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EXPLORING THE EXPERIENCES OF TEACHERS TEACHING MATHEMATICS TO HEARING-IMPAIRED LEARNERS IN AN INCLUSIVE LEARNING ENVIRONMENT

By

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DECLARATION

I, Medupe Richard Tshabalala, declare that the master's research dissertation that I herewith submit at the University of the Free State is my independent work and that I have not previously submitted it for qualification at another institution of higher education.

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ABSTRACT

Mathematics teaching is among teachers' most challenging yet rewarding tasks worldwide. However, teaching mathematics to deaf and hard-of-hearing learners has received less attention. Hence, this study explored teachers' experiences teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment. The study involved two qualified mathematics teachers and was carried out in a special school in the Motheo District, Free State. Data was collected through lesson observations of two consecutive lessons per teacher, followed by a semi-structured interview with the teachers. Piaget's constructivism and Vygotsky's sociocultural learning theories guided the study. The reflexive thematic analysis used for data analysis revealed that language is at the heart of the difficulty for the teacher teaching mathematics to deaf and hard-of-hearing learners and that sign language should be at the interface for pedagogy. It was also discovered that there were no didactic approaches for teachers to teach mathematics to deaf and hard-of-hearing learners. However, in the study's data collection, teachers used spiral approaches, demonstration, and peer tutoring to enhance mathematics teaching for deaf and hard-of-hearing learners. It was then concluded that repetition and demonstration are vital in teaching mathematics to HI learners. Based on the study's findings, the recommendations were that teachers teaching mathematics must undergo in-service training to be equipped with the strategies and skills to teach deaf and hard-of-hearing learners. It is also recommended that teachers familiarize themselves with technological tools that enhance mathematics teaching to deaf and hard-of-hearing learners. The study may contribute to different stakeholders in the education system in several ways. This study may help other special education teachers learn and understand the situation around teaching mathematics to deaf and hard-of-hearing learners. Mathematics teachers are likely to develop strategies to improve mathematics teaching in special schools for deaf and hard-of-hearing learners after the findings in this study. The study has great potential for policymakers to use the findings to develop policies to address challenges experienced by mathematics teachers.

Keywords: Experience, Hearing-impairment, Mathematics teaching, Inclusive education, Mathematics teacher

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LIST OF ACRONYMS/ABBREVIATIONS

ANS	Automated Nervous System
ASL	American Sign Language
dB	Decibels
DBE	Department of Basic Education
DoE	Department of Education
FSDoE	Free State Department of Education
HI	Hearing-Impairment
HP	Hearing peers
MKO	More Knowledgeable than other
NCTM	National Council of Teachers of Mathematics
PSL	Pakistan Sign Language
QASOS	Quality Assurance and Standard Officers
RTA	Reflexive Thematic Analysis
RTS	Reciprocal Teaching Strategies
SASL	South African Sign Language
SEN	Special Education Need
TA	Thematic Analysis
UFS	University of the Free State
UNESCO	United Nations Educational Scientific and Cultural Organization
WHO	World Health Organization
ZPD	Zone of Proximal Development

CHAPTER 1
INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

"Teaching is said to be the passageway through which education reforms must travel if they are to make it through the doors of the classroom and improve student learning" (Stigler, 1999)

Mathematics teaching is one of the most challenging yet rewarding tasks for many teachers worldwide, and its abstract nature makes it even worse for learners with special needs. Despite its abstractness in nature, Das (2019) infers that mathematics is teaching scientific thinking to the students, and this thinking skill is a mental block because the student is required to take the exam through the tests. Mathematics has been a largely neglected subject in the education of deaf and hard-of-hearing children (Bunch et al., 1987; Lavanya & Vaijayanthi, 2019). Consequently, Spaull and Kotzee (2015) instigate that mathematics education in South Africa is concerning. Studies have revealed that mathematics teachers in South Africa generally lack the content and pedagogy to teach mathematics, especially to learners experiencing a deficit in learning from primary school, which later causes underperformance in final schooling years (Graven, 2016; Taylor & Taylor, 2013). However, Das (2019) puts it that there is a high attrition rate, which causes a challenge for schools to provide qualified special education teachers for learners with disabilities, primarily because of the continuing teacher shortage. This growing and pervasive shortage of special education teachers has been reported to threaten the quality of education of learners with disabilities. According to Taylor (2011), if interventions are to be done, they must first deal with teachers' understanding of the deficit they are dealing with and ways to address it to develop learners' mathematical proficiency successfully. This study sought to find the teachers’ knowledge of the deficit 'hearing impairment' and how they address this learning disability in their daily teaching.

According to Genc and Erbas (2020), teachers' beliefs are essential for promoting mathematical literacy for all learners, and they should use appropriate instructional strategies. It is thus justifiable that teachers are important assets and investments in improving student learning in the regular education system. If the government fails to invest in them, they will fail to execute their duty. This research also sought mathematics teachers' methods and strategies to promote mathematical literacy in inclusive learning environments. It is included in Section 5(1) of the South African Schools Act (84 of 1996) that "Schools must admit learners and serve their educational needs without unfairly discriminating them in any way". Therefore, Khathare (2020) infers that teachers must create a conducive environment where learners share mathematical ideas during mathematics tasks, and the setting for the research was an inclusive learning environment. In reaction to the South African Schools Act, Genc and Erbas (2020) also indicate that teachers need to be inclusive of all learners and that mathematics literacy does not mean everyone has to be literate on the same level. Still, the teacher's responsibility is to ensure that all learners are mathematically literate according to their needs and interests. To be mathematically literate means that learners are expected to be familiar with and have enough understanding of the contexts that will allow them to use their mathematical knowledge (Genc & Erbas, 2020). Therefore, this dissertation reports on the study conducted in a special school in the Motheo District, Free State. Through this study, the experiences of teachers working with learners living with disabilities, especially deaf and hard-of-hearing learners, in an inclusive school were explored. Mathematics teachers have a significant role in ensuring that learners with hearing impairment (HI) receive an equal mathematics education to those of their hearing peers (HP).

1.2 BACKGROUND OF THE STUDY

Inclusivity has been one of the burning issues globally, and the goal has always been to ensure that members of society receive equal opportunities for all and to embrace the beauty of diversity among us. According to UNESCO (1994), inclusive education addresses and responds to all learners' diverse needs by increasing participation in learning, cultures, and communities and reducing exclusion from education. UNESCO (1994) reported that its primary goal for the education system is to create conducive learning for educators and learners to embrace the challenges and benefits of diversity.

In 1999, the Department of Education (DoE) in South Africa noted that they had not done enough to promote inclusive education (DoE, 1999).

However, in 2015, the report on the execution of White Paper 6 on Inclusive Education (2015) shows that the Department of Basic Education (DBE) ascertained the necessity for attitudes and commitments to change across the systems to implement inclusive education throughout South Africa, where training on a macro-scale should take place and monitored after that. Moreover, Le Hanie (2017) revealed that continuous training is a prerequisite for inclusion to be successful because not all teachers teaching at inclusive schools truly understand the concept of inclusion. It could be that not enough has been done to date because, in the Free State Province, there are still limited schools catering for learners with special needs, which indicates that the government could still be lagging behind its plan.

In the Free State Province, there are only two schools of this kind. The study, therefore, focused on schools in the Motheo District, the deep rural area of Mangaung Municipality. The school was established in August 1985, catering to about 200 deaf and hard-of-hearing learners. It is a Special Education Need (SEN) school for deaf and blind students from Year 3 up to Grade 12, hoping to offer a complete education and look after the well-being of learners from a different cross-section of personal, social, and economic backgrounds. The school plays a vital role in the community of Thaba-Nchu, focusing on the special needs of learners with deafness and some who are further disadvantaged by multiple disabilities from all walks of life.

There are multiple types of disabilities, such as those that affect a person's vision, movement, thinking, remembering, learning, communication, hearing, mental health, and social relationships. However, given the scope of work, the disability in question was hearing loss or impairment. The World Health Organization (2021) quotes the broad official definition of disabling hearing loss:

> *“Hearing loss greater than 35 decibels (dB) in the better hearing ear. Hearing loss may be mild, moderate, severe, or profound. It can be one ear or both and lead to difficulty in hearing conversational speech or loud sounds. They rely on sign language for communication.”*

Mathematics teachers in many parts of the world face more significant challenges when teaching math skills to deaf and hard-of-hearing learners because they are remarkably different from their hearing peers. There is also the issue of limited special education teachers for mathematics, where many districts find themselves in an unfortunate position of hiring unqualified personnel (McLeskey & Billingsley, 2008). One prevailing issue is communication between teachers and learners because of language. Like South Africa, in the United States of America, only a small number of teachers with deaf and hard-of-hearing learners could use American Sign Language in classrooms. In contrast, other teachers were not conversant in sign language (Rwoley & Heather, 2005). Nadal and Collet (2020) also support the notion that making sign language a core pedagogy requirement is critical; therefore, "sign-maths" were implemented in mathematics teaching. In teacher training for deaf and hard-of-hearing teachers, it is thus essential to incorporate sign language as one of the prerequisites. To prove the importance of incorporating sign language in pedagogy in Kenya, Muguna (2011) reported that most of the methods that were applied to teaching mathematics to deaf and hard-of-hearing learners, which indicated that the teachers were knowledgeable and aware of the deficit (diversity), included sign language, total communication, dramatizing, use of exact English, visual aids, pantomime, role-play, eye contact, lip-reading, gestures and use of signed English.

The deaf and hard-of-hearing learners were deemed different from their hearing peers regarding their visual reliability. Therefore, pedagogical considerations should be varied to suit the students' learning nature, needs, and interests. In South Africa, there has been a lot of emphasis on the use of participatory methods when teaching mathematics to deaf and hard-of-hearing learners (Prinsloo, 2000), and UNESCO (2010) has put forward that there is a dire need for teachers to develop more pedagogies for diversity, effective use of learning support, use of other experienced teachers and adequate use of resources for learners to participate fully. Five years later, Spaull and Kotze (2015) indicated that despite all the recommendations made by UNESCO, most people agree that mathematics education for deaf and hard-of-hearing learners in South Africa is still concerning. Therefore, for this reason, the intensive search for pedagogies could be undertaken by teachers of the deaf and hard of hearing to improve mathematics skills in South Africa.

In the United States of America, teachers were reported to use mobile devices to teach mathematics education to deaf and hard-of-hearing learners. In their study, mobile games, such as instructional games, were an area of interest rapidly developing for use by deaf and hard-of-hearing learners as a targeted sub-population (Shelton & Parlin, 2016). Parlin (2016) further indicated that these mobile games are self-reporting results to the learners where they learn orienteering skills and help deaf and hard-of-hearing learners practice reading to solve mathematical problems. According to the teacher's instructions, this strategy can be implemented in South African schools on conditions that learners may only use cell phones in the classroom for educational purposes (DoE, 2018). Therefore, it is good practice to incorporate e-learning in mathematics teaching for the deaf and hard-of-hearing.

Moreover, in Tanzania, Mtuli (2005) revealed that teachers and learners in a secondary school for deaf and hard-of-hearing students had insufficient training and learning facilities. The preparation to meet the new inclusive education system for learners and teachers was minimal. In South Africa, like other countries, Le Hanie (2017) indicated that teachers used technology in various ways to teach mathematics to deaf and hard-of-hearing learners.

Besides the use of technology, a study by Khathare et al. (2020) revealed that there is still hope for teachers of deaf and hard-of-hearing learners and recommended that different methods may be employed, methods such as demonstration, participatory education, educational technology and peer tutoring, especially teaching mathematics to deaf and hard-of-hearing learners for good performance. Presenting additional methods, visual props, and technological assistive devices will improve learning-ability and produce more significant results in qualitative skills performance in mathematics class teaching and mathematical operations. In South Africa, Le Hanie (2017) reported that teachers often find it challenging to use visual lessons, as it consumes a lot of preparation time. Considering all of this, the study intended to explore the teaching of mathematics to deaf and hard-of-hearing learners in a selected inclusive school in the Motheo District.

1.3 RATIONALE FOR THE STUDY

My experience as a mathematics teacher at a deaf school in the Thabo-Mofutsanyana District triggered me to conduct this study. It was the first experience in my teaching career to see a school faced with this situation. The consequences of poor teaching methods motivated me to conduct the study since they negatively impacted the learners' performance. Negative results in accounting classes, demotivation and learners failing the subject were some of the negative consequences of the experiences the teachers had in the Thabo-Mofutsanyana Special School for the Deaf.

The negative consequences of teaching deaf and hard-of-hearing learners resulted in the migration of teachers to mainstream schools, leaving a shortage of teachers behind. Teachers, especially novice teachers, are experiencing severe stress because they are teaching their subjects in a language they do not understand (SASL) and for which they were not trained. The experience of teaching a non-hearing person who only communicates with sign language was indeed an experience on its own, considering that the abstractness of the language of mathematics was enticing. Therefore, we needed to explore the mathematics teachers' perspectives in dealing with this situation. Hence, the study aimed to examine the experiences of the teachers who teach mathematics to deaf and hard-of-hearing learners in the selected special school.

This study may help other special education teachers learn and understand the situation around teaching mathematics to deaf and hard-of-hearing learners. Mathematics teachers are likely to develop strategies to improve mathematics teaching in special schools for deaf and hard-of-hearing learners after the findings in this study. The study has great potential for policymakers to use the findings to develop policies to address challenges experienced by mathematics teachers.

The study has advantageous potential for researchers, especially those focusing on the experiences of teachers teaching mathematics to deaf and hard-of-hearing learners, which they may wish to use this study to inform further research studies.

1.4 STATEMENT OF THE PROBLEM

Deaf people across the world generally experience inadequate access to education programs. Since I am the mathematics teacher of deaf and hard-of-hearing learners in a special school in the Free State, I have noticed many attempts made by the teachers to address the mathematics performance of deaf and hard-of-hearing learners, such as the extension of the teaching time, invitation of other mathematics teachers from different schools and the organization of extra classes, but no visible change has occurred in the school. According to Owiko et al. (2018), the consistently low performance of learners with hearing impairment in mathematics is a worrying phenomenon compared to regular learners in education. The inadequate teacher refresher programs have been deemed a problem. Compared to other parts of the world, knowledge of teachers' experiences remains lacking in South Africa. Hence, the necessity of conducting the current study is to explore the experiences of teachers teaching mathematics to deaf and hard-of-hearing learners at one of the South African special schools in the Free State.

Special schools are faced with special teacher attrition, as it worsens the shortage of teachers, leaving many districts in the unfortunate position of hiring unqualified personnel and requiring limited resources to be directed towards recruitment and induction (McLeskey & Billingsley, 2008), meaning that many special education teachers might be migrating away from special schools, leaving special schools with unqualified teachers, who struggle to teach learners with special education needs. However, my literature search has not yielded much regarding the perspective of teachers teaching mathematics to deaf and hard-of-hearing learners, particularly in South Africa Free State. I believe by conducting this study, the gap in the literature will be closed.

1.5 AIMS AND FOCUS ON THE STUDY

The study aimed to explore the mathematics teachers' experiences in an inclusive learning environment teaching deaf and hard-of-hearing learners.

1.6 OBJECTIVES OF THE STUDY

The aim is comprehensive; therefore, the following objectives were formulated to achieve the aim:

- To establish mathematics teachers' knowledge of deaf and hard-of-hearing learners' needs for mathematics in the selected school.
- To establish methods employed to teach mathematics to deaf and hard-of-hearing learners in the selected school.
- To identify the possible challenges for teaching mathematics to deaf and hard-of-hearing learners in the selected school.

1.7 RESEARCH QUESTIONS

This research sought to answer the following questions:

1.7.1 Primary research questions

- How do teachers teach mathematics to deaf and hard-of-hearing learners in an inclusive school?
- What are the experiences of mathematics teachers teaching deaf and hard-of-hearing learners?

1.7.2 Sub-research questions

The following sub-questions were used to help answer the primary research question:

- What knowledge of deaf and hard-of-hearing learners do mathematics teachers have?
- Which methods are currently used to teach mathematics to deaf and hard-of-hearing learners?
- What are the challenges to teaching mathematics to deaf and hard-of-hearing learners?

1.8 SIGNIFICANCE OF THE STUDY

There was a small report on the teachers' experiences in an inclusive environment teaching learners with hearing impairment mathematics. This research is hoped to contribute to understanding deaf culture, mathematics teaching, and learning strategies to help improve the literacy level of mathematics education in inclusive schools. Curriculum, language proficiency, and methods of delivery (teaching) in the mainstream uphold the learners' values and prepare them for life beyond high school, which is not the same for learners living with special needs in an inclusive environment. It was anticipated that through the participation of the teachers in this research, this study would offer a platform for inclusive school stakeholders, especially the managers, to reflect on available resources and strategies, if any, and how they may assist the schools in improving academic performance. It was hoped that this research would contribute to knowledge creation in these areas.

1.9 OVERVIEW OF THE THEORETICAL FRAMEWORK

This study is underpinned by Vygotsky's sociocultural learning theory and Piaget's social constructivism as theoretical frameworks. The two theories were chosen to guide the study and frame the research questions holistically. This chapter briefly discusses the aforementioned theories, but lengthy discussions are in Chapter 2. The reason for choosing these two frameworks was motivated by the value they contribute to this study.

1.9.1 Vygotsky’s sociocultural learning theory

Vygotsky's social learning theory guided the study. According to Vygotsky (1978), social learning combines cognitive development and culture, not the developmental stages that underlie cognitive development. Vygotsky argues that learning differs across cultures rather than being a universal process steered by structures and processes.

1.9.1.1 Piagetian constructivism

The study was also underpinned by Piagetian constructivism. Matthew (1998) believes Piagetian constructivism is part of a more significant historical setback to the modernist's conception of objective reality in general and the use of empirically validated specific teaching methods. Based on educational practices, Jean Piaget's theoretical practices have had a noteworthy influence.

1.10 CLARIFICATION OF KEY CONCEPTS

The clarification of key concepts in this study is done briefly in this section and is later detailed in Chapter 2; thus, only the meaning of each is provided here.

1.10.1 Hearing impairment

Hearing impairment is a concept used as an umbrella for all degrees of hearing loss, which includes hard-of-hearing and deafness. According to the University of Washington (2017), many hearing-impaired prefer being called Deaf or Hard-of-hearing, depending on their degree of hearing, because hearing impairment to them is a deficit or abnormality. The two categories are commonly known for their inability to hear their voices, although they may also have speech that is difficult to understand.

1.10.2 Inclusion

The term ‘inclusion’ is broad and could be used in vast areas of education. For this research, the term will be narrowed down to inclusivity within the curriculum or inclusion in learning and an inclusive learning environment. Still, a vast understanding is detailed in Chapter 2 of the study.

1.10.3 Mathematics

The subject of mathematics is the numerical and calculation part of man's life and knowledge. It helps man to give exact interpretations to his ideas. Mathematics deals with quantitative facts and relationships, as well as with problems involving space and form. Mathematics occupies a critical and unique position in the school curriculum from the very elementary level. It has been made a compulsory subject of study from the primary level up to Grade 12 (Lavanya & Vaijayanthi, 2019).

1.10.4 Experiences

Dewey defined experience as the interaction of the environment and organisms. He describes it as dynamic, unified, communicative, historical and socially oriented. Dewey describes the experience as “dynamic”; it constantly changes because there will always be fresh and new interactions between organisms and the environment (Acampado, 2019).

1.11 OUTLINE OF THE CHAPTERS

Chapter 1: Background of the study

Chapter 2: Theoretical framework and literature review

Chapter 3: Methodology

Chapter 4: Data analysis

Chapter 5: Findings and discussions

1.12 CHAPTER SUMMARY

Chapter 1 was an orientation to the study. It served as an introduction by providing the background and rationale for conducting the survey. As a researcher, I was very interested in the teaching experiences of the teachers who teach mathematics to deaf and hard-of-hearing learners. My experience as a teacher in a circuit where the school experienced this phenomenon evoked such an interest.

The next chapter discusses the literature review on exploring the experiences of teachers teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORKS

2.1 INTRODUCTION

This study aimed to explore teachers' experiences teaching mathematics to deaf and hard-of-hearing learners. To realize this purpose, this study focused on Vygotsky's sociocultural learning theory and Piaget's constructivism as theoretical frameworks informing this study. In this regard, attention is focused on the historical origins of the two theories, after which the focus shifts to the literature. The arguments for employing the two theories and how they fit the study's objectives are discussed. The key concepts that underpin this study were discussed in a previous chapter. However, other concepts are discussed in this section. These are inclusion, hearing-impairment and mathematics.

2.2 THEORETICAL FRAMEWORK

The subsection discusses the two theoretical frameworks in this study: sociocultural learning theory and constructivism. The discussions begin with the origins, principles, nature of reality, the relationship between the researcher and participants, and the role of the researcher according to each of these theoretical frameworks.

2.2.1 Historical background (origin and principles) of Vygotsky's sociocultural learning theory

One of the lenses the study researched was through the social learning theory of Vygotsky. According to Vygotsky (1978), social learning combines cognitive development and culture, not the developmental stages that underlie cognitive development. Vygotsky argues that learning differs across cultures rather than being a universal process steered by structures and processes.

2.2.1.1 Principles of Vygotsky's sociocultural learning theory

There are three principles of Vygotsky's social learning theory: Zone of Proximal Development (ZPD), more knowledgeable others and scaffolding.

a) Zone of Proximal Development (ZPD)

The idea of Vygotsky (1978) of the Zone of Proximal Development (ZPD) states that learners and those learning from (teachers) co-construct knowledge, making the social environment where learning takes place have a considerable impact on how and what they think about. This social environment contains cognitive and linguistic skills, in which, according to Vygotsky (1978), language and thought are intertwined for about three years, becoming a sort of internal dialogue for understanding the world.

Vygotsky talks about elementary mental functions, which he refers to as the basic cognitive processes of attention, sensation, perception, and memory. Children improve themselves by using those basic tools in interactions with their sociocultural environment, using whatever their culture provides. In the case of memory, for example, Western cultures tend towards note-taking, mind-maps, or mnemonics, whereas other cultures may use memory tools, like storytelling.

The theory deduces that teachers apply appropriate pedagogy strategies to improve mathematics performance among learners with hearing impairments if applied in mathematics. According to Christmas et al. (2012), teaching mathematics in the child's zone of proximal development is taken as a way to improve the deaf or hard-of-hearing learner's performance.

b) More Knowledgeable Other (MKO)

According to Vygotsky (1978), the More Knowledgeable Other (MKO) is the expert with greater knowledge than the child. Saul (2023) infers that MKO works collaboratively with the child operating in the zone of proximal development, where the child dependently does a bit of learning they cannot do on their own. Shaffer (1996) gave an example of a learner who did not perform well given their first jigsaw in an attempt to solve a puzzle.

The father then sat with the child and demonstrated some basic strategies, such as finding all corners/edge pieces, providing a couple of pieces for the child to put together, and offering encouragement when she did so. In the current study, the teacher collaboratively works with deaf and hard-of-hearing learners in mathematics class, ensuring that the learning material is translated into the language they understand and ensuring that sign language is at the interface of the pedagogy, as well as demonstrating the concept with examples accessible to the child's knowledge and constantly offering encouragement when learners solve the problems independently.

c) Scaffolding

Scaffolding is the stage where the learner has evolved to learn more, independently enlarging the zone of proximal development. For Vygotsky (1978), language is at the heart of scaffolding because it is the primary means by which the MKO and the child communicate ideas. When language is internalised, it is enormously influential in cementing understanding of the world. He further emphasises that the internalisation of speech (a child's inner voice) becomes private, whereas social speech differs because it happens among people. The bottom line is that the richer the sociocultural environment, the more tools will be available to the child in the ZPD and the more social speech they will internalise as private speech. It does not take a genius to prove that the learning environment and interactions are everything (Vygotsky,1978). The teacher or knowledgeable peer mediates and scaffolds the learner through this theory. Still, individual differences make it challenging for teachers to identify every learner's zone of proximal development. However, Christmas et al. (2012) infer that despite the setbacks, ZPD, if correctly applied, could improve mathematics performance in schools of deaf and hard-of-hearing learners.

2.2.2 Historical background (origins) of Piagetian constructivism

The other lens through which the study was researched was Piagetian constructivism. Matthew (1998) believes Piagetian constructivism is part of a more significant historical setback to the modernist's conception of objective reality in general and the use of empirically validated specific teaching methods. Jean Piaget's theoretical practices have had a noteworthy influence on educational practices.

2.2.2.1 Principles of Piaget's constructivism

Piaget's sociocultural constructivism has two principles: Education as a scientific endeavour and constructivism assumption in education.

a) Education as a scientific endeavour

Widely defined, relevant educational teaching practices are narrowed to the learner's instructional level without curbing developmental theory. As a result, the focus shifts primarily from the child's developmental focal point to an emphasis on the curriculum (i.e. instructional relevant level and materials) and an environment in which instructions take place (teacher behaviour) (Carnine et al., 1996).

Comprehending the concept of educationally appropriate practice is the view that schooling is regarded as an intervention made to produce some identifiable adjustment/change on a range of distinctive socially valued dimensions in the child's development (Demo, 1995). Mayer (2000) further underpins that educational theory is vital, and for it to be practical and durable, it must undergo empirically based tests of refutation. By doing so, the self-correcting mechanism of the scientific methods gives off a process in which a particular theory and related practices can be accepted, discontinued, or modified.

b) Constructivist assumptions in education: considering data.

Developing a mentalist's belief in the natural predisposition towards learning and not distracting the natural learning process are the key assumptions underpinning the current constructivist teaching practices. One crucial notion developed by mentalists contends that learners have an active role in interpreting the learning process; thus, education cannot be teacher-directed but child-directed. Based on these assumed realities, constructivist teachers adapt their teaching style, approach and content to accommodate the child's developmental stage and learning needs. According to Waite-Stupiansky (1997), children need to progress through levels of representation at a rate that fits their level of understanding. Children may achieve only surface-level memorisation without deeper understanding if highly abstract symbols are presented too quickly, such as flashcards with printed words".

The belief that emphasizes the importance of a learner's more profound level of understanding is assumed to occur if social interaction and context occur. Waite-Stupiansky (1997) states that the context provided by social interactions among peers is a natural learning environment in which logical reasoning can develop. The feedback is usually immediate, and motivation to succeed is high".

Matching the teaching style to the child's aptitude for the general or special education content, while a tenet of developing mentalism and constructivist practice is not an empirically defensible practice context, is necessary for learning to occur. The claims for contextualized learning are overstated and reject the considerable body of research on the importance of decontextualized learning, as anyone who has ever played tennis, a musical instrument, or learned to drive a car will attest. There is well-documented evidence that (1) human cognitive processing breaks down large tasks into smaller ones, and (2) learning transfer and generalization occur and are more efficient than only stimulus-specific context learning (Stone & Clements, 1990).

2.2.3 Epistemology and ontology

2.2.3.1 Epistemology

This element focuses on the understanding the researcher needs to acquire to deepen their understanding of research by focusing on the nature of human knowledge (Kivunja & Kuyini, 2017). Based on the theoretical frameworks guiding the study, it was important to note that knowledge is co-created and that there is no single truth of reality. As a result, the epistemology of the study assisted the researcher in understanding that to deepen their understanding of the teaching of mathematics to deaf and hard-of-hearing learners, they allowed the space where participants created knowledge by sharing their lived experiences. The researcher guides this study as a facilitator, and their duty is to guide their participants. For knowledge to be created, the researcher needs other stakeholders to share knowledge; however, they must have experience with it and probe into the scope of the study.

2.2.3.2 Ontology

Ontology is a branch of philosophy dealing with the assumption that something is real or makes sense (Scotland, 2012). Furthermore, according to Kivunja and Kuyini (2017), ontology is believed to be known and helps conceptualize the nature and form of reality. The ontology, according to the theories guiding the study, assisted me in understanding that reality is co-created. In this study, the realities of the teachers are explored when they share their experiences teaching mathematics to deaf and hard-of-hearing learners. As a researcher, I then understood that there are different realities to the same phenomenon; it depends on how individuals experience it. The two teachers shared different perspectives due to their realities of teaching mathematics to the same disability (hearing impairment) at the same special school. These multiple realities were seen in the methods and challenges shared by the two teachers in the semi-structured interview sessions. The researcher's role in exploring the teachers' realities was that of a facilitator. I understood that I needed not to empower them but to allow them a space where learning is exchanged among us but with proper guidance. The purpose of ontology in the study was to help me answer the research questions on the methods and challenges used by the teachers in the study, where the researcher was taught that there are multiple realities to a single phenomenon.

2.2.4 The role of the researcher

The theoretical framework places the researcher as one of the study's knowledge creators without limiting the participants' roles in both theories. According to Mathobela (2015), the researcher transforms the participants' experiences from verbal to textual form. These descriptions of the participants' experiences were not dependent on the researcher as someone who possesses the power to create knowledge from the participants. The role of the researcher as a facilitator depowers themselves. It allows the participants to take centre stage, guiding them as knowledge creators in the study through their lived experiences as teachers of mathematics to deaf and hard-of-hearing learners.

2.2.5 The relationship between the researcher and co-researchers

The relationship between the researcher and its participants was such that the researcher and the participants were knowledge creators. Through sharing their lived experiences, the participants contributed to the knowledge creation in the study just as much as the researcher. The researcher and participants have distinct roles in creating knowledge, where the foundation of their relationship was built from common understanding, mutual trust and respect.

According to the theoretical framework guiding the study, the researchers, as facilitators of the study, allowed themselves to be on the same footing as their participants, where learning was exchanged among them as both parties are significant contributors of knowledge creators in the study and participants were assured of the power they hold in the study. Mokoena (2017) support this motion and infers that participants feel accommodated in the study and have participated in their emancipation and that of their school. This gesture of harmonious relationship between the researcher and participants is made possible by striving for a common goal of finding solutions to the challenges presented in the study experienced in the contexts of schools.

2.2.6 Rhetoric

Michael (2002) implies that rhetoric is how researchers use language in their discussions, which affects the meanings of the words in a connotative manner. According to the theoretical framework of this study, the type of relationship employed by the researcher and participants is such that both parties hold equal powers as knowledge contributors to the study. Consequently, the researcher's use of language in their discussions will not be dictating because both the researcher and the participants have the common understanding that they learn from each other. Therefore, the participants are allowed to express how they feel or think.

2.2.7 The relevance of bricolage for the study

The focus of this sub-section is to justify the choice of Vygotsky's sociocultural and Piaget's constructivist theories for this study over other theoretical frameworks. Using both theories as an anchor for this study places mathematics teachers and deaf and hard-of-hearing learners at the centre of the research process. According to Matusov and Hayes (2000), Piaget and Vygotsky were the most inspirational child development psychologists and theoreticians of learning. In their claims, Piaget focuses on the individual as an actor and active learner; his critique of existing educational and social institutions often hinder cognitive development; he claims that cooperation and dialogue of power-equal partners is necessary for individual growth. Moreover, Vygotsky emphasises semiotic, tool mediation, activity and guidance, and his claim that history, culture, institutions and society are vital for understanding the child's development keeps attracting educators (Matusov & Hayes, 2000).

Using both theories resonates with my idea that deaf and hard-of-hearing learners as active learners in the study require an educational and social institution encompassing semiotic and tool mediation. Moreover, teachers are facilitators who guide cognitive development and ensure power-equal partnering. Both theories, when merged, aim to advance the child's cognitive development.

Moreover, Scott and Palinscar (2013) infer that the sociocultural theory of cognitive development also accounts for the role that experience plays in advancing development, thus accommodating Vygoskian ideas about the social nature of learning. This is why the measure of expertise of the teachers in an inclusive environment teaching mathematics to deaf and hard-of-hearing learners plays a significant role in their ability to divulge the teaching of a learner with heating-impairment.

2.3 OPERATIONAL CONCEPTS (TITLE KEYWORDS)

This sub-section intends to define and clarify key concepts in the study to mitigate the misconceptions and misinterpretations a reader may develop reading this study.

2.3.1 Inclusion

As was previously stated in Chapter 1, the concept of inclusion is broad and could be used in vast areas of education. According to the DoE (2001) and Mamadjanovna et al. (2022), inclusion means all learners should get support because children with disabilities need a friendly educational environment where teaching strategies developed are best suited for the learners' learning needs. For this research, the concept of inclusion will be narrowed down to inclusivity within the curriculum or inclusion in learning and an inclusive learning environment. Mamadjanovna et al. (2022) further allude that inclusive approaches render opportunities for children to become part of society; thus, correctional organisations are developing a closed world for the child where attention is focused on their "lack". This inclusive approach involves the development of programs designed specifically for the "lack", wherein implementation is done in isolation from boarding schools.

According to Cliffe (2012), inclusive curriculum practice refers to making the curriculum accessible to learners experiencing barriers to learning by developing, refining, and designing programs of study best suited for their learning needs. To achieve this, various stakeholders and professional support should collaborate to dissolve the barriers and move toward the goal of inclusive curricula. According to Gravestock (2011), the modes in which mathematics is communicated may be the reason for technical and pedagogical barriers. The latter author further claims that mathematics is a cumulative and abstract subject in nature, so concepts may not be fully assimilated in a stipulated time, impacting teaching and assessment design. Therefore, the mathematics team within the school should meet with support professionals and collaborate to identify barriers specific to mathematics amongst deaf and hard-of-hearing students, find practical solutions, and design inclusive curricula for the future.

In inclusive classrooms, closer attention to incorporating multi-level teaching, learning, and assessment in lesson planning and teaching strategies is crucial. It must be devised (Nel, 2013) because Education White Paper 6 (EWP6) asserts that inclusive education acknowledges diversity within our classrooms and declares that all learners can learn when supported. The fundamental idea is that every child should belong, learn, and engage and that inclusive settings provide support and attend to the diverse needs of all learners (Hanna et al., 2022).

In promoting educational inclusion, technological progress and its implementations significantly improve the quality of education, specifically for deaf and hard-of-hearing learners (Alejandro & Laberiano, 2022). Qureshi and Qureshi (2021) developed a mobile application that managed to reduce the learning time for sign language teachers. It focused on augmented reality to benefit students learning sign language through mobile-D methodology. This mobile application is not limited to befitting teachers only. Still, all deaf and hard-of-hearing students will be able to interact with their hearing peers and eliminate the standards of society where hearing-impaired have a more significant percentage of unemployment (Alejandro & Laberiano, 2022).

2.3.2 Hearing Impairment (HI)

Hearing impairment is commonly known as loss of hearing. Nazia et al. (2023) define hearing impairment, according to The World Health Organization (WHO), as a disability due to hearing loss of > 35 decibels in a better-hearing ear because the threshold for normal hearing is 20 Decibels (dB). Hearing impairment is regarded as a significant disability globally and dominates developing countries because of weak economic reforms. The severity of hearing impairment was positively correlated with the financial burden on parents and caregivers, mainly because of the absence of neonatal hearing screening for their stillborn, as it is costly.

Hearing impairment causes impediments in speech and language development because it is a disability that is imperceptibly hidden and usually escapes early intervention (Ahmetovic et al., 2021; Hou et al., 2020). According to Kumar and Teo (2021), when the child is not reacting to typical environmental sounds, parents suspect their children may be deaf and hard-of-hearing because the neonatal hearing screening was not performed after birth.

In a study conducted in Pakistan, parents were said to have been late in noticing impairment in their children, with 35% reporting it before the age of six months, 14,3% at 13-18 months, and the remainder even later (Nazia et al., 2023). According to Africa and Charleston Franklin (2019), even children with negative neonatal screening results can be diagnosed with hearing impairment later in their screening at school. It is noted with regret that a lack of knowledge and awareness regarding rehabilitation facilities and the critical age of language and speech development has a significant contribution (Kumar & Teo, 2021).

2.3.3 Mathematics

The subject of mathematics is the numerical and calculation part of man’s life and knowledge. It helps man to give exact interpretations to his ideas. Mathematics deals with quantitative facts, relationships, and space and forms problems (Lavanya & Vaijayanthi, 2019). Mathematics occupies a significant and unique position in the school curriculum from the very elementary level. It has been made a compulsory subject of study from the primary level up to Grade 12 (Lavanya & Vaijayanthi, 2019). According to Das (2019), mathematics is known as the discipline that is a queen of all subjects and a science-based course. It is thus regarded as a unique subject explaining the natural phenomena of life in society and encourages the acquisition of specialized science skills and knowledge. In the same vein, mathematics is said to have contributed to the development of civilization, and it grows in civilization as the quantity demand of people increases.

2.3.3.1 Mathematics teacher

Deaf and hard-of-hearing learners require a teacher with a special education qualification. According to Das (2019), teaching mathematics requires reading into concepts that contradict what the theory of mathematics implies, and sometimes teachers do not have sufficient knowledge. However, Levin et al. (2015) infer that projections indicate that there is currently a growing shortage of mathematics teachers in rural and high-poverty urban schools. Levin et al. (2015) further suggest that this problem is exacerbated by learners living with disabilities who live in poverty, reducing the likelihood that highly qualified special educators will teach them.

In the United States, 49 states reported a shortage of special teachers (National Coalition on Personnel Shortages in Special Education and Related Services, 2016), and enrolment in teacher preparation is lower than at any point since the National Center for Education Statistics (NCES, 2016). However, the shortage of special mathematics teachers seemed to be a growing global issue in rural and urban areas, but it was worse in poverty-stricken areas.

2.4 RELATED LITERATURE

This sub-section discusses the literature related to the experiences of the teacher teaching mathematics to hearing learners in inclusive learning environments, with a particular focus on mathematics teachers' knowledge of hearing impairment, the challenges, methods, critical conditions, threats, and risks, as well as indicators of success for teaching mathematics to deaf and hard-of-hearing learners from the international, regional, and local points of view. These are important because they provide insight into how mathematics is taught as an abstract subject, especially for learners with physical disabilities and hearing impairment.

2.4.1 Possible challenges for teaching deaf and hard-of-hearing learners mathematics in an inclusive learning environment

Mathematics is one of the challenging subjects for many students, and thus, it is a demanding job for teachers to teach it in a way that accommodates the learning needs and interests of all pupils. It is an even more significant challenge for teachers of the Deaf to teach mathematics to learners with learning disabilities because of its complexity in terms of language and operations as one of the setbacks. The National Council of Teachers in Mathematics (NCTM) challenged the traditional concepts of mathematics education. It eluded that unless Deaf students are taught accordingly, the standards will continue to impact their mathematics education negatively (Roberta et al., 1997), simply indicating that didactical approaches in mathematics do not match the learning needs of deaf and hard-of-hearing learners. Thus, Krause (2018) reported that mathematical discourse requires mathematical terms and signs for deaf and hard-of-hearing learners. So far, no didactical approach has helped teachers with the challenge of learning about mathematical ideas and attaching a mathematical sign to them, reflecting the same idea simultaneously (Krause, 2018). According to Kelly and Lang (2023), the combination of language, cognitive, and experiential factors has been attributed to poor performance in mathematics of deaf and hard-of-hearing learners. Pagliaro and Ansell (2000) dictated that in word problems in particular, the primary contribution to poor mathematics performance in general has been identified to be the inability of deaf and hard-of-hearing learners to comprehend the English language. Kelly and Lang (2023) also reported that deaf and hard-of-hearing learners perform poorly in problem-solving tasks. The reason suggested by Marshark et al. (2002) is that there may be a lack of persistence for deaf and hard-of-hearing learners in solving problems; for them, concepts usually appear less interconnected.

Nevertheless, school management and teachers were encouraged to familiarise themselves with technological tools and complementary learning approaches. Still, teachers mentioned the challenge with constructivist assistive technology in that it was difficult for them to integrate it into the curriculum since it is a new approach and learners are often distracted by it (Khathare, 2020). Edyburn (2000) and Khathare (2020) noted that technological assistive devices might greatly benefit learners, especially the ones living with disabilities in subjects such as mathematics, and thus, teachers and school management have the responsibility to make time to learn, practice, and become skilful with technological tools and complementary learning approaches to benefit their teaching and their student's learning. However, in most rural areas, schools cannot access technological tools; thus, learners with hearing impairment remain behind in mathematics compared to their hearing peers (Khathare, 2020).

One other challenge with teaching mathematics to deaf and hard-of-hearing learners is language. It was noted by Krishna (2017) that in American classrooms, only a few teachers use American Sign Language (ASL), while other teachers use variations of sign languages, such as signed English or total communication. According to Nadal and Collet (2020), learners appreciate the intensive use of sign language in the interface. The teachers' variation to sign language may negatively impact the learners' understanding and thus result in poor mathematics achievement. Mathematics is tied to English print, making English comprehension vital for deaf and hard-of-hearing students. However, deaf and hard-of-hearing learners struggle to comprehend English, making it a challenge for teachers to ensure that they teach students how to interpret and express mathematical concepts in written English, as well as in Sign Language (Roberta et al., 1997) and this meant that for teachers to help learners with limited language abilities, more visual support should be incorporated into exemplar tasks (Chilvers, 2013). A key issue arising about deaf and hard-of-hearing learners with a limited language base is that it may prevent them from developing and comprehending mathematical language (Rowley & Heather, 2005).

2.4.2 Literature review of strategies responding to challenges identified

Teaching methods are dynamic, context-dependent, and require a periodic review.

According to Marasabessy (2021), Deaf and Hard-of-hearing learners are a group of people requiring specialised education. Lavanya and Vaijayanthi (2019) put it that mathematics is abstract in nature, and it takes an expert in the field to apply specific methods to teach the subject, making this occupation challenging. Kelly and Lang (2023) indicate that mathematics teaching requires thinking and analytical strategies. In examining generic thinking skills that make it possible to solve problems in mathematics, Woditsch (1991) suggested that characteristics of good problem-solving include selective attention, sustained analysis, analogising, suspension of closure and auto censorship, which gives conscious, focused, and undivided attention to a problem. In the view of the National Council of Teachers of Mathematics (NCTM, 2000), problem-solving in mathematics is not only a goal for learning mathematics but a significant means of doing so, and the teachers' role is to instil the skill of solving problems in their learners.

Teachers of hearing learners have been reported to be more successful than their Deaf and Hard-of-hearing peers. According to Kelly and Lang (2023), the poor performance of deaf and hard-of-hearing learners in this area has been attributed to a combination of linguistic, cognitive, and experiential factors. Taxler (2000) reported that deaf and hard-of-hearing learners do not perform satisfactorily in problem-solving tasks and achieve way below hearing learners. Findings revealed that the reasons why teachers of the hearing-impaired struggle to improve their mathematics performance are perpetuated by the words that have a particular meaning in mathematics, which is different outside mathematics, multiple ways of expressing a single concept in various forms, abbreviations and symbols.

In a mathematics class in Indonesia, teachers were observed to incorporate sign language in their teaching. Still, besides using sign language, it was indicated that a lot of emphasis was placed on material exposure. Parasnis et al. (1996) stated that there are not potentially solid and supportive educational models for deaf and hard-of-hearing learners, leading to teachers and parents developing a negative attitude towards their deaf and hard-of-hearing children about available career options. However, Marasabessy

(2021) reported that teachers in Indonesia are said to complement mathematics teaching through different methods, including contextual, realistic, cooperative learning models, problem-solving, and a combination of several of these methods. Nadal and Collet (2020) agree that using sign language intensively in the interface is vital; however, due to the ubiquity of written texts in French education, when incorporating ICT in the teaching, instructions are required to support navigation for a search word-by-word tool in ‘’sign ‘maths’’.

Krause (2018) revealed that mathematical discourse, in the case of deaf and hard-of-hearing learners, requires mathematical signs for mathematical terms. So far, teachers still lack a didactic approach to attaching a sign to a mathematical idea. It was noted that to overcome this, by gradually and intensively planting mathematical concepts, there is a need to increase learning time and offer motivation, and learners should be engaged in fun learning models that involve attractive teaching aids in their learning process. Kelly and Lang (2023) noted that teachers' analysing all information available and explaining answers while solving algebra problems led to improved results. It was further indicated that most real-life difficulties in mathematics are not well-defined. Therefore, learners with a hearing impairment must be given considerable practice with problem representation and re-presentation. Marasabessy (2021) then recommended that mathematics teachers of the deaf and hard of hearing are required to improve the delivery of more practical lessons than theoretical lessons (Marasabessy, 2021). According to Kelly and Lang (2023), teachers of the Deaf, who give more instructional attention to concrete visualisation strategies than analytical strategies, are more successful in teaching mathematics to deaf and hard-of-hearing learners. Marasabessy (2021) infers that teachers must share their best practices on various platforms, such as meetings, teacher training programs, workshops, seminars and conferences to supplement this. Naomi and Revathi (2019) reported that schools nowadays face several challenges in educating students, especially deaf and hard-of-hearing learners.

Naomi and Revathi (2019) further advised that in addition to being responsible for effectively teaching academic subjects, such as mathematics, reading, and writing, teachers of the deaf and hard of hearing must increasingly deal with non-academic factors influencing the instruction they provide. Marasabessy (2021) puts it that curriculum must be designed to lead to the development of the deaf and hard-of-hearing learners, which requires the infusion of scientific disciplines and academic content with unique unifying language for deaf and hard-of-hearing learners. Kelly and Lang (2023) reported that certified mathematics teachers support certification and preparedness in mathematics. They infer that it makes a difference in overcoming challenges related to teaching deaf and hard-of-hearing learners. In two of the three types of educational settings, most teachers lack the skill to teach learners with hearing impairment and have inadequate certification and preparedness in mathematics.

In the same vein, Cosa et al. (2019) revealed that teachers in America have the skill to create a positive association between American Sign Language and the usage of sign language, counting on procedural strategy in mathematics problem-solving. Kelly and Lang (2023) infer that teachers of the deaf and hard-of-hearing instil general skills, such as reading, following instructions, and making simple mathematical influences, which are practical techniques for solving many word problems in mathematics. Marasabessy (2021) notes that teachers in Indonesia are experiencing difficulty describing concepts and developing the learners' skills in disciplines such as mathematics. It was indicated in the study that the Indonesian education curriculum has not met the requirements for deaf and hard-of-hearing learners because there is no special treatment in the National Selection for State Universities Entrance examination process.

Moving forward, it was suggested that teachers should select words used in defining concepts carefully to teach concepts correctly and to use hand signs for concepts in their lessons. It was then concluded that prospective teachers are more successful in the subject of drawing polygons than the subject of defining them (Gurefe, 2022).

2.4.3 Critical conditions necessary for teaching mathematics to deaf and hard-of-hearing learners in an inclusive environment

Knowing the nature of the learners you teach and how they learn best is imperative as a teacher. According to Moores (1978), mathematics has been an area of strength for most deaf and hard-of-hearing learners. Moores (1978) believes that students with a hearing impairment can excel in mathematics. However, their reading and writing English print setbacks affect their possibility of performing in mathematics studies. Ottem (1980), in the same vein, concurs that deaf and hard-of-hearing learners can perform at the same level as their hearing peers only when the task involves one dimension. Still, the performance drops significantly when two or more dimensions are involved in the problem. Kelly and Lang (2023) cited that these learners have difficulty transferring learning from one context to another, and remembering what has been previously learned is a problem.

According to Bull et al. (2018), the main reason for lower performance in mathematics is that they have less acuity in the Automated Nervous System (ANS) than their hearing peers. Hence, they have difficulty with mathematics reasoning. Poorer acuity makes deaf and hard-of-hearing learners suffer weak numerical discrimination compared to their hearing peers. Bull et al. (2018) and Harries et al. (2013; 2011) are all in agreement that deaf and hard-of-hearing learners lack domain-general skills, which makes them perform poorly on counting recall and digital recall tasks and are thus classified as weak serial recall in short term memory and working memory. Poor automated nervous system acuity and domain-general skills make deaf and hard-of-hearing learners account for poor mathematics performance more than their hearing peers (Bull et al., 2018; Marcelino et al., 2019).

The studies' analyses have identified the delay in mathematics achievement for deaf and hard-of-hearing learners, as compared to their hearing peers and according to Costa et al. (2019), the delay is observed independently of the nature of numerical tasks, such as number operations, multiplicative reasoning, and geometric reasoning. Lang and Pagliaro (2007) have had a different perspective regarding memory for geometric imagery terms, noting that deaf and hard-of-hearing learners have a good memory of geometric images being the best predictor for geometric terms/words, thus exhibiting better results in this area. Similar performance patterns are observed for both hearing-impaired and their hearing peers, which in this case is in their visual-spatial schematic representation (Marcelino et al., 2019).

Kelly and Mousley (2001) infer that the strength of deaf and hard-of-hearing students, concerning non-numerical abilities, is in quantitative representation and non-verbal arithmetic skills; however, they are weak in non-symbolic estimation tasks. According to

Kelly and Mousley (2001) and Marcelino et al. (2019), there is also a positive association between proficiency in American Sign Language and sign language counting on procedural strategy in mathematics problem-solving. Thus, language plays a vital role in discourse in a classroom.

However, according to Taxler (2000), studies showed that deaf and hard-of-hearing learners perform poorly in problem-solving tasks, achieving below their hearing peers. Glennon (1981) cited Kelly and Lang (2023) and deduced from evidence that in examining generic thinking skills necessary for successful problem-solving skills of deaf and hard-of-hearing learners, Woditsch (1991) suggested selective attention, sustained analysis, analogising, suspension of closure, and auto censorship, are all characteristics of good problem-solvers, who are conscious, focused and have undivided attention to the problem.

Studies indicated that these difficulties in mathematics for deaf and hard-of-hearing learners start close to the beginning of formal schooling and later cause under-performance in the final years of schooling (Kelly & Mousley, 2001). This is an important indication for laying a good foundation. In all these aspects, language seems to be the relevant determining factor for mediating the difference between the deaf and hard-of-hearing and their hearing peers.

2.4.4 Threats and risks facing strategies addressing challenges (language and speech development)

Barham and Bishop (1991) noted that when teachers of the deaf are asked about the problems their learners have with mathematics, the intuitive feeling they seem to have is that language is at the heart of their difficulty. According to Marasabesy (2021), the learners and teachers of hearing-impaired use sign language, whereby they use their hands as a symbol to convey the message. Kelly and Lang (2023) infer that mathematics requires language and reading skills.

English is one universal language spoken by 20% of the world’s population, making it a common language that makes the world's business easier. According to the Washington

Post, English is the most preferred language for written publications because it is easier to learn English than other languages (Language Gallery, 2023). Taxler (2000) reported that learners who are deaf or generally deaf and hard-of-hearing have difficulty reading and writing English. Kelly and Lang (2023) noted that mathematics requires English language and reading skills to be competent in the subject. Barham and Bishop (1991) and Pagliaro and Ansell (2000) infer a problem with linguistic content for deaf and hard-of-hearing learners. It is implied that there are conflicts of structures between spoken English and reading structures compared to sign language, making this a primary contribution to the difficulty of teaching mathematics to deaf and hard-of-hearing learners. Rudner (1978) identified that the English language structure in the written and verbal instructions for mathematics causes a unique difficulty for deaf and hard-of-hearing learners. These language structures include conditionals (if when), comparative (greater than the most), inferential (should, could, because, and since), and lengthy passages. For these reasons, Kelly and Lang (2023) noted that regarding instructional settings, teachers fail to engage deaf and hard-of-hearing learners in cognitively challenging word problems. Teachers were found to resort to more practice questions in mathematics than problem-solving situations because of language barriers for learners with hearing impairments.

Marasabessy (2021) alluded that most teachers combine speech and gestures to substitute sign language. However, Rowley and Heather (2005) alluded that the key to successfully teaching mathematics to deaf and hard-of-hearing learners is understanding and developing mathematical language from the language of instruction to native speech.

2.4.5 Teacher's perspective of indicators of success for teaching deaf and hard-of-hearing learners' mathematics in an inclusive learning environment

A teaching experience is related to specific beliefs, such as self-efficacy for classroom management, and the ability to engage students is thus associated with years of experience (Berger et al., 2018; Huberman, 1992; Klassen & Chiu, 2010). Teachers have a particular belief system for their classroom functionality, and their beliefs can either build or break classroom management. The NCTM has challenged the traditional concepts by pointing out that if teachers do not change the standards and how they teach deaf and hard-of-hearing learners, then the mathematics performance of Deaf students will remain poor (Schroeder et al., 1997).

The ultimate goal of mathematics education is to enable students to be literate and capable of solving mathematics problems effectively. To ensure that learners are becoming literate, teachers are responsible for creating an environment where students can share ideas during mathematics activities (Khathare, 2020). Moreover, Geetha and Ranjitha (2019) infer that deaf and hard-of-hearing learners should always have a chance to practice applying language to solving word problems because learners with hearing impairment are developmentally disabled in geometric skills because they have relatively poor linguistic skills. Teachers are therefore required to train to develop geometrical skills by using sign language, 2D objects, 3D objects and graphical and diagrammatic representation to develop the skill (Lavanya & Vaijayanthi, 2019).

Most teachers are still in the traditional teacher-centred era of chalkboard and sign language only, which is ineffective in that space. However, Khathare (2020) has urged that teachers should use a constructivist approach where learning effectively is supported by effective pedagogies and acquiring knowledge through the process of active constructions. One of the leading constructivist approaches teachers have incorporated in their teaching is the use of technology. Teachers explained that constructivist assistive technology has benefited their teaching, creating a learning environment where teachers become facilitators and guides instead of instructors. Teachers explained that constructivists' assistive technology has given them confidence, encouragement, and motivation, fostering a positive attitude toward teaching mathematics to deaf and hard-of-hearing learners. Besides the constructivist approach, Gurefe (2022) infers that using gestures when teaching a concept such as polygons is crucial because they allow alternative information organization where analytical thinking or speech could not be easily obtained. Furthermore, while teachers had never taught with technology, teachers used the Reciprocal Teaching strategy (RTS), which erased the struggle teachers faced in traditional classrooms (Khathare, 2020).

In Pakistan, teachers reported using mobile applications to teach deaf and hard-of-hearing learners. Moreover, teachers reported that it has been easy for them and that this approach enhanced the learning skills of the Deaf students. Mathematics teachers in Pakistan then concluded that the learning of deaf and hard-of-hearing learners improved through a mobile application interface to learn fundamental mathematical concepts using Pakistan Sign Language (Parvez et al., 2019). The study by Kibass (2012) has recommended that a special e-learning program be made part of classroom instruction, as it assists teachers in improving and speeding up their delivery of concepts. It was also noted to enhance learners' understanding of topics, such as basic lower primary geometry, and their perception of the classroom learning environment.

Findings from the teachers indicated that demonstration, use of natural objects, approach and attach response, and explaining keywords or items in advance were some of the methods employed in Kenya, and QASOS also indicated the reliance on teacher-centred approaches to teach mathematics to deaf and hard-of-hearing learners in Kenya (Singh et al., 2020). Morgan (1998) and Singh et al. (2020) argued that to ensure that struggling and bright learners effectively learn, teachers should use a combination of teaching methods, including hands-on materials and traditional teaching methods. They further indicated that using different and meaningful interactions, incorporating basic mathematics concepts, such as number-counting, quantity, time/sequence, and categorization into day-to-day routines, improves performance in mathematics for Deaf students.

According to Morgan (1998) and Singh et al. (2020), some teachers use the teach-test method to enhance mathematics learning, supporting routine practice as the most substantial educational practice for teachers to use in their classrooms to promote mathematics achievement. This is an indication that different concepts in mathematics require a particular approach or combination of approaches and utilization of resources, such as incorporating e-learning programs. In my view, rural schools will continue to lag behind because of the inaccessibility of resources.

2.5 CHAPTER SUMMARY

Chapter 2 presented detailed international, regional, and local relevant studies regarding teachers' experiences teaching mathematics to deaf and hard-of-hearing learners.

Relevant studies displayed the teachers' experiences in terms of the challenges, strategies, conditions, threats, risks, and indicators of success. This chapter also presented the two theoretical frameworks guiding the study: Piaget’s constructivism and Vygotsky’s social learning theory. Also in this chapter was a clarification of key concepts contributing to the experiences of teaching mathematics to deaf and hard-of-hearing learners.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter 2 dealt with the theoretical framework underpinning this study to justify the need to explore mathematics teachers' experiences teaching learners with hearing impairments in inclusive classrooms. Chapter 2 also included a literature review based on the research questions drawn from local and international scholars. In this chapter, I present the research design and methodology, aligning the research questions for this study. As it proceeds, it briefly overviews the concepts of 'research design and methodology' and how they are used in the study. In this case, qualitative research is discussed as a methodology for collecting data. The paradigm in research and a chosen paradigm are discussed, and their relevance to the study. Furthermore, the research site, sample selection, data collection, and analysis strategies are discussed. The chapter then concludes with critical discussions on trustworthiness, validity, and ethical considerations applicable to conducting this study.

3.1.1 Understanding the research design and methodology

Before commencing this section, it seemed essential to clarify the design and methodology as the closely linked and misinterpreted concepts. These two concepts, research design and methodology, are often used interchangeably. Still, according to Edmonds and Kennedy (2017), the method provides theoretical, philosophical, and data analytic positions. In contrast, the design indicates the time the data will be analysed and gives the structure, indicating if one case, group or multiple groups will be associated with the process. This is a broad term used to structure the logic and flow of all systematic processes that are followed to gain insight into the research problem (Kivunja & Kuyini, 2017).

3.2 RESEARCH METHODOLOGY

As stated above, the methodology provides the stance for theory, philosophy, and data analysis. Buckley and Chiang (1976) define research methodology as a strategy the researcher uses to plan an approach to solve an emerging problem. Crotty (1998) also refers to research methodology as a comprehensive strategy, exhibiting the researcher's choice and use of methods to yield anticipated outcomes. Jamshed (2014) concurs with Buckley and Chiang that the choice of methodology rests upon the nature of the research problem.

The main research problem in the study is that there are no didactical approaches for teachers teaching mathematics to deaf and hard-of-hearing learners. Consequently, Singh et al. (2020) infer that teachers of the deaf and hard of hearing still use teacher-centred approaches, which are ineffective in that space. The choice of methodology in this study allowed the investigator to explore teachers' lived experiences, teaching mathematics to deaf and hard-of-hearing learners on a day-to-day basis. This qualitative approach has helped me as a researcher to respond to the main research question:

"How do teachers teach mathematics to deaf and hard-of-hearing learners?"

3.2.1 Qualitative approach

As stated above, this study is qualitative. According to Keeves (1997), a qualitative approach is the logic, plan, and processes of the research design, methods, approaches, and procedures used in an investigation. In the words of Jamshed (2014), the qualitative research method is considered relevant if it is used to investigate new study fields to ascertain and theorize important issues. This is where qualitative studies contend to study human activities from the participant's point of view (Babbie & Mount, 2004). Moreover, Cabin and Strauss (2008) infer that the qualitative approach is subjective research, which permits the specialists to get at the internal experience of members to decide on the shape of implications. In the context of this research, I was involved in gathering the teachers' experiences pertaining to teaching mathematics to deaf and hard-of-hearing learners in an inclusive school in the Motheo District. Bogdan and Biklen (1982) indicate that the main instrument is the researcher in the middle, where the researcher studies the phenomenon in its natural setting.

According to Bryan (2008), in the qualitative method's data collection stage, data cannot amount to numerical form because it includes people's thoughts, behaviours, and motivations, which ultimately will yield anticipated results. The qualitative method was deemed appropriate for this study because, according to Okeke and Van Wyk (2016), researchers in this approach use methods such as interviews and observations as data collection methods to explore in-depth the participants' social world, providing access to what is 'inside' the person's mind. The two data collection methods are discussed in detail later in the chapter's 'data collection process'.

3.2.2 The key aspects of qualitative research and how it will be applied in this study

The critical aspect of qualitative research is the paradigm. In educational research, the paradigm is defined as the researcher's 'worldview' (Kivunja & Kuyini, 2017; Mackenzie & Knipe, 2006). Below is an extensive explanation of the paradigm and the choice and relevance of the paradigm in the study.

3.2.3 Research paradigm

In a qualitative approach, several paradigms were proposed by authors, but Candy (1989) suggested that they all be grouped into three main taxonomies, namely critical theory, constructivism, participatory and interpretive paradigms. For this research, the interpretive paradigm and its relevance to the study were explored. According to Kivunja and Kuyini (2017), the choice of paradigm in research highly depends on essential elements of paradigm, in particular epistemology, ontology and axiology, because they guide a choice of methodology. The methodological implications of a paradigm choice infuse the research questions, selection of participants, data collection instruments and collection procedures, and data analysis because of the relationship between paradigm and methodology.

3.2.3.1 Interpretive paradigm

According to Weber and Henderson (2012), the roots of interpretivism are in symbolic interaction and phenomenology, believing that the way people regard objects determines the nature of objects and that value and theory-neutral facts do not exist. Myers (2019) and Okeke and Van Wyk (2016) also believe that interpretivism does not begin explanations from pre-existing theoretical models but instead draws out theories from empirical evidence. For this reason, the interpretive paradigm assisted me in using the participants' words and actions during participant observation and semi-structured interviews to determine meanings and interpretations that led me to an in-depth understanding of teaching mathematics to deaf and hard-of-hearing learners.

The interpretive paradigm motivated me to seek the experiences of the teachers. Therefore, I had to consider the different interpretations of the participants regarding their day-to-day narration of the classroom situations in the special school in Motheo District for me to gain further in-depth insight (Chen, 1996). The primary purpose of choosing interpretive research was to study how teachers use their teaching methods to give them meaning and demonstrate how these norms explain their behaviour (Junjie & Yingxin, 2022). According to Junjie and Yingxin (2022), interpretivism considers mathematics teachers to be different from natural phenomena because the teachers have the potential to create depth in meaning.

For this reason, Wellington and Szcerbinski (2007) infer that interpretivism asserts that truth and knowledge depend on how people interpret reality in different histories and cultures, using narrative data for research. Therefore, the following sub-section will entail that interpretivism takes into cognisance the relativist ontology and subjective epistemology in that humans are taken to be entangled with knowledge (Junjie & Yingxin, 2022).

3.2.3.2 Essential elements of the interpretive paradigm

As stated above, according to Kivunja and Kuyini (2017), the elements necessitated the research to choose a paradigm, which ultimately guides towards a particular methodology. The following will give a brief discussion of each component.

a) Epistemology

Moustakas (1994) claimed that interpretivist epistemology studies the interconnection between the researcher's subject. It concerns individuals expressing their meaning, voice, standpoint, experience, thoughts, and feelings. This element focuses on the understanding the researcher needs to acquire to deepen their understanding of research by focusing on the nature of human knowledge (Kivunja & Kuyini, 2017). Furthermore, Wellington and Szcerbinski (2007) asserted that knowledge in interpretivism depends on how people interpret reality in different cultures and histories. In this study, the researcher used semi-structured interviews to understand the teachers' knowledge regarding learners with hearing impairment and gain knowledge of teaching mathematics. This assisted me in answering the research question regarding the teachers' knowledge about learners' learning needs. The depth of understanding of the two teachers differed according to their level of experience teaching mathematics to deaf and hard-of-hearing learners; those with more experience had more thoughts and meanings than the others.

b) Ontology

Ontology is a branch of philosophy dealing with the assumption that something is real or makes sense (Scotland, 2012). Furthermore, according to Kivunja and Kuyini (2017), ontology is believed to be known and helps conceptualize the nature and form of reality. This is an area of research where what is reviewed by literature was conceptualized by fieldwork where observations of mathematics teachers in an inclusive environment were made to make sense of the phenomena in question. Wellington and Szcerbinski (2007) further note that the ontology of interpretivism ascertains that the truth depends on how people analyse reality in different histories and cultures. In the study context, the participants interpreted their experiences of teaching mathematics according to how they analysed the reality of teaching deaf and hard-of-hearing learners; for example, some may have found their expertise pleasant, while others may have experienced more challenges. This branch of philosophy helped me acquire the teachers' assumptions according to what is believed to be known through their own lenses.

3.3 RESEARCH DESIGN

According to Ahuja (2010), the research design is used as a plan to arrange the conditions for data collection and analysis in a way that aims to integrate relevance to the research questions and purpose with the procedure. For a mind refresher, the following are research questions that must align with the research design.

3.4 RESEARCH QUESTIONS

3.4.1 Primary research questions

1. How do teachers teach mathematics to deaf and hard-of-hearing learners in an inclusive classroom?
2. What are the experiences of teachers teaching mathematics to deaf and hard-of-hearing learners?

3.4.2 Sub-research questions

1. What are the challenges to teaching mathematics to deaf and hard-of-hearing learners, and how can teachers address them?
2. What knowledge do mathematics teachers need of deaf and hard-of-hearing learners learning mathematics?
3. What methods are currently used to teach mathematics to deaf and hard-of-hearing learners?

Akhtar (2016) alluded that research can only be valid if the conclusion is accurate and the research design is the conceptual blueprint for research. Literature shows that research design is the compass directing the researcher in finding a way to execute their way to plan for research methodology. According to Okeke and Van Wyk (2016), the different approaches to research designs include qualitative, quantitative, and mixed methods research designs. Lichtman (2013) alluded that qualitative research design has five popular research approaches: ethnography, grounded theory, phenomenology, case study, and narrative. The study adopted a case study as the research design.

3.5 CASE STUDY DESIGN AND ITS ORIGINS

Solberg and Solberg (2006) put it as follows: there is no easy way to explain or describe the concept of a case study. Thomas (2011) defines a case study as analysing systems studied by one or many methods to obtain a comprehensive view. Yin (2013) describes a case study as an empirical inquiry using multiple data sources, where real-world context phenomenon is being investigated and boundaries between context and phenomena are not evident. Rashid et al. (2019) concur with Yin (2013) that a case study consists of a detailed investigation, where empirical data is often collected over time to analyse the context and phenomenal processes. Creswell (2013) puts it that a case study is a method within various forms of qualitative research instead of confining it to an approach or a 'tradition'. Gustafsson (2017) defined a case study as an intensive study about a person, group of people, or a unit to generalize several units.

Case study research is an in-depth scientific investigation of a real-life phenomenon and its environmental context (Ridder, 2017). In a case study, as a part of the investigation, contextual conditions are not controlled like in experiments. The case study research neglects the scope of possibilities the research provides by mainly narrowing it to its "explorative" function. However, the potential advantage is that it offers an opportunity to look deeper into the cause of the phenomena and provide a detailed description and analysis of why and how a thing happens (Fiss, 2009).

Edmonds and Kennedy (2017) allude to the fact that many disciplines use different case studies to examine the phenomena. Gustafsson (2017) pointed out that although the case study method is widely used, it is not entirely understood. Yin (2014) clarifies the significance of using a case study by indicating that the purpose of the study determines the types of case studies, whether they are exploratory or descriptive. This study's purpose was to explore the lived experiences of mathematics teachers, which makes adopting an exploratory case study even more appropriate.

Gustafsson (2017) puts it that the qualitative case study method requires tools to function. According to Flick (2009) and Mason (2002), for the exploratory case study to function, data is collected using interviews, archives, and observation of participants. The study used observation to answer one of the leading research questions. The secondary research questions were responded to using interviews, which were later analysed after an in-depth examination of the case in question, where two entities identified were as small as two individuals (Lichtman, 2013). The phenomenon in question here as a case study was teaching mathematics to hearing–impaired learners with a single entity identified: two mathematics teachers. The case analysis took place after an in-depth analysis of the data.

Pearson et al. (2015) indicate that Stake (1995) suggested three types of case studies based on the study purpose: intrinsic case study, instrumental case study, and collective case study. According to Gustafsson (2017), besides identifying the case and specific type of case study to be used, the researcher has to decide whether to choose a single case study or a multiple case study to understand the phenomena. The study then adopted a single case study, where two teachers from the same school were used to explore mathematics teachers' experiences teaching deaf and hard-of-hearing learners.

3.5.1 Benefits of using a case study in this study

This study adopted a single case study design. As stated by Hancock et al. (2021), the importance of an exploratory single case study is to develop a theory in the case of a single phenomenon. Gustafsson (2017) alluded that single case studies best describe the existence of a phenomenon. Morgan (2012), in their perspective of a single case study across all disciplines, implied it as a complex singular event, ranging from industry, town, institution, or a physical, biological, or social phenomenon that the researcher may examine as an event in question. It explores relations among elements of whole diverse methods, emphasising that a whole is an open-ended event existing in the real-life context (Markova et al., 2019).

For this reason, the case study is even more beneficial for the study because data is generated from the natural setting, and as a result, rich raw data is achieved from a real-world context. Open-ended questions involved the engagement between the researcher and participants, and questions were such that they allowed the participants to be more open in their responses and were not limited to ‘yes’ or ‘no’ answers. In instances where the object of the study was a complex problem or situation as a whole, the object was not fragmented into elements but rather as a whole.

Markova et al. (2019) reported that a single case study could be dialogical or non-dialogical. Still, both use the same research methods for their respective purposes: interviews, observations, and in-depth ethnographic fieldwork. The study setting allowed the dialogue to take place in teaching deaf and hard-of-hearing learners mathematics holistically, and the researcher engaged with the participants in the interviews. When a single case study is used, a more careful and comprehensive study is made because the researcher can question old theoretical relationships and explore new ones (Gustafsson, 2019). Yin (2014) concluded that a single case study represents the single theory of the critical test.

Based on the choice of a case study for this project, the study aimed to create a high-quality theory, and single case studies were deemed to produce a better extra theory, making single case studies better than multiple case studies. Dyer and Wilkins (1991) and Gustafsson (2017) also concur that for the researcher to have a complete understanding of the subject, a single case study provides a deeper digging, and a choice of a single case study design assisted me in gaining an in-depth understanding of the phenomenon in question. Barzelay (1993) alludes that for people to frame and solve problems arising from a familiar factual context, a single case study can help improve collective problem-solving results.

According to Markova et al. (2019) and Rolls (2014), a single case study does not necessarily mean studying a single person in isolation. However, researchers chose to conduct a single case study with embedded units, allowing the researcher to analyse the case from within, between, and across, making exploration to build a strong theory (Gustafsson, 2017), granting the researcher the powerful ability to look at sub-units located in a more significant case (Yin, 2003). The study opted to utilize two mathematics teachers as a study unit, where the generalisation about the experiences of teaching mathematics to deaf and hard-of-hearing learners was made to develop new theories.

3.5.2 Description of research site

The study occurred in a rural special school comprising primary and high schooling. The chosen field site was in the Motheo District (coordinates: 29°07'S 26°13'E), approximately 280 km from Thabo Mofutsanyana District and was the only inclusive school for deaf and hard-of-hearing students nearby. The school is for the Blind (116) and Deaf (226) learners from grade R to 12. Initially, the research was supposed to take place in an inclusive school for hearing and deaf and hard-of-hearing learners in the senior phase. However, due to the scarcity of such a school, the researcher had to opt for a special school for the Deaf, where classes comprised of the same disability (Deaf), doing mathematics as a subject in grades 8 and 10. The blind learners were excluded purposively because the study focused on hearing impairment despite their presence in this school.

3.5.3 Logistics

Logistics is a form of practice whereby what is lacking internally is outsourced by either people or firms for the resources to be accessible (Ali et al., 2023). As stated above, the researcher resides in the Thabo Mofutsanyane District, and due to ethical considerations, research was set to take place in the Motheo District, which is 324,4km apart. The data collection process, set to take place for one week, implied that accommodation arrangements had to occur within the said district.

3.6 THE SELECTION OF CO-RESEARCHERS/PARTICIPANTS

The selection of participants was purposive. According to Okeke and Van Wyk (2016), the researcher conducts research with the intention and purpose of purposive sampling.

This is the non-random technique determined by certain criteria specified by the researcher based on the scope of research (Etiikan et al., 2016; Nurul et al., 2023). The selection criteria required that the participants be mathematics teachers and teaching deaf and hard-of-hearing learners. As a result, two mathematics teachers were selected as co-researchers for the study. The two participants were chosen because they could share their in-depth experiences of teaching mathematics to deaf and hard-of-hearing learners. The two participants were used as tools to collect data through observations and semi-structured interviews.

3.6.1 The composition of the research team

The research team comprised the researcher and two participants, who were mathematics teachers of deaf and hard-of-hearing learners in a school for deaf students. Drawing from the elements of the qualitative approach, the study used the qualitative method because it provided opportunities for individual cases. The co-researchers were purposely selected on the criteria that they are teaching mathematics to deaf and hard-of-hearing learners. The composition was chosen to allow a relationship between the participant and the researcher to create knowledge for the study. According to the study's theoretical framework, the researcher is a more knowledgeable facilitator than others (MKO). The participants are co-researchers and co-creators, and both operate in the zone of proximal development to create knowledge. Furthermore, Krueger (1994) infers that this composition of the research team gives meaning to the data within a particular context in the qualitative approach.

3.6.2 The researcher and co-researcher relationship

According to Montgomery (2012), Oakley (2016) and Rapley (2006), it is encouraged that researchers should be more open, honest, and willing to share their own experiences in conversations or interviews to develop a strong rapport with the participants. Pope (2020) indicated that during the research project, the researcher should be more comfortable sharing their subjectivity and be aware of how that may affect their interaction with the co-researchers. I was comfortable sharing my personal and academic life with the co-researchers in the meeting, and this created room for comfort when interviews were conducted. Besides, making consistent contact with the participants before the actual interviews regarding logistics around the data collection process encouraged a conducive mood between the researcher and co-researchers during the actual conversations and interviews.

3.7 DATA COLLECTION PROCEDURES

According to Cresswell (2009), in qualitative research, instead of relying on surveys for data, like in quantitative research, the researcher becomes an instrument for data by asking all the questions and collecting observations. Based on the research design and methodology, the data collection techniques chosen for the study were participant observations and semi-structured interviews.

3.7.1 Participant observations

Bernard (2013) infers that observation is paying careful attention to the surroundings. The primary point is understanding how any institution, organization, or community works, which is best achieved through participant observation. In the current study, mathematics teachers of Grades 8 and 10 were carefully observed, paying special attention to their actions and interactions with deaf and hard-of-hearing learners. Hennick et al. (2011) define observation as a method researchers use to systematically observe and record people's behaviour, actions, and interactions. In the study, the researcher used an observation schedule to record the two mathematics teachers' systematic behaviour, actions, and interactions during their observations, teaching mathematics to deaf and hard-of-hearing learners. Okeke and Van Wyk (2016) and Rowlands (2005), in the same vein, concur that the researchers observe and report data, reflecting the subjective perspectives of the participants to understand the participants' actions, roles, and behaviours (expressions of feelings among participants). Bernard (2013) infers that researchers usually observe and help intellectualise what they already know.

Bernard (2013) put it that when choosing a field site, ensure that it promises to provide easy access to data. Hennick et al. (2011) alluded that the research questions and purpose usually guide the focus and location of the observations. The participant observation helped the researcher to answer the main research question, ‘How do teachers teach mathematics?’ Hennick et al. (2011) say that observation is often combined with in-depth interviews to provide complementary data to comprehend issues in different views. It is also noted that there are two types of observations: complete participant observation and non-participant observation. This study adopted participant observation. Bernard (2013) puts it that two or three nights after participant observation, the researcher should be ready to invite the participant for an interview. This is because, from the previous observation, the researcher would have gathered the fine distinction of etiquette and familiarised themselves with the native language of that particular environment. During participant observations during contact time of the school timetable, the participant was observed conveying a mathematics lesson to deaf and hard-of-hearing learners. The role of the teacher in class was observed, as well as their interactions with the learners and resources used. In the same breath, Bernard (2013) infers that participant observation gives the researcher a broad understanding of what is happening in the classroom, which boosts their confidence, giving meaning to the data.

Bernard (2013) puts it that there are multiple reasons for insisting on participant observation, and amongst others, it reduces the person’s change of behaviour towards reacting to being observed. Another reason is that participant observation would have allowed the researcher to formulate questions, based on previous experience during face-to-face interviews. The observation schedule developed will be used as a tool to reflect on the subjective view of the participants, and in the same vein, the synopsis has given the researcher a good idea of how teaching mathematics to the hearing-impaired looks like, which might allow the researcher to develop certain hypotheses from the qualitative notes during interviews (Bernard, 2013). In the same vein, observations are said to identify silent norms and values in the school's culture, which later clarify uncertainties from other data sources in a study (Hennick et al., 2011).

According to Bernard (2013), it isn't easy to make an entry doing observation fieldwork. As a result, the researcher should, in their position, have a written document explaining themselves and the project they are doing, which must be signed by the university authority. If the researcher is studying any hierarchically organized community, first find and see the gatekeepers and inform them that you will maintain confidentiality, and nobody will be personally identified. The lesson synopsis and observation schedule were designed and written immediately after participant observations, noting all the events that transpired during the observations and were later used as a part of analysis and interpretation.

3.7.1.1 Data generated through participant observation

The lesson synopsis presents the teacher's name, grade, duration, class size, topic and description of the lesson for each participant. Four synopses are presented from the two mathematics teachers at the school each, teaching mathematics to the deaf and hard-of-hearing learners. The participant observations took place during contact time in the presence of the learners, although the main focus was the teacher. During the participant observation, the observation schedule (see Annexure E) was used for data collection, and after that, field notes and lesson synopses were developed (see Annexure B). After the presentation of the lesson synopsis, the following are the general discussions regarding the observations. Documents taken from the participants that formed part of the lesson were taken in the form of pictures and attached as figures.

3.7.2 Semi-structured interviews

According to Roulston and Choi (2018), semi-structured interviews are less tightly formatted in terms of the organization of topics, as opposed to other forms of interviews, making it easier for the researcher to preset open-ended questions. The research questions designed before the actual interview session were adjusted just before the interview sessions after observations. Moreover, Jamshed (2014) states that open-ended questions allow in-depth interviews, which is why this form of interview is widely employed in various professions for research. In this study, semi-structured interviews seemed more relevant because they allowed the participants to use their in-depth experiences to create knowledge through open-ended questions, encouraging a harmonious setting that permitted them to express their feelings and thoughts.

Furthermore, Roulston and Choi (2018) allude that in semi-structured interviews, the Interviewer's sequencing of questions is led by participants, and questioning is based on the same topics. Based on the role of the researcher in the study, the researcher is not a dictator of the research, and their rhetoric should be such that it must be accommodative to the participants. As a result, the participants, as co-researchers in the study, were allowed to express how they felt and think by answering questions in the sequence in which they felt more comfortable.

Jamshed (2014) puts it that semi-structured in-depth interviews use a format that allows individuals or groups of people. In the study, this format allowed individuals to express their own reality in teaching mathematics to deaf and hard-of-hearing learners without being implicated by the thoughts of the other. This format further assisted me as a researcher in analysing how participants interpret their realities based on a single phenomenon based on their different cultures and experiences.

Dicicco-Bloom and Crabtree (2006) and Jamshed (2014) argue that to achieve the set time for interviewing, it is significant to have a semi-structured interview guide and a planned presentation of questions. The interview schedule was used as an interview guide, composed of planned questions presentation. The guide helped me, as a researcher, focus on the study's objectives more comprehensively and systematically. Similarly, in semi-structured interviews, probing questions are formulated concerning the participants' responses; these were the potential follow-up questions guiding the participants should the participants not have mentioned that critical information (Roulton & Chai, 2018). This was done by beginning with broader questions and formulating open questions before moving to more specific questions (Sulton & Choi, 2018). The question asked of the participants was: *'Tell me more about your experience as a teacher to deaf and hard-of-hearing learners?'* This was a broader question that ended up involving formulating open questions before moving to more specific ones.

To promote openness in questioning with the participants, I needed to allow the participants to respond to the questions in the sequence they felt comfortable answering; this strategy helped me as a researcher to develop trust and mutual respect among the researcher and participants. The identified topics will form the basis for questions to be asked the participants in the semi-structured or open-ended interview (Roulston & Choi, 2018). The semi-structured interviews took place after the participant observations in the study, and the semi-structured interviews were used to reflect on events that occurred during observations. Since this was an open-ended interview, the researcher generated their questions in a free-ranging conversation directed by what the participants said about the research topics. Consequently, Creswell (2007) alludes that the researcher should consider recording interviews to ensure that the interview is captured effectively. However, this matter can sometimes cause a dilemma between the researcher and the respondent. The semi-structured interview data was collected through the voice recording of participants using the audio tape. Permission was requested and granted before recording the interview to avoid controversy.

3.7.3 Documents review

Nieuwenhuis (2007) deduced that reviewing documents to gather data helps the researcher comb through the written data, which may illuminate the phenomenon under investigation. In the context of this study, I wanted to check documents that would provide information on the resources that mathematics teachers used to teach deaf and hard-of-hearing learners, specifically. This type of study needed to depict the nature of the study, which focused on the inclusive learning environment. I was expected to gather the teachers' lesson plans before the actual lesson, but unfortunately, they were not available for my receiver. The lesson plans were required to expound the evidence of topics, assessment activities, and resources used by the teachers teaching deaf and hard-of-hearing learners mathematics in an inclusive learning environment. The document analysis helped the researcher to answer the following research question:

‘Which methods are currently used to teach mathematics to deaf and hard-of-hearing learners?' The document reviews also served as a tool to verify findings from interviews (Yin, 1994) in Chapter 4.

Table 3.1 below represents the data collection process for the observations, interviews, and documents.

Table 3.1: The data collection process

Day	**Activity**	**Role of the researcher**	**Role of the participant**	**Tools used**	**Documents collected**
1	Participant Observation	Taking field notes	Teaching	Observation Schedule	Notes, teaching aids (pictures) and activities (Pictures)
2	Participant Observation	Taking field noted	Teaching	Observation Schedule	Notes, resources (Pictures) and activities (Pictures)
3	Semi-structured interviews	Interviewer	Interviewee	Interview schedule	none

3.8 METHODS OF DATA ANALYSIS

Thematic Analysis (TA) was employed for this study. The following process or steps were conducted to analyse the collected data, according to Bhandari (2020):

- Prepare and organize data,
- Review and explore data,
- Assign codes examining the data for patterns, themes, or any repeated information that may emerge,

- Develop the data,
- Identify recurring codes.

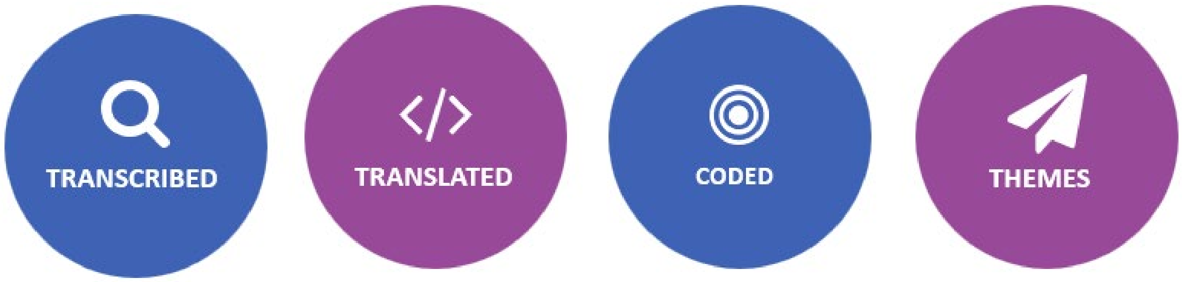


Figure 3.1: The process through data analysis

The data collected through semi-structured interviews in the study was later analysed through TA, particularly the reflexive thematic analysis, as outlined below:

3.8.1 Thematic analysis process

This study adopted TA as a method to analyse collected data, including participants' observations, interviews, and documents. These qualitative data sets were then subjected to TA, which, according to Forbes (2022), is an analytical method that identifies patterns of meaning across the data. Castleberry and Nolen (2018) state that TA is a commonly used method to analyse data across all qualitative designs. The qualitative design employed for the study was a case study design, particularly the single case study design. The single case study design allowed the participants to express their experiences teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment. TA is described as a descriptive method that reduces data from big chunks to a flexible way that allows the reader to understand discoveries (Castleberry & Nolen, 2018). This method enables the researcher to identify, analyse, and report patterns (themes) within the data.

However, Braun and Clarke (2020) and Braun et al. (2019) noted that TA is not a homogenous method but an umbrella term emphasising different approaches to conducting TA. As a result, the study adopted the reflexive thematic analysis.

a) Reporting

This phase is the core and entails assessment, analysis, and interpretation of the empirical evidence that has been collected. The different points of view of the participants are presented in sufficient detail and depth to enable the reader to gauge the accuracy of the analysis (Ngulube, 2015).

b) Trustworthiness

Replicability, reproducibility, and transparency are excellent research quality checks. Guba and Lincoln (1989) recommend the four criteria to ensure judgment of the soundness of qualitative research such as internal validity, external validity, reliability, and objectivity. According to Koch (2006), trustworthiness in the study increases when the researcher keeps an audit trail of their work. I have a research diary where I document the evidence of the study, which assisted me in identifying my biases before, during, and after the study; this diary also had me report or realize if and how subjectivity may have crept in and affected certain areas of my study. An audit trail may be the single most pivotal technique for trustworthiness as it organizes the evidence purposely to ensure that someone external to the study can review data and processes independently to form an opinion on the credibility and consistency of the outcomes (Mishoe, 2003).

3.9 RELEVANCE OF QUALITATIVE RESEARCH IN THE STUDY

Qualitative research involves the collection and analysis of non-numerical data to understand the opinions or experiences of the participants (Hamed, 2022), and this study was aimed at exploring the experiences of teachers teaching mathematics to deaf and hard-of-hearing learners and, as a result, the qualitative approach seemed relevant to the study for this main reason. To complement the pre-statement, qualitative uses, observations, document analysis, and interviews are some tools used to generate perceived data. In this study, participant observations and semi-structured interviews were used as data collection methods, and relevant data for the study was collected.

3.10 SUITABILITY OF THE QUALITATIVE RESEARCH AND THE TWO THEORIES FOR THIS STUDY

Piaget's social constructivism allowed the researcher to observe learning from different cultures. Vygotsky's social learning theory enabled the researcher to observe participants in their own social settings, exploring their educational teaching practices. Qualitative research allowed the researcher to gather in-depth insights into the opinions and experiences of the participants using participant observations and semi-structured interviews.

Piaget's social constructivism and Vygotsky's social learning theory seemed suitable for qualitative research because they all observe and recognize the experiences the participants bring to the research process and how these shape the outcomes. According to Glassman and Erdem (2014), it is the duty of the researcher to involve the participants who have lived these experiences in their study. During the data collection processes, the participants spoke about their experiences, including issues within their contexts. By creating a platform for participants to speak openly, they could share their perspectives on the issues at hand, thus strengthening our relationship and creating new knowledge based on multiple perspectives.

3.11 ETHICAL CONSIDERATION

The ethical process involving human research is a crucial step to consider. As a researcher working in an inclusive school in a rural community, I believe that one needs to be mindful of the sensitive nature of the setting. Teachers working with learners living with disabilities have not been given proper respect and treatment in the past. Hence, they tend to be more fragile and require more consideration.

In an attempt to adhere to the ethical aspects of conducting research, several presentations to the ethics body were conducted during the research proposal on how the research objectives will not temper with the morality of the participants I am working with. I then took it upon myself to ask permission from the University of the Free State Ethics Committee to enable me to conduct this human research, and permission thereof was granted after the careful realization that the study complies with ethical considerations (Ethical clearance number: UFS-HSD2022/2029/3).

Moreover, the school where research was conducted was the special school within the DBE, and as a result, a letter requesting permission to conduct research at the school was written to the Free State Department of Education (FsDoE), and again, permission was granted. There are gatekeepers within the school, and letters of consent were sent to the principal explaining the reasons for conducting research at their school and requesting permission. This seemed important as the study participants were the school members, and a permission letter from the principal would grant access to the participants. Permission from the principal was granted.

For all the participants, a letter of consent was sent to mathematics educators in the school, seeking acknowledgement to participate in the study. In the letters, the aim and objectives of the study were clearly stated, and that participation was voluntary. In addition, confidentiality for participants and the school's identity was stressed, and pseudonyms were used instead of real names.

The researcher established an honest and comfortable relationship with the participants during the research process to build trust and conductivity with the other party. By so doing, the researcher aimed to protect participants against any harm or humiliation that might happen during participant observations or interviews. The researcher assured the participants that the information they provided would not be used against them. They should not hesitate to say anything if they are uncomfortable with questions or processes.

The study did not pose a high risk to participants. However, the study caused minor inconvenience in terms of lost time for the participants. As a result, the researcher ensured that the interviews took place at the most convenient time for participants. The participants were asked about convenient times and places to conduct the interviews.

The researcher also explained to the participants that information must be taken as notes and recordings. All electronic information stored on the password-protected laptop will be destroyed. Hard copies will be burned five years after completion of the study. If the need arises for the stored data to be re-used, it shall be subjected to further research ethics review and approval.

3.12 CHAPTER SUMMARY

Chapter 3 explained in detail the research methodology and design used in the study. It described the paradigm, sampling, and data collection methods, which took the form of participant observations, document reviews, and semi-structured interviews used to explore teachers' experiences teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment. The qualitative approach to the study was aimed at understanding the teachers' experiences on the issues and experiences they encounter teaching deaf and hard-of-hearing learners mathematics.

CHAPTER 4
DATA ANALYSIS

4.1 INTRODUCTION

In Chapter 3, the design and methodology used in the study were discussed. In this chapter, the data collection process and analysis strategies will be looked at again, and the data coding will be described in detail. This study explored teachers' experiences teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment. Data was generated using participant observation and semi-structured interviews to achieve this aim. This study seeks to understand teachers' experiences teaching mathematics to deaf and hard-of-hearing learners, framed within the context of Vygotsky's sociocultural learning theory and Piaget's constructivism. The data analysis was completed through RTA, as discussed in section 4.3. The data in this chapter is systematically organized into overarching themes, each consisting of sub-themes (see Table 4.2) that provide a nuanced understanding of the participants' perspectives. The research questions guiding this study were as seen in section 1.7. The answers to these questions are integral to understanding teachers' experiences teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment.

4.2 OVERVIEW OF FINDINGS

The participants' observations were conducted to see how the daily teaching occurs in a mathematics class of deaf and hard-of-hearing learners. After the observation, semi-structured interviews were conducted to obtain the in-depth experiences of the teachers teaching mathematics to deaf and hard-of-hearing learners in the specified special school.

Firstly, this chapter presents the brief profiles of the participants, then presents the participants' observations as a lesson synopsis, and, secondly, presents and discusses themes that emerged from semi-structured interviews. Thereafter, the data collection process and analysis are examined, while the coding is described in detail. Final findings, conclusions, and recommendations are discussed in the preceding Chapter 5. The research focused on two teachers teaching mathematics to deaf and hard-of-hearing learners. This chapter, therefore, addresses the research objective of exploring the teaching experiences of the two selected teachers in teaching mathematics to deaf and hard-of-hearing learners. The data collection process and data collection strategies are looked at and discussed in detail.

4.3 DATA ANALYSIS

Braun and Clarke (2019) infer that during RTA, the reflection of the researcher's interpretive analysis of the data conducted at the intersection of the data set, theoretical assumptions of the analysis, and analytical skills or resources were considered. Forbes (2022) brought forth six phases through which RTA works, which are not necessarily a clear-cut step-by-step process. It is a description of doing RTA, from scribbling a set of notes familiarising yourself with the data throughout to coding, developing themes, and naming them, demonstrating the organic and systematic nature of the method. The six-phase process (see Figure 4.1 for analysis), which Braun and Clarke (2020, 2014, 2013; 2012) proposed; was used in the study as a guideline to facilitate and help the researcher to identify and attend to important aspects of TA.

4.3.1 Phase one

During phase one, the researcher familiarised himself with the data set by reading and re-reading it. The researcher became intimate with the data by listening to the interview recordings before transcribing and taking notes.

4.3.2 Phase two

In phase two, the researcher generated initial codes of the data set, using descriptive notes that were the fundamental building blocks for generating themes at the subsequent stage—the process involved producing succinct, shorthand descriptive labels for information relevant to research questions.

4.3.3 Phase three

Phase three was the theme generation stage. This phase began when all relevant data had been coded, and this is where the researcher evaluated entire codes developed and merged them into a theme, according to how the codes may have a shared meaning that helped answer the research question(s). At the end of this stage, the researcher produced a thematic map that collaborated codes and data themes concerning their respective themes (Braun & Clarke, 2020; 2012).

4.3.4 Phase Four

Phase four involved the reviewing of potential themes. During this phase, the researcher was required to do a recursive review of the candidate themes concerning the coded data items and the entire data set (Braun & Clarke, 2012; 2020). At this stage, it was uncommon for the researcher to find any candidate theme that did not match the information addressing the research question(s).

4.3.5 Phase five

Phase five involved defining and naming themes. At this point in the analysis, the researcher was tasked with presenting an analysis that detailed a thematic framework. Each theme and sub-theme were linked to both the data set and its respective research question. At this point, the researcher had subjected a final revision to the names of the themes and identified the data items to use as extracts when writing up the analysis results. All the reported data was subjected to a deeper analysis, going beyond reporting what the participant may have said.

4.4 BIOGRAPHICAL INFORMATION OF PARTICIPANTS

This section briefly describes the background of the two participants in the study, which is also shown in Table 4.1. The participants' identities were protected, as stated in section

3, so pseudonyms are used instead of real names. The two participants were pseudonym-ed, John and Salamina.

4.4.1 John

John is a male teacher with one year of experience as a mathematics teacher at a special school for deaf and blind learners. John teaches mathematics classes from Grades 7-9 in the senior phase, teaching only the hearing-impaired section. John holds a Bachelor of Accounting degree, and the highest qualification is a Postgraduate Certificate in Education, the highest certification qualifying him to be a teacher.

Two lessons were observed in John’s Grade 8 class of 13 deaf and hard-of-hearing learners. The theme of the first lesson was percentages, and the second lesson was algebraic expressions.

4.4.2 Salamina

Salamina is a middle-aged woman with more than ten years of experience in teaching. With more than ten years of teaching experience, Salamina has been dedicated to teaching mathematics to deaf and hard-of-hearing learners. She teaches at the special school for the Blind and Deaf, teaching FET phase classes from Grades 10-12 in the deaf section. Salamina holds the highest qualification in Bachelor of Education Honors, specializing in mathematics education.

Two lessons were observed in Salamina's Grade 10 class of four deaf and hard-of-hearing learners. The theme for the first lesson was quantities, and the second lesson was based on trigonometric ratios.

Table 4.1 below summarizes the participants’ most relevant biographical information.

Table 4.1: Biographical information of the two participants

Participants	John	Salamina
Qualifications	B.Com Accounting Postgraduate Certificate in Education	B.Ed (Senior and FET) B.Ed Hons: Curriculum Studies (Mathematics Education)
Mathematics teaching experience for hearing learners (years)	0	3
Mathematics teaching experience for HI learners (years)	1	10+
Gender	Male	Female

4.5 DATA COLLECTION PROCESS

The initial aim of the study was to generate data in an inclusive learning environment in a classroom consisting of both deaf and hard-of-hearing learners and their hearing peers in one setting. Still, due to the scarcity of such a school, the context of the school had to change to a specialised classroom for only deaf and hard-of-hearing students. The data collection occurred at a special school in Thaba-Nchu, Motheo District. The school consists of primary and high schools and serves Deaf and Blind learners from all walks of life. The school's principal was initially contacted through email and telephone, and permission to conduct the research was requested and granted. The school's principal referred me to the Head of the Department (DH) and the school's Deputy Principal (DP). The meeting was held with the DH and DP, where the scope of the research was discussed, and permission to invite the possible study participants was granted. Two possible participants were identified and contacted - John in the senior phase and Joyce (DP) in the high school. Due to unforeseen circumstances, Joyce had to cancel because she was requested to attend to the commitments of the school, which was to be held outside school premises for the whole period the data was to be collected. Therefore, other participants were identified, contacted, and invited to participate in Joyce's place.

The participant was pseudonym Salamina in the high school (FET phase). Before the data collection process, arrangements were made directly with the participants regarding their availability, and an agreement was reached.

As per the data collection process, the arrangement was discussed, and there would be two participant observations and one interview thereafter for each participant, which was adhered to. Observations took place in the presence of the deaf and hard-of-hearing learners, and after that, interviews took place based on what was observed and the teacher's own experience. The observation varied from 30 to 50 min, according to the period durations and class disturbances. The interviews took place outside contact time and were conducted during the free period. The duration of interviews varied from 30 minutes to half an hour, respectively.

John was observed in a Grade 8 class, and the sign language interpreter was in the midst. The duration of the period in school was about 50 minutes, and the first lesson with John took approximately 45 minutes. The delay was caused by learners rotating from class to class, and the lesson was delayed. On the day of John's second lesson, John was on time, but because of rotation, the learners got in late and reduced the duration of the lesson to nearly 45 minutes as well. On the other hand, Salamina was observed in a Grade 10 class for the Deaf. The first period of Salamina was on the day assembly was held, and the lesson was delayed. The lesson took nearly 35 minutes. The second lesson on Salamina was a typical day on a Friday, so I was told periods are cut to 35 minutes. Thus, the learners' rotation affected the duration, and the lesson was less than 20 minutes.

During participant observations, documents used in class for the lesson were taken in pictures, worksheets, tests and textbook pages; none of them used the lesson plans but solely depended on applicable textbooks for the entire lesson.

4.6 DATA ANALYSIS STRATEGIES

This section focuses on strategies used to generate data for the study. It is important to note that data was generated through participant observations using lesson synopses and observation schedules (see Annexure F) and then semi-structured interviews using an interview schedule (see Annexure E).

4.6.1 Data generated through participant observation

The lesson synopsis presents the teacher's name, grade, duration, class size, topic and description of the lesson for each participant. Four synopses are presented from the two mathematics teachers at the school each, teaching mathematics to the deaf and hard-of-hearing learners. The participant observations took place during contact time in the presence of the learners, although the main focus was the teacher. During the participant observation, the observation schedule (see Annexure E) was used as a tool for data collection, and thereafter, field notes and lesson synopses were developed (see Annexure B). After the presentation of the lesson synopsis, the following are the general discussions regarding the observations. Documents taken from the participants that formed part of the lesson were taken in the form of pictures and attached as figures.

4.6.1.1 Lesson synopses for participant observation

The lesson synopsis was developed post-participant observation, using the observation schedule in Annexure E as a tool for generating data.

Lesson Synopsis

Teacher	Grade	Lesson Duration	Class Size	Topic
John	8	45 min	13	Percentages

Descriptive Synopsis of John's lesson 1
The lesson starts a bit late as the teacher is waiting for the learners and the interpreter and they arrive approximately five minutes later. The lesson begins with John introducing the interpreter for the day and both of them greets the learners. John is the teacher in class and the interpreter translates the words of John in South African Sign Language (SASL). At the beginning of the lesson John explains to the learners that there is a question on previously written June exam that falls under topic 'Percentage' that he wishes to make a remedial thereof because the learners had performed bad at it. John then starts distributing question paper to the learners and starts reading the questions and the interpreter translating the question in SASL to the learners. John then writes the question on the chalkboard using keywords as follows: <u>Monthly Expenditure (figure [] question 6.3. Extraction)</u> • Rent - 0,346 • Transport Costs – 20 % • Groceries - $\frac{13}{50}$ The interpreter as she translates, contextualise all the expenditures by attaching signs to them. John explains before attempting the questions that every expense above has to be expressed as a percentage, and explains that if expense is given in either decimal or fraction form, to convert it to percentage it needs to be multiplied by 100. <u>Monthly Expenditure</u> • Rent – [0,346 $\times 100 \;= \mathbf{34,6\%}$] • Transport Costs – 20 %

John then allows the opportunity to learners to try determining the amount of 'Groceries' to determine and learner it as follows

- Grocery -: $\frac{26}{100} \times 12500 = \boldsymbol{R3250}$

John concludes the lesson by giving learners similar task to do as classwork, but due to time he asked them to turn it into homework [see figure 3] and the lesson ends.

My initial impression of the lesson: John was addressing the error analysis and for me this exercise is very important after every task as it corrects misconceptions and errors stuck with the learners and it gives both the teachers and learners an opportunity to do reflection. Also the presence of the interpreter in class translating from teacher-to-learner and vice versa was a biggest highlight because it indicated the issue of language barrier between the teacher and learner as a result interpreter was the medium of instruction in class, otherwise John looked competent and prepared although there wasn't any lesson plan .

Teacher	Grade	Class Size	Lesson Duration	Lesson Topic
John	8	13	45 min	Algebraic Expressions

Descriptive Synopsis of John's lesson 2

The learners arrive late in class and the lesson is delayed. Learners greets and apologize to John for the delay from a previous period. Today John is alone in class and there is no interpreter for translations. John had already written on the chalkboard the notes and reads as follows:
 	
<u>Algebraic Language</u>
 	
• Term
• Expression
    - Monomial
    - Binomial
    - Trinomial
• Exponents
Today John is using SASL and also being verbal at the same time. John seem like finding it hard to incorporate sign language and from time to time he fingerspells and learners where possible gives John signs that corresponds to the word, so John depends on learners for the signs. At the beginning of the lesson John attaches signs to algebraic language Type equation here.'Term, expression and exponents'. Using the following example;$2x + 2p + 1$; explains that there are three terms '2x', '2p' and '1' are each a terms and usually separated by a sign in between. John did not have a sign to attach to 'expression' instead he fingerspells it and learners seems lost because it's not internalised. Instead he then explains that expression has types:
 	
• Monomial – signs as 'one term' and example he gives is '2', 'x' or '2x'
• Binomial – signs as 'two terms' and example he gives off is '2x + 2p'
John then decides to give learners an opportunity to sign 'Trinomial' and the learner indeed sign it as 'three terms' then John emphasise it with an example.

- Trinomial - signs as 'three terms' and explains as '2x + 2p + 1'

After ensuring that learners understand expressions, John then proceeds to attach a sign to 'Exponents' and all learners' memories are jogged from previous grades as they seem to know the sign. John signs 'Exponents as 'Number to the power' squashing fingers repeatedly to indicate number and poking top of his head to indicate power. He writes on the chalkboard '$2x^3$' and explain '2' as a number, 'x' as a base (no sign attached) and '3' as a power. John then ask learners to give more examples to give examples of exponents and majority of learners has answers wrong and John gives more examples for emphasis. John then proceeds to ' Addition and Subtraction of expressions' and writes on the chalkboard '$6p + 4a + 2p - a$ and signs to learners that only terms with same variable can add and signs it as 'same letters'. He then proceeds to 'multiplication of expressions' and writes on the chalkboard '$6(p + 2x)$ and $-6(x - 3)$' and before he could proceed explaining these distributive properties, he minds the learners that :

- $- \times - = +$
- $- \times + = -$
- $+ \times + = +$

John then concludes the lesson by giving the learners Home activity because time had relapsed.

Initial impression of the lesson: **John depends on interpreter for communication and interaction with the learners due to language barrier. John does not keep the lesson short to assess learners, all assessments are done outside classroom I think it's because learners has hard time understanding the lesson. John was very persistent and patient with the learners as there was a lot of repetition that took place during the lesson. Learners with hearing-impairment have low concentration span as they use more eye to consume information which led to classroom mismanagement at some point.**

Teacher	Grade	Lesson Duration	Topic	Class Size
Salamina	10	35 minutes	Quantity	4

Descriptive Synopsis of Salamina's lesson 1
The learners came in late in class from the assembly, approximately 10 minutes late. The lesson begins with Salamina greeting the class. Salamina explains to the learners that she will be off content for the day because of time. She indicates that she had designed worksheets for the lesson, a unique grocery list for each learner in class and theirs is to attach prices depending on the value and quantity of an item. Salamina then hands out the worksheets to the learners. After handing out the list to the learners, she recognises the confusion on each learners' face, showing inability to continue with the task. She asks learners what could be the problem, and learners indicate in Sign language that they are unfamiliar with the items. Salamina then begins to contextualise items by attaching signs and sizes to different items and at some point using some real-life objects (visual aids) that were available in the classroom. After a long discussion between Salamina and the learners a light seemed to have been shed, learners begin to write. The worksheets are as follows: Learner 1 1. 20 pieces' cheese slices – R .... 2. 500 ml Juice – R............ 3. 25g Maynard's sweets – R.... Learner 2 1. 1 Bar Chocolate Cadbury – R.... 2. 500 ml Nivea lotion – R....... 3. 1 kg Corn Flakes – R.... Learner 3 1. 23g Simba Chips – R.... 2. Bath Soap – R.... 3. Loaf Brown Bread – R.... 4. 300 ml Coke – R.... Learner 4 1. 500ml water – R....

Figure 4.1: Lesson synopsis

4.6.2 Observation schedule for lesson observations

Various aspects of observation that have been the focal point of this study included mode of communication, teaching aids and teaching methodology.

4.6.2.1 Mode of communication (language)

Teaching mathematics to deaf and hard-of-hearing learners took place in several ways. In John’s class, the first lesson presented was through the SASL interpreter. I learned that learners can only receive mathematics lessons in their home language. John was delivering his lesson in English, code-switching to Sesotho, and the interpreter was tasked to translate the lesson to the learners in South African Sign Language. In the process, there was interaction from the teacher to the interpreter and learners to the interpreter. Thus, the interpreter was a messenger between learners and John in class.

To my surprise, there was no interpreter during the second lesson in John’s class, and this time, John used sign language to address his lesson. Although John was the one translating the lesson, he was still voicing. John seemed to experience difficulty translating the lesson in sign language most of the time, so he had to emphasize using hand and body gestures to contextualize his lesson.

In Salamina’s class, no interpreter was present in either of the lessons observed. The teacher translated the lessons into sign language while voicing in English and code-switching to Sesotho. Salamina seemed like an experienced teacher compared to John, as she was flowing in terms of sign language. However, she would get stuck here, and there was satisfying interaction between learners and the teacher.

South African Sign Language was used to help learners access the mathematics content. In this case, the sign language interpreter plays a vital role in translating the mathematics content to reach the learners as intended by the teacher.

4.6.2.2 Teaching aids (resources)

The textbook (see Figure 4.2) in John's class was the primary source of information for both lessons observed. In the first lesson, John was revising the previously written June examination paper (see Figure 4.3), specifically focusing on the topic ‘’percentages’’, and although John was using question paper and the memorandum, there was a constant reference from the textbook.

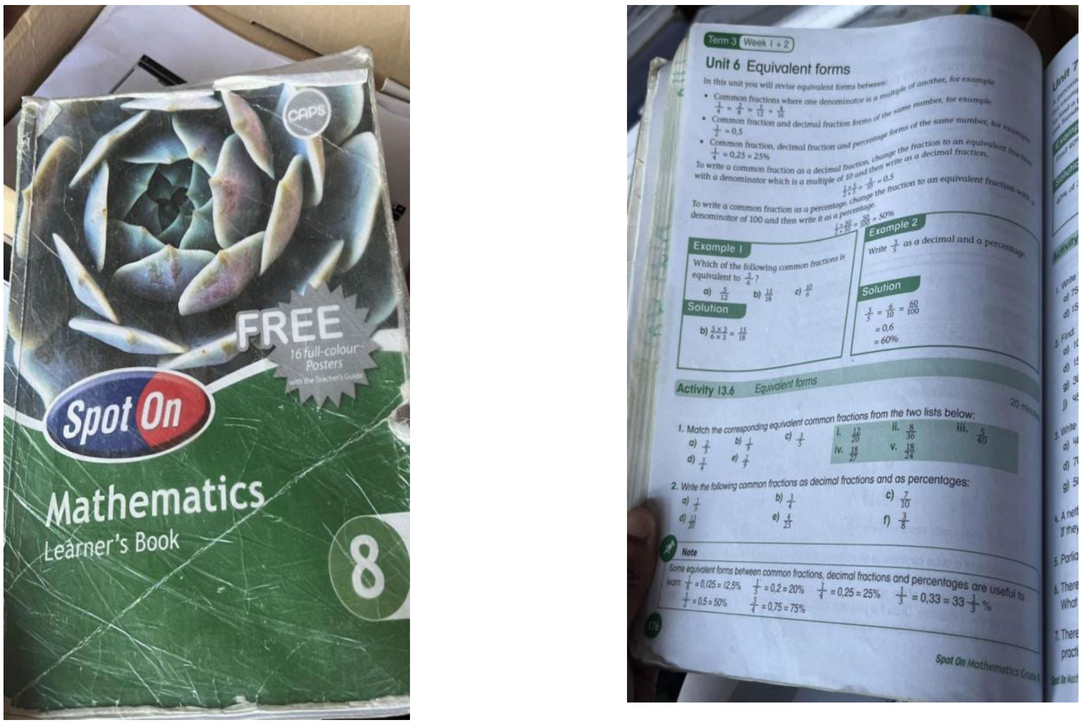
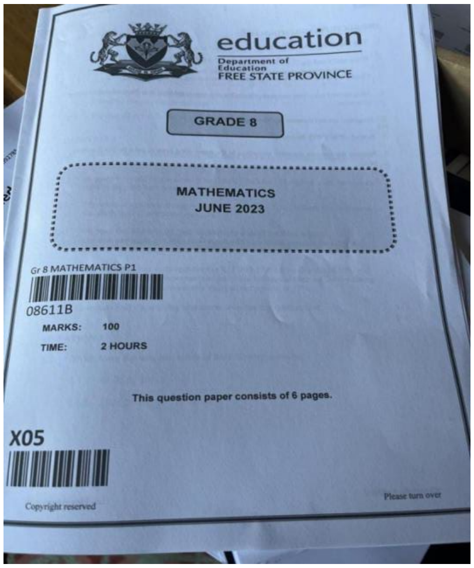
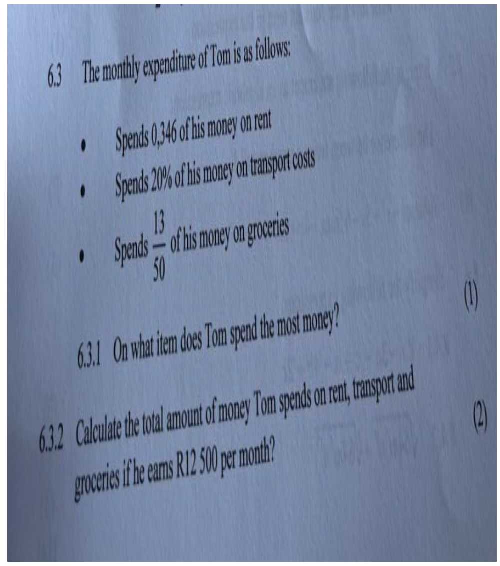
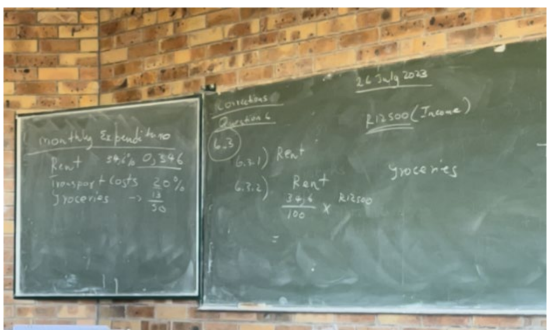
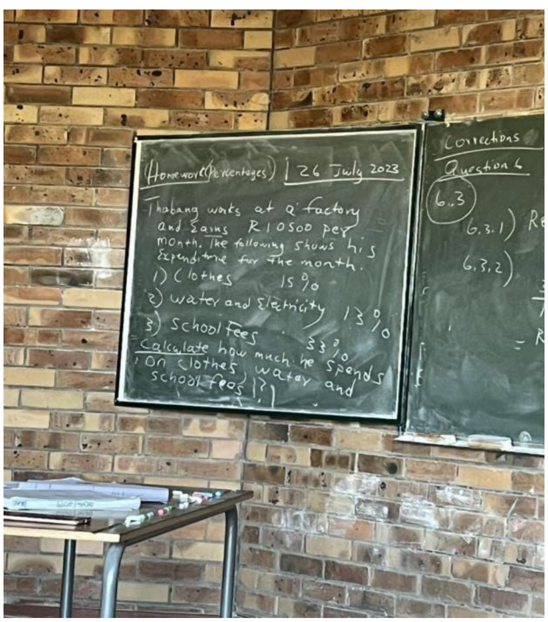


Figure 4.2: Textbook used John's lessons, and the topic dealt with









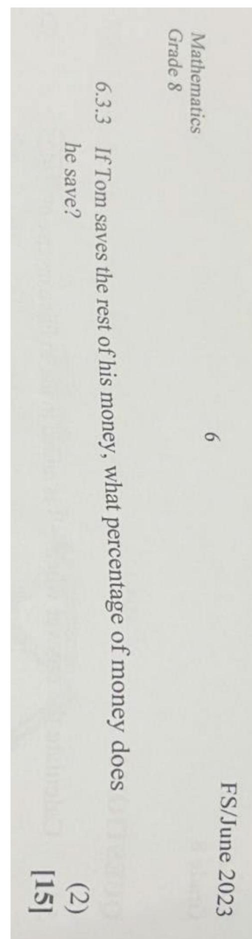


Figure 4.3: Examination paper that was revised, and the section dealt with

On the other hand, Salamina used visual organisers as teaching aids in her lesson. She designed hand-outs for the learners, which were ‘grocery lists’, which she used to quantify items, and learners responded by matching the corresponding prices to the list of items. A grocery list (see Figure 4.4) included items learners bought daily at the store. When the learner could not understand the item on the list, she used some of the live items she had brought to class to contextualise what was written in the text.

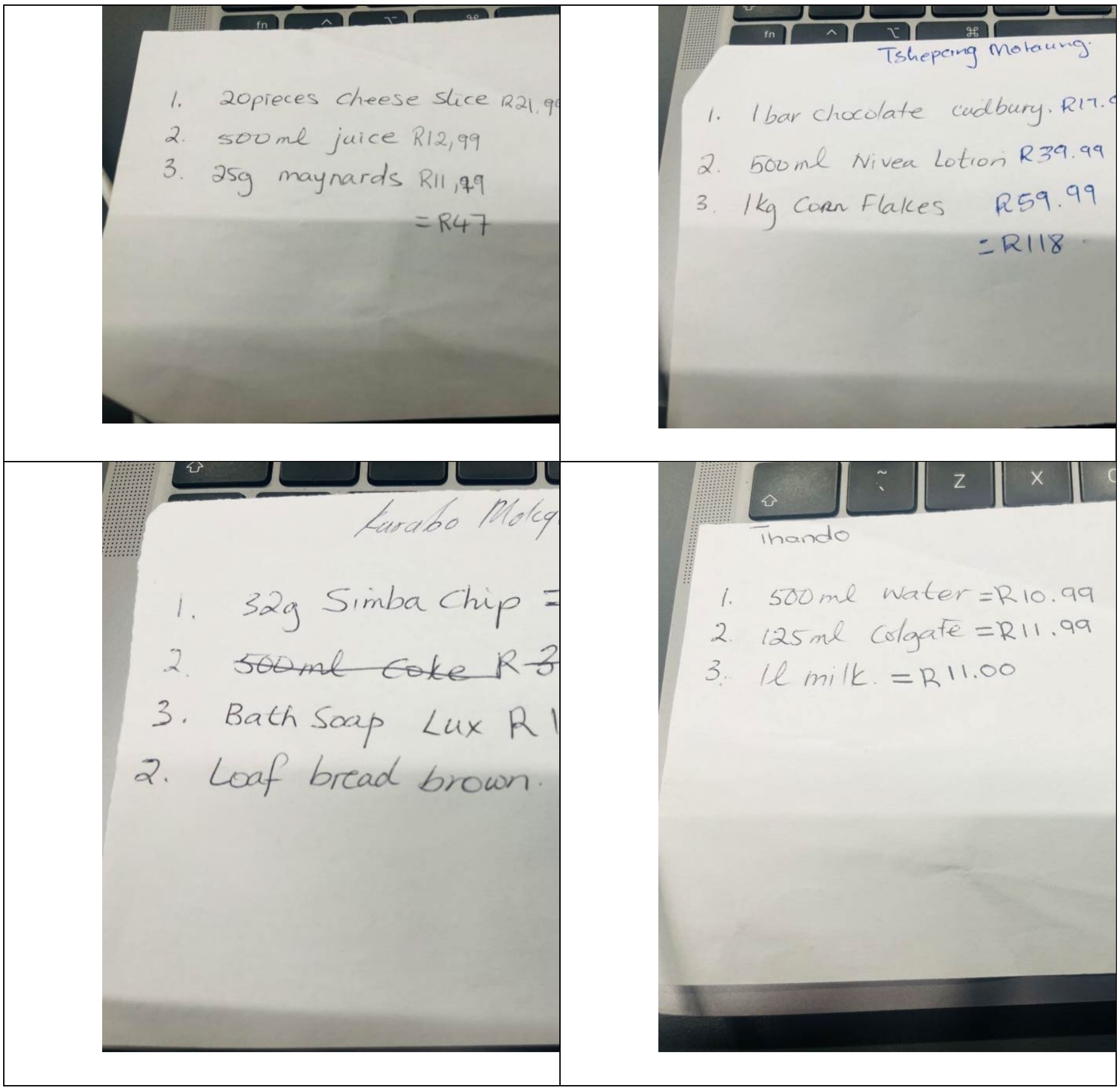


Figure 4.4: Worksheets given to learners as grocery lists to insert corresponding prices

As a result, mathematics was brought to life using visual organisers, which meant learners could access the mathematics content using visual aids. Textbooks also played a significant part in the lesson in ensuring that mathematics is accessible to deaf and hard-of-hearing learners in the classroom. In Salamina's second lesson, the chalkboard method was extended, where learners were instructed to discuss the task displayed on the board as a group (see Figure 4.5).

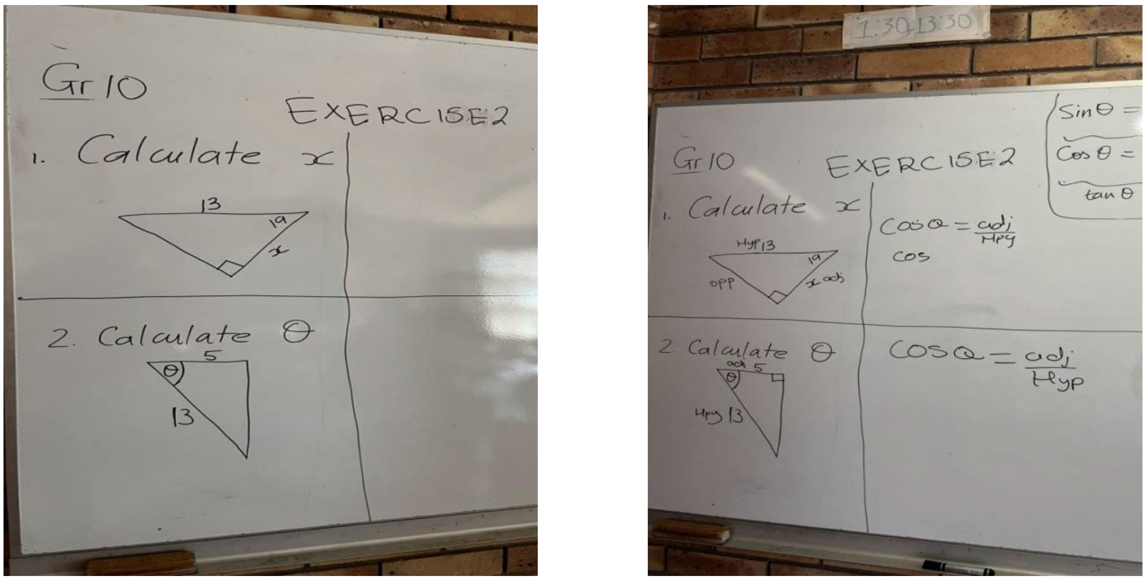


Figure 4.5: Trigonometry task displayed on the board for learners to discuss and respond to

The participant administered this task in the first frame for the learners when she realized the learners were struggling. The participant then went through the task with the learners step-by-step, guiding them to the answer by ensuring that the correct steps were followed. These steps are in the second frame, where trigonometric ratios were now provided to solve the problem for the learners.

4.6.2.3 Teaching methodology

In John's class observations, lessons seemed to be more teacher centred. John presented the information to the learners, and the learners passively received the knowledge presented. However, towards the end of the lesson, some learners started to engage with the lesson while some seemed restless and were having their conversations outside the lesson, showing no interest in what John was teaching. During the entire lesson, while John was teaching, no assessment was given to check the learners' level of understanding.

Salamina's lesson started with an assessment; she handed out the 'grocery lists' to the learners upon arrival. In the beginning, most learners did not understand the task, but Salamina started instructing learners on the given task in general. Still, due to individual misunderstandings among the learners, she had to stand up and provide individual support, and thereafter, they began engaging with the task.

In the second lesson, Salamina wrote an assessment on the chalkboard (see 3.4), and learners gathered and began to discuss what was written on the board. She immediately stopped them as they were starting to respond to the task. She began guiding their steps while reminding them of the basics, where learners responded positively to the task after extensive repetition.

The spiral approach was used in Salamina's class to access the learners' mathematics content with specialized individual support.

4.6.3 Data generated through interviews

The process of transcribing, coding, and emergence themes are presented in this section. The inclusion and exclusion criteria for coding are presented in the table form.

4.6.3.1 Transcribing the data

The data is transcribed verbatim to text from the audiotape and translated into English, where the participant used the indigenous language (Sesotho). During transcribing, most of the Sesotho phrases were translated into English, and where Sesotho vocabulary was essential, the word(s) were kept as part of the transcribing. Please note that care was considered during the translation not to interpret the words of the participants. Emerged uncertainties were addressed by listening to the audio again.

4.6.3.2 Coding of the data

The six-phase analysis process proposed by Braun and Clarke (2020; 2014; 2013; 2012) was used in coding the data, as discussed in section 3.5.1.1. The table was used to assign codes after examining the data for patterns or any repeated information that may emerge. The codes were later grouped to develop the code family (Themes), as shown in Table 4.1. Codes were ascribed based on the practices the mathematics teacher should use in teaching deaf and hard-of-hearing learners. The themes then emerged according to how the codes may have a shared meaning that helped answer the research question(s).

Table 4.2: List of code families (Themes) and their members (Codes)

Knowledge and conditions for teaching HI	Challenges teaching mathematics to HI	Strategies enhancing delivery of T&L		Views on the curriculum for HI	Environment that fosters T&L for the HI	Teaching methods enhancing learning for HI	Effects of language in the T&L of maths for HI	Inclusivity
[MT4] Hearing impairment- Have little to no hearing at all	[MT2] Challenge- difficult teaching mathematics to the deaf	[MT6] Strategy- Workshops learning about deafness	[MT19] Support- Subject advisors' school visits	[MT10] Curriculum- Most concepts have no signs	[MT41] Environment- Class of HI, there's a lot of signing.	[DOE81] Method- fingerspelling doesn't bring context at times	[MT15] Language	[MT56] Inclusion- accommodation of all differences
[MT5] Hearing- impairment	[MT8] Challenge- They cannot relate mathematics to everyday life	[MT9] Strategy- Interpreter translates concepts effectively	[DOE112] Support- Math teachers require content training for HI	[MT34] Curriculum- knowing how to assess differently	[MT42] Environment- U-shaped seating arrangement enhances learning	[DOE84] Method- Language used for teaching is a mix of signed Sotho & English	[DOE93] Language- SASL lacks vocabulary	[MT57] Inclusion- aligning all learners to be all equal
[MT7] Hearing impairment- struggle grasping information	[MT12] Challenge- Most interpreters lack a mathematics background	[MT11] Strategy	[DOE113] Support- Teachers receive SASL training	[MT37] Curriculum- Caps coupled with technical skills	[MT43] Environment- perfect sight for chalkboard	[DOE86] Method- Lesson planning depends on the pace of learners, not ATP	[DOE101] Language- SASL structure differs from English in text, causing misunderstandin g and inability to read	[MT58] Inclusion-
[MT33] Hearing- impairment- Restless and exhibits less attention span	[MT14] Challenge- Signing is new and challenging for teachers	[MT13] Strategy- team teaching with the interpreter	[DOE114] Support – Workshops by SA	[MT40] Curriculum- Specialised question papers foster T&L.	[MT45] Environment	[DOE88] Method – Teaching with examples enhance understanding	[DOE126] Language- teacher as a mediator of	[DOE134] Inclusion – ensures equality

							mathematics and SASL.	
[MT53] Hearing impairment- Cannot read English	[MT21] Challenge- Apps are only basic signing	[MT16] Strategy- Workshops for sign language	[DOE127] Support- support is not reciprocated as in the main steam	[DOE66] Curriculum- does not align with the HI learners	[DOE117] Environments- Stressful	[DOE89] Method- Incorporated ICT in the teaching	[DOE125] Language- Maths and English are difficult for learners to understand	
[MT59] Hearing impairment- can be teachable and achieved in mathematics	[MT25] Challenge- Some signs for some concepts don’t exist	[MT17] Strategy- Workshops make delivery of lessons easier	Support- DoE invests in Deaf experts	[DOE68] Curriculum- Inability to complete prescribed teaching plan		[DOE90] Method-Learner-centred approach encourages learning among learners		
[DOE69] Hearing impairment – Inability to relate maths problems to real-life situations	[MT30] Challenge- no content workshops approach for the deaf	[MT18] Strategy- teacher team teaching with the interpreter	[DOE128] Support- enhance SASL communication	[DOE78] Curriculum- Mathematics vocabulary for HI is difficult		[DOE91] Method- HoH teaching concepts to other Deaf learners.		
[DOE73] HI- is not a disease	[MT31] Challenge- Teachers struggle with content delivery	[MT20] Strategy- Apps translating maths terms to a sign	[DOE131] Support- DoE invests in Deaf experts	[DOE96] Curriculum- curriculum taught HI is not befitting		[DOE94] Method- Incorporating SASL with mathematics		

[DOE75] HI- can born deaf or deafened alive	[MT48] Challenge- Delivery of content is a challenge	[MT22] Strategy- Utilising experienced teachers	[DOE97] Curriculum- content is mostly not appropriate because SASL is introduced late	[DOE98] Method- learners achieve through concessions
[DOE87] HI- learners are forgetful	[MT61] Challenge- systems are not in place	[MT24] Strategy- creating the same signs throughout all phases	[DOE118] Curriculum- Difficulty delivering prescribed curriculum	[DOE100] Method- Learners depends upon teachers examples
[DOE99] HI- they mostly recall than answering high-order questions	[DOE72] Challenge- Teacher's inability to communicate in SASL	[MT26] Strategy- Fingerspelling terms supporting with examples	[DOE130] Curriculum- Varied curriculum fosters T&L for the Deaf	[DOE106] Method- Differentiation approach
[DOE103] HI- slow in completing tasks and still submit incomplete work	[DOE76] Challenge- Overcrowd in the classroom	[MT27] Strategy- training on differentiating curriculum		[DOE109] Method- Attaching signs to math terms
[DOE123] HI- lack of basic mathematics	[DOE79] Challenge- DoE says HI learners cannot read spoken language	[MT28] Strategy- Adaptations of Curriculum		[DOE116] Method- learners are highly dependable on

						teachers examples		
	[DOE92] Challenge- DBE condones math for the Deaf	[MT29] Strategy- training on approaches enhancing T & L for the deaf				[DOE132] Method- Spiral approach enhances T & L of the Deaf		
	[DOE104] Challenge- Teacher's uncertainty over translation done by the interpreter	[MT35] Strategy- Differentiated assessment				[DOE133] Method- Repetition enhances the learning of the deaf		
	[DOE107] Challenge- Differentiation approaches a challenge; some learners have multiple disabilities	[MT36] Strategy- Integrate Curriculum with practical skills						
	[DOE108] Challenge- Sign language is not taught in universities	[MT44] Strategy- Clear writing on chalkboard or projector						
	[DOE110] Challenge- Teachers make	[MT47] Strategy- use experienced teacher						

	individualised signs inconsistent from grade to grade.	
	[DOE111] Challenge- No developed signs for maths; SASL just officiated	[MT49] Strategy- specific content problems consult other schools
	[DOE115] Challenge- SA is not aware there are deaf schools	[MT50] Strategy- team teaching encourages effective T&L.
	[DOE121] Challenge- ICT material and textbook not interpreted for the deaf	[MT51] Strategy- designing practical examples
	[DOE124] Challenge – Difficult teaching maths to the Deaf	[MT52] Strategy- interpreter simplify T&L through translation
		[MT54] Strategy- preparation with the interpreter ensures that learners receive

	the message as intended	
	[MT55] Strategy- Regular assessment improves problem areas	
	[MT60] Strategy- stakeholders' involvement in the education of Deaf learners	
	[MT63] Strategy- Incorporation of ICT and all visual organisers	
	[DOE67] Strategy- overload makes teaching HI unbearable	
	[DOE70] Strategy- Ratio of 1:5 of normal school to a special school in classrooms	
	[DOE77] Strategy- C-	

	shaped arrangement in classroom
	[DOE83] Strategies- Catch up programs enhance teaching for HI
	[DOE85] Strategy- New teachers are paired with Interpreters (Team-teaching).
	[DOE102] Strategy – Interpreters are needed for reading and understanding
	[DOE122] Strategy – Drawing to explain concepts

4.7 DATA PRESENTATION AND INTERPRETATION

After data was analysed and themes developed from codes, this section seeks to present and discuss the findings from participants that emerged from the data. After the data was presented, the previous literature from Chapter 2 of the study was discussed. The reader must take note of themes that emerged from data analysis, and they are not a direct extraction of the research questions.

4.7.1 The knowledge of hearing impairment necessary for mathematics teachers

The teacher of HI learners should possess the specific knowledge necessary to enhance the mathematics teaching experience.

4.7.1.1 Knowledge which contributed to the creation of the experience of the learning needs of HI learners

It emerged during the interviews that the participants in this study saw the importance of experience as an essential component and aspect of teaching HI learners mathematics. As a result, the co-researchers and I began divulging their knowledge of the learning needs of HI learners and their impact on the teaching and learning of mathematics. According to Scott and Palincsar (2013), Lev Vygotsky's sociocultural theory also supports this claim. In sociocultural theory, cognitive development must also account for experience's role in advancing development.

The first participant indicated one year of experience teaching mathematics in an HI classroom, and the second had over ten years of experience in an HI mathematics classroom (see Table 4.1). As a result, the participant with more experience had so much to say than the first participant. However, participants mentioned that from their experience, a hearing-impaired person has limited hearing in either one or both ears and no hearing at all. Moreover, the second participant extended by eluding that HI is not a disease but a condition where one is born with it or could be deafened alive. According to the participants, learners bearing HI are generally forgetful, slow in understanding, restless, and exhibit less attention span, impacting difficulty in completing mathematics tasks on time. The claims made by the participants are solely from their experiences working with HI; no form of education has been imparted to them in the form of workshops or training. This is why Piaget's theory of constructivism argues that "people produce knowledge and form meanings based upon their experiences" (Ellwood, 2020).

Participants noted that HI learners are teachable and can achieve in mathematics; however, achievement cannot be as fast as that of the hearing person because, according to the nature of their disability, they cannot relate mathematics to their everyday life, making it challenging to answer high-order questions, but can only recall. What was also found intriguing was the ratio of one HI learner to five normal-hearing learners. Thus, one participant noted that one HI learner is equivalent to five in normal hearing schools. The class size must be small because the seating is arranged in a C or U-shape for learners with hearing impairment.

Here is what the participants had to say when asked about their knowledge of hearing impairment in their exact words. John, the Grade 8 mathematics teacher, said:

> *"These are learners with hard-of-hearing. Some of them can hear very little, while some of them cannot hear at all. We do attend some workshops about learners who are deaf. Their condition is natural. As I told you yesterday, it's difficult for learners to grasp information, they cannot relate mathematics to their everyday life. Also, learning how these learners behave is important for us as teachers because, as you have seen, they are restless in class, and every two minutes, you have to reprimand them. In a hearing-impairment class, there's a lot of signing, and seating arrangement should be such that nobody obstructs the view of the other; normal seating arrangement is U-shaped."*

Salamina was the Grade 10 mathematics educator who also had something to say about her knowledge of deaf and hard-of-hearing learners:

> *"Hearing impairment is not a disease, therefore not treatable. Being deaf means no message is going through. Hence you find some with a little hearing having cochlear implants to be hearing. Some people are born deaf, while some are deafened while alive. It's been more than ten years teaching mathematics to deaf and hard-of-hearing learners, a challenging journey, and it hasn't gotten any better because the department does not address issues of the teachers in Deaf schools. I am going on pension next year, and the curriculum still does not match the type of learners. It's a lot of work because the teaching*

becomes slow for them to understand, and they require repetition. The learners we are teaching are very forgetful and lack confidence. They are good at cramming examples and unable to apply logic. You leave this place very tired because you are standing in front of these learners repeating one thing, and they still don't hear you; it's difficult to complete the prescribed ATP. These learners are heavy, and because of their disability, one learner in a special school is equivalent to five learners in a normal school; imagine having 20 learners in a class equalling 100 learners according to the ratio."

Previous studies have shown similar and contrasting trends to these findings. Based on previous studies, Nazia et al. (2023) define hearing impairment, according to The World Health Organization (WHO), as a disability due to hearing loss of > 35 decibels in a better hearing ear because the threshold for normal hearing is 20 decibels (dB). Similar to the findings cited by Glennon (1981), evidence indicates that Hearing-Impaired (HI) learners show unreflective behaviour and lack persistence in working through complex problems. Likewise, Kelly and Lang (2023) cited that HI learners have difficulty transferring learning from one context to another, and remembering what has been previously learned is a problem. In contrast with the findings, the literature reveals that deaf and hard-of-hearing learners lack domain-general skills, which makes them perform poorly on counting recall and digital recall tasks and are thus classified as weak in serial recall short-short-term memory and working memory (Bull et al., 2018; Harries et al., 2013, 2011).

Considering both findings from participants and the previous literature, the implication is that they are fully aware and knowledgeable about the nature of the disability in question. One participant also indicated that workshops on hearing impairment are attended. Furthermore, it seems that the nature and behaviour of deaf and hard-of-hearing learners impact poor performance in mathematics studies. Emphasis has been made on both findings and literature that, because of unreflective behaviour and lack of persistence, deaf and hard-of-hearing learners cannot answer high-order questions; however, in contrast to the literature, findings revealed that deaf and hard-of-hearing learners perform well on recall type of questions in mathematics.

4.7.2 Challenges hampering the success of teaching of mathematics to deaf and hard-of-hearing learners

The previous section focused on the knowledge and aspects considered necessary for enhancing the experiences of the teachers teaching mathematics to deaf and hard-of-hearing learners. However, the focus shifts to the challenges teachers experience that may impede the successful teaching of HI learners mathematics.

4.7.2.1 Language as a threat in classrooms teaching HI learners mathematics

Findings revealed that teachers encounter distinct challenges teaching mathematics to HI learners. Based on data analysis, one prominent challenge was that language is at the heart of the participants' difficulty and that sign language must be at the interface for pedagogy. It is without a doubt noteworthy that hearing-impaired communities communicate using sign language all over the world. In South Africa, South African Sign Language has just been officially officiated as the twelfth official language, which means many citizens are not yet conversant with the language. To bridge this gap, participants reported an unreliability of interpreters.

Most importantly, interpreters in the school are few. They were mainly allocated to inexperienced teachers, and the difficulty is eased when the interpreter is available in the class lesson. The participants also highlighted that it becomes challenging to develop mathematical content in sign language because no training had been offered, mainly because workshops that were granted focused on the development of sign language rather than pedagogy.

Participants noted that challenges with delivering mathematics content as intended are because of language constraints, and therefore, there is a reliance on interpreters for translation to bridge the gap. The participants were notified that there was a lack of mutual trust between themselves and interpreters as to whether the translation reaches the learners as intended; one participant also noted that interpreters are offered to teachers who are new and inexperienced. Participants also reported that mathematics requires learners to relate it to real-life situations. Still, the language barrier burdens their content delivery as the context requires real-life experience. John, in his verbatim, had this to say on this matter:

> *“I started teaching mathematics in January 2022, and this is my second year. This was the first school I started teaching mathematics. Teaching mathematics has been difficult for me, especially teaching learners with deafness. As I told you yesterday, it's difficult for learners to grasp information. They cannot relate mathematics to their everyday life. This is why, at some point, you need to have services of the interpreters to help explain some of the concepts. Some concepts have no signs. Di sign tsa most concepts tsa maths hadiyo* [Assistance of interpreters help].*”*

In a case where participants had basic sign language knowledge, it was reported that the sign vocabulary for mathematics was minimal. The participant said that she had to create her signs for the mathematics concepts and that there were no guidelines. In a case where there are no signs, the participants opted for fingerspelling the terms, but according to her, fingerspelling does not bring context to the term or concept. Participants also mentioned that these individualised signs for concepts are inconsistent from grade to grade, thus creating confusion for the learners as they progress. In substantiating why they ended up with individual signs, participants reported that there are applications for retrieving ‘signs’ but only for basic concepts, so they do not benefit much from these ATPs. Salamina had something to say regarding this challenge:

> *“Mathematics vocabulary for deaf and hard-of-hearing learners is difficult for teachers. There is no dictionary or any guideline that assist teachers of the Deaf to learn math vocab. Department of Education says deaf learners cannot read any spoken language, yet books are written in English, and the language is foreign to them. Fingerspelling sometimes does not help as it doesn’t bring context but total misunderstanding to the learners.”*

Findings based on the two participants suggested that language is at the heart of the difficulty among the mathematics teachers of deaf and hard-of-hearing learners. The language problem occurs when the participants create their own signs without proper guidelines to contextualise their mathematics lessons. Such a scenario usually leads to paralysis, a lack of confidence in the teachers, and poor learner performance. Past studies support this claim when Kelly and Lang (2023) revealed that regarding instructional settings, if the teachers fail to engage deaf and hard-of-hearing learners in cognitively challenging problems and resort to more practice questions in mathematics because of language barriers, this can decide the direction mathematics education takes.

Rowley and Heather (2005) regard the key to successful mathematics teaching to deaf and hard-of-hearing learners as understanding and developing mathematical language from the language of instruction to the native speech. This displays the centrality of sign language in teaching mathematics to the deaf and hard-of-hearing. Infighting over this native language is likely to affect mathematics teachers of HI negatively. The literature highly supports the intensive use of sign language at the interface and is regarded as a critical factor in successful teaching (Nadal & Collet, 2020). Otherwise, most teachers without the knowledge of this native language will be reluctant to enrol to teach mathematics at schools with learners with a hearing disability. This action could lead to a lack of mathematical education background for learners with hearing impairment, and therefore, the concept of inclusivity will not be upheld.

4.7.3 Methods used by the teachers of deaf and hard-of-hearing learners to teach mathematics

The focus of this sub-section is on the remedies to try to curb the plausible threats discussed above.

4.7.3.1 Didactic approaches used by teachers to circumvent the threats

Data has revealed that a specific didactic approach is one of the initiatives employed by the teachers of HI learners in special schools. These didactic approaches are dependent on the availability of resources, especially for deaf and hard-of-hearing learners; there is a likelihood that the subject will perform. With regards to the unavailability of specific instructional material and didactic approaches for teaching mathematics to deaf and hard-of-hearing learners for the teachers of the school, the participants were of the view that it becomes difficult to teach hearing-impaired mathematics. For instance, the following scenarios exist at the school regarding the mathematics teachers' experiences with deaf and hard-of-hearing learners. This is what the participants had to say:

> *"There are experienced mathematics teachers at the school whom I consult for help, especially with attaching signs to mathematics terms. During my preparation, I identify*

*concepts that I am unable to teach to deaf learners and consult with experienced teachers as to how they taught or teaching that concept so that I understand how am going to deliver that lesson properly so that all learners' understanding is prioritised. For example, the way normal 'x' is seen in sign language it is translated differently so it is important to know how it is translated. Some of the signs for some concepts does not exist in South African Sign Language. That's where you have to fingerspell the term/concept and support it with the example in a case where the sign is not available. I think the training on differentiating curriculum will be of paramount importance and also a training on adapting curriculum to better suit their disability without distorting the CAPS document/curriculum. Training also on approaches teachers of hearing-impaired could use that will enhance their understanding for different topics will greatly help the teachers of special schools with deaf and hard-of-hearing learners. Usually, the training we receive is generally for all teachers to be able to communicate using SASL, there are no specific workshops targeting content specific for approaches/methods when dealing with the specified disability. The content generally, I am okay. The only problem is the delivery of the content to the learners. More importantly, I think they should align the curriculum and integrate it with more hands-on experiences that are more practical that they can see. Unfortunately, the same instructional material that is used in normal school for hearing learners is used in special schools for learners with deficit to hearing, the likes of textbooks, ATP's and pictorials. Because the argument is that they are writing the same question paper as main-stream learners" (*John).

In line with the above research findings, the other participant had this to say as well:

"First of all, it is difficult to do lesson preparation for these learners because we don't have the means to talk to them, and even if I have prepared, the lesson will ultimately change because you have to move according to their understanding and not prescribed ATP. Learners usually not performing in previous task, which makes it difficult for me to plan ahead. I am unable to teach mathematical concept to deaf learners because they are ignorant. They will sign correctly and write differently; you stand the entire day repeating the same thing (Spiral method). They are good at cramming examples and unable to apply logic. They would literally copy and paste the examples you have taught them without fail. Even incorporating ICT doesn't work with these learners because they still can't follow because the language used, is foreign to them. Most of the time, I use learner-centred approaches where they teach one another, because they understand each other more. I usually utilize hard-of-hearing to explain concepts to other deaf learners, because at least hard-of-hearing have little to

moderate hearing. The same support given to mainstream schools should be reciprocated in Deaf schools. The only support we get is how to communicate using SASL to deaf people. It does not go deeper into how to effectively teach mathematics content to a deaf person. There should be specific instructional materials for mathematics teaching of deaf people and varied curriculum suitable for deaf learners that will benefit them beyond matric" (Salamina).

Participants reported experiencing difficulty in teaching mathematics to deaf and hard-of-hearing learners. Previous research is also of the same view that schools nowadays face many challenges in educating students, mainly deaf and hard-of-hearing learners (Naomi & Revathi (2019). According to previous research, teachers must share their best practices on various platforms, such as meetings, teacher training programs, workshops, seminars and conferences (Marasabessy, 2021). However, research findings revealed that the content workshops they attend focus on didactical approaches for regular hearing learners, where good teaching practices do not assist in teaching deaf and hard-of-hearing learners. Furthermore, they infer that some subject advisors, in most instances, have no idea that some schools offer mathematics to deaf and hard-of-hearing learners. It is for this reason that it is believed that there are still no didactical approaches for teaching mathematics to deaf and hard-of-hearing learners thus far (Krause, 2018). Hence, Singh et al. (2020) and Quality Assurance and Standard Officers (QASOS) in Kenya infer that teachers of the deaf and hard-of-hearing are still employing teacher-centred approaches. The research findings revealed that teachers had to devise their own thought-out methods. One of them involved consultations with experienced mathematics teachers, where one participant reported that during preparation, he identified concepts he could not teach to HI and consulted with other teachers.

Nevertheless, previous literature reported that certified mathematics teachers support certification and preparedness in mathematics, and certification makes a difference in overcoming challenges related to deaf and hard-of-hearing learners. Above all, the majority of the teachers who lack the skills to teach learners with hearing impairment have inadequate certification and preparedness in mathematics. Participants reported that resources are limited. In cases where resources are available, experts do not provide training on using specific materials for the deaf and hard-of-hearing. Principally, textbooks and ICT materials are incompatible with deaf and hard-of-hearing learners as these materials require interpretation for HI learners. According to the previous literature, most rural schools cannot access technological tools, which makes learners with hearing impairment remain behind in mathematics compared to hearing learners (Khathare, 2020). However, Edyburn (2000) and Khathare (2020) noted that technological assistive devices may greatly benefit learners, especially the ones living with disabilities in subjects such as mathematics and that teachers and school management have the responsibility to make time to learn, practice and become skilful with technological tools and complementary learning approaches to benefit their teaching and learners' learning. Teachers mentioned that they experience the challenge of constructivist assistive technology and struggle to integrate it into the curriculum since it is a new approach and learners are often distracted by it (Khathare, 2020). A recommendation was then made by Marasabessy (2021) that mathematics teachers of deaf and hard-of-hearing learners need to improve the delivery of more practical lessons than theoretical lessons.

Participants reported that they require training on different approaches to enhance their teaching. They also mentioned that the training should include adaptation of the curriculum. In some cases, participants noted that it is challenging to adopt the differentiation approach because, at times, a learner may have multiple disabilities other than hearing impairment. The popular strategy participants practised was the spiral method, which was used to repeat lessons. Concessions were where learners were given extra time and access to an interpreter and a scribe. However, the challenge of adopting the two strategies is that they require additional time, thus creating a workload for teachers. As a result, I encountered difficulties completing the annual teaching plan. Participants also noted that moving at the same pace as the learners during teaching is essential, and they also indicated that they do not design lesson plans because they are usually ineffective in a classroom for the deaf and hard of hearing. It is said that their next lesson is determined by the learners' progress on a topic. Previous studies recommended that special e-learning programs be part of classroom instruction, as they assist teachers in improving and speeding up their delivery of concepts and enhance learners' understanding of topics, such as basic lower primary geometry and their perception of a classroom learning environment (Kibass, 2012). This e-learning program is also seen in Pakistan, where teachers reported the use of mobile applications to teach deaf and hard-of-hearing learners, and the teachers reported this approach to have enhanced the learning skills of the deaf and hard-of-hearing learners in learning basic mathematical concepts, using Pakistan Sign Language (Parvez et al., 2019).

However, repetition and regular assessments of the problem areas have been reported to be one strategy that improves mathematics comprehension for deaf and hard-of-hearing learners. Among other things, participants reported that they utilise catch-up programs to put this teaching strategy into practice. In the same view, previous literature has shown that most real-life problems in mathematics are not well-defined. Therefore, learners of hearing impairment must be given considerable practice with problem representation and re-presentation (Kelly & Lang, 2023). Participants alluded that mathematics vocabulary in sign language makes teaching mathematics to deaf and hard-of-hearing learners even more complicated because of the limited vocabulary in 'math signs'. Most concepts have no signs, and it was noted that South African Sign Language was introduced later, making the mathematics curriculum seem like it is not befitting for the deaf and hard-of-hearing. Participants suggested that the curriculum be coupled with practicality rather than theory to compensate for the lack of vocabulary, where more visual organisers are used to explain the mathematics content. Participants described that they often use figures to explain abstract mathematics content and that their teaching for HI learners integrates more visual and practical organisers. If fingerspelling is used instead of an actual sign, it is supported with more practical examples to contextualise it. This scenario was found to exist at this school and contributed to the teachers' experiences teaching mathematics to deaf and hard-of-hearing learners. Subsequently, previous research also revealed that deaf and hard-of-hearing teachers, who give more instructional attention to concrete visualisation strategies than analytical strategies, are more successful in teaching mathematics to deaf and hard-of-hearing learners (Kelly & Lang, 2023). In the same view, Singh et al. (2020) revealed that some of the methods employed by Kenya and QASOS included demonstration, use of objects, approach and attach response, and explanation of keywords or items in advance.

4.8 CHAPTER SUMMARY

Chapter 4 focused on the analysis, presentation, and discussion of findings from mathematics teachers of deaf and hard-of-hearing learners. Relevant documents were reviewed, as explained in Chapter 3. This chapter presented the views of the mathematics teachers of the HI, pertaining to their experiences teaching mathematics in a classroom of HI learners. As part of that discussion, the initiatives that mathematics teachers of HI employed in exploring their experiences were also discussed. This study was concerned with evoking the experiences of mathematics teachers of HI by looking at their knowledge of HI, challenges and the methods provided by these teachers in addressing the research problem. The next chapter focuses on the conclusions and recommendations generated from the findings discussed in Chapter 4.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The previous chapter presented and interpreted the findings from semi-structured interviews and participant observations. Drawing from the findings, this chapter presents conclusions, and based on the conclusions, recommendations are made. In a brief implication for future research, conclusions are made based on the recommendations. Nevertheless, before conclusions, recommendations and implications are discussed, a summary of the study is made.

5.2 STUDY SUMMARY

Chapter 1 provided the introduction and background of the study. The background, interest, and reason for pursuing the study were expressed regarding teachers' experiences teaching mathematics to HI learners. The chapter also outlined the problem statement, purpose, rationale, research questions and objectives, and theories and key concepts discussed in this chapter. Chapter 2 presented the review of the literature, as well as the theories guiding this study. Research studies and debates held locally and internationally were discussed in the review. Theories guiding the study were also discussed in that chapter. Chapter 3 discussed the research design and methodology that was used to generate data in an attempt to respond to the research questions of the study. The findings and discussion were presented in Chapter 4, and the current Chapter 5 presents conclusions and makes recommendations.

5.3 CONCLUSIONS OF THE STUDY

The study aimed to explore the teachers' experiences teaching mathematics to deaf and hard-of-hearing learners in an inclusive learning environment. Moreover, the study intended to explore the HI learners' learning needs, methods, and ways to mitigate the challenges they encountered in their experience as mathematics teachers of the HI learners. For this reason, HI learning needs, methods and challenges were used as crucial findings to provide the structure of conclusions in this chapter. Chapter 4 presented and discussed the findings that emerged from the data analysed. Therefore, Chapter 5 discusses the conclusions thereof.

5.3.1 Deaf and hard-of-hearing learners learning needs for mathematics

The study's first objective was to establish the mathematics teachers' learning needs of HI learners, which was achieved when our findings revealed that there is a specific knowledge related to the impairment that is imperative for mathematics teachers to know of. For this reason, it can be concluded that this knowledge may significantly contribute to the experience of the teachers as experts in the subject. It was then noted that hearing impairment is associated with unreflective behaviour and persistence to work through complex problems. Furthermore, the current study's findings revealed that deaf and hard-of-hearing learners lack problem-solving skills and often leave tasks incomplete. It is without a doubt that deaf and hard-of-hearing learners perform poorly in their problem-solving tasks, noting that mathematics is abstract in its nature and prominent skills are required to work through mathematical tasks. However, previous literature revealed that deaf and hard-of-hearing learners lack domain-general skills and are thus classified as weak in serial recall, short-term memory and working memory, contributing to poor recall.

In contrast to this finding, it was revealed that deaf and hard-of-hearing learners are good with recall tasks, but unfortunately, all the skills, including problem-solving, are required to perform in mathematics. Consequently, the participants focused more on recall tasks than problem-solving in their lessons, and it is not surprising that deaf and hard-of-hearing learners are still lagging in terms of performance compared to their hearing peers because to perform in mathematics, all levels of Bloom's taxonomy must be covered. This problem emanates from the unpreparedness and incompetency of the teachers because Kellly and Lang (2023) reported that certification for mathematics teachers supports preparedness in mathematics, and it makes a difference in the ability to overcome challenges related to teaching deaf and hard-of-hearing learners. Above all, drawing from the findings, it can be concluded that teacher preparedness for deaf and hard-of-hearing learners depends on certification, which was unfortunate for this school. I am saying this because the teachers' profiles suggest that the teachers were not properly qualified. Hence, the issue of teachers experiencing difficulties in teaching mathematics to deaf and hard-of-hearing learners dominated the discussions with research participants. Furthermore, we can assume that higher institutions are partially to blame as sign language is not compulsory to student teachers, making it hard for them to adjust to such work environments, which may contribute to the poor performance of HI learners.

5.3.2 Methods used to teach HI learners mathematics

The study's second objective was the methods used to teach mathematics to deaf and hard-of-hearing learners in the selected school, and this objective was achieved when the findings revealed that there are no didactic approaches to teaching mathematics to deaf and hard-of-hearing learners. Based on the evidence, it can be concluded that participants find it difficult to teach mathematics to deaf and hard-of-hearing learners. As a result, during interviews and participant observations, teachers used the teacher-centred approaches where the teacher communicated with the textbook and chalkboard more than engaging the lesson with the learners. Similar findings were indicated by Karuru and Khathare (2020) that teachers of the deaf and hard-of-hearing are still employing teacher-centred approaches. However, during the participant observation and interviews in the other classroom, the teacher illustrated and mentioned that she uses peer-to-peer learning among her learners, where hard-of-hearing learners would promptly explain concepts to other deaf learners. It can, therefore, be concluded that there is no didactic approach for teachers of the hearing-impaired teaching mathematics; teachers just employ any method that works for their learners. According to the participants' profiles, it is evident that participants are not properly certified to teach mathematics to deaf and hard-of-hearing learners. As a result, they were not prepared to do so. Teachers' unpreparedness dominates the discourse, characterized by poor learner reception of mathematics concepts. The poor learner reception was associated with their unreflective behaviour and lack of persistence to work through problems. As a result, learners were reported to master and recall tasks better than problem-solving. It can be concluded that teachers focus more on recall tasks. One prominent method popular among the participants was the spiral method, considering the nature of the deaf and hard-of-hearing learners in that they were associated with slowness and difficulty completing tasks. In response to these characteristics, participants reported that they opted for repetition of the lessons and regular assessments on catch-up programmes.

During the interviews, the participants revealed that the mathematics vocabulary for deaf and hard-of-hearing learners is challenging to teach, and there are no guidelines for developing math signs. Among other methods used by the participants, findings revealed that demonstration was a popular method for teaching mathematics to deaf and hard-of-hearing learners. During the discussion, participants indicated that they used drawings to illustrate the mathematics concepts. When the sign for a particular concept was unavailable, they reported fingerspelling and supported it with the example. It can, therefore, be concluded that demonstration is vital for teaching mathematics to deaf and hard-of-hearing learners.

Previous studies have indicated that technology has a powerful impact on teaching mathematics to deaf and hard-of-hearing learners. However, teachers indicated that e-learning requires sign language in the interface, making incorporating it in their teaching challenging. Participants have also noted a lack of resources, especially in rural areas, such as technological devices to help teach learners with hearing impairment. However, even when such specialised teaching aids are available, no experts can train them on their usage. Besides, teachers indicated that ICT does not help them as the language is still foreign to their learners and needs to be interpreted. Findings also revealed that participants suggested that the curriculum be coupled with more practical skills, where learners will experience mathematics physically and refrain from theorising it. Besides, Morgan (2008) and Singh et al. (2020) suggested that using a combination of teaching methods and not relying on only one will ensure that all bright and struggling learners are included in the teacher's lesson effectively, for example, a teacher could be employing traditional teaching methods with hands-on-materials. Findings also revealed that participants used peer tutoring as one of the methods in the classroom, where teachers team up, and learners learn from one another in a classroom, which also encouraged participation among learners.

5.3.3 Challenges to teach mathematics to deaf and hard-of-hearing learners

The third objective was to identify the possible challenges of teaching mathematics to deaf and hard-of-hearing learners in the selected school. This objective was met when findings revealed that it is challenging for teachers to teach mathematics to deaf and hard-of-hearing learners. Findings have shown that language is at the heart of the difficulties teachers are experiencing in the classroom. For this reason, evidence revealed that mathematics teachers are not prepared to teach mathematics to deaf and hard-of-hearing learners because they are not certified, according to the participant profile (see section Table 4.1). This evidence shows that teachers of deaf and hard-of-hearing learners do not receive proper training before the actual practice.

Consequently, research findings have shown that sign language for deaf and hard-of-hearing learners must be on the interface for pedagogy. It can then be concluded that for hearing-impaired education, pedagogy is coupled with sign language because it is prominent that sign language be used at the interface at all times. To bridge the language gap, mathematics teachers required support from sign language interpreters to translate the verbal lesson into sign language. However, according to the research participants, having an interpreter in class is a privilege for new and inexperienced teachers in the system.

Findings revealed that teachers of the deaf and hard-of-hearing attend content workshops; as stated by the literature, workshops provide a platform for teachers to share good practices (Marasabessy, 2021). Yet, teachers of hearing-impaired infer that content workshops cater to hearing learners' learning needs. It is thus safe to conclude that workshops are still a challenge for mathematics teachers of deaf and hard-of-hearing learners and do not serve their learning needs.

Findings have also revealed that mathematics teachers of deaf and hard-of-hearing learners have a challenge with lesson planning, as participants indicated that they do not necessarily plan their lessons but rather that their lessons depend on the learners' pace. What I also found intriguing was the class size for deaf and hard-of-hearing learners, namely that there are very few learners in a classroom, ranging from one deaf or hard-of-hearing learner to five normal-hearing learners. This implies that deaf and hard-of-hearing learners require a lot of individual support. However, teachers indicated that the challenge of overcrowding in classes of deaf and hard-of-hearing learners does not correspond to the designated class ratio. It can be concluded that overcrowding in hearing-impaired classrooms is also a dominant contributor to mathematics teachers' challenges, as this factor hinders the individual support required for deaf and hard-of-hearing learners. The more significant numbers in classrooms contribute to the teachers' frustration and end up with the number of learners failing a grade. Findings revealed that the Departmental Policy condones mathematics and causes a backlog of deaf and hard-of-hearing learners without basic mathematics skills, challenging the teachers' lesson planning.

The participants also reported that they experience challenges incorporating e-learning in their mathematics teaching for deaf and hard-of-hearing learners because it is not interpreted and does not have sign language. Khathare (2020) concurs with these findings and infers that most schools in rural areas cannot access proper technological tools. As a result, deaf and hard-of-hearing learners remain behind in mathematics compared to their hearing peers. It can be concluded that teachers in rural schools for deaf and hard-of-hearing learners do not incorporate e-learning because of the inaccessibility of proper tools.

5.4 LIMITATIONS OF THE STUDY

The research limitations in the current study informed the shortcomings in terms of the study's findings. The following limitations will present the foundation for future research:

- The limited number of schools for deaf and hard-of-hearing learners in the province has directly affected the weight of the findings regarding the number of teachers per school who would have been chosen to participate in the current study.
- No schools included hearing and hearing-impaired classrooms, and that indirectly affected the study's findings because there was no comparison.
- Learners were not part of the research. It would have been ideal to hear their views regarding their teachers’ teaching methods and how they received them.

5.5 HIGHLIGHTS OF THE STUDY

The following assumptions made the highlights of the current study:

- Besides the teachers not having proper qualifications to teach deaf and hard-of-hearing learners, findings revealed that teachers with more experience with HI learners produce better results.
- Inadequate SASL proficiency for teachers remains the main challenge to teaching mathematics to HI learners.
- Specific learning materials are required for teaching HI learners mathematics.

5.6 RECOMMENDATIONS FOR THE STUDY

Based on findings made in Chapter 4 and conclusions of the current chapter, recommendations are made and discussed below.

The findings and conclusions were divided into categories: knowledge of teachers' learning needs of HI, challenges, and methods used by mathematics teachers of deaf and hard-of-hearing learners. Evidently, the teachers are knowledgeable about the disability in question, at least in theory rather than practicality, because there is very little that they can do with this bit of knowledge to enhance their teaching. My view is that although the teachers are aware of this physical disability, they cannot control the parameters of hearing impairment, such as unreflective behaviour, slowness and lack of persistence, depending on the type of teaching that exists. However, the effect and severity of these factors could be minimized. The conclusion was that mathematics teachers are unprepared to teach deaf and hard-of-hearing learners. Therefore, mathematics teachers should be certified and prepared to teach learners with hearing impairment. The main reason for preparedness is to navigate the parameters of hearing impairment through their teaching and to support the learners holistically.

The second recommendation addresses the challenges mathematics teachers face when teaching hearing impairment. The conclusion reached here is that mathematics teachers of the deaf and hard-of-hearing learners are indeed experiencing challenges. As a result, language was at the heart of difficulty for mathematics teachers of the deaf and hard-of-hearing learners because sign language was found to be required in the interface for pedagogy. For this reason, unpreparedness was found to be a significant factor for the difficulty of the mathematics teachers. Although it was reported that there are interpreters for South African Sign Language to bridge the language gap, findings revealed that only new and inexperienced teachers had the privilege to translate their lessons. It is, however, recommended that mathematics teachers require proficiency in sign language as a prerequisite to teach deaf and hard-of-hearing learners. Teachers must be adequately prepared and certified to teach learners with hearing impairment before the actual teaching. As a result, South African schools with deaf and hard-of-hearing learners will have teachers with enough knowledge to promote mathematics education for deaf and hard-of-hearing learners and develop envisaged mathematics education for all, regardless of the disability. Proficiency in sign language will encourage the professional confidence of teachers of the deaf and hard-of-hearing learners as subject specialists and the design of mathematics learning material with sign language in the interface for pedagogy. Although findings revealed that mathematics teachers of the deaf and hard-of-hearing learners experienced challenges in incorporating e-learning as their teaching method, because of the inaccessibility of relevant technological tools, I recommend that school management and teachers invest and familiarize themselves with technological tools and complementary learning methods, because Edyburn (2000) and Khathare (2020) strongly infer that technological assistive devices may greatly benefit learners, especially the ones living with disabilities in subjects like mathematics.

The third recommendation concerns the mathematics teaching methods for deaf and hard-of-hearing learners. The conclusion reached is that teachers use a lot of demonstrations and participation in their teaching. Mathematics teachers use mathematics signs for mathematical terms or concepts. Where it is difficult to construct them, or they are unavailable, they fingerspell the term and support it with an example. However, there is no manual or guide for teachers on developing the mathematical signs or concepts in the language deaf and hard-of-hearing learners are taught (SASL). Therefore, teachers should seek assistance from sign language experts in mathematics, who may be subject advisors and subject specialists, in terms of constructing the mathematics vocabulary. In an interview, teachers suggested that incorporating mathematics theory with more practical and visual organisers for deaf and hard-of-hearing learners in mathematics classrooms is critical. Teachers of deaf and hard-of-hearing learners were reported to focus more on recall tasks than problem-solving skills because deaf and hard-of-hearing learners are slow and lack persistence in working on complex tasks. This leaves room for improvement for teachers to find ways to consider methods to incorporate problem-solving skills in their mathematics teaching. Besides, teachers also use peer tutoring as one of their teaching methods, where hard-of-hearing explains concepts to other deaf learners, encouraging participation among learners. It is, however, recommended that different methods in mathematics be infused to deaf and hard-of-hearing learners, rather than just relying on learners to teach other learners, such as demonstration, peer tutoring, and use of technology.

5.7 RECOMMENDATIONS FOR FUTURE RESEARCH

The study used a qualitative research methodology to understand better teachers' experiences teaching mathematics to deaf and hard-of-hearing learners. However, this does not give a holistic perspective on the experiences of deaf and hard-of-hearing learners learning mathematics, but it was confined to mathematics teachers. I would have liked to explore the experiences of deaf and hard-of-hearing learners learning mathematics. I wish to state that there is a need to examine the experiences of the subject advisors, subject heads and district officials regarding the support they offer to teachers teaching mathematics to deaf and hard-of-hearing learners. In short, I am proposing that a large-scale mixed methods study be conducted to understand this phenomenon holistically and the roles of all stakeholders involved. The study findings can provide a small portion, and more damage might continue unnoticed if something is not done.

5.8 CHAPTER SUMMARY

Chapter 5 dealt with the conclusions and recommendations of the study. Before conclusions and recommendations, a summary of the whole study was provided. The study aimed to explore teachers' experiences teaching mathematics to deaf and hard-of-hearing learners. Moreover, the study sought to examine the teachers’ knowledge of the learning needs of HI learners, methods for teaching, and challenges teachers encountered when teaching mathematics to deaf and hard-of-hearing learners. This chapter's conclusions and recommendations were made based on conclusions made in Chapter 4. In addition, recommendations for future research were outlined as well.

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APPENDICES

Appendix A: Ethical Clearance

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

19-May-2023

Dear Mr Medupe Tshabalala

Application Approved

Research Project Title:
Exploring the experiences of teachers teaching mathematics to hearing impaired-learners in an inclusive learning environment

Ethical Clearance number:
UFS-HSD2022/2029/3

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

205 Nelson Mandela Drive
Park West
Bloemfontein 9301
South Africa

P.O. Box 339
Bloemfontein 9300
Tel: +27 (0)51 401 9337
duplessisA@ufs.ac.za
www.ufs.ac.za

Appendix B: Permission to conduct research at selective schools

Enquiries: M.Z. Thango
Ref: Research Permission. M.R. Tshabalala
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

1427 Mangaung Village
Witsieshoek
QwaQwa
9870

Dear Mr. M.R. Tshabalala

PERMISSION TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION: MOTHEO DISTRICT

This letter serves to inform you that you have been granted permission to conduct research in the Free State Department of Education within the Motheo Education District. The details in relation to your research project with the University of the Free State are as follows:

Topic: Exploring the experiences of teachers teaching Mathematics to hearing-impaired learners in an inclusive learning environment.

1. **List of schools involved**: Bartemia school for Deaf and Blind.

2. **Target Population:** Two educators teaching Mathematics in grade 7-9 at the selected school.

3. **Period of research:** From the signature of this letter until 30 September 2023. Please note that the department does not allow any research to be conducted during the fourth term (quarter) of the academic year. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension. The researcher is expected to request permission from the school principals to conduct research at schools.

4. The approval is subject to the following conditions:

   4.1 The collection of data should not interfere with the normal tuition time or teaching process.

   4.2 A bound copy of the research document should be submitted to the Free State Department of Education, Room 101, 1st Floor, Thuto House, St. Andrew Street, Bloemfontein or can be emailed to the above-mentioned email address.

   4.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.

   4.4 The ethics documents must be adhered to in the discourse of your study in our department.

5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours Sincerely,

Mr. MZANDO W. JACOBS
DIRECTOR: QUALITY ASSURANCE, M&E AND STRATEGIC PLANNING

DATE. 22/02/2023

RESEARCH APPLICATION BY M.R. TSHABALALA, PERMISSION LETTER 22 FEBRUARY 2023, MOTHEO DISTRICT
[illegible] M&E and Strategic Planning Directorate Private Bag X20565, Bloemfontein, 9300 Thuto House, Room 101, 1st Floor, St Andrew Street, Bloemfontein

Enquiries: M.Z. Thango
Ref: Notification of research: M.R. Tshabalala
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

District Director
Motheo District

Dear Mr. Moloi

NOTIFICATION OF RESEARCH: PERMISSION TO CONDUCT RESEARCH PROJECT IN MOTHEO DISTRICT

This letter serves to inform you that Mr. M.R. Tshabalala has been granted permission to conduct research in the Motheo District under the auspices of the University of the Free State. The details in relation to the research project are as follows;

Topic: Exploring the experiences of teachers teaching Mathematics to hearing-impaired learners in an inclusive learning environment.

1. **List of schools involved**: Bartemia school for Deaf and Blind.
2. **Target Population**: Two educators teaching Mathematics in grade 7-9 at the selected school.
3. **Period of research**: From the signature of this letter until 30 September 2023. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours. The researcher is expected to request permission from the school principals to conduct research at schools.
4. **Research benefits:** This research is aimed at contributing to the knowledge and understanding of Deaf culture, Curriculum differentiation, teaching and learning strategies to help improve the low achievement levels in Mathematics among hearing-impaired learners. Curriculum, language proficiency and teaching methods in main stream upholds the learners' values and prepare them for life beyond high school which is not the case in special education, thus this research is envisaged to provide awareness and knowledge to the Mathematics teachers of the Deaf to reflect on resources and strategies available to help improve the Mathematics education of hearing-impaired learners in respective inclusive schools.
5. The Sub-directorate of Research and policy will make the necessary arrangements for the researchers to present the findings and recommendations to the relevant officials in the Department.

Yours Sincerely,

Mr. MZAMO W. JACOBS
DIRECTOR: QUALITY ASSURANCE, M&E AND STRATEGIC PLANNING

DATE: 22/02/2023

RESEARCH NOTIFICATION: M.R. TSHABALALA, 22 FEBRUARY 2023, MOTHEO DISTRICT
QASME, M&E and Strategic Planning Directorate Private Bag [illegible], Bloemfontein, 9300 · [illegible] House, Room [illegible], [illegible] Floor, St Andrew Street, Bloemfontein.

Appendix C: Informed consent letter to the principal

1427 Mangaung Village
Witsieshoek
QwaQwa
9868
richardmedupe@gmail.com
Cell: 067 407 2449

12 February 2023.
Dear Sir/ Madam.

Request to conduct research.

I am a master of Education candidate with specialisation in mathematics education at the University of the Free State. My research is aimed at exploring the experiences of teachers of the hearing impaired learners teaching mathematics. I therefore request to use your school for collection of data.

The data collection process will take place as follows:

- Two mathematics teachers teaching hearing impaired learners will be invited to participate.
- Two lessons per educator will then be observed with the same mathematics class. The learners will be present in class together with the researcher when observations takes place.
- Semi-structured interviews per teacher will also be requested which will take place after the lesson observations. These interviews will be conducted outside school hours at a convenient time and place for the teacher.
- Audio recording will be used to store data
- Lastly would like to have access to documentation such as the teacher's preparation file.

I'd also like you to note that myself and supervisor only will have access to the audio recordings which will be password protected .Collected data will only be used for academic purposes only.

I would also like to assure you that participation is voluntary and participation and anonymity of participants is guaranteed. Promise that upon completion of my masters' degree feedback in the form of written report will be given .For any queries please feel free to contact me.

If I am to be granted an opportunity to conduct the research at your school, kindly sign and return the letter as a sign of declaration of your consent.
Yours Faithfully

-----------------------------------   ________________________

Researcher: MR Tshabalala   Date

-------------------------------------   __________________________

Supervisor: DR N Mpalami   Date

I hereby grant consent to Mr MR Tshabalala to observe two of my mathematics lessons, conduct interviews as well as having access to the preparation documents for his research. I also grant consent for Mr Tshabalala to record his interviews on audio-tape and analyse the preparation documents.

Principal's names: ---
Signature & Date: ---
Email Address: ---
Contact Number: ---

Appendix D: Informed consent letter to the teachers

1427 Mangaung Village
Witsieshoek
QwaQwa
9868
richardmedupe@gmail.com
Cell: 067 407 2449

12 February 2023.
Dear Sir/ Madam.

Letter of consent to Mathematics teacher.

You are hereby invited to participate in the research study where I will be collecting data by observing your mathematics lessons with your hearing impaired learners and later interview you about your experiences. My research is aimed at exploring the experiences of teachers of the hearing impaired learners teaching mathematics. You will also be asked to allow me to have access to your preparation documents for analysis.

The data collection process will take place as follows:

- Two mathematics teachers teaching hearing impaired learners will be invited to participate.
- Two lessons per educator will then be observed with the same mathematics class. The learners will be present in class together with the researcher when observations takes place.
- Semi-structured interviews per teacher will also be requested which will take place after the lesson observations. These interviews will be conducted at convenient time and place for teachers outside school hours.
- Audio recording will be used to store data
- Lastly would like to have access to documentation such as the teacher's preparation file.

Should you declare yourself willing to participate in this research, you will be one of two Teachers that form part of my research project. Your participation is voluntary and Confidentiality and anonymity will be guaranteed at all times. You may decide to withdraw at any time without giving any reasons for doing so. You and your school will not be identifiable in the findings of my research and only my supervisor and I will have access to the audio recordings which will be password protected. You will have access to the interview transcriptions should you wish. The data collected will only be used for academic purposes. All data collected with public funding may be made available in an open repository for public and scientific use.

After the successful completion of my Master's degree, I will give feedback of my findings to

the school in the form of a written report.
If you are willing to participate in this research study, please sign this letter as a declaration of your consent, i.e. that you participate willingly and that you understand that you may withdraw at any time.

Yours sincerely

___________________________ ____________________________

Researcher: Mr. MR Tshabalala Date

____________________________ ____________________________

Supervisor: Dr. N. Mpalami Date

I hereby grant consent to Mr. MR Tshabalala to observe two of my mathematics lessons, conduct an interview with me as well as have access to my preparation documents for his Master's degree research. I also grant consent to Mr. MR Tshabalala to audio-tape the interviews and analyse my preparation documents.

Teacher's name: ____

Teacher's signature: ____

Date: ____

Email address: ____

Contact number: ____

Appendix E: Interview transcripts

R-: Tell me about your mathematics teaching experience

P-: It's been more than 10 years teaching mathematics to the hearing impaired learners , a challenging journey and it doesn't get any better because department does not address issues of the teachers in Deaf schools . I am going on pension next year and the curriculum still does not match the type of learners and it's a lot of work because the teaching becomes slow because for them to understand, they require repetition. You leave this place very tired because one is standing in front of these learners repeating one thing and they still don't hear you, It's difficult to complete prescribed ATP. Most of the time they are within school premises, their world is so small that they cannot even relate most of things. These learners are heavy and because of their disability, one learner in a normal school is equivalent to 5 learners in a special school, so imagine having 20 learners in a class equalling to 100 learners according to the ratio.

R-: What is your highest level of qualification?

P-: My highest obtained qualification is Honours degree specializing in curriculum studies (Mathematics). I did this qualification many years ago you were probably still small.

R-: Do you have any Special Education Needs qualifications?

P-: No, I don't have any .I came to the school without the knowledge of sign language and I learnt how to communicate here.

S

R-: Do you know hearing impairment

P-: Hearing impairment is not a disease therefore not treatable. Being deaf means no message is going through hence you find some with a little hearing having cochlea implants to assist their little hearing. Some people are born deaf while some are deafened while alive.

R-: What challenges do you face when teaching mathematics to hearing-impaired learners?

P-: One of the major challenges is overcrowd in classes. Deaf learners in a classroom are supposed to sit in a C-shape so that nobody obstruct the view of the other ,but having 20 learners in a small class hinders the setting because they are forced to sit in rows and it creates disciplinary problems . Another challenge is load shedding, learners are unable to see the signing space because they are more visual as they unable to hear which causes a chaos in the classroom. Mathematics vocabulary for hearing impaired learners is difficult for teachers, there is no dictionary or any guideline that assist teachers of the deaf to learn vocab. Department of Education says deaf learners cannot read any spoken languages yet books learners use are written in English and the language is foreign to them. Fingerspelling at times does not help as it doesn't bring contexts and brings a total misunderstanding to the learners. Lack of schools close to homes makes it difficult for parents to fully participate in their children's education. Learners are always 2-3 weeks late from home after the holidays when schools re-open. This creates a delay in covering ATPs as expected by the DBE. Catch-ups are also difficult and contributes to more delays .

R-: What is the language of teaching and learning in the classroom? (Are you familiar with Sign Language)

P-: Mixed, Signed English or Signed Sotho, Although according to the school policy English is LoLT. This create confusion because in the free state there are only two schools for the Deaf and accepts learners from all over the country with different tribes. Interpreters are available but are for new teachers not familiar with sign language, because as an experienced teacher I don't have much confidence that translation is in anticipated mathematics context.

R-: How long have you been teaching mathematics to learners with hearing impairment?

P-: More than 10 years

R-: How do you explain mathematical concepts to the best of your knowledge (allowing them to have the same understanding as their hearing peers)

P-: First of all it's difficult to do lesson preparation for these learners because we don't have means to talk to them and even if I have prepared, the lesson will ultimately change because you have to move according to their understanding and not the prescribed ATP. Learners usually not performing on a previous task makes it difficult for me to plan ahead. I am unable to teach mathematical concepts to deaf learners because they are so ignorant, they will sign correctly but write different thing. Learners we are teaching are very forgetful and lacks confidence. They are good at cramming examples and unable to apply logic. They would literally copy and paste the examples you have taught them without fail. Even incorporating ICT doesn't work with these learners because they still can't follow because the language used is foreign to them. Most of the time I use learner –centred approaches where they teach one another because they understand each other more .I usually utilise hard-of-hearing to explain concepts to other deaf learners because at least hard of hearing have a little to moderate hearing .The fact that DBE condones mathematics from lower grades but expect good results for mathematics will always be a wild idea for me, learners will continue failing mathematics drastically. The SASL lacks vocabulary itself as a language, it becomes a disaster when you have to incorporate SASL with mathematics abstract nature, the textbooks are written in English and it becomes useless for them to study independently using textbooks because the language is foreign to them if it's not interpreted.

R- Do you think the mathematics curriculum you teach is of best interest to hearing-impaired learners?

P- No, the curriculum we are teaching hearing-impaired learners does not prepare them for life after school because most of them don't even make it to university because they just don't qualify or the universities are just not prepared for them . These learners are just kept busy here just so they don't roam the streets, but to be honest it's not developmental at all. The content taught is not appropriate for most learners due to their school entry into the language, they are introduced to proper sign .A few learners may achieve grade 12 but through concessions (Interpreter and Scribes).They are unable to provide answers from high order questions, mostly recall. They depend upon examples provided by educator, and if the question require application of prerequisite knowledge, then it's a struggle. SASL structure differs greatly with that of English and that results in inability to read and understand the questions properly hence the need for interpreters. For a three hours test or exam, it takes them five hours to submit an incomplete work. We are not certain if the message (content) delivered when teaching using sign language is interpreted by them as intended .In overcrowded classes especially intermediate and senior phases, there are 16-20 learners in class and ratio of learners (special: main steam = 1:5) making number of learners with 20 in class to be 100.Differentiation approach becomes a challenge because some of these learners have multiple challenges and admission into the school is mainly Deafness.

R- Is there any training that you would like to have for you to be an effective mathematics teacher for hearing-impaired learners?

P- First of all, we were not taught sign language at higher institution. At this point it is difficult to attach signs to mathematical terms or concepts. I have to create my own signs that makes sense to myself alone , another teacher in the same school teaching mathematics have their own signs that makes sense to them alone creates confusion and chaos for learners as they move from grade to another . There are no developed signs because SASL has just been officiated as one of the languages in South Africa. As mathematics teachers we need content training for hearing –impairment. We do receive SASL training but it only enable us to communicate, it is not compatible with mathematics curriculum. Workshops conducted by Subject advisors are not empowering teachers of the deaf, because they only address issues of the main stream teaching. Subject Advisors are not even aware that there is schools for the deaf, they even scared of visiting such schools for support, so teachers are told to do whatever they can. They are only chasing ATPs, learners are slow, and teachers are always behind work schedule.

R- Do you have specific instructional material for teaching mathematics to learners with hearing impairments?

P- These learners nature is to be spoon-fed. They literally copy same examples you taught them. This environment is stressful and your anxiety levels peak .You stand the entire period repeating one thing, when ask them something else related they will repeat what you signed to them without understanding. It's difficult to teach prescribed curriculum simply because learners cannot relate and have got no idea of what is being explained. There are no specific instructional material for the deaf. Textbooks and other ICT materials are designed to suit normal hearing person who can read and write English, videos are for hearing people because they are not interpreted for the deaf.

R- What is your point of view about teaching mathematics to hearing-impaired learners?

P- I have to draw at times just to give them a picture of what I want to address .The fact that DBE has an idea that Deaf learners fail maths and still condone it makes the teaching of it difficult for teachers because if learner has been passing to next grades with the mathematics that is been condoned simply means that learner lacks basic mathematics .It's also difficult teaching deaf learners mathematics because they cannot relate it to their real life routines and the mathematics language as well as English is strange to them .

R- Do you have remedial strategies for mathematics difficulties?

P- Honestly speaking, I am not even sure at times whether my sign language to them knocks sense because even some of them struggle understanding and speaking sign language. There are times where I try signing something only to them to mean something else. There is a lot of miscommunication in class and they are even scared of asking questions because they are clueless .The presence of the interpreter is sometimes useless because they are usually just the experts in language but not experts in mathematics ,so narration of translating mathematics content is just not correct .

R- What kind of support do you get from the Department of Education to teach mathematics to hearing-impaired learners?

P- The same support given to main stream schools should be reciprocated in Deaf schools. The only support we get is how to communicate using SASL to deaf people, it doesn't go deeper into how to effectively teach mathematics content to a Deaf person .There should be specific instructional materials for mathematics teaching of the Deaf and varied curriculum suitable for Deaf child that will benefit them beyond matric. Department of Education should invest in experts when comes to Deaf education, like subject advisors specific to mathematics of deaf learners. Spiral Approach is compromised because of timed ATP's and repetition is vital for deafness. Department of Education encourages condoning mathematics and learners are expected to pass at the end of Grade 12, foundation of most concepts becomes difficult in the next grade.

R- What does inclusion mean to you, and do you think it's being implemented properly?

P- Ensuring that all learners regardless of their background receives equal opportunities and treatment.

Transcribing John's interview

R-: My first question is, please tell me about your mathematics teaching mathematics

P-: I started teaching mathematics last year January and this is my second year. This is the first school started teaching mathematics. Teaching mathematics has been difficult for me especially teaching learners with deafness.

R-: What is your highest level of qualification
P-: BCom Accounting and Post Graduate Certificate in Education, and they are both NQF 14.
R-: Do you have any Special Education Need Qualification? A qualification that qualifies you to work with hearing-impaired learners.
P-: No
R-: Do you know what hearing impairment is?
P-: Yes, these are learners with hard-of-hearing. Some of them can hearing very little, while some cannot hear at all. We do attend some workshops about learners who are Deaf. The condition is natural.
R-: What are some of the challenges you face teaching mathematics to hearing-impaired learners.
P-: Like I told you yesterday, it's difficult for learners to grasp information. They cannot relate mathematics to their everyday life. This is why at some point you need to have the services of the interpreters to help explain some of the concepts. Some concepts have no signs , like $\boldsymbol{sin\theta}$. Di sign tsa most concepts ka maths ha diyo. Assistance of interpreters helps.

R-: Since you get a help of assistant in class, when doing your planning, do they form part of your planning, do you invite them and plan together? Are they familiar with mathematics as a subject?

P-: Mostly ba entse sign language university. Subject haba e tsebe for instance, o thole o qetetse maths secondary. The just chooses an interpreter for you, whether they have mathematics background or not, as long as they able to communicate in South African Sign Language.

R-: What is the language of teaching and learning in the classroom?
P-: Akere nna I use English and the interpreter will translate to Sign Language, some of the signs are new, and also sign language is universal. So LoLT is English and Sign Language. We are workshopped for sign language at the school though. We get certificates at the end of workshops.
R-: The support you get from the school and the department strengthen your mathematics teaching for the hearing-impaired?
P-: Most of the support we receive from the school is workshops for Sign Language communication. Workshops makes the delivery or execution of the lesson easier because we get taught basic skills to communicate in Sign Language. Again there is an interpreter whom we do team teaching with. Subject advisors do school visits and support us in terms of accountability and giving us the material and ensuring that communication is active.
R-: How do you ensure that hearing-impaired learners understand mathematical concepts at the same wavelength with their hearing peers.
P-: There are Apps that helps with translating a mathematics term to a sign, it's for basic signing though. Also there are experienced mathematics teachers at the school whom I consult for help especially with attaching sign to mathematics terms. During my preparation I identify concepts that I am unable to teach to Deaf learners and consult with experienced teacher as to how they taught or teaching that concept, so that I understand how am going to deliver that lesson properly so that all learners understanding is prioritised. For example, the way normal 'x' is seen, in sign language it translated

differently so it is important to know how it is translated. These signs are usually taught from the foundation phase level and same sign is used throughout the grades. Some of the signs for some concepts does not exists in South African Sign Language. That's where you have to fingerspell the term/concept and support it with the example in a case where the sign is not available.

R-: As a teacher with just 1-year experience in the field, what kind of training would you require from the Department of Education, that would make you an effective mathematics teacher for the hearing-impaired learners?

P-: I think the training on differentiating the curriculum will be of paramount importance and also a training on adapting curriculum to better suit their disability without distorting the CAPS document/curriculum. Based on their disability training on approaches teachers of the hearing-impaired could use that will enhance their understanding for different topics will greatly help all teachers of special schools with hearing impaired learners. Usually the training we receive at the school is generally for all teachers to be able to communicate using SASL, there are no specific workshops targeting content specific for approaches/ methods when dealing with the specified disability. The content generally I am okay, the only problem is the delivery of the content to the learners. Also learning how these learners behave is important for us as teachers to know, because as you have seen them, they are restless in class, every 2minutes you have to reprimand them. I also feel like we can be taught how we can assess them in a different way because they I am assessing them right now is not productive.

R-: Do you think that the curriculum that is offered for hearing-impaired learners is compatible for their success after school?
P-: Yes, because others are able to continue with their studies to different Universities, but most importantly I think they should align the curriculum and integrate it with more hands-on experiences like plumbing, welding, skills that are more practical that they can see, bricklaying's. In other words, they be taught CAPS coupled with technical skills.

R-: Do you have any specific instructional materials for hearing-impaired classroom?
P-: Unfortunately, the same material that is used in normal school for a hearing learners is used in special schools for learners with deficit to no hearing, the likes of textbooks, ATP's and pictorials. Because the argument is they are writing the same question paper as main-stream learners. The only thing we do differently is that in a class of hearing-impaired there's a lot of signing and seating arrangements should be such that nobody obstruct the view of the other, normal the seating arrangement is U-shaped. They have a perfect sight for chalkboard. When using chalkboard also the writing must be clear same as when using a projector. The movement of the teacher on the chalkboard should be such that learners are able to follow and able to engage with the lesson.

R-: Is there any remedial strategies you use for difficult concepts in the classroom?
P-: Usually utilise experienced teachers, sometimes as a teacher I understand the concept but I can see the problem is my delivery to the learners then that's where I

consult with experienced teachers. If I have specific content problems, I consult with even teachers of other school teaching the subject. For remedial purposes I would treat them with the past different papers and eventually they would come around. Team teaching is very important in this regard.

R-: How do you ensure that hearing-impaired learners whom aren't able to hear or express themselves are able to comprehend concepts that require a sense to hear and ability to express themselves?
P-: Examples I design for them in class are very practical, explain concepts that are difficult, I utilise SASL interpreter because they able to give them a picture, aba atometse to whatever I want them to experience or to understand. Because also they cannot read by themselves because English is foreign to them and their English is weak and they cannot express themselves. The preparation with the interpreter ensures that learners receive the message as intended and feedback from assessments will indicate if they received a direct translation. Regular assessments, quizzes, short tests, projects and informal tests from department are utilised and the feedback determines problem areas of the learners and immediately attends to them.

R-: What does inclusion mean to you?
P-: Accommodating different learners from different economic backgrounds, others coming from abusive, poor rich background means these learners are not the same. So from my observation, aligning all learners to be all equal. At the school inclusion is properly implemented, especially because it's a special school.

R-: What is your point of view to teaching mathematics to hearing-impaired learners?
P-: My view is that if there are correct structures in place, learners can be teachable and achieve in mathematics. All stakeholders must be involved in the education of Deaf learners. At the moment the systems are not in place, because the learners' existence is only memorable during celebrations of 'Deaf Awareness's' whereas in normal settings they are neglected. Personnel and infrastructures play vital role. Incorporation of ICT and all visual organisers because they depend on sight.

Appendix F: Observation schedule

Observation Schedule

Exploring the experiences of teachers teaching mathematics to hearing-impaired learners in an inclusive learning environment.

Student Name: Tshabalala MR

Contacts: 067 407 2449

Date: _______________

Place: ________________________

Bio Data

1. Grade : _____
2. Teachers Gender : ___________________

Characteristics to look for :	Descriptive field notes :
Classroom Setting	
Lesson Planning • **Lesson preparation** • **Lesson objectives** • **Class Activities**	
Content Taught	

Teaching Aids • **Visual Organisers**	
Mode of communication	
Teaching Methodology • **Pupils Participation (Group/Individual)** • **Teachers Approach/Strategies**	
Interaction	

Thoughts and Reflections	

Appendix G: Letter from Language Editor

Michelle Woolley

WRITER EDITOR PROOFREADER TRANSLATOR

Bachelor of Library and Information Science: B.Bibl.
Reference & Research Librarian
Bachelor of Arts **Honours** in **Translation Studies and Editing**

Associate Member of Professional EDITORS' Guild (PEG)

CERTIFICATE OF EDITING

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EXPLORING THE EXPERIENCES OF TEACHERS TEACHING MATHEMATICS TO HEARING-IMPAIRED LEARNERS IN AN INCLUSIVE LEARNING ENVIRONMENT

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