qualitative approach was used in the study. The qualitative approach assists in identifying issues from the participants' perspectives and gaining an understanding and interpretations that they give to their actions, events, or objects. It also seeks a contextualized understanding of phenomena, explains behaviour and beliefs, identifies processes, and understands the context of people's experiences (Hennink et al., 2020). This study intended to describe the extent to which mathematics examinations are accessible to students with HI by interviewing, observing students during administration of mathematics examination, analysing documents, having a FGD with mathematics teachers and students with HI.

This study employed a case study design that accorded me the opportunity to concentrate on one area of study: accessibility of mathematics examinations to students with HI, which consequently enabled me to gather in-depth information from the real situation on the ground (Kaiser et al., 2017).

3.2 Research site

According to Tuckman and Harper (2012), research location simply means a particular area. The research was conducted at Clifftop secondary school for the Deaf (Pseudonym). The school admits both learners with and without hearing impairment aged between 13 and 25 years. In Kenya, these students are in form one to form four and in Clifftop each class has three streams. One stream among the three is for hearing students while the remaining two are for the students with HI.

I selected this school because it is a special school for students with HI and these students participate in countrywide assessments and in addition the teachers were trained to handle students with HI. This is a unique feature intended for this study whose aim was to examine the extent to which mathematics examinations are accessible to students with HI. The site was therefore relevant to my study and provided me with the needed information to answer questions for my study.

3.3 Sample and sampling procedure

Schreiber and Asner-Self (2011) define a sample as the selected items, units, or elements from which the research conclusion will be made. The study targeted principals, teachers, students in a school for the hearing impaired. In this study, the target population comprised of three mathematics teachers, one principal, one head of the mathematics department and five form four students with HI.

Since the study was about the accessibility of mathematic tests to students with HI, the mathematics teachers and head of the mathematics department and students who have hearing impairment were sampled purposively. The reason for purposively selecting the teachers was because they taught students with HI mathematics simply meaning they had some common characteristics a fact that concurs with Etikan et al. (2016) who suggests that the reason for purposive sampling is to select research participants grounded on some comparable traits they possess. The three mathematics teachers had taught students with HI for more than five years and had numerous experiences on the way learners used to perform the mathematic test and were conversant with how accessibility in testing improves performance and therefore they were the appropriate source of information.

For deeper insight into the issue of accessibility in mathematics examinations, I choose the form four class for observation and focused group discussion. The students were drawn from the form four class due to the fact that these students had done many summative examinations and the teachers were cognizant of the student's behaviour and performance in mathematics examinations. Teachers helped in randomly selecting the best five students who performed well in mathematics and who could express themselves adequately on their feelings about the accessibility of mathematics examinations to participate in a FGD.

The teachers and the head of the mathematics department availed diverse experiences, the challenges and performance of students with HI in mathematics to this study, bringing into view data-rich in a multiplicity of opinion and observation based on their level of experience. I also included in the sample the principal since she was a teacher of mathematics and as an administrator, she had vital information not only on adaptations in assessment but also accessibility of mathematics examinations.

3.4 Data collection methods and tools

The data was collected through document analysis FGD, classroom observation and interviews. By using multiple sources of data collection, it helped in the triangulation and corroboration of the findings. The use of dissimilar sources of data collection was motivated by Pole and Hillyard (2016) assertion that combining diverse methods allows distinct kinds of data to be collected and consequently varied kind of knowledge is produced from it.

3.4.1 Semi-structured interviews

I conducted semi-structured one-on-one using interviews with the principal and the head of the mathematics department to gain an understanding of their views regarding the accessibility of mathematics examinations to students with HI and the strategies that can be employed to make mathematics accessible. I used an interview guide (Appendix A) that comprised of open-ended questions which gave me a chance to be flexible and probe the respondents to gain in-depth information needed for the study. The interviews lasted approximately 30 minutes at a location that the participant found convenient.

3.4.2 Focus Group Discussion

This is a sort of group interview in which a group of carefully selected participants discuss a certain topic under the direction of the researcher as a moderator to collect the necessary data. I conducted two FGD in this study to acquire information about the accessibility of mathematics assessments from students and teachers. I used FGD with students because it is advisable to use FGD so that the students can give their views freely without anxiety. Moreover, Cohen et al. (2011) advocate for the utilization of FGD to yield joint views rather than personal views. The main shortcoming of focus group discussion is that they tend to produce less data compared to one-on-one interviews and are thus beneficial for triangulation. This study had two FGD. The first group was for mathematics teachers who teach the form three and four classes. The teachers were of single gender-male since the only female mathematics teacher is the principal who I had interviewed separately. The second group comprised of five form four students a FGD guide was used (appendix D). The discussion allowed to provide rich information for this study about the accessibility of mathematics examinations to the students themselves.

The teachers' focus group lasted 30 minutes and was conducted during lunch break so as not to interfere with the teaching schedule. For the students, the discussion was scheduled after the lessons which was the time we had agreed with their teacher. The students' FGD examined the students' rating of the accessibility of mathematics examinations and the concepts that they find easy to tackle in an examination, it also examined the students' opinions and experiences towards making mathematics examinations accessible. For teachers, the discussion revolved around the setting of examinations, administration, students' performance in mathematics examinations and how the tests and main exit examination can be made accessible to students with HI. This method was selected because students with HI have less confidence when interviewed alone and placing them in groups helped boost their confidence and thus enrich their responses. Further for teachers, a group discussion helps them to bring different perspectives into view that fit within the formulated research questions. This FGD provided rich data on the extent of accessibility of mathematics examinations to students with HI and the different strategies that can be employed to enhance accessibility in mathematics examinations.

3.4.3 Document analysis

Documents considered to be relevant to provide further information related to this study were analysed. The documents analysed included the KCSE examination results for the past three years and the students' mathematics examination papers. I used document analysis protocol (appendix E) for systematic scrutiny of test items to establish the accessibility of mathematics examinations to students with HI.

The integral aim of analysing the mathematics examination items was to enable me to study keenly whether there were any modifications done to mathematics examinations, the performance of students in responding to modified and non-modified mathematics examination and the performance of students with HI in mathematics examinations compared to English tests which had been modified. Document analysis enabled me to corroborate the data collected from semi-structured interviews, FGD and observation leading me to arrive at accurate conclusions on the accessibility of mathematics examinations to students with HI.

3.4.4 Observation

Ishtiaq (2019) defines observation as "the practice of a researcher in the natural setting of a class where the action is taking place." As a result, a classroom observation is appropriate for this study because I was able to observe first-hand how students with HI behave during mathematics examinations.

Through non-participatory observation, I observed two tests administration sessions without participating in such processes, that is, during the administration of a standardized test and a modified test. An observation guide (appendix F) was used for systematic observation and recording.

With the help of the mathematics teacher, I identified five questions drawn from different topics and in different formats such as graphs, long-worded questions containing difficulty mathematical vocabulary, direct work out question and a question testing real life experience. The questions were written on the chalkboard during test administration.

Before the administration of the first standardized test, I observed that the students were anxious when I mentioned to them that I was going to administer a mathematics examination. During the test, most of the students were quite unsettled and some kept requesting permission to borrow items such as rulers and erasers, there was a delay in starting and completing the test which had not been modified. Two of the students completed the test within 45 minutes by the end of the one hour only 15 students had completed the test. The rest requested to be added more time to complete the test.

After marking the standardized test, we noted that that most students failed the long worded question and we thus modified it and changed the difficulty vocabulary replacing it with simple word which did not alter the original question. We then administered the same test with the modified question to the same students.

During the second test which had the word problem modified by simplifying the language, the students were eagerly overconfident and most of them completed the test before the one-hour schedule was over. I observed that the students were relaxed, started the test immediately and noted improvement in completion time with 14 out of the 23 students completing the test under 45 minutes and the remaining 9 completed before the scheduled completion time of one hour was over.

The advantage of observation is that it enables the researcher to collect information that depicts what is currently happening to the real station. Elimination of subjective bias is accurately done. However, it is expensive in terms of time consumption and sometimes it describes the internal situation, making the participant forge the situation, hence some information may be forged (Kothari, 2004).

3.5 Data analysis Procedures

According to Daniel (2019) data analysis involves transcribing information, coding categorizing data into themes according to the research questions.

In this study, descriptions and theme text were used to analyse the qualitative data from interviews, documents, FGD and observations (Creswell & Clark, 2017). Field data was organized and transcribed by transcribing material from interviews, documents, FGD and observations into a word processing document. A preliminary analysis of the data was carried out by going over it to gain a general notion of what it represented. The data was then coded, and the codes were used to create themes in the context of the research questions. In qualitative data analysis, coding is a critical component. The process of converting a text database to descriptions and themes is known as coding. The information was simplified to make it more understandable in the context of the study questions. The data was grouped into themes using content and thematic analysis. Content analysis is the process of coding data for specific words or content. The technique of organizing data into themes to answer research questions is known as thematic analysis (Alhojailan, 2012).

Finally, the results were conveyed in narrative discussions or commentary quotes, with descriptive examples from interviews, FGD, documents and observations utilized to highlight the points and bring the data to life. I interpreted the meaning of the research based on the report. Interpretation entails making sense of facts.

Comparisons between the findings and the literature were used to interpret the findings (Creswell, 2013). As a validation technique, the research was then validated using triangulation (Lauri, 2011). Triangulation is a method for assessing data correctness that necessitates the use of various data sources or numerous data collection methods. The data collected from the documents were utilized to supplement, clarify, or confirm the data gleaned from the interviews, FGD and observations.

3.6 Ethical Issues

Ethical consideration while carrying out research is critical at all levels of the research from proposal development to publication an assertation which has been made by Akaranga and Makau (2016) hence it is compulsory for the researcher to adhere to appropriate ideals at all stages. To conform to the expected ethical issues, I had to request prerequisite approval from relevant bodies and obtain informed consent from the research participants before data collection. In this respect, I sought clearance from the Aga Khan University (AKU) Ethical Review Committee which granted me an Ethical clearance certificate. Upon approval, I sought clearance to conduct the study from the National Council of Science, Technology, Innovation (NACOSTI) to collect data in the identified location. Thence I proceeded to the county commissioner in the jurisdiction under which my research location falls and was granted authorization, further permission was sought from the County Director of education to be allowed to access the identified institution.

Before engaging my research participants, I sought permission from the school principal which was granted as soon as I presented the relevant documents. The principal introduced me to the teachers and directed the head of the mathematics department to give me all the support I needed. During data collection, I explained to the participants the purpose of the research and assured them of the confidentiality of the information collected and their safety. I further explained that participation was free and voluntary, and one was free to opt-out any time. Once a participant opted to participate, I requested them to sign the consent form (see appendix G & L)

Involving students with HI to participate in FGD required them to sign an assent form (See Appendix K) and obtain permission from their parents or guardians but since the school is a residential school and students were drawn from afar, I requested consent through the principal who signed (appendix J) on behalf of the parents.

To maintain the anonymity and confidentiality of the participants I used pseudonyms during analysis and report writing. The collected data was stored in a locked bookshelf, and the digital data was stored on my laptop, which was secured with a password only I knew. In exchange for reciprocity, I promised to share a summary of the findings with the school after the study.

3.7 Limitations and Assumptions

There was a general assumption that there were modifications and accommodations in place to make mathematics examinations accessible to students with HI, however, this was not the case in practice, but the teachers were knowledgeable about how modifications and accommodations can be provided to make mathematics accessible and were able to expound on the same. Therefore, to ensure that the study was not affected by the absence of modified examination, I together with the mathematics teacher modified one item of the standard test and administered the test to the students.

This study involved a small sample size of one principal, one HOD, three teachers and five students from a single school and for this reason, generalizing the findings is not recommended.

Students who were part of the respondents presented their responses in KSL which in some instances resulted in distorted or limited answers to the questions asked. To overcome this, I asked the students to clarify and expound their points further and I would record their responses in English.

3.8 Rigour and trustworthiness

Rigour of a study refers to the extent of confidence in data presentation and methods used to ensure the quality of a study (Lemon & Hayes, 2020).

To increase rigour to the study, I used multiple methods of data collection which included interviews, FGD, document analysis and observation. I corroborated and triangulated the data collected from interviews with observations and documents which reduced systematic bias hence a thick description of the findings.

3.9 Conclusion

This chapter has outlined the research methodology that was used during the study by highlighting the research design used, study location, sample and sampling procedure and data collection methods. It has also expounded the data analysis procedure, rigour and trustworthiness of the findings and the ethical considerations followed during data collection.

CHAPTER FOUR

FINDINGS OF THE STUDY

4.0 Introduction

In this section, I present the findings that emerge from data collected following the process described in the previous chapter. The findings answer the research question "To what extent are mathematics examinations accessible to students with HI?"

Findings indicate that the accessibility of mathematics examinations or the degree to which the mathematics test permits a learner to demonstrate their knowledge of the target construct was limited for those with hearing impairment. Data shows that deaf learners were only able to tackle a few concepts in mathematics.

Findings are presented in three broad parts. The first part is based on the accessibility of mathematics examination to students with HI, the second part looks at the aspects of mathematics that are accessible to students with HI, while the third and final part covers the strategies that teachers can use to make mathematics examinations accessible to students with HI.

4.1 Profile of the respondents

The respondents consisted of three mathematics teachers drawn from form three and four. All three were male teachers because the only female mathematics teacher is the principal of the school under study. The teachers had teaching experience with students with HI of more than five years. Both the principal and the head of the mathematics department had been in the school for over eight years. The head of the mathematics department has been a teacher for more than fifteen years and a HOD for ten years further the teachers who were interviewed had teaching experience above five years. Therefore, this means that teachers hold sufficient experience to be able to teach mathematics to students with HI a fact that concurs with the findings from researchers such as (Akinsolu, 2010; Akpo & Jita, 2012; Daso, 2013; Wiswall, 2013) who found out that students achievement in mathematics is significantly related to teachers' years of experience.

The principal stated that all teachers in the school who are employed by the Teachers Service Commission (TSC) hold a degree in special education with the education of learners with hearing impairment as their area of specialization meaning they were qualified to instruct students with HI. Further, the principal indicated that they had proficiency in KSL which is the language of instruction in schools for the Deaf. This reveals that the teachers hold the prerequisite qualifications needed for one to be able to instruct students with HI. This revelation is in line with (Baumert et al., 2010) study that has shown that teacher preparation in mathematics and mathematics education positively influences the quality of instruction and, therefore, student achievement. In this case, I conclude that teachers are professionally qualified to instruct students with HI.

4.2 Performance of students with HI in mathematics examinations.

Mathematics is one of the compulsory subjects in the I secondary school curriculum. It is a prerequisite in tertiary education and careers related to science, mathematics engineering and technology. Most recently mathematics has been made among the cluster of subjects that a person aspiring to train as a teacher in Kenya must pass with a C grade. Data reveals that most of the students with HI perform dismally in mathematics compared to other subjects in the KCSE. Analysis of the KCSE mathematics results in recent years - 2018 to 2020 presents the reality of the deficient performance. The subject mean score of KCSE mathematics, English and KSL for the three years are as shown in the table below (Kenya National Examination Council (KNEC), 2021).

Table 1: KCSE mean subject score 2018-2020

Year Subject	**2018**	**2019**	**2020**
English	3.40	3.20	3.07
Mathematics	1.63	1.54	1.69
Kenyan Sign Language	7.10	7.25	7.32

This suggests that indeed mathematics performance has been poor compared to other subjects that have minimal test design accommodations and modifications such as English and Kenyan Sign Language. This difference in performance between modified and standard examination performance was noted by the HOD who stated that “Deaf pass in English because it is a bit adapted and in KSL because it is their language of communication and therefore easily understood by them" (HOD1, interview of 9th September 2021).

This was corroborated by another teacher who said that "Mathematics is not adapted, and the language used is complex for the deaf to understand so you find them passing well in KSL because they understand it better than mathematics" (PP1, interview of 8th September 2021).

The findings corroborate with numerous studies (Noorian et al., 2013; Pagliaro & Kritzer, 2013; Wood et al., 1986) that concluded that students with HI indeed do have difficulty in understanding mathematics when appropriate instructional adaptations and test modifications and accommodations are not provided.

4.3 Practices of students with HI in accessing mathematics examinations.

Findings show that students with HI have challenges accessing mathematics examinations administered to them. Accessibility is measured in terms of the extent to which a test taker can make meaning and respond to the intended construct (Beddow et al., 2011).

Overall students with HI seemed to have limited access to mathematics examinations. However, it was found that students with HI answer test items according to how easy they understand the item. During FGD, Paul a student with HI noted the following when asked how they used to tackle mathematics examination "it is easy for me to answer questions that need simple calculations and require use calculator. I also find it easy to answer questions that have drawings and requires remembering the formula" (FGD with students, 10th September 2021). Another student, Jane, added: "I find it easy to answer questions that have short sentences, number calculations and drawings such as solids and geometrical constructions" (FGD with students, 10th September 2021).

The above suggests that students with HI usually access mathematics by use of a calculator and the assistance of graphics in tests. This was corroborated by a teacher who observed that the "Majority of students usually attempt questions of numeric values which can easily be solved using calculators and questions that have graphics and illustrations" (FGD with teachers, 10th September 2021). This shows that students can access mathematics test items when allowed to use calculators and when to involve graphics and/or drawings are included. This agrees with (Maccini & Gagnon, 2006; Nunes & Moreno, 2002; Peltier & Harrison, 2018) who in their studies found out that allowing the use of calculators and including graphics in mathematics tests makes tests accessible to students with HI. However, these findings are in contradictions with Rosdiana et al. (2019) who posits that students with HI have challenges in drawings related to geometry.

Moreover, When the HOD was asked to give his views on the sections of mathematics tests learners perform better, he observed that:

> *"Students with HI can answer simple equations, construct drawings such as angles, chords, respond to questions that deal with the volume, area, surface area and perimeter of solids and any other item which is not verbose them (HOD1, interview of 9th September 2021).* His observations echo that of the teachers.

Furthermore, the findings were corroborated by analysis of students' examination answer sheets (see figure 2) revealed that most of the students were eager to attempt test items that involved drawings and basic calculations that required the use of a calculator, however, they had challenges solving items that involved word problems.

From the evidence above, it can be concluded that students with HI can access items that are direct, short-stemmed, contain or require drawings and simple arithmetic computations which agrees with (Maccini & Gagnon, 2006; Peltier & Harrison, 2018) and have difficulties in accessing items involving word problems as posited by (Ansell & Pagliaro, 2006; Ray, 2015).

4.3.1 Improving access to mathematics examinations for students with HI

Overall students with HI seemed to have limited access to mathematics examinations. The way mathematics examinations are set and administered assumes students with HI have no difficulty accessing the tests. The lack of access leads to poor performance by students with HI in mathematics. This means there is a need to increase access to mathematics examinations. Data collected revealed that both teachers and students agree that mathematics examinations ought to be adapted to make them accessible. Paul, a student said "I want maths exam to have short sentences-questions. Have simple language that I can understand (FGD with students, 10th September 2021). Another, Joel added: "possible for students to ask teachers for support, sometimes teachers ignore the students. The language used should be easy for the deaf to understand. More time should be added to make it easy to complete." (FGD with students, 10th September 2021). Yet another student added: examination should not have many questions with words... balance word problems and numerical calculations questions**.** I also understand questions that use simple English not difficult English (FGD with students, 10th September 2021).

Furthermore, another student added:

> Jane*:" if the exam has long worded questions it makes it difficult for me to understand. The examiner should make questions shorter. Reduce the number of word problems in tests. More questions with numerals, Drawings should be well illustrated for clear understanding. Simple questions not complicated." (FGD with students, 10th September 2021).*

The above data reveals that limited access to mathematics examinations is caused by language barriers, item format, response presentation and timing. There is a need therefore to provide necessary accommodations and modifications to mathematics examinations to make them accessible. Scholars such as (Huber et al., 2014; Li et al., 2013; Oommen & Mathai, 2021) affirm that the language barrier limits a student with hearing impairment from interpreting the meaning of an assessment task. This has been attributed to insufficient vocabulary among students with HI and problematic language structures which impose difficulties when reading performance is analysed and consequently affects a learner performance in mathematics (Traxler, 2000). Second, due to processing-speed issues and cognitive efficiency, pupils with hearing impairment have been observed to be affected by the time element (Lewandowski et al., 2013). Exams are frequently administered under timed conditions purely for the sake of convenience, with no regard for the fact that humans process and display certain skills at different speeds for numerous reasons (Gregg & Nelson, 2012).

Accommodations mean changing materials and procedures to give students access to instruction and assessments and enhance the authenticity of their assessment results (Hallahan et al., 2020). Accommodations in assessment entail changes in the method of presentation, response, scheduling and setting that do not alter the intended construct but permit students to respond to assessment tasks.

On the other hand, modifications are changes to the test items to remove constructs that inhibit students with special needs from responding to assessment tasks. Some of the modification strategies put forward include simplifying the stem, decreasing the length of item stimuli and stems, eliminating unnecessary visuals, and reducing the spread of information required for responding to the items across pages, eliminating unnecessary or implausible distractors and reducing the length of answer choices (Beddow et al., 2013). In mathematics, this means that the test item will have test items with shorter stimuli and stems.

Data revealed that teachers and test developers only provided increased font to accommodate learners who might have low vision. It is worth noting that some students with HI have other disabling conditions such as low vision and thus using large font size benefits such hearing impaired students who have low vision as an additional disability. There was no other form of accommodation or modification provided to students in mathematics examinations with teachers and principals pointing out that they could not provide accommodation because the final national summative examination was not adapted or modified in any way. Since adapting internal mathematics examinations would be inconvenient to the students. This challenge is pointed out by the principal:

> *"The mathematics examination is not modified since it would be pointless to modify internal examination whilst the KCSE is not modified. If we modify internal examination the students are likely to perform well however, this will be a disadvantage to them during KCSE as it is not be modified and no accommodation is offered thus, they will encounter the construct that would have been eliminated in internal tests." (*PP1 interview, 8th September 2021).

This seems to be in line with Kimani (2012) who posit that for any assessment to be adapted it starts with adapting instructional materials and then internal tests are adapted subsequently followed by national examinations.

4.4 Concepts in mathematics examinations that are accessible to students with HI

Data revealed that not all concepts of mathematics examinations items are inaccessible to students with HI. Some concepts are easily accessible to students with HI without the need for accommodation or modification and regardless of the item characteristics such as length, format, and language. Some of the concepts are discussed in the next section.

4.4.1 Arithmetic

Arithmetic encompasses the fundamental parts of number theory, measuring arts, and numerical computing, that is, the processes of addition, subtraction, multiplication, division, raising to powers, and root extraction (Serre, 2012).

The findings revealed that students with HI indicated that they were more likely to respond to test items that involved arithmetic calculations because in the words of one student “I find them easily as they include numerical values calculations (FGD with students, 10th September 2021). Another student added that he preferred tests with numbers “I like questions with numbers … long sentences me understand zero” (FGD with students, 10th September 2021). Yet, another student added, “I like answering commercial arithmetic they are easy for me to calculate” (FGD with students, 10th September 2021).

Teachers were of the same view as the students as they noted that the students preferred mathematical test items that test numeric computations. One teacher stated, “I have also noted they attempt questions with numerical sums” (FGD with teachers, 10th September 2021).

Moreover, an interview with HOD revealed that most students usually attempt questions that fall under arithmetic computations which corroborates the students' sentiments. The HOD said, "Deaf students answer questions that involve numerical calculations" (HOD1 interview, 10^{th} September 2021).

Further, data from the documents was in concordance with responses from the student and teachers as scrutiny of students answers sheets (see photo 3) shows that the students always attempted test items that involved numbers or arithmetic

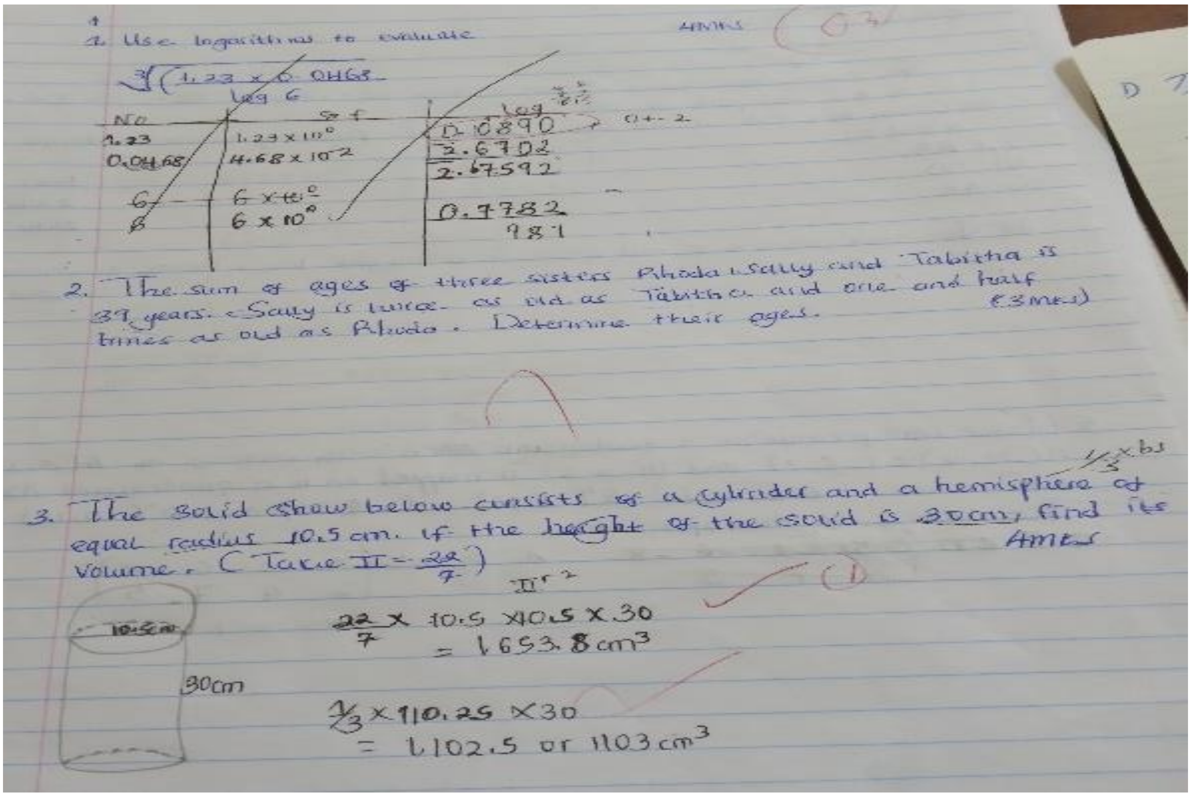

Figure 2: photo of students' completed maths test

computations.

This means that students with HI easily access mathematics concepts related to arithmetic computations which are in concordance with (Barbosa, 2014; Leton & Dosinaeng, 2019) whose studies concluded that arithmetic representation in students with HI was good. However, this is inconsistent with (Braden et al., 1994; Bull et al., 2011; Hyde et al., 2003; Noorian et al., 2013; Nunes & Moreno, 2002; Powers, 2011). who pointed out that most students with HI have challenges learning arithmetical skills even if they have the roughly same level of non-verbal intelligence as hearing peers.

4.4.2 Geometry

Geometry is a part of mathematical content that is taught at every level of education. While research report by Rosdiana et al. (2019) shows that geometry is a challenging topic to the general population and more so the students with HI.

The finding revealed that students with HI are more likely to attempt items that test the concepts of geometry. When students were asked to mention the concepts of mathematics which they always attempt or find easier to attempt four out of the five students who were involved in the FGD listed geometry as one of the concepts.

Further, scrutiny of the test administered shows that the students were eager to attempt the test item that tested knowledge of the volume of two geometrical shapes.

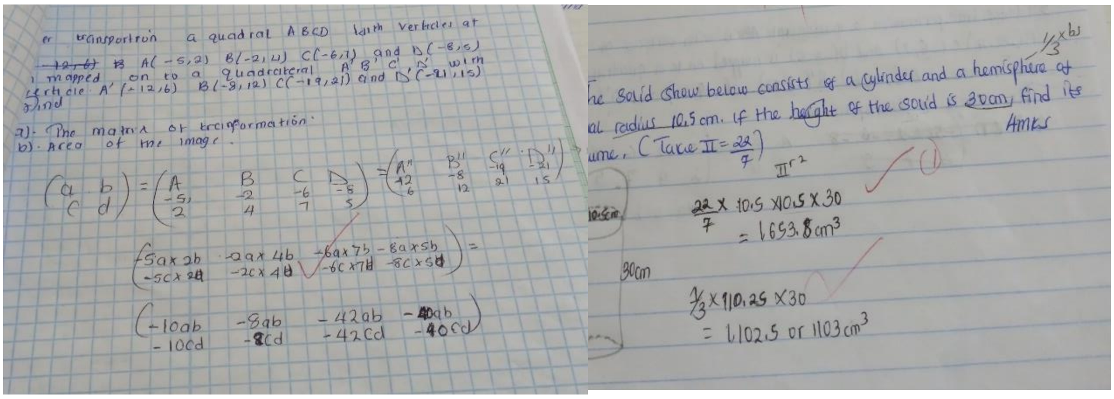

Figure 3: photo of sections of students' assessment sheet

From the documents analysed it can be suggested that students can attempt test items that require basic recall of formula or facts and items involving geometrical shapes and constructions. This agrees with Husniati et al. (2020) who posit that most of the students with HI can understand the concept of geometry. However, these findings seem to disagree with Giménez and Rosich Sala (2007) who affirm that students with HI have difficulty making calculations of geometry materials.

4.4.3 Questions that test a single domain

The challenges students with HI face are because of their limited English vocabularies which limits them in making meaning out of test items. Test items can contain several domains to be tested. The domains can range from knowledge and skills to cognitive construct that focuses on mathematical problem-solving. Cognitive ability consists of a domain of complex tasks.

Arithmetic word problems that are wordy usually contain more than one domain and as such students with HI find it difficult to make meaning of the constructs being tested. Consequently, they avoid attempting such items and when they do it is just for the sake of it. When students were asked which test items, they were more likely to answer they indicated direct questions which in this case means questions that contain a single domain and students can make meaning. One student said: “if exams have long worded questions, I find it difficult to understand. Should make questions shorter. Reduce the number of word problems in tests (FGD with students, 10th September 2021).

This means that deaf students have difficulty working out mathematics items that test abstract concepts such as word problems. This correlates with (Akuba et al., 2020; Curto Prieto et al., 2019; Marschark et al., 2015) who posit that students with HI have been shown to tend toward item-specific processing, focusing on individual item information rather than relations among items.

4.4.4 Knowledge level questions

A good and reasonable examination paper must consist of various difficulty levels in line with blooms taxonomy to accommodate the different capabilities of students. Bloom (1956) identified six levels of thinking which should be considered during item or test development. The original levels were revised by Anderson in 2001 (Wilson, 2016). According to Forehand (2011) Bloom’s taxonomy is a multi-tiered model of classifying thinking based on six cognitive levels of complexity, which include i) remembering, that is, recalling relevant long-term memory knowledge, ii) understanding (determining the meaning of instructional messages, including oral, written, and graphic communication), and iii) application (using procedures to perform exercises or solve problems). iv) analysing, which entails breaking up material and determining how components relate to one another and a larger structure or purpose, iv) assessing, which entails making judgements based on criteria and standards, and lastly vi) creating which is putting elements together to make a coherent whole and an original product.

Data collected revealed that students indicate that they found it easy to answer questions that tested recall of facts, that is, questions within the knowledge level of blooms taxonomy. For example, all the five students indicated that they preferred questions that were short because they found it easier to make meaning out of the questions as opposed to lengthy word problems. For example, one student stated, “I can answer questions with short sentences. (FGD with students, 10th September

2021). This was corroborated by the HOD who reported that students with HI have challenges solving mathematical problems that were set above knowledge level. As such he suggested "mathematics examination should have more direct questions as students can answer (HOD1 interview, 10th September 2021).

Moreover, the teachers were of the same opinion as they agreed that students with HI were rarely able to solve mathematical problems that required the application of several skills in one question. As one of the teachers suggested, "mathematics examination should (language) use short sentences and direct questions for easier comprehension (FGD with teachers, 10th September 2021).

My interpretation data reveals that students commonly attempt questions that require recall of previously learnt fact such as test items that requires one to use a formula to solve a mathematical question and leave out questions that are beyond their knowledge level. This is in concordance with Swanwick et al. (2005) who in their study on an exploration of barriers to success in mathematics by deaf children concluded that students with HI preferred direct methods of working rather than mental calculation when tackling computational problems. This also resonates with Ericsson and Smith (1991) who observed that knowledge level questions are relatively easy and can be solved by mere recall and recognition of facts. However, it should be noted that this does not apply to all students with HI as some students are able to solve abstract mathematical calculations.

4.5 Strategies to promote access to mathematics examinations for students with HI

In this section, I present the strategies suggested by teachers that can be used to ensure access to mathematics examinations and examinations to learners with hearing impairment.

Data revealed that mathematics examinations were not modified or adapted to ensure accessibility. The principal, HOD and teachers cited the lack of accommodation in the final KCSE mathematics examination as the reason for not modifying formative and internal teacher-made mathematics examinations and other internal mathematics examinations. However, they suggested several strategies that can be used to promote accessibility such as language modification, shortening the stem, changing response format, adding extra time, removing, or clarifying graphics and visuals.

4.5.1 Simplifying the language

The language of instruction in schools for the deaf is KSL whilst the language used in the setting of mathematics examinations and other assessments is English (Ngota, 2012). The disparity in the language used for instruction and assessment has been attributed to the poor performance of deaf learners in mathematics. Kimani (2012) claims that using purely the English language in designing test items contribute to the poor performance of learners with hearing impairment in mathematics as they struggle with the level of language and vocabulary used. The findings from data collected revealed language is considered as the major hindrance to access to mathematics and calls for its modification were made by respondents for example the principal stated:

> *"The instructional materials should be adapted so that the language used can be easily understood by the learners. That is, it should be modified to make it easy for the students with HI to master mathematics concepts….it should do away with testing English language competence and focus on mathematical reasoning…the vocabulary should be simplified for the learner to grasp the facts and concepts.*
>
> *In KCSE, the mathematics examination the language used should be simple for HI students to understand and respond to the test items. This is because currently the vocabulary and language used are for testing English, not mathematics skills and concepts." (*PP1 interview, 8th September 2021).

This suggests that there is adequate evidence that simplifying language in other tests have enabled students to access examination and subsequently improved performance in those subjects and hence the same can be replicated in mathematics tests. This was corroborated by the HOD who said:

> "*During HOD meeting in the school, we had discussed the problem of language used in maths which has contributed to poor performance. The word problems and vocabulary used in mathematics are the biggest contributor of poor performance in maths by deaf learners and should be modified for the*

students with HI to understand and access mathematics examination." (HOD1 interview, 10th September 2021).

Moreover, during FGD the teachers agreed that the language is a critical factor in mathematics accessibility and should be looked at since students with HI have a low level of language literacy. One of the respondents stated:

> *"Make the language to be simple for the deaf to understand the questions. That is to change the language so that it is testing maths knowledge not English language competence by also doing away with difficult vocabulary in maths. Although this should be done with caution to avoid changing the standard of the tests."* (FGD with teachers, 10th September 2021).

Interpretation from data reveals that the complexities of the English language used in mathematics examinations inhibits access to tests and should be modified which resonates with Plath and Leiss (2018) who affirms language level of students with HI affects mathematics reasoning. Modification in language should be to eliminate difficult vocabulary and linguistic structures in mathematics examination items that are not relevant to the construct being tested. This resonates with Scarpati et al. (2011) who cautions against diluting the quality of tests in the name of providing accommodations.

4..5.2 Shortening the stem.

Research shows that students with HI perform dismally in problem-solving tasks, achieving well below hearing students (Traxler, 2000). Kelly and Mousley (2001) reported that deaf students' problem-solving performance declined on word problems as the computational information increased. Students with HI perform well like their hearing peers in general especially when the tasks involve a single domain, however, their performance drops significantly when two or more domains are involved in word problems (Ottem, 1980). This means that test items that are verbose affects mathematics performance and thus reducing the domains or words in an item would improve access to mathematics examination. Data collected in the field is in concurrence with the findings of these studies like one student pointed out: "If the exam has long worded questions me understand impossible. Should make questions shorter…. Reduce the number of word problems in tests." (FGD with students, 10th September 2021).

During FGD, teachers echoed similar sentiments on the need for shortening the item stem or stimuli. The teachers were of the view that verbose test items have proven to be a difficulty for a long time due to the limited cognitive abilities of students with HI. As one teacher said, “It (examination) should be adapted for the HI and only use short sentences and direct questions for easier comprehension (FGD with teachers, 10th September 2021).

The HOD expressed similar views regarding shortening the stem. He said: “Use of questions which are short and contain simple language (HOD1 interview, 10th September 2021).

This revelation was corroborated by a scrutiny of the students’ mathematics answers worksheet after administering a standardized test showed that most of the students left test items that were wordy unanswered. This resonates with what the teachers and the students themselves said concerning their access to verbose mathematics examination items.

The suggestions resonate with Kettler et al. (2011) who performed an exploratory analysis of common modifications used in items that were empirically well enhanced for students with disabilities, finding that shortening an item stem is a potentially helpful modification.

4.5.3 Clarifying visuals and graphics

Mathematics examinations do not only involve word problems and arithmetic calculations but also include items that require test takers to interpret, construct or extend geometrical construction among other figures and drawings. Sometimes these visuals are either not labelled or contain too much information that ends up confusing the test takers. For example, in Consortium for Alternate Assessment Validity and Experimental Studies (CAAVES) study on the use of visuals in tests conducted by Kettler et al. (2011), found out that adding graphics to word problems tended to result in less accessible items, where such cases arises Beddow et al. (2013) suggested that visuals short be clarified or eliminated to increase access to test.

Data collected revealed that most of the students with HI preferred visuals that were simple and correctly labelled. One was categorical about the importance of visuals by saying: “I want drawings to have information inside to make them clear example angles or numbers for clear understanding.” *(*FGD with students, 10th September 2021).

Another student pointed out that he prefers test items that contain visuals, but visuals that are simple he said: “I like questions for drawings/ constructions if have simple instructions.” (FGD with students, 10th September 2021).

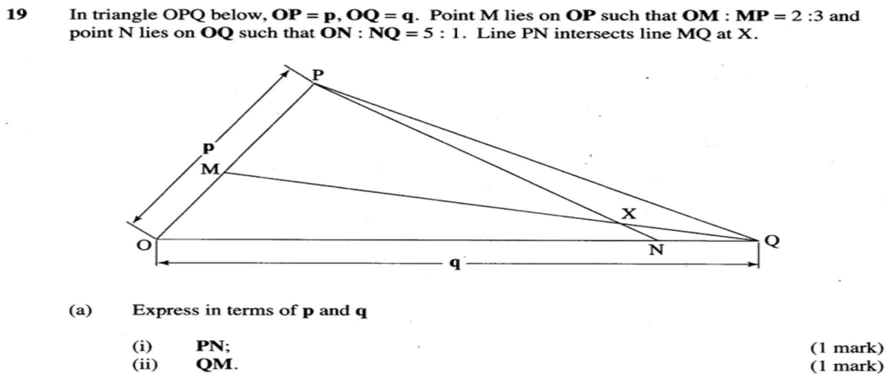

Figure 4: sample diagram that needs clarification

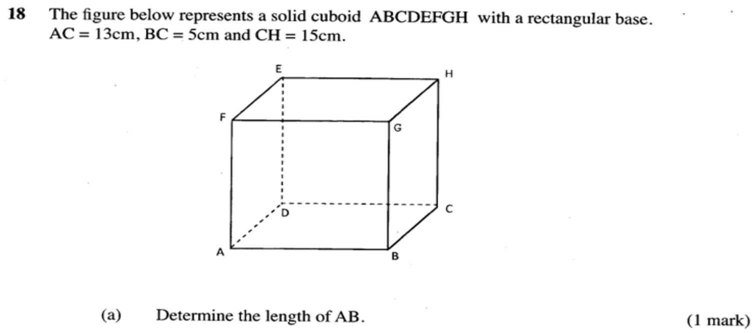

Figure 5: a visual diagram considered to be clear

The two figures above depict test items with visuals that either need clarification (Figure 6) based on the learners and another one the students identified as clearly presented (Figure 7) and therefore easily accessible to the students.

This reveals that if the visuals are clear the items become accessible to some of the students. This resonates with Clark et al. (2011) who advises that the visuals should be labelled only to the extent necessary for understanding the construct being tested. The findings also agree with (Sealey et al., 2014); Zhe (2012) who affirm that symbols and figures facilitate students with HI in solving problems and performing a series of calculations.

4.5.4 Extended time

The use of extended time as a method of providing accommodation to students with disabilities in assessment has been controversial yet that notwithstanding it is one of the most frequently used accommodation strategies.

The study found that extended time could be used as a method of accommodation in mathematics examination. The KCSE mathematics examinations run for two and half hours and this timing is used in all the internal mathematics examinations. Although the principal and the HOD recommended extending time, their suggestion was time to be extended in the school timetable so that the teachers could be able to cover all the mathematics concepts prior to the final assessment test. The principal while giving recommendations on how performance in mathematics can be improved suggested that.

> *"KICD should consider extending the time allocated for mathematics in the timetable. "The time is inadequate to prepare deaf students for examination. A gap year would be appropriate so that students have time to master concepts and then they be taught how to tackle the examination questions. Or the content tested be reduced to be for the first two classes instead of the four classes. I am hopeful that the new education system where the secondary school calendar will run for three years might change the performance in mathematics due to reduced study syllabus."* (Principal interview, 8th September 2021).

In addition, the HOD responding as to whether there are any accessibility measures provided in mathematics was of similar sentiments by stating:

> "*…adding more time in KCSE examination was also not well thought out because most students hardly utilize the added time as they do not grasp concepts and therefore do not tackle the difficult questions. more mathematics lessons should be added in the timetable to provide teachers with adequate time to help in mastery mathematical concepts"* (HOD interview, 8th September 2021)

However, a classroom observation during the administration of a 5-item standardized and modified test revealed otherwise since the students took much more time in the test than anticipated. The maximum amount of time allocated for these two tests was one hour. However, within one hour of the first test majority of the students had not yet completed the test and requested additional time to complete the test. Given the fact that they were unable to complete just 5 items within one hour then it becomes an uphill task to complete a standard test with fifty items. Extending the time would help the students with HI to complete the tests. This is consistent with the findings of studies undertaken by academics such as (Eduwem & Tommy, 2021; Fuchs et al., 2008; Mandinach et al., 2005; Schulte et al., 2001), which indicate that some test accommodations can benefit students with HI. Specifically, the accommodations of prolonged exam time give students with learning difficulties including those with hearing impairment an advantage over students without disabilities, especially on more complicated or difficult arithmetic topics. In conclusion, the findings suggest that extending the examination time benefits students with HI by allowing them to complete the tests at their own pace.

4.4.5 Changing response format

The response format is the way a test taker presents their response for example by writing, verbally responding, visual response, pointing to the answers just to name a few. Changing response format has been found to improve access to tests by different scholars, for instance, a study by Eduwem and Tommy (2021) found that students do better on tests that require them to give answers on a separate answer script because they have enough space to write all their answers compared to tests which they are to write the answers on the same sheet with the questions. Another study by McKevitt et al. (2013) reported that accommodated test scores of students were significantly higher compared to non-accommodated scores of students in terms of response format.

Findings revealed that students had limited mathematics computation skills and are unable to do calculations and arrive at the appropriate responses to test items. Due to this challenge both students and teachers pointed out that access to mathematics examinations can be improved by changing the response format to test items. During teachers' FGD, the teachers believed changing the response format was an appropriate strategy to enhance access to test by students with HI as one teacher pointed out by saying: “Learners can be allowed to use sign language to put forth their response rather than writing down their response.” (FGD with teachers, 10th September 2021).

During the interview with HOD raised similar recommendations when asked what accommodation and modification strategies ought to be put in place to make mathematics accessible. He said “Students should be allowed to use sign language to answer some of the questions language (HOD1 interview, 10th September 2021).

From the findings, it can be interpreted to mean that changing the response method to test items would increase the access to test by the students. This is in line with one of the strategies recommended by Beddow et al. (2013) of making tests accessible to students with special needs. However, it is worth noting that neither the teachers nor the HOD pointed out how responding in sign language to mathematical test items should be applied. This, therefore, means that the findings are inconclusive on the applicability of responding using sign language to mathematics word problems. It suffices to say that this strategy looks much more practical in language-related tests as pointed out by (Cawthon & Leppo, 2013) who state that allowing the students to respond in sign language is specific to language characteristics of students with HI.

4.4.6 Changing test item format

Test items are usually set in different formats depending on either the level of education, knowledge being tested, category of learners or intent of the test. Test item format can be in form of multiple-choice questions, true/false items, essay questions or filling in blanks.

Findings indicate that students with HI have challenges in making meaning out of mathematics test items set in certain formats such as lengthy word problems, test items containing difficult vocabulary or complex calculations. However, they were able to respond easily to multiple-choice questions, direct questions and fill in blanks. When asked to suggest some of the accommodation strategies he thought to be adopted the HOD said: “Use of multiple-choice questions in the national examination should be encouraged.”

Moreover, during the FGD the teachers expressed similar sentiments to those of the HOD by suggesting a change in testing format to help students with disabilities to access mathematics test items. The teachers felt that word problems posed a challenge to the students with HI and observed that some students had done well in their Kenya Certificate of Primary Education mathematics examination due to the nature of the test item, that is, multiple-choice questions. This was depicted by one teacher who said: “Use of multiple-choice questions or filling in blanks in the national examination would ensure students performed well in mathematics as some of them passed well in KCPE which shows if questions are set-in multiple-choice format” (FGD with teachers, 10th September 2021)

Therefore, this can be interpreted to mean that if the format of the test item is changed from essay questions to multiple-choice questions, filling the students will more likely be able to access the examination. This agrees with observations made by (Beddow et al., 2013; Cawthon & Leppo, 2013; McKevitt et al., 2013; Swanwick et al., 2005) that changing the response format of test items, especially from essay format to multiple-choice questions increase access to test. However, the teachers forgot to indicate that multiple-choice questions are prone to guesswork and therefore not recommended for mathematics tests items where students are expected to demonstrate their mathematical ability which is in line with Klufa (2015) on the arguments against the use of multiple-choice questions. Further, it seems like the teachers were not aware of the fact that it is challenging to change word problems into multiple-choice questions without altering the intended construct and consequently affecting the validity of the test score a fact that agrees with studies by (Cawthon et al., 2013; Elliott et al., 2010; Kettler, 2012; Thurlow & Kopriva, 2015).

4.6 Behaviour of students during mathematics examination.

Mathematics motivation is one of the factors linked to math accomplishment in deaf and hard-of-hearing children. (Hannula, 2006) argued that motivation is a capacity to guide action that is integrated into the system that controls emotion. This potential may manifest in cognition, emotion, or behaviour. Part of understanding whether the mathematics examinations are accessible to students with HI include observing their behaviour during test administration. Data collected from observation reveals that the Students with HI behaved differently during the administration of the two tests (modified and standard test). During the taking of the standard test the students portrayed some anxiety because they were not ready for the test, some took too long to start the test while some had so many queries and unnecessary movements such as borrowing a ruler, eraser while some kept glancing at what their classmates were doing. Mathematics anxiety is defined by (Tobias, 1993) as cited in (Zakaria et al., 2012) as "a sensation of tension, worry, and anxiety that happens in individuals while interacting with numbers and mathematical processes, as well as when solving mathematical problems" (p. 260).

Further, the students took more time to complete the test than expected. By the end of the one hour, only 15 out of the 23 students had completed the test. During the second day of test administration which had one of the items modified to remove construct irrelevant words, the students portrayed a different behaviour, this time they were calm and composed. No anxiety and unnecessarily movements were noted.

A comparison in the performance of two tests shows that all the students failed question 2 which is a word problem testing real-life experience. It was deemed to have construct-irrelevant words such as ‘twice’ and ‘determine.’ When the item was modified in consultation with the mathematics teacher, the two words were replaced with appropriate words that were ought to be mathematical and would help the students to access the question. Improvement in attempt and completion rate was noted. More students attempted to do the modified test item although some still got the answer wrong. This resonates with (Cawthon & Leppo, 2013; Qi & Mitchell, 2012) who posit that modification in tests improves access to test for students with HI.

From the findings, this can be interpreted to mean that if the construct irrelevant domains are eliminated then access to test is improved.

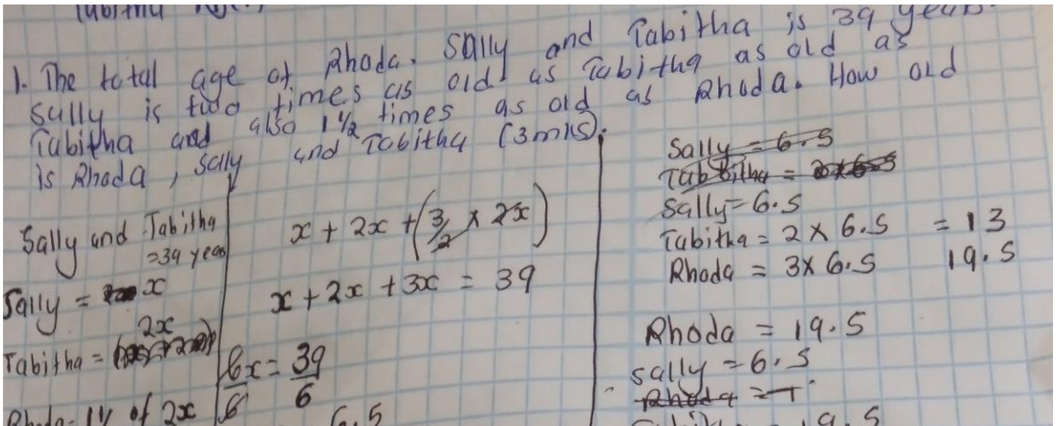

Figure 6: modified question

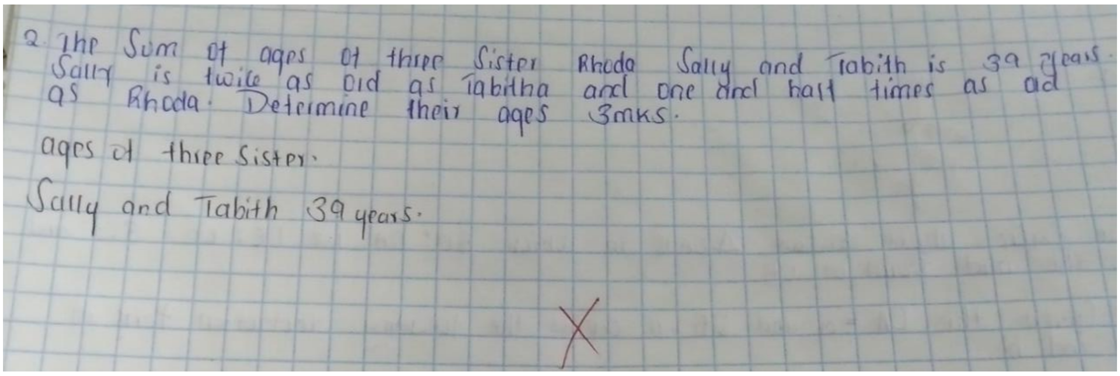

Figure 7: standard test item

Further, a scrutiny of students answers worksheet (figure 6 and 7) reveals that after modifying the test items, the students had gained a form of access to the question and were thus able to attempt it after modification. This suggests that removing irrelevant constructs helps to improve access to the test items for students with HI.

The findings are in line with Carey et al. (2017) who observed that in high school students, mathematics anxiety is negatively connected with math achievement and academic success. This is also in line with (Beddow et al., 2013; Cawthon et al., 2013; Kettler, 2012; Pagliaro & Ansell, 2012; Thurlow & Kopriva, 2015) who posit that providing accommodations to students with HI ensures access to tests.

4. 7 **Conclusion**

This chapter has discussed the findings and how they relate to literature. The accessibility of mathematics examinations to students with HI have been examined and the strategies necessary for improving accessibility discussed.

The findings revealed that mathematics examinations are hardly accessible to students with HI because no form of accommodation has been provided to these students. Consequently, this was found to be the major contributor to poor achievement by students with HI in mathematics. In addition, the findings revealed that not all aspects of mathematics are inaccessible to students with HI. Further, the examination revealed that teachers were conversant with accommodation and modifications strategies that could be employed to ensure access to mathematics tests by students with HI however their hands were tied for lack of an official policy from the government.

In the next chapter I present a summary of the key findings, the lessons learnt and recommendations.

CHAPTER 5

SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.0 Introduction

This study examined the extent to which mathematics examinations in Kenya are accessible to students with HI in terms of the strategies the students employed in tackling mathematics tests and the aspects of mathematics that they considered accessible. In this chapter, I summarize the key findings to the research question, suggest recommendations to the Kenya National Examination Council, Ministry of Education, Kenya Institute of Curriculum Development, and teachers of mathematics. Finally, I discuss the lessons learnt during the research process and conclude the research findings.

5.1 Summary of findings

The findings are summarised as the practices of students with HI to access mathematics examinations, aspects of mathematics that are accessible to students with HI and the strategies used in making mathematics examinations accessible to students with HI.

5.1.1 Access mathematics examinations by students with HI

The study revealed that students with HI employ diverse strategies in their attempt to access mathematics examinations. This was demonstrated by their ability to tackle direct test items, attempt to solve questions on geometry and graphics, simple equations and statistics. There was suggestive evidence that mathematics test items with complex language content were inaccessible to the students. From some of the gaps on the students' answer sheets, it can be assumed the cause was some concepts being difficult to teach. However, to make a conclusive analysis this need to be followed up by a discussion with the students with HI about their familiarity with areas of the mathematics curriculum and where they perceive the greatest challenges to be.

Second, the study revealed that given some form of accommodations such as the use of specific tools, extended time among others the students with HI were able to access mathematics tests with ease than when no form of modifications or accommodation is provided. This was demonstrated by the students having been able to complete the administered test after being added extra time and by the students completing or attempting test items that could be easily executed by using a calculator.

Although the focus was on access to testing, there arose another issue, that of how mathematical concepts are accessed. It emerged that the quality and experience of sign language use in the teaching of certain mathematics concepts made access to the curriculum easier because sign language is a visually–spatially organized language. Teachers argued that the language lends itself well to the teaching of mathematics, particularly for concepts of size, location, and spatial relationships. As a result, it can be concluded that students with HI are receiving the most appropriate access to the mathematics curriculum. However, this is not to say that all deaf students should be taught mathematics in sign language, but rather that an assessment should be made on the extent to which the language of instruction responds to individual learning strengths and consequently enhances access to mathematics tests.

Priori conclusion reveals that access to mathematics examinations is a fundamental aspect of ensuring fairness in testing, yet it is almost lacking in the current standardized mathematical tests for students with HI. Conversely, accommodation in other subjects has proven to increase accessibility and hence improved performance in those subjects.

5.1.2 Aspects in mathematics examinations that are accessible to students with HI

The study established that there are few mathematics concepts that students with HI easily access. Most of the concepts ranged from simple arithmetic to abstract concepts like statistics. However, it was revealed that access to these items depends on the way the test items were constructed such as the language used, number of domains in the test item, format of the item and instructions (stimuli) provided.

It is clear from the results that the students comprehend an average of the test items offered. These signs show that students with HI have mathematical competence. Based on the results of the concepts, it can be concluded that students with HI can understand mathematics concepts if they are within their cognitive ability and that if supported by appropriate accommodations, they will gain a conceptual understanding of mathematics, though it might take a long time.

Further, it was revealed each student with hearing impairment have diverse characteristics as far as understanding concepts of mathematics is concerned. For instance, whereas one student can have challenges understanding one aspect of mathematics another one can be having an easy go at the same aspect. Therefore, there means that a comprehensive analysis of each aspect of mathematics needs to be done to ascertain which concepts are easier for most of the students with HI.

5.1.3 Teacher strategies to promote access to mathematics examinations for students with HI

The study indicates that Mathematics examinations are barely accessible to students with HI and have contributed to the low performance of students with HI in nationwide mathematics examinations.

The study established that accommodations were absent in internal mathematics tests, and this was attributed to the Kenya National Examination not offering any form of accommodations or modification in mathematics to students with HI. However, the teachers felt that the mathematics examinations ought to be adapted to make them accessible to students with HI. Consequently, they suggested several strategies for practice which include tactics and viewpoints that educators, policymakers, and suppliers such as test developers may employ. While these recommendations are not exhaustive, they are based on the conceptual frameworks and research described in the previous two sections of this report.

The most obvious but difficult recommendation is to consider language when developing accessible assessments for students with HI. This concern is not only about how language is used in assessment, but also about how there are interactions or nuances in the assessment process.

Another strategy fronted was using clear visuals, however, teachers pointed out that one needs to be cognizant that if the visuals are poorly rendered or does not represent the target construct recognisably, the visuals may leave the student with less access to the test content.

Further, the provision of extra time and test-wiseness are among the strategies that were suggested by the mathematics teachers. It is worth noting that test-wiseness is hardly recognized as an accommodation strategy in the extant literature, but rather as study skills, nevertheless teachers felt it can play a big part in promoting access to mathematics tests. This strategy arose because the teachers believed that the students must be familiar with the kind of questions that are asked and the style in which they are delivered because of their educational experiences. Otherwise, the relationship between education and test scores will deteriorate. However, they noted that although test developers cannot guarantee classroom behaviour, they can strive to accurately depict the material provided, particularly the common tasks that students must perform.

The study concluded that it should not escape us that as much as these strategies are meant to improve access to mathematics tests, test developers need to consider the unique needs of the test-takers with hearing impairments to establish the most dominant concern to settle for the best strategy.

Though this study did not examine the effect of teacher experience and qualifications on students' performance. Findings show that teachers were trained and possessed adequate experience to handle the students with HI and applied appropriate strategies in their teaching method.

In conclusion, the study revealed that one of the most important considerations in creating accessible assessments is to verify that changes to the tests function as intended.

5.2 Recommendations

Based on the findings of the study, I suggest the following recommendations to the Ministry of Education, KICD and KNEC.

5.2.1 Ministry of Education

The study revealed that mathematics examinations were highly inaccessible to students with HI as there are no accommodations or modifications provided in both internal and national standard examinations in Kenya. Although there is sufficient evidence in English and KSL subjects that providing accommodations benefits students with HI by increasing access to tests this has not been replicated in mathematics an area that students with HI have continued to perform dismally.

Since the ministry of education oversees the formulation of policies on curriculum change, the ministry should call for the review of mathematics instructional materials to increase access for students with HI. By reviewing the instructional materials in liaison with KICD then it will be easy for the KNEC to provide the necessary accommodations in mathematics examinations to students with HI.

5.3 Suggestion for further research

This is the first study of its kind in Kenya and focused on a single school in the whole country. Further studies on the accessibility of mathematics examinations to students with HI can be conducted in more schools for the Deaf to clearly understand the extent of accessibility of mathematic tests to students with HI countrywide.

5.4 Challenges faced

One challenge was administering two tests under the recommended standard timing for national assessment. Since the school was in progress and there was an oncoming internal assessment, it was quite challenging to administer the tests within the expected timing. Notwithstanding the challenge of timing, I was able to set and administer a 5-item test with the aid of the form 4 mathematics teacher. After administering the test in its standard format, we identified the word problem that students had difficulty in and made some modifications in the language without changing the intended construct and thereafter administered the test again after one day.

5.5 Lessons learned

Several lessons were learned from this study. Firstly, I learnt that students with HI face much more challenges in mathematics than anticipated.

Secondly, I learnt that the manner in which a researcher designs and administers the research instruments determines the richness of data collected to answer the research questions.

5.6 Conclusion

This study sought to find out the extent to which mathematics examinations are accessible to students with HI. The study found out that mathematics examinations are highly inaccessible to students with HI. Further findings indicated that accommodation was needed to improve access for students with HI. This could be done via diverge strategies such as modifying test items by reducing the length of the stem, simplifying language, clarifying visuals, extending time and eliminating construct-irrelevant domain.

It was established that providing accommodations to students with HI in the national examination would help level the playing field thus improving the performance of these students particularly in mathematics and overall academic achievement in general.

Ultimately, based on the literature reviewed around accommodation in assessment and the findings of this study, it can be argued that enhancing access to mathematics tests would influence the outcome of mathematics scores of students with HI in Kenya. It would also contribute to fair and inclusive assessment procedures, as enshrined in Kenya's Persons with Disabilities Act 14 of 2003 and promoted in the United Nations Sustainable Development Goal number four target four-point-five, which aims to ensure equal access to all levels of education for persons with disabilities.

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APPENDICES

Appendix A: Interview guide for principal

Date………………………. Time……………………….

Introduction

My name is **Peter Mwangi Kabethi, an M.Ed.** (Assessment, Measurements and Evaluation) student at the Aga Khan University; Institute of Educational Development, East Africa- Dar Es Salaam, Tanzania. I am conducting research as part of my course in which I shall explore the extent to which mathematics examination is accessible to hearing-impaired students. The findings of this research will provide useful information to educational stakeholders on areas of improvement in ensuring that mathematics examinations are accessible to students who are Hearing Impaired. The main purpose of this interview is to collect information that will be used only for the purpose of this research and not otherwise. Confidentiality is guaranteed and the discussion shall take about 30 minutes.

Part A: profile Questions

1. Kindly introduce yourself.
2. How long have you been serving as a principal in this institution?

Part B: school demographics

3. Are all the teachers trained to teach students with HI?
4. How many mathematics teachers do you have in the school?
5. How are examinations prepared in this school? (probe for whether exams are modified and if yes which one and why)
6. How are the tests modified/adapted to meet the needs of the students who are hearing-impaired?
7. How do students respond to modified and non-modified exams?
8. Is the KCSE mathematics examination adapted to suit the needs of the students with HI?
9. Are there any issues that you would like to share about making mathematics examinations accessible to students with HI?
10. Do you have a policy on the setting of internal examinations? probe whether it is localized at school or a government policy

Appendix B: Interview guide for Head of Department (Mathematics)

Date………………………. Time…………… (HoD) pseudonym____________

Introduction

My name is **Peter Mwangi Kabethi, an M.Ed.** (Assessment, Measurements and Evaluation) student at the Aga Khan University; Institute of Educational Development, East Africa- Dar es Salaam, Tanzania. I am conducting a study on the extent to which mathematics examinations are accessible to students with HI. The main purpose of this interview is to collect information that will be used only for the purpose of this research and not otherwise. Confidentiality is guaranteed and the interview shall take about 30 minutes.

Before we start our interview. I would like to kindly ask you to go through the consent form ask any questions for clarity if the question is not clear. I would like to videotape our discussion and I will summarize what you have said and integrate it into my final report.

[The interviewee read the consent form, answers any questions, interviewee sign form and provision a copy of the form. Turn on the video recorder]

Part A: profile Questions

1. Kindly introduce yourself
2. How long have you been serving as the head of the mathematics department in this institution?

Part B: semi-structured interview

1. On average how many mathematics examinations do give the form 4 students do in one term?
2. Who sets the internal mathematics examinations in this school?
3. What is accessibility in testing? Do you have a policy on ensuring accessibility?
4. What sorts of accommodations (adaptations) do teachers employ in mathematics examinations?
5. Are the accommodations (adaptations) effective in your opinion?

6. Are the national final exit mathematics examinations adapted to suit the needs of the students with HI?

7. Are other subjects' tests adapted and if yes, why has mathematics examinations not been adapted?

8. What are the benefits of adapting tests to students with HI?

9. How is the performance of students with HI in KCSE mathematics examinations compared to their hearing peers?

Appendix C: Focus group discussion (FGD) with mathematics teachers.

Date_________ Time ________ School code_____________ Total members __________

Introduction

My name is **Peter Mwangi Kabethi, a M.Ed.** (Assessment, Measurements and Evaluation) student at the Aga Khan University; Institute of Educational Development, East Africa- Dar Es Salaam, Tanzania. I am conducting research as part of my course in which I shall explore the accessibility of mathematics examinations to students with HI. The findings of this research will provide useful information to educational stakeholders on areas of improvement in ensuring that mathematics examinations are accessible to students who are Hearing Impaired. The main purpose of this discussion is to collect information that will be used only for the purpose of this research and not otherwise. Confidentiality is guaranteed and the discussion shall take about 45 minutes.

Question for discussion	Explanation
When are assessments conducted in this school?	
How many times are the students with HI assessed in a term?	
What process do you follow in mathematics examination construction?	
Is there a specific policy/criterion on how mathematics examination meant for students with HI should be constructed? *Probe which and how it is followed*	
Which features do you modify (adapt) in mathematics examination items?	
Which format of mathematics item do learners with hearing impairments usually answer in tests?	
Which areas of mathematics examination items appear challenging to students with HI?	
Is the KCSE mathematics examination adapted?	

If no probe why it should be adapted.	
How do you ensure that the adapted tests are valid?	
Do you consider Bloom's taxonomy while constructing mathematics examinations?	
Do you think making the KCSE mathematics examination accessible to students would be of benefit? *If yes, probe why and which benefits. Any evidence that shows accessibility helps*	
Which way do you think mathematics examinations should be modified/adapted to meet the needs of students with HI?	

Appendix D: Focus group discussion (FGD) with students.

Date_________ Time ________ School code_____________ Total members __________

Introduction

My name is **Peter Mwangi Kabethi, an M.Ed.** (Assessment, Measurements and Evaluation) student at the Aga Khan University; Institute of Educational Development, East Africa- Dar Es Salaam, Tanzania. I am conducting research as part of my course in which I shall explore the accessibility of mathematics examinations to students with HI. The findings of this research will provide useful information to educational stakeholders on areas of improvement in ensuring that mathematics examinations are accessible to students who are Hearing Impaired. The main purpose of this discussion is to collect information that will be used only for the purpose of this research and not otherwise. Confidentiality is guaranteed and the discussion shall take about 45 minutes.

1. How do you find the mathematics examination to be?
2. Do you understand all the concepts or some?
3. Do you like all the questions asked?
4. Which questions do you find easier to answer?
5. How do you ensure you get some marks in the mathematics examination?
6. Do you think mathematics examinations should be changed and how?

Appendix E: Document analysis protocol

Date: ___________________Place: ________________________________

Objective: ____

TYPE OF DOCUMENT	**PERSON/ OFFICER**	**INFORMATION REQUIRED**	**INFORMATION OBTAINED**
KCSE exam results	Principal	What are the scores for subjects where the examination is modified before modification and after modification? Is there any significant difference in performance between modified/ unmodified examinations?	
Mathematics exam analysis	H.O.D Mathematics	1. What have the scores been for modified examinations in the last 3 years? 2. What have the scores been for unmodified examinations/ standardised like mathematics in the last 3 years? 3. What is the difference in the test items between a modified and unmodified examination/ standardised?	
Mathematics exam papers	teachers	1. - What is the difference in the test items between a modified and unmodified examination/ standardised? 2. How do students perform on the same test item when it is modified and when it is not modified?	

Appendix F: Classroom Observation schedule

Date: ______________________________ **Time**:

____

Number of participants

____

Objective: investigating the behaviour of students with HI during adapted and standardized mathematics examinations.

S/N	Things to be observed	Observations
1	The behaviour of the students during the administration of mathematics examinations. -confidence - tension -asking for clarification -discomfort -anxiety -blank stares -delay is starting or completing the test	
2	Time taken to complete the tests 10 minutes 20 minutes 30minutes 40 minutes 50 minutes 60 minutes	

Appendix G: Ethical Consent form for teachers

Research topic: Accessibility of mathematics examinations to students with HI.

I have been informed of the requirements of the study and fully understand what will be expected of me as a participant.

I, therefore, agree to be amongst the participants in this study with the following conditions. *Put a tick (✓) as appropriate against each statement.*

- ☐ *This study focuses on the accessibility of mathematics examinations to students with HI.*
- ☐ *The purpose of this study is to explore the extent to which mathematics examinations are accessible to students with HI.*
- ☐ *My identity as a research participant will remain confidential and my name and responsibility/ role in the school and the name of the school will not be used at any point in the research or in reporting the findings.*
- ☐ *I maintain the right to withdraw from the study at any point in time.*
- ☐ *I will be interviewed as part of the study.*
- ☐ *My voice/video will be recorded during my interview.*
- ☐ *My records (teacher-made mathematics examinations, KCSE results analysis and internal examinations result in analysis) will be analysed for this study.*
- ☐ *Photographs (or scans) of my work or classroom will be taken for research purposes.*
- ☐ *I hold the right to refuse to answer any question.*
- ☐ *I will receive the summary of the final report of the study.*
- ☐ *The findings of this study may be used in conference presentations and academic publications.*

I express my willingness to participate in this study by signing this form.

Name: ………….……………… **Designation**: ……………………………….

Signature: …………………………… **Date**: ……………………………………

Name of the school:……………………………………………………..

Researcher's Name: Peter Mwangi Kabethi. **Contact**: P.O Box 125 Dar es salaam.

Appendix H: Information sheet and consent form

Title of study: Accessibility of mathematics examinations to students with HI.

Principal researcher: Peter Mwangi Kabethi

Institute: Institute of Educational Development, East Africa, Aga Khan University.

Introduction

I am Peter Mwangi Kabethi, a Master of Education student at the aforementioned University. I am carrying out a study on how mathematics examinations are accessible to students with HI. Since your institution is sampled, I would like you to participate in the research study.

Purpose of this research study

The purpose of this study is to investigate whether mathematics examinations are accessible to students with HI.

Procedure

In this study I intend to interview the Head of Mathematics department, mathematics teachers and five form four students and have a look at work documents namely, teacher-made formative and summative mathematics examinations marked students' mathematics examinations and KCSE exams results. I wish to observe the learners sit for standard and adapted mathematics examinations in the form four classroom and record an interview and focused group discussion. All the findings will be solely for this study.

Risks or benefits

There is no risk involved in this study except using a few minutes of the teachers' busy schedules during the interviews and observation in class. The research findings will be shared with the mathematics department and may help in forming a basis for further research and/ or improving the assessment of mathematics.

Right of refusal to participate and withdrawal

You are free to choose to participate in the study. You may refuse to participate without any loss of benefit to which you are otherwise entitled to. You may also withdraw anytime from the study without any adverse effect on the management of your school or any loss of benefit to which you are otherwise entitled to. You may also refuse to answer some or all the questions if you do not feel comfortable with the questions.

Confidentiality

The information obtained from your school will remain confidential. Nobody except the principal investigator has access to it. The name and identity of your school and students will also not be disclosed at any time. However, data may be seen by Ethical Review Committee and may be published in a journal and elsewhere without giving your name or disclosing your identity.

Authorization

You will be asked to sign a consent form to indicate your voluntary participation. You will receive a copy of the form. Your consent does not take away any legal rights in the case of negligence or other legal faults of anyone who is involved in the study. Nothing in the consent form is intended to replace any applicable national, state or local laws.

Available sources of information.

For further questions, you may contact the principal investigator: Peter Mwangi Kabethi.

Phone No. +254714922656 (SMS ONLY)

Email: peter.kabethi@scholar.aku.edu

Appendix I: Informed consent for the use of information and pictorial Data

This is to inform you that information, photographs and video recordings would be taken during the interview

from……………………………………to…………………………………..

at………………………………………………………………………………………

…………………………………………………….

On behalf of the Aga Khan University, Institute for Educational Development East Africa (AKU-IED, EA); I write to seek your permission to use information, photographs and video presentation and any other legitimate activity carried out by AKU.

Kindly indicate your consent by signing the section below.

Thank you,

Signature: ________________________________

Name: **Peter Mwangi Kabethi**

Designation: **Principal Researcher**

Date: ________________________________

CONSENT FORM

I agree to let the photographs and/ or video data be used for the purposes mentioned above on behalf of my institution.

I reserve the right to withhold the consent and it will not be incumbent upon me to provide the reason for doing so.

Name:

____

Designation: ____

Institution: ____

Signature: ______________________________ **Date**: ___________________

Appendix J: Ethical consent form for parent/ guardian of a minor

Research topic: Accessibility of mathematics examinations to students with HI.

I have been informed of the requirements of the study and fully understand what will be expected of my child/ student as a participant. I, therefore, agree for my child to be amongst the participants in this study with the following conditions. *Put a tick (□) as appropriate against each statement;*

- □ *This study focuses on the accessibility of mathematics examinations to students with HI.*
- □ *The purpose of the study is to investigate the extent to which mathematics examinations are accessible to students with HI.*
- □ *The identity of my child/ student as a research participant will remain confidential and the name and responsibility/ role in the school and name of the school will not be used at any point in the research or in reporting the findings.*
- □ *My child/student maintains the right to withdraw from the study at any point in time.*
- □ *My child/ student will not be judged by any answer that she or he provides.*
- □ *My child/student will participate in an interview.*
- □ *The voice/video of my child/ student can be recorded during the interview.*
- □ *My child's/ student's mathematics examinational papers will be checked and photographed.*
- □ *My child/ student holds the right to refuse to answer any question.*
- □ *A summary of the final report of the study will be shared with the school.*
- □ *The findings of this study may be used in conference presentations and academic publications.*

I express willingness for my child/student named___________________________to participate in this study by signing this form.

Name of the parent:……………… Signature: …………………Date: ……………..

Name of the school: ……………………………………………………………

Researcher’s name: Peter Mwangi Kabethi

Researcher’s contact: P. O Box 125, Dar es salaam

Appendix K: Assent form for learners

ASSENT FORM FOR LEARNERS

I have been given full information on the aim, the purpose and my participation in the study by the researcher from Aga Khan University, Institute of Educational Development- Eastern Africa.

I, therefore, agree to be amongst the participants in this study with the following conditions. *Put a tick (□) as appropriate against each statement.*

- ☐ *The purpose of this study is to investigate the extent to which mathematics examinations are accessible to students with hearing loss.*
- ☐ *I will not be judged by any answer that I will give.*
- ☐ *My identity will not be disclosed in the research findings.*
- ☐ *My past and present mathematics examinations will be checked and photographed.*
- ☐ *I will participate in an interview.*
- ☐ *I have been briefed verbally and in writing about the purpose and duration of the study.*
- ☐ *My parent/ guardian has given consent on my behalf.*

By my signature, I agree to be a participant in this study.

Name:

____

Name of the Institution:

____

Signature of the participant:

____

Date:

____

Appendix L: consent form for the principal

The study focuses on the accessibility of mathematics examinations to students with HI in Kenya.

I, ………………………………………………………………………….. (Principal's name) of……………………………………………………………… (School name), agree to participate in the above-mentioned research conducted by Mr. Peter Mwangi Kabethi the researcher, a student at the **AGA KHAN UNIVERSITY-** Institute for Educational Development, Eastern Africa. I understand that as a participant in this study:

- ☐ *My name and the Name of our school will remain confidential to the researcher.*
- ☐ *The information I share will not be used for any other purpose apart from the purpose of this study.*
- ☐ *I will share relevant documents and give time to a face-to-face interview that will be video/audio recorded.*
- ☐ *I have the right to decide on the documents to give and the documents not to give.*
- ☐ *I have the right to decide on the questions to answer and the not questions to answer during the interview.*
- ☐ *I have the right to withdraw from the study at any time if my rights are violated.*
- ☐ *I will get to know the research findings by receiving a summary of the report of the study.*

By signing this consent form, I express my willingness to take part in the study because I have read and been informed verbally about the purpose of the study.

Name of Participant……………………………Signature………
Date…………………

Signature of the researcher………………….…..
Date………………………………………

Appendix M: Research clearance from AKU

THE AGA KHAN UNIVERSITY

Ref.: *AKU-IED, EA/2021/168/fB* **Date:** *August 20th, 2021*

Peter Mwangi Kabethi,
Aga Khan University,
Institute for Educational Development East Africa (IED EA),
P.O Box 125,
Dar es Salaam,
Tanzania.

ETHICAL CLEARANCE CERTIFICATE

Dear Peter Mwangi Kabethi,

This is to certify that your research project entitled, ***"Accessibility of mathematics tests to students with hearing impairment: A case study of a school for the deaf in Nyeri county - Kenya."*** undertaken as part of the dissertation project in the master of education program at IED EA has been approved for Ethical Clearance.

Yours Sincerely,

Dr. Fortidas Bakuza
Chair ERC - Tanzania

Cc: Dissertation Supervisor: Dr. Mweru Mwingi

Salama House, 344 Urambo Street, P.O. Box 125, Dar es Salaam, Tanzania Tel: +255 22 215 2293, 22 215 0051, Fax: +255 22 215 0875; Email: iedea@aku.eduwww.aku.edu

Appendix N: Clearance certificate from NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 601270

Date of Issue: 06/September/2021

RESEARCH LICENSE

This is to Certify that Mr.. Peter Mwangi Kabethi of Aga Khan University, has been licensed to conduct research in Nyeri on the topic: ACCESSIBILITY OF MATHEMATICS TESTS TO STUDENTS WITH HEARING IMPAIRMENTS: A CASE STUDY OF A SCHOOL FOR THE DEAF IN NYERI COUNTY-KENYA. for the period ending : 06/September/2022.

License No: **NACOSTI/P/21/12639**

601270

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document,
Scan the QR Code using QR scanner application.

Appendix O: Research Authorization by County Commissioner

THE PRESIDENCY

MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT

E-mail: nyericountycommissioner@yahoo.com
Telephone: 061 2030619/20
Fax: 061 2032089
When replying please quote

NYERI COUNTY COMMISSIONER
P.O. BOX 33-10100
NYERI

Ref. No. NYC/ADM 1/57.VOL.VIII/ (21)

Date: 7th September, 2021

Peter Mwangi Kabethi
P.O BOX 401-10101
KARATINA

RE: RESEARCH AUTHORIZATION

Reference is made to your letter dated 6th September, 2021 on the above subject.

Approval is hereby granted to carry out research on the topic "***Accessibility of mathematic tests to students with learning impairments a case study of a school for the deaf in Nyeri County.***"

The period of study ends on 6th September, 2022.

P. Mugo
For: County Commissioner
NYERI COUNTY

COUNTY COMMISSIONER
NYERI COUNTY

Appendix P: Research Authorization by County Director of Education

REPUBLIC OF KENYA

MINISTRY OF EDUCATION
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION

E-Mail –centralpde@gmail.com
Telephone: Nyeri (061) 2030619
When replying please quote

OFFICE OF THE COUNTY
DIRECTOR OF EDUCATION
P.O. Box 80 - 10100,
NYERI

CDE/NYI/GEN/23/VOL.IV/53

7th September, 2021

Peter Mwangi Kabethi
P.O Box 401 – 10101
KARATINA

RE: RESEARCH AUTHORIZATION.

Reference is made to Secretary National Commission for Science, Technology and Innovation Research License No: NACOSTI/P/21/2639 issued on 6th September, 2021 on the above subject.

I wish to inform you that you have been given authority to do your research on **"Accessibility of mathematics tests to students with hearing impairments: A case study of a school for the deaf in Nyeri County - Kenya." For the period ending on 6th September, 2022.**

For: COUNTY DIRECTOR OF EDUCATION
NYERI
P. O. Box 80 - 10100, NYERI
Tel: 061-2030658

DANEL KARANJA
FOR: COUNTY DIRECTOR OF EDUCATION
NYERI

Copy to:

National Commission for Science,
Technology and Innovation,
P.O. Box 30623-00100
NAIROBI