Instructional strategies used by teachers to facilitate construction of mathematics knowledge by visually impaired learners

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MEd

In the

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The University of Pretoria

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DECLARATION AND ETHICS STATEMENT

I, **Mary LIAGA**, declare that this thesis is my own unaided work, both in conception and execution. It is being submitted for the degree of Master of Education in the Department of Sciences Mathematics and Technology at the University of Pretoria, South Africa. It has not been submitted before for any degree or examination at this or any other university.

I have also obtained, for this research, the applicable research ethics approval and declare that I have observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for researchers and the Policy Guidelines for responsible research.

Mary Liaga

Pretoria, October 2019

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ABSTRACT

This study investigates how mathematics teachers help Visually Impaired (VI) learners to construct mathematics knowledge. This investigation involved identifying the challenges encountered by high school mathematics teachers in teaching mathematics to VI learners, the approaches used and the assistive technology used to adapt and modify the curriculum to accommodate VI learners, and also aid the learners to access and construct mathematics knowledge. A constructivist approach was employed, allowing a discussion of how high school mathematics teachers redefine their position from that of a teacher to that of a facilitator who guides and stimulates VI learners to construct their own knowledge.

A case study of two teachers from one of the special schools that offer mathematics up to FET phase was conducted. Data were collected from the teachers through classroom observation and semi-structured interviews. The study revealed that the teachers' experience resulted in a variety of challenges in teaching mathematics to VI learners. This finding further reveals that the approaches used to teach mathematics to VI learners are not different from those used in mainstream education. However, modification to the curriculum content is inevitable. Additionally, the selection of the appropriate approach and the effectiveness of using it to assist the VI learner depends on the skill, knowledge and the experience of the teacher in teaching mathematics to VI learners.

The study also revealed that assistive technology is essential for enlarging the text to the correct font of the learner and translating print text to braille to help blind learners complete their tasks. For example, while a transformer HD is used to enlarge text, the scientific notebook, Math Type and Duxbury programs are used to generate braille text. Additionally, the Tactile View and View Plus programs are used to produce embossed sketches, while Perkins braillers and talking calculators provide further independence. Due to the limited number of participants in the study and the focus on a single case, the dissertation does not aim to generalise the results to all special needs schools in South Africa. However, the findings will be of great benefit to those teachers teaching mathematics in special needs schools with VI learners to take a step forward in introducing mathematics at FET phase level.

Keywords: Visually Impaired learners, high school, mathematics knowledge, braille, case study research

LANGUAGE EDITING CERTIFICATE

Exclamation Translations

To whom it may concern

The dissertation entitled, "Instructional strategies used by teachers to facilitate the construction of mathematics knowledge by visually impaired learners" has been edited and proofread as of 06 November 2019.

As a language practitioner, I have a Basic degree in Languages, an Honours degree in French and a Master's degree in Assessment and Quality Assurance. I have been translating, editing, proofreading and technically formatting documents for the past nine years. Furthermore, I am a member of the South African Translators' Institute (SATI) and the Professional Editors' Guild (PEG).

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ABBREVIATIONS

CAPS	Curriculum Assessment Policy statements
CCTV	Closed Circuit Television
DBE	Department of Basic Education
DAISY	Digital Accessible Information System
DoE	Department of Education.
FET	Further Education and Training
GET	General Education and Training
IDEA	Individual with Disability Education Improvement Act
NCTM	National Council of Teachers of Mathematics
NCLB	No Child Left Behind
WHO	World Health Organisation
VI	Visually Impaired
ZPD	Zone of Proximal Development.
USA	United States of America
OCR	Optical Characters Recognition

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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

Teaching mathematics to learners with visual impairment is a challenge, not only in South Africa but also globally (Maguvhe, 2015). This can be attributed to the fact that most of the content in the mathematics curriculum is abstract and is often presented using visual illustrations such as graphs, tables, and diagrams (Rule, Stefanich, Boody & Peiffer, 2011). This makes learning difficult for Visually Impaired (VI) learners who have either inadequate or no visual input during mathematics experiences (Sahin & Yorek, 2009). Teaching mathematics to VI learners, therefore, requires skilled educators to adjust the strategies used in teaching mathematics to enable the learners' access to mathematics and construct knowledge (Hassan, 2017).

Generally, many teachers who teach mathematics to VI learners, even in special needs schools, are not equipped with the necessary skills and knowledge to teach VI learners (Bayram, 2014). This view corroborates that of Fraser and Maguvhe, (2008), who find that most mathematics educators in inclusive as well as in special needs schools, which cater to learners with visual impairments, are in possession of only a general Bachelor of Education degree. This implies that they are not necessarily equipped with the pedagogical techniques necessary to teach mathematics to VI learners (Sahin & Yorek, 2009). They are expected to teach these learners, even without adequate training (Donohue & Bornman, 2015). The consequence of this may be that teachers become overwhelmed with the challenges they experience in teaching mathematics to VI learners, especially at the higher secondary school level where mathematical concepts become more sophisticated and more abstract (Rule et al., 2011). They then resort to either excluding the learners or discouraging them from studying mathematics in the Further Education and Training (FET) phase (Maguhve, 2015)**.**

It is noteworthy that several studies (Buhagiar & Tanti, 2013; Maguvhe, 2015; Rule et al., 2011) have indicated that VI learners have the same cognitive ability levels as their sighted counterparts and therefore can learn the same mathematics content as sighted learners. Jackson (2002) supports this claim by asserting that constructing mathematical knowledge involves the ability to create mental representations, which is inborn and does not depend on sight. According to Sedaghatjou (2017), understanding mathematical concepts can be established without the use of the sense of sight; other senses such as audio and touch can be developed and used. It is thus evident that VI learners can construct mathematical knowledge when teachers make use of the appropriate instruction approaches and instruments to make mathematics accessible to VI learners (Buhagiar & Tanti, 2013). However, Bayram (2014) observes that the strategies through which VI learners learn mathematics are slightly different from those of the sighted and therefore must always be adapted to special education needs.

1.2 THE RATIONALE OF THIS STUDY

In South Africa, out of the 22 public special needs schools for VI learners, only two schools offer an opportunity for VI learners to study mathematics and science at FET Phase level (Maguvhe, 2015). Most of the teachers I have interacted with from some of these special needs schools have expressed their hesitation in offering mathematics to VI learners at higher secondary learning level. These teachers have openly said that mathematics is complicated for a VI learner and they fear that they would face challenges in teaching mathematics to a VI learner. Furthermore, they do not believe that VI learners would be able to pass mathematics in the Matric exams even if given the opportunity. I find this inconsistent with what the South African bill of rights on education enforces (Constitution, S. A. (1996) Gov.za. 2017). The bill of rights advocates for everyone to have the right to further education, for which the government should take equitable measures.

Given the fact that I am a mathematics teacher in one of the special needs schools that offers mathematics to VI learners at FET phase level, I have asked myself the following questions: firstly, What difficulties do mathematics teachers encounter in teaching mathematics to VI learners at high school? Secondly, what instructional strategy can be employed by mathematics teachers to overcome these difficulties and make mathematics accessible to VI learners? This led to my interest in investigating the teaching strategies that mathematics teachers use to enable VI learners to successfully construct mathematics knowledge in high school.

The South African government's obligation, as found in White Paper 6 special education needs, stresses the need for equipping special needs schools with resources and professional skills to cater to the needs of the learners despite their disability (Department of Education (DOE), 2001). This white paper emphasises the need to address inequalities in special needs schools to reflect the face of South Africa. It is not clear or certain whether the government has fulfilled its mandate, as stated in White Paper 6 to all schools with learners with VI. The findings of this study will be of great benefit, not only to special needs schools with VI learners in South Africa, but also to policymakers.

1.3 PROBLEM STATEMENT AND RESEARCH QUESTIONS

All education disciplines and learning areas make use of mathematics in one way or another (Kohanová, 2006). The importance of mathematics in South Africa is acknowledged because it is offered at all levels of the schooling system. Mathematics has also been recognised in the Curriculum and Assessment Policy Statement (CAPS) document as one of the four mandatory learning areas that every learner must pass to meet the minimum requirements to be promoted to the next grade in the General Education and Training (GET) band (DOE, 2012).

A large population of VI learners display low achievement in mathematics despite its significance (Pidgeon, 2012). The major hindrance in the understanding and learning of mathematics among VI learners in special needs and inclusive schools is mainly due to a lack of skilled teachers to implement and articulate the mathematics curriculum content. Another factor is the negative attitude towards teaching mathematics (Maguvhe, 2015). The discouragement and negative attitude that the VI learners receive from their teachers make them less confident in studying mathematics (Mercer & Miller, 1992).

Having acknowledged that VI learners have the same cognitive ability to learn mathematics as sighted learners, there should be no reason why these learners should not be given the same opportunity to learn mathematics at senior as well as FET phase level, like their sighted counterparts. Moreover, as mentioned earlier, there are two South African schools that are successfully teaching mathematics to these learners at FET phase, which implies that all other public schools should be capable of teaching mathematics to VI learners. The main assumption of this study is that the successful teaching and ability to make mathematics accessible to VI learners at high school requires appropriate classroom instruction strategies to be used by teachers. According to Smith (2007), successful classroom instruction practices also require the ability of teachers to adapt and modify mathematics curriculum content using technological assistive devices and other varied instructional strategies to meet the needs of each learner.

The purpose of this study was to explore the classroom instructional approaches used by mathematics teachers with assistive technology devices used to mediate learning, and the challenges experienced by teachers in teaching mathematics to VI learners in high school. To achieve this, an in-depth study was conducted with the following specific objectives:

To identify the challenges experienced by mathematics teachers in teaching mathematics to VI learners.

To identify the instructional approach used by mathematics teachers to assist the VI learners to access and construct mathematical knowledge.

To establish the preferable assistive technology devices to enhance the acquisition of mathematics knowledge by VI learners.

The primary question underpinning this study is:

How can the instructional strategies used by mathematics teachers to facilitate VI learners' construction of knowledge be described?

The secondary research questions are:

1. What are the challenges experienced by mathematics teachers in teaching mathematics to VI learners in high school?
2. What are the instructional approaches used by mathematics teachers to help VI learners construct mathematics knowledge?
3. Which assistive devices are used to enhance the acquisition of mathematics knowledge by VI learners?

Mathematics is one of the school learning areas considered difficult for VI learners because of its visual and abstract characteristics. Most special needs schools in South Africa do not offer mathematics at FET Phase. As discussed in the introduction, from a total of 22 public schools with visual impairment learners, only two schools provide an opportunity for VI learners to study mathematics at FET level. This study will provide information for teachers who teach mathematics to VI learners to gain insight into classroom instructional strategies that can be used to make mathematics accessible. The study should provide detailed analyses of the challenges encountered in the teaching of mathematics and provide suggestions on the mechanisms to minimise these to benefit the VI learner.

1.4 METHODOLOGICAL CONSIDERATIONS

The focus of the study was on investigating the challenges presented in the teaching of mathematics to VI learners, instructional approaches used by mathematics teachers to help VI learners construct mathematical knowledge, and the assistive technology devices used by these teachers in the teaching of mathematics. In order to explore the strategies that can be used to help learners construct knowledge, the qualitative data were collected through interviews and the classroom observation of two mathematics teachers for Grade 9 and Grade 10 VI learners. Twelve classroom observations and four semi-structured interviews were conducted to generate qualitative data for analysis. The qualitative data analysis was done by categorising the collected data into themes and sub-themes as they emerged from the study.

1.5 CONCEPT CLARIFICATION

Special needs schools: these are ordinary schools that are equipped with greater support resources to cater to learners who require high intensity and very specialised support. For example: Special needs schools that cater only to Visually Impaired learners (Department of Education, 2001).

Visual impairment: a person who has inadequate vision caused by disease, accidents or inborn. This includes "low vision/ partially sighted, functionally blind, and blind (near or totally)" (Sahin & Yorek, 2009, p.20

Accommodations: accommodation is a way of incorporating instructional materials, techniques and learning styles into the teaching and learning of a VI learner while maintaining the same curriculum content and conceptual difficulties as in the general curriculum. An example is the use of brailled text, enlarged print copies, closed-circuit television (CCTV) and computers and software to teach the same content with its conceptual difficulties to VI learners (Okumbe & Tsheko, 2010).

Adaptation: the changes made in the teacher's instruction strategies and to the intended objective while keeping the content knowledge unchanged to meet the needs of the learner. These changes may include a slight modification of conceptual difficulties and giving a smaller workload to the VI learners (Okumbe & Tsheko, 2010).

Assistive Technology device: technological equipment and tools used to make mathematics accessible to blind and partially sighted learners. These include computers and software, talking calculators, Perkins braillers and braille books (DePountis, Pogrund, Griffin-Shirley & Lan, 2015).

Compensatory skills: the skills used by the VI learner to access the learning material, which are mostly tactile and audio (La Voy, 2009).

Perkins brailler: assistive technology devices that blind learners use to write assignments and take notes (Bitter, 2013).

Constructivist learning: learning where learners construct their knowledge by being actively involved in learning (Banda & Olusengun 2015).

1.6 ORGANISATION OF THE DISSERTATION

This dissertation consists of five chapters, which are briefly summarised below.

- Chapter 1 provides a general introduction and conceptualisation of the study.
- Chapter 2 presents the literature review and theoretical framework. This chapter provides an in-depth discussion of the relevant literature for the study and a synthesised presentation of Constructivist Theory, on which this study was based.
- Chapter 3 delves into the methodology used for the study, including the selection of participants for the study, data collection techniques, data analysis, discussion, trustworthiness and ethical consideration.
- Chapter 4 is an in-depth analysis of the findings based on the data obtained from the classroom observations and semi-structured interviews with the mathematics teachers.
- Chapter 5 comprises a discussion of the findings in the in line with the research questions of the study, the literature review, and the conceptual framework on which this study is based.
- Finally, Chapter 6 provides the conclusions and reflections of the study. This conclusion is arrived at from the findings, reflections of the study, implications, and recommendations. This chapter will also comment on the limitations of the study.

CHAPTER 2 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

This chapter reviews the relevant literature on conceptual and practical strategies in the teaching and learning of mathematics for learners who are living with visual impairment. The chapter begins with a definition of VI and a description of the senses that VI learners use in learning mathematics. The chapter is structured around three sub-questions, namely: the challenges presented in teaching mathematics to VI learners; the approaches used by mathematics teachers to help learners construct mathematics knowledge; and, assistive technology devices used by mathematics teachers to help VI learners construct mathematics knowledge. The chapter ends with a discussion of the theoretical and conceptual framework that underpinned this study, followed by a summary of the chapter.

2.2 VISUAL IMPAIRMENT

It is imperative to understand and define a visually impaired person as scholars have attached various definitions to persons with visual impairments. Agesa (2014) describes a visually impaired person as an individual who has inadequate vision caused by diseases, accidents or congenital disability. Maguvhe (2005) speaks of a visual impairment person as someone who cannot tell the difference between light and darkness, one who is unable to recognise objects in the environment or only perceives light. Many scholars (Cox & Dykes, 2001; Mulloy, Gevarter, Hopkins, Sutherland & Ramdoss, 2014) categorise visual impairment according to the severity of the impairment, namely, “low vision, partially sighted, functionally blind, and blind (near or totally)” (Sahm & yorek, 2009, p.20. The World Health Organisation (WHO) classifies VI into two categories: first, low vision, commonly known as partially sighted; and second, blindness (Pascolini & Mariotti, 2012). According to Smith (2008), the term visual impairment is a cumulative term that refers to a person with any degree of vision loss that causes an impediment in doing any task that requires light (Smith, 2008).

La Voy (2009) adds that partially sighted or low vision persons have diminished visual acuities that hinder them from processing visual information to the same degree as a sighted individual. Partially sighted individuals have a visual acuity of less than 6/18 to light perception, even with corrective lenses (Pascolini & Mariotti, 2012). This means that an object that a normally sighted person can see when placed at a distance of 18m, requires a partially sighted person to move a distance of 6 meters closer. The blind, on the other hand, have either no light perception or have a minuscule light perception of less than 3/60 in the dominant or better eye (Pascolini & Mariotti, 2012). These are not fraction indications, but these rather indicate the distance (3m) from the eye chart that a VI person and a normal sighted person (60 metres) must stand to see and identify the same image.

2.3 VI AND MATHEMATICS LEARNING

Although sight in learning mathematics has been assumed to be fundamental in the acquisition and understanding of concepts, Sedaghatjou, (2018) argues that comprehending and constructing mathematical knowledge goes beyond sight. The author further claims that the acquisition of knowledge involves the use of other sensorial perceptions and the ability of the learner to reflect on and link the new concepts to their prior knowledge. Buhagiar and Tanti (2013) state that learning can be acquired through other senses, such as touch and hearing. Mugo (2015) conducted a comparative study on the rate of transmission of knowledge through visual, tactile and audio cues among learners, which indicated that learners' grasp of information is faster through the visual modality than it is through auditory and tactile modalities. However, while sighted learners can scan through texts, tables, charts and diagrams at a glance to obtain a general overview of the information, VI learners are unlikely to grasp or comprehend such abstract and illustrated information at a glance quickly because of the nature of braille. It is also argued that the auditory and tactile senses, which are the channel of learning for VI learners, are much slower than sight because reading mathematics with fingers involves touching one-character detail at a time in comparison to getting general ideas at once by seeing (Mugo, 2015). This argument has been widely supported in the literature (Buhagiar & Tanti, 2013; Swan, 2017) as VI learners take longer to understand the mathematics curriculum content, most of which appeals to the sense of vision because VI learners require more cognitive processing capacity to understand mathematics through the tactile modality.

In South Africa, VI learners receive their education either in special needs schools or in mainstream schools where they are integrated into the general population of sighted learners. The mathematics syllabus is designed to be uniform across all grades in all schools. However, VI learners have insufficient vision to work through the mathematics curriculum content, which is abstract and utilises graphics such as graphs, charts, tables and drawings (Buhagiar

& Tanti, 2013) at the same pace as sighted learners. The construction of mathematical knowledge by VI learners to a large extent depends on the assistance they receive from their teachers (Hassan & Salleh, 2017). Unfortunately, research has shown that many teachers who teach mathematics to VI learners lack the necessary skill to help learners construct mathematical knowledge (Bayram at al., 2015). Yorek (2009) confirms that the same situation is common in Turkey where teachers who teach mathematics to VI learners fail to facilitate learning and, as a result, VI learners lose confidence in pursuing mathematics at higher education levels.

2.4 CHALLENGES THAT TEACHERS EXPERIENCE IN TEACHING MATHEMATICS TO VI LEARNERS

Mathematics teachers teaching VI learners experience challenges. Research has shown that this problem is not experienced only in South African special needs schools, but other researchers have revealed that it takes place in other nations as well (Maguhve, 2015). For instance, in Turkey, a study done by Bayram at al. (2015) revealed that teachers teaching mathematics to VI learners possessed limited knowledge about the learners, hence they struggled to teach them. Oira (2016) discusses the challenges faced in Kenya by teachers in assisting VI learners to use technology in learning. In this study, the challenges experienced by teachers are discussed here from the perspective of a lack of knowledge about the VI learner, lack of time, lack of competent skills to teach mathematics to VI learners, lack of knowledge of mathematics braille code, and a lack of competence in technology, as well as inadequate resources and time constraints.

2.4.1 Teachers' lack of knowledge about the VI learner

The South African government White Paper 6 on special education policy outlines more ancillary support that will be given to teachers who teach learners with different needs in education to cope with the demand of the learners (DOE 2001). The reality is that this legislative support for teachers has not sufficiently been implemented and many teachers who teach mathematics to VI learners do not seem to understand how the VI learners construct mathematical knowledge. These teachers believe that VI learners can understand mathematics concepts at foundation phase level (La Voy, 2009), but doubt the capability of the VI learners studying mathematics at high school. Many do not seem to be convinced that VI learners have the potential to acquire mathematical knowledge and, moreover, they find it challenging to mediate the learning of mathematics due to the negative attitude they have toward teaching mathematics to VI learners (Maguhve, 2015). This discourages VI learners from pursuing mathematics in higher education (Hassan & Salleh, 2017).

2.4.2 Lack of skills to teach mathematics to VI learners

Globally, research reveals that the poor performance of VI learners in mathematics is attributed to the lack of skilled teachers to effectively teach mathematics to VI learners (Hassan & Salleh, 2017; Louw, 2015). Most teachers who teach these learners are only in possession of general qualifications to teach in mainstream education (Kapperman, Heinze & Skicken, 2010) and are not trained to handle inclusive teaching or teach in special needs schools with VI learners (Hassan & Salleh, 2017). According to the research done by Maguhve (2015), South African mathematics teachers are reluctant to teach mathematics to VI learners because they lack innovative skills where resources are limited and that the teachers tend to pass the blame to the VI learners, saying they are unable to understand the subject matter.

Additionally, teachers are not provided workshops or given in-service training to gain skills in teaching VI learners. Unskilled and inexperienced teachers, therefore, find teaching mathematics to VI learners very challenging (Rule et al., 2011). Consequently, some teachers omit to teach some topics in the mathematics syllabus, such as geometry, which they believe to be challenging for VI learners (Buhagiar & Tanti, 2013). This disadvantages the VI learner, who is already at a disadvantage when learning abstract mathematical concepts, as opposed to sighted learners.

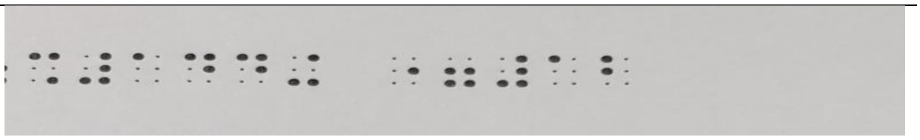
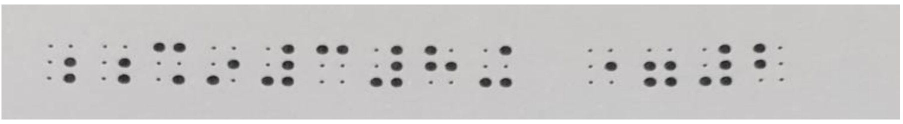
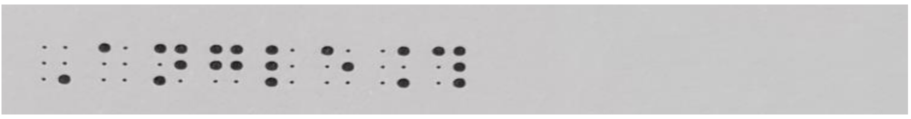
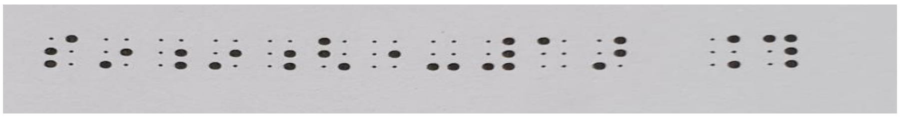
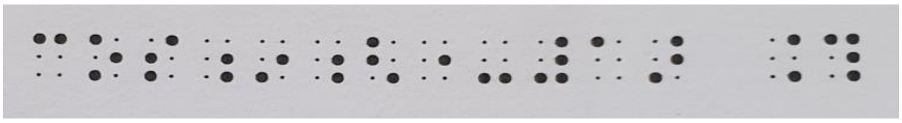
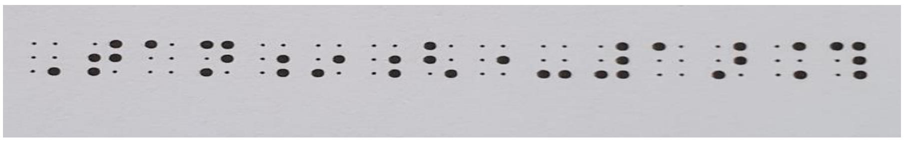
Furthermore, during lesson presentation, unskilled teachers resort to mainstream teaching habits such as the use of gestures, pointing and the use of body language during lessons (Rule et al., 2011). According to Sedaghatjou (2018), the use of “gesticulations” (signals instead of words) and ambiguous words such as ‘this’ and ‘that’ makes it difficult for a VI learner to follow mathematical explanations. Rule et al. (2011) add that expressions such as *that* and *thi*s used to explain mathematics contents act as barriers to the construction of knowledge of a blind learner.

Ultimately, the success of VI learners greatly depends on the teacher's professional skills embedded in their pedagogical knowledge, namely, knowledge of subject content, knowledge of VI learner characteristics, knowledge of strategies of teaching, and curriculum knowledge (Hassan & Salleh, 2017).

2.4.3 Lack of knowledge of the mathematics braille code

Adequate knowledge of the braille code is essential in teaching mathematics to VI learners. According to Gulley, Smith, Price, Prickett and Ragland (2017), VI learners underachieve in mathematics partially because they experience a crisis in braille code literacy because they are hardly taught during the lesson. Many teachers teaching mathematics to VI learners have inadequate knowledge of braille. According to Kapperman, Heinze, and Sticken (1997), teachers teaching mathematics to VI learners are expected to introduce new mathematics braille codes that are relevant to the learning content. Accordingly, they argue that the precise and correct mathematics code should be introduced in all mathematics learning opportunities. For example, when introducing the topic of trigonometry to Grade 10 VI learners, some braille code as shown in Table 2.1 should be revised with the learners.

Table 2.1: Symbol and braille equivalent.

Print format	Braille format
$\sqrt{144} = 12$	
$\sqrt[3]{8} = 2$	
Angle θ	
Angle ϕ	
$\sin^{-1}\theta$	
$\cos^{-1}\theta$	
$\tan^{-1}\theta$`	

According to Zhou, Ajuwon, Smith, Griffin-Shirley, Parker and Okungu (2012), most mathematics teachers are not capable of using braille notation for mathematics. Research has shown that the majority of teachers who teach blind learners are not proficient in braille (Bayram, 2014). They experience challenges in reading learners work and teaching them new braille notation for the new symbols that appear in the text. In South Africa, the report by Fish-Hodgson and Khumalo (2015), titled “Left in the dark (failure to provide quality education to blind and partially sighted learners in South Africa)”, showed that, by the year 2014, there was a total of 123 teachers in the 22 public registered special needs schools in South Africa who did not know braille. Further, in the report, 407 teachers only had an elementary knowledge of braille and had no idea of contracted braille.

2.4.4 Lack of technological knowledge

Competence skills in the use of assistive technology devices are considered significant in the teaching of a technical subject such as mathematics (Ngubane & Khoza, 2016). Teachers of VI learners are required to select quality and appropriate assistive technology tools from the ever-increasing number of equipment in the market. Most mathematics teachers teaching VI learners experience challenges with the use of assistive technology tools due to inadequate teacher training (DePountis et al., 2015). Scholars have indicated that the absence of formal training for teachers in the use of assistive technology together with inadequate in-service training poses a challenge to their ability to teach VI learners (Mugo, 2015; Opie, 2018; Smith, 2008). According to research done by Smith, Kelley, Maushak, Griffin-Shirley and Lan (2009), 57.7% of the teachers who participated in the research stated that they did not have sufficient knowledge in the use of assistive technology devices. They claimed that they had not received formal training to use assistive devices. Hence, they were unable to incorporate assistive technology devices in mathematics, such as refreshable braillers and note-takers that are less time consuming but increase the technological skill of the VI learner (Zhou, 2012).

According to Mugo (2015), inadequate training for teachers in the use of technology and computer software leaves them with only the option of reading information to VI learners. This method of facilitating learning is not effective and is time-consuming. As a result, VI learners may not have the same quality of education as sighted learners.

2.4.5 Inadequate resources

Inadequate assistive technology and other teaching and learning materials in an institution for VI learners is not a recent phenomenon (Mugo, 2013). Research has revealed that in most special needs schools for VI learners, teachers are not enabled to successfully help learners construct mathematical knowledge due to limited resources (Maguhve, 2015). These resources include all teaching/learning materials such as brailled books, computers and computer programs (Butler, Holloway, Marriott & Goncu, 2017). In some instances, the assistive technology available in these schools is outdated, and there are no funds for upgrading or teachers do not know how to look for funds to buy modern technological equipment (Zhou, 2012). In Oira’s (2016) study, it was established that due to a limited number of computers in the teacher's resource centre, teacher’s lessons were negatively affected.

Most textbooks, which are suitable for teaching/learning mathematics in high school, are available in print but there is a paucity of braille copies. Additionally, in a situation where braille books are available, some are written with an error while others miss important content such as diagrams. This puts more pressure on a mathematics teacher to find alternative ways of teaching the missing information.

2.4.6 Time constraints

The writing and reading of braille material take longer than the writing and reading of a standard text (Bitter, 2015). This is because braille readers can only read the character under their finger at a pace of one at a time (Sedaghatjou, 2018). Also, braille and its linearity make working in braille more complicated and time-consuming (Bayram, 2014). It is evident that the pace at which VI learners read and write their tasks is slow as compared to sighted learners and hence teachers require extra time to complete the prescribed syllabus on time. Giesen, Cavenaugh and McDonnall (2012) suggest that support programmes outside of the normal school operational hours must be scheduled to assist such learners in catching up with the syllabus.

VI learners require individual attention to meet the needs of every learner. Teachers facilitating mathematics to these learners should put in sufficient time to allow the learners to construct their knowledge. Providing individualised teaching is time-consuming and may lead to the set syllabus not being completed timeously (Negash, 2017). Mathematics teachers should note that VI learners often become exhausted from extra concentration to compensate for the loss of sight (Rule at al., 2011).

2.4.7 Summary

VI learners are individuals who have poor or no sight caused by diseases, accidents or congenital disability. They use touch and auditory senses to learn mathematics, which has been termed as visual and abstract. Teachers who teach mathematics to these learners should have special skills to help them overcome their barriers and construct mathematical knowledge. The reality has been that most teachers who facilitate mathematics to VI learners possess only a bachelors degree that qualifies them to teach in mainstream education. They lack the skills to help learners construct knowledge. They do not understand how VI learners learn; and their braille literacy and technology competence is not adequate. Additionally, they experience time constraints in covering the syllabus because the mode through which VI learners learn is slow as compared to that of sighted learners.

2.5 INSTRUCTIONAL APPROACHES USED IN TEACHING MATHEMATICS TO VI LEARNERS

Blind and partially sighted learners are a heterogeneous group with different needs and learning requirements (Freser & Maguvhe, 2008). To meet individual needs, mathematics teachers should employ multiple teaching approaches that are appropriate to the learning style, desire, interest and potential of the learners (Bayram, 2014). The National Council of Teachers of Mathematics (NTCM) (2000) demands that teachers must use their professional judgement with each learner to provide the approach to learning that matches the needs of that learner. According to a study done by Hassan and Salleh (2017) on appropriate teaching approaches and strategies used to teach VI learners, teachers should strive to better learners' understanding and achievement.

There is no single approach to teaching mathematics to VI learners that are deemed as appropriate for all teachers. The choice of a particular approach in the lesson is determined by the knowledge and skill of the teacher, and the ability of the chosen approach to help the VI learners achieve to their maximum potential (Rule et al., 2011). It should be noted that the teaching approaches used to teach mathematics to sighted learners are also applicable for teaching VI learners (Spindler, 2006). According to Hassan and Salleh (2017) and Rule et al. (2011), the instructional approaches used to teach learners with disabilities do not differ from those used to teach sighted learners. However, due to the learners' limited ability to see, adapting and modification, the teaching content and approaches is inevitable (Hassan & Salleh, 2017).

2.6 ADAPTING AND MODIFYING THE CURRICULUM

Teachers who teach mathematics to VI learners are familiar with terms such as adaptation, accommodation and modification of the curriculum. However, in most cases, these terms are used interchangeably without clear distinction. Curriculum adaptation is defined as the process of modifying teaching methods and the outcomes intended for learners without altering the complexity of the curriculum content (Okumbe & Tsheko, 2010). These changes are allowed in the education system to provide all learners with an equal opportunity to benefit and equally achieve well despite their diverse needs (Zhang, Wong, Chan & Chiu, 2014).

Accommodation is the use of diverse pedagogical approaches in the delivery of the curriculum to the learners without fundamentally changing or lowering the standard of content or assessments (Okumbe & Tsheko, 2010). This often means rethinking the method to be used for teaching the curriculum, marking some changes to the homework and assignments to ensure that VI learners have access to equal education (Marson, Harrington & Walls, 2013). An example of this is the use of tactile materials and auditory aids for teaching VI learners. This provides VI learners with equal opportunities to participate in class activities as much as sighted learners do (Rule et al, 2011). Curriculum modification involves carefully altering curriculum components such as content, the specific objectives and the modes of assessments for the diverse needs of the learners (Okumbe & Tsheko, 2010). Curriculum accommodation and modification have a positive impact on the learning of VI learners as they make learning effective, goal-driven and principled (Maguhve, 2005).

The Department of Education (2011) White Paper 6 policy document on Special Needs Education (building an inclusive education and training system) emphasises that learners with a disability have different needs in learning and can learn with adequate support. Teachers are to be empowered and mandated to adapt and modify the mathematics curriculum to meet the needs of each learner (Bouck & Meyer, 2012). These require changes to specific components in the education domain such as content, classroom instructional strategies, time-on-task and learning materials, as well as the objectives of the lessons to suit the needs of each learner (Okumbe, & Tsheko, 2010).

2.6.1 Modification to curriculum content

The mathematics curriculum content offered to VI learners is the same as that offered to mainstream learners (Hassan & Salleh, 2017). For example, the South African CAPS curriculum is designed and structured to be implemented in all Department of Basic Education (DBE) schools, special needs schools for visual impairment included. Five content areas are to be experienced across all grades, which are: (1) Number and number relation, (2) Functions and algebra, (3) Space, shape and measurements, (4) Data handling, and (5) Probability (DoE, 2013). At each grade, the learning outcomes and the assessment standards are increased in terms of scope and depth of the learning of content and the skills to be developed. The VI learners have visual barriers that prevent them from accessing the curriculum in the same manner as sighted learners (Rule et at., 2011). For instance, while sighted learners read and write text, blind learners use tactile and audio forms of learning to access the curriculum, while partially sighted learners rely on enlarged texts and graphics to access mathematics (Sedaghatjou, 2018).

Despite these modes of learning, most high school mathematics textbooks are designed to serve sighted learners and not their VI counterparts (Bouck, Meyer, Joshi & Schleppenbach, 2013; Silman, Yaratan & Karanfiller, 2017). Therefore, all currently available books and learning materials need to be adapted and modified to accommodate the VI learner. These materials all need to be translated into braille and large print formats to be accessible to the VI learner (Rule et al., 2011; Sahim & Yorek, 2009). Although some books have been translated into braille and large print, many of them have not. Also, some of them have mistakes in their editing. Therefore, such materials require constant reviews and updates to reduce errors and ensure that they provide the same information for VI learners as they do for sighted learners. At the same time, tactile graphics such as embossed tables, graphs and charts that replace print illustrated diagrams need to be provided for the blind learner.

2.6.1.1 Modification to instruction strategies

Blind and partially sighted learners are a heterogeneous group with different needs and learning requirements (Freser & Maguvhe, 2008). Therefore, mathematics teachers should employ multiple teaching strategies that are appropriate to the learning style, aspiration, interest and potential of the learners (Bayram, 2014). On the same note, the NCTM (2000) demands that teachers must use their professional judgement with each learner to provide the learning technique that matches the needs of that learner. According to research done by Hassan and Salleh (2017) on appropriate teaching approaches and strategies used for teaching VI learners, ‘induction and deduction’ strategies that are based on the diversity of the learners, their understanding, attention, competence and imagination, should be used to strive for better achievement. These authors further concluded that modifying classroom instruction according to individual needs to improve their understanding and efficiency. They suggest that teachers should use diverse strategies during classroom experiences that are “teacher-centred, student-centred, activity- centred and material centred” (p. 57).

2.6.1.2 Modification to experiential time

The writing and reading of braille material take longer than the writing and reading of the standard text (Bitter, 2015). This is because braille readers can only read the character under their finger at a pace of one character at a time (Sedaghatjou, 2018). In addition, braille and its linearity make working in braille more complicated and time-consuming (Bayram, 2014). Giesen, Cavenaugh and McDonnall (2012) suggest that support programmes outside of the normal school operational hours must be scheduled to assist slow learners in catching up with the syllabus to cope with the academic demands of mathematics. These authors also indicate that there is a positive correlation between extended contact time for VI learners and mathematics achievement. Although giving enough activities to learners gives them sufficient practice in the content being covered, VI learners often become exhausted from the extra concentration required to compensate for the loss of sight (Rule at al., 2011).

2.6.2 Possible approaches in teaching mathematics

Some research has been carried out to develop possible approaches that can be used to teach mathematics to learners with disability (Gersten, Chard, Jayanthi, Baker, Morphy & Flojo, 2009). Examples of these studies include a meta-analysis study synthesis from 42 interventions with a focus on addressing approaches used in the teaching of mathematics to learners with disability (Gersten et al., 2009). According to Gerstein et al. (2009), six possible approaches to teaching mathematics to learners with disability were highlighted and discussed. These were: direct instruction, problem-solving, students’ verbalisation of solutions steps, the use of mathematics representation, and ranging and sequencing examples from concrete to abstract, as well as the peer tutoring approach.

Another meta-analysis study compiled by Schroeder, Scott, Tolson, Huang and Lee (2007) from 61 studies focused on effective science teaching strategies. According to Schroeder et al. (2007), the highest-ranked strategy to enhance learning is contextual teaching where teachers use examples from the immediate environment of the learner in solving a problem. Other teaching strategies, which tended to overlap each other, were the collaborative strategy, questioning strategy, inquiry strategy, use of manipulatives and others. Table 2.1 comprises a list of scholars and a short description of the possible approaches that can be used to help VI learners to construct mathematical knowledge.

Table 2.2: An overview of the possible teaching approaches for learners with a disability, as mentioned by different scholars

Approaches	Wadlington & Wadlington (2008)	Rule et al. (2011)	Louw (2015)	Steedly et al. (2008)	Gersten et al. (2009)
Direct approach	Teachers should break concepts into smaller units and present them step-by-step.		Teacher explains or models the concepts and then gives the learner an exercise to practice.	The teacher clearly states and follows defined instruction sequences.	The teacher demonstrates step by step how to solve a problem; learners follow the steps.
Contextual	Emphasis on skills and concepts appropriate for learners' life.	Relate new knowledge to the previous topic.	Facilitate learning through contexts.		

Scaffolding and peer tutoring	Students benefit from extra instruction with a math tutor.	Blind learners working collaboratively with sighted peers during learning.	Learners construct their knowledge when the teacher provides scaffolds.	Students work in pairs to help one another learn.	Verbalisation is critical in scaffolded instruction. Verbalisation encourages discussion.
Use of manipulatives	The teacher should start teaching using a concrete object before presenting abstract concepts.	Use Manipulative and other tactile materials to provide sensory information.	Use of actual material that learners can manipulate.	Learners manipulate concrete materials such as blocks and geometric figures before abstract or symbol terms.	
Problem-solving	Teachers break down skills and concepts into smaller parts and present a lesson using step by step procedures.	Problem-solving skills benefit learners with disabilities.	problem-solving techniques help learners to think actively.	Allow the student to think aloud while working through a problem.	Use of heuristics.

The approaches that were mention by Wadlington and Wadlington (2008), Rule et al. (2011), Louw (2015), Steedly et al. (2008) and Gersten et al. (2009) were scaffolding and problem-solving. They all agree that learners with a disability benefit from being assisted individually through scaffolding or tutoring. Although scholars have indicated problem-solving, it is only

Wadlington and Wadlington (2008), Louw (2015), and Steedly et al. (2008) who elaborated on the four stages of problem-solving according to Polya (1957). Other preferred approaches mentioned by most scholars, as seen in the table, were explicit/direct instruction and the use of manipulatives. The least discussed approach was the contextual approach.

The scholars differed on how new mathematics knowledge for learners with a disability should be approached. Wadlington and Wadlington (2008) argue that mathematics teachers should instruct learners using tangible objects and only introduce abstract concepts after multiple experiences. Wadlington and Wadlington (2008) further find that concepts should be broken down into manageable units and taught systematically. Louw (2015) agrees that mathematics learning should start with a concrete level before abstraction, while Rule et al. (2011) emphasise the contextual approach where the teacher should stimulate the interest of the learner by linking the new knowledge to their past experiences. According to Steedly et al. (2008), approaching mathematics through direct instruction is primarily effective as it allows the teacher to pace the lesson according to the ability of the learner and at the same time monitor the concept development. Gersten et al. (2009) agree with Steedly, claiming that the direct approach enables mathematics teachers to give step-by-step instruction.

2.6.3 Direct instruction

Direct instruction is an approach to teaching that allows the teacher to explain the concept to learners using a step-by-step method, followed by the teacher providing different learning activities that allow the learners to practice individually or as a group until the concept or skill is mastered (Louw, (2015). According to Scholars such as Gersten et al. (2009), Steedly et al. (2008) and Wadlington and Wadlington, (2008), direct instruction is the most effective method for teaching mathematics to learners with disability. They said that the direct strategy to teaching encourages interaction between teacher and learner and provides the teacher with an opportunity to monitor the learners' progress of acquiring concepts constantly. According to Steedly et al. (2008), direct instruction encourages effective pacing of the lesson; enhances students’ attention; allows time for the learner to think and respond appropriately; and encourages classroom participation and continuous assessment. In instances where multiple examples are used, the approach enables the teacher to meet the different needs of the learners, clearing up any misconception that learners may develop (Jayanthi et al., 2008).

According to a review of the National Mathematics Advisory Panel (2008), direct instruction improves special needs learners' achievement in mathematics in working with numbers, solving word problems, and transferring known skills to abstract concepts. The advisory panel acknowledges the fact that direct instruction has continuously displayed a positive result when used in teaching mathematics to learners with disabilities. However, they note that explicit instruction should not be used exclusively. In their recommendation, they add that teachers of learners who experience barriers to learning should regularly teach mathematics using direct instruction, but not all the time. Steedly et al. (2008) summarise the benefit of direct instruction as seen in Figure 2.1 below.

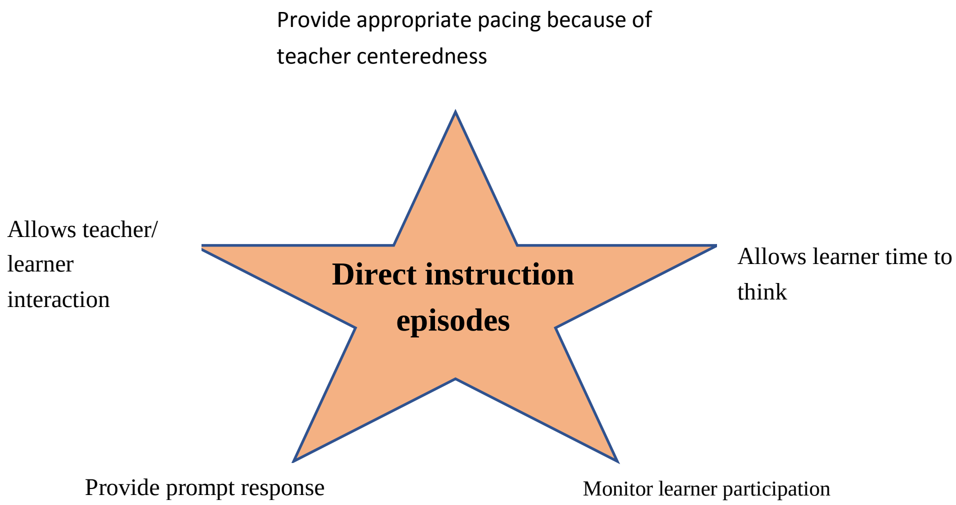


Figure 2.1 The advantage of direct instruction strategy (Steedly et al. 2008)

2.6.4 Contextual instruction

Researchers like Rule et al. (2011), Wadlington and Wadlington, (2008), and Louw (2015) encourage the contextual approach to teaching learners with a disability where mathematics teachers relate new knowledge to already mastered the content. They explain that building new ideas onto prior knowledge allows these learners to construct meaning regarding what they are learning and, as a result, develop ownership of the new knowledge. Louw (2015) suggests that mathematics teachers use examples from the immediate environment that is familiar to the learners to enhance learning for VI learners, as it is difficult for them to make connections by themselves.

The mathematics teacher who wishes to use authentic real-life context should bear the following in mind: firstly, the content to be experienced should be aligned with the appropriated age and interest of the learner (Louw, 2015). The learner should not be made to see mathematics content as disjointed units but rather connected to other learning areas, and relevant to real-life situations (Wadlington, & Wadlington. 2008). Secondly, contextualised experiences should be modelled in the context of mathematics to achieve a set outcome (Louw, 2015).

2.6.5 The use of manipulatives

The use of manipulatives during lesson instruction is regarded as the most effective approach for teaching mathematics to learners with disability (Louw, 2015; Rule et al., 2011; Steedly et al., 2008; Wadlington & Wadlington, 2008). According to Wadlington and Wadlington (2008, p.5), concrete objects such as: "geoboards, base ten blocks, Cuisenaire rods, geometric blocks, counters, and play money should be used at the introduction phase of the topic to model mathematics concepts." This will allow learners with a disability to manipulate real objects when learning mathematics and provide them with sensory information that supports their mental construction of knowledge (Rule et al., 2011).

In this regard, the teacher should demonstrate the concept in a representational form (Steedly et al., 2009), for example, walking on a number line to get the sum and difference of numbers (Wadlington & Wadlington, 2008). Lastly, teachers should use numbers and symbols that represent mathematics in an abstract form.

Steedly et al. (2009) illustrated the three steps to be followed when teaching the concept of 'fractions'. The first step is to split or fold a circle into four. The learner should touch each piece and develop a mental representation of $\frac{1}{4}$. The second step is for the learner to complete a worksheet by counting or finding out what fraction is shaded (the activity can be adapted for blind learners). Finally, abstract symbols and number should be employed, for example $\frac{3}{7} + \frac{5}{7} =$.

2.6.6 Peer tutoring

Peer tutoring, as discussed by Steedly et al. (2008), refers to working together in pairs to assist one another to construct knowledge of the study materials or to complete an academic task. Peers can deliberately be paired according to intellectual differences (i.e. a low achiever works together with a high achiever) or age (an older learner tutors a younger one) (Jayanthi et al., 2008). It is common practice for the peer groups to position themselves and assign the roles that each plays during tutoring sessions. One may assume the role of a tutor while the other that of a tutee. Teachers find it beneficial for learners to exchange their position during the discussion because explaining a concept to another person helps build confidence and increases knowledge construction (Steedly et al., 2008). According to Rule et al. (2011), VI learners gain substantially in learning when they are paired to work collaboratively with a sighted peer. They further find that once a VI peer gets support from other learners, they become socially connected and actively involved in the lesson.

2.6.7 Scaffolding

Scaffolding is an approach that enables learners to solve a problem or accomplish a goal which initially they could not achieve without assistance (Wood, Bruner & Ross, 1976). In the education structure, the learner is the novice or less knowledgeable person who is being assisted by a teacher (who is more experienced) to carry out classroom activities that require support to understand (Louw, 2015). Scaffolding has been compared to the temporary scaffold that is used during construction to support the building, which is eventually removed once the building is completed (Bakker, Smit & Wegerif, 2015). The metaphor has a deeper meaning as it can be interpreted as implying that classroom activities are difficult for learners initially, but after they have received support, they can complete tasks easily (Noriega & Zambrano, 2011).

Many teachers use the concept of scaffolding as an approach to teaching. The scaffolding approach is also a common approach in teaching learners with disabilities because it is interactive. Initially, the interaction was between the tutor and the tutee, but, in recent years, it has broadened to include collaborative learning (Bakker, Smit & Wegerif, 2015). Additionally, Noriega and Zambrano (2011) argue that when this approach is used appropriately, learners are made to understand the concepts easily as the teacher splits the concepts beforehand into smaller parts that the learners can manage progressively (Noriega & Zambrano, 2011). However, the amount of support a teacher provides to the learner depends on the ability of the learner to grasp concepts.

Scaffolding is related to Vygotsky’s Zone of Proximal Development (ZPD). ZPD is defined by Vygotsky as “the distance between the actual development zone as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance.”(Shabani, Khatib, & Ebadi, 2010, p 238). The role of the adult is to frame the knowledge close enough to the learner’s potential so that they can grasp the knowledge and integrate it into already existing experiences as they construct knowledge (Roberts & Beamish, 2017). This means that the learner (the tutee) can only be guided up to their maximum potential. Louw, (2015) argues that instructions in the ZPD should not be too easy to bore the learner or be too difficult that the learner is unable to develop the skills, but should be sufficient for their cognitive level.

Anghiler, (2006) views scaffolding in mathematics as a hierarchy of three levels, the basic level being an environmental provision. At this level, there is no direct interaction between the teacher and the learner. The teacher facilitates learning using tools such as manipulative materials, measuring instruments and puzzles to organise the sequence of activities that learners will explore. At this level, learning can take place in small groups or through peer collaboration. The second hierarchical level constitutes interactions between the teacher and learners through explaining, reviewing and restructuring the mathematics concepts to be experienced. Firstly, the teacher systematically explains what he or she has planned with little input from the learners. Secondly, the teacher reviews the content and allows the learners to construct their own learning through observing, touching and verbalising what they see and think, and then justifying their explanation. In the meantime, the teacher interprets the learners’ actions and talk using prompting and probing questions and through parallel modelling. Lastly, by restructuring, the teacher engages in modifying the learning concepts to make them more accessible to the learners.

The third level is the highest in the hierarchy of scaffolding deals with developing conceptual thinking. At this level, teachers offer support for learners to develop a range of representational tools (words and symbols), make connections, and generate conceptual discourse.

The above views on the scaffolding approach to mathematics teaching differ from that of Oers (2014). According to Oers (2014), a scaffolding strategy approach used in teaching mathematics depends on the nature and goal for the learning as experienced by the learner. If the goal of mathematics is for the learner to perform operations accurately, then learners should learn about the correct form of how to master mathematical operations. The author further suggests three general strategies of scaffolding that can be adapted for the teaching of mathematics. These are listed as modelling (where an example is a demonstrated to the learner), giving advice (where a suggestion is provided on how to solve the problem) and coaching on specific ways of solving the problem correctly. If the goal is to develop mathematical concepts and problem-solving, a broader approach to scaffolding is employed that takes cognisance of the learners' prior knowledge and problem-solving and collaborative skills.

2.6.8 Problem-solving

The National Council of teachers of mathematics (NCTM, 2000) has defined the problem-solving strategy as a process of finding a solution to a mathematics problem whose methods of finding a solution are not predetermined. They continue by explaining that learners need to have frequent experiences with mathematics to formulate, grapple with and solve sophisticated problems that are demanding. By doing so, they develop critical thinking skills, determination, inquisitiveness. And confidence in situations outside mathematics (NTCM, 2000)

Attaining proficiency in the problem-solving technique increases learners' ability to understand concepts while reducing their dependence on memorising (Rule et al., 2011). The problem-solving approach consists of organised steps to be followed to realise the desired goal. Polya (1957) identifies four steps to be followed when using the problem-solving approach. The first step is to understand the mathematical problem and its context. The second step is to lay out a plan and strategies on how solving the mathematical problem is to be approached. The third step is to use the desired strategy and knowledge of mathematics to execute the plan, check if the steps were followed correctly and prove that the answer to the question is correct. Finally, learners must reflect on the solution of the problem and check on whether their arguments are logical. Jayanthi et al. (2008) recommend a multiple/heuristic strategy as a contemporary technique to problem-solving. The authors have identified four essential steps, which, if followed, could lead to the correct solution. These steps are: "Read the problem; Highlight the keywords; solve the problems and Check your work" (Jayanthi et al., 2008, p.1210). Wadlington and Wadlington (2008) add that once learners have identified the problem, they should design a plan on how to solve it and execute the plan through heuristic steps.

2.6.9 Summary

The teaching approaches used to teach VI learners are the same as those used in mainstream schools. However, the prefered approach for teaching mathematics to VI learners may be adapted to help learners construct mathematical knowledge. As discussed in this chapter, the proposed approaches are the direct approach, contextual approach, scaffolding approach, peer tutoring, the use of manipulatives, and problem solving. No single approach is adequate on its own in teaching mathematics to VI learners. The VI learner has benefited through diverse approaches in their lesson to cater to the varied needs of the individual learner. The most important aspect that the teacher should consider when planning for a mathematics lesson is to select an approach that makes mathematics accessible to all learners; an approach that will encourage the active participation of learners to achieve their goal.

2.7 TECHNOLOGICAL ASSISTIVE DEVICES AND COMPUTER PROGRAMS

The legislative acts and laws mandating the inclusion of assistive technology in the field of education for individuals with special education needs resonate well with education professionals advocating for accessible education for all (Smith, 2008). For instance, the South African Constitution protects the rights of everyone in South Africa. In section 9, the constitution specifically states that no one may be discriminated against, among others, on the grounds of disability (Constitution, S. A. (1996) Gov.za. 2017). In United States of America (USA), the Individual with Disability Education Improvement Act (IDEA) public law, passed in 1975, advocates for the use of assistive technology to benefit all learners with disabilities in achieving their educational goals (IDEA, 2004). The No Child Left Behind Act of 2001 supports inclusive education in schools to ensure accessible education for all learners (NCLB; 2002). These laws support an education strategy for VI learns that integrate assistive technology throughout the learners' daily learning.

The Assistive technology devices range from any item the teacher uses as a teaching aid to high tech and sophisticated technology available on the market (Akpan & Beard, 2014; DePountis et al., 2015). These can be categorised into three groups, namely, no-tech, low-tech, and high-tech (Mugo, 2013; Oira, 2017; Smith, 2008). No-tech devices constitute all learning materials that do not make use of electric energy in their operation. This may consist of the simple teaching aids and concrete objects used in the classroom that provide VI learners with tactile experiences. Low-tech instructional materials include Perkins Braillers, Braille books, talking calculator such as the OrionTI-84, black line and magnifying tools (Bitter, 2013). Perkins Braillers are a simple tool with six keys and a space bar used by blind learners to write in braille (Bitter, 2013). There are two types of Perkins Braillers - a standard Perkins Brailler, which is generally heavy and noisy while in use; and a next-generation brailler, which is light, with less noise and creates high-quality braille (see figure 2.2). Braillers provide a VI learner with an opportunity to access mathematics through writing (Smith, 2008).

Figure 2.2: A standard Perkins Brailler and new generation Perkins Brailler

High-tech devices constitute computer and specialised computer software (Depounties 2015; Oira, 2017). Examples of these include the Duxbury Braille translator speech output software, which includes job access with speech (JAWS) for windows and nonvisual desktop access (Mugo, 2015); braille embossers; iPad; print magnification devices; and screen readers (Oira, 2016). The Duxbury braille translator is a computer program used by teachers to translate printed text into braille (DePountis, 2015). Speech output software or screen readers are computer programs that enable blind learners or partially sighted learners to read the text displayed on the computer screen (Oira, 2016). An example of output speech software is JAWS, which is a computer program that can provide speech and braille output and can be connected to an embosser. An embosser is a special printer that produces a braille output (Mugo, 2013; Oira, 2016)

The South African National Council for the Blind (SANCB) strives to supply and support tested assistive devices for prospective users according to the functionality of sight of the user. They advocate for VI learners to be fully independent in their daily life with the use of assistive technology (SANCB).

2.7.1 Types of technology used by VI learners to write braille

According to the research done by Oira (2017) on modern technology used by VI learners in secondary schools, assistive technology such as Perkins Braillers, refreshable braille display, note-takers, large screen devices, smart braillers, audiobooks, smartphones and computers are significant in the education of VI learners.

A refreshable braille display is an assistive device that is used as an alternative to a Perkins Brailler (Bitter, 2015). The author states that a refreshable braille display can be connected to a computer via USB or Bluetooth, or be used as a stand-alone device. Once connected to a computer, round-tipped pins rise through the holes on the flat surface of the device, which the blind learner uses to read the text on the computer or write text that can be printed in braille. The advantage of refreshable braille is that it can be used to download e-books and other learning materials. Likewise, when the refreshable braille display, as shown in Figure 2.3, is not connected to a computer (stand-alone), it can be used to write mathematics exercises.

Figure 2.3: A refreshable braille display

Although a refreshable braille display is essential in the learning of mathematics, it cannot be used to display graphics content like graphs, which are commonly used in the mathematics curriculum. In its place, an audio graphing calculator may be used (Derick, 2008), which uses different tones to depict the slope of a graph (see Figure 2.4). For instance, when the slope of the drawn graph is high, the device will produce a high pitch to represent a steep slope, and as the slope of the graph becomes gentle, the pitch changes spontaneously to a low one (Bitter, 2013).

Figure 2.4: A talking scientific graphics calculator

Other assistive technology used by VI learners to learn mathematics is large text print access, which is commonly known as CCTV. This assistive technology device increases the font of the text for easy reading by partially sighted learners. From Oira's (2017) findings, it can be seen that most learners acknowledged that computers connected to Optical Character Recognition (OCR), speech output, a refreshable braille screen display and braille printers aided the VI learners to complete assignments independently and they could engage in research on the internet.

OCR is a scanner that translates written text to digital text, while speech output is a screen reader that produces a voiced version of the text displayed on the computer screen with the use of a keyboard and text-to-text converter (Bitter, 2013). The author further explains that the screen reader forms a different model from that of the screen and interprets the text from the operating system. An example of screen readers in the market is Jaws, which was discussed in Section 2.4

Oher audio outputs used by VI learners to access mathematics are the Digital Accessible Information System (DAISY), such as digital talking books that can be used in the place of braille text (Mugo, 2013). According to Bitter (2013), speech output provides VI learners with a different format from the usual tactile access to mathematics. Accordingly, the author says that speech output devices are a quicker way of scrolling back and forth through the text for vital information while familiarising oneself with the mathematics algorithm, as well as clarifying details of expressions.

From research done by Bouck et al. (2013) on the eText player, commonly known as 'read hear', which is another form of audio output device, it was indicated that VI learners successfully accessed and generally understood all algebraic expressions the first time it was read and did not require a second reading of the same text to understand it. However, Bitter (2013) cautions that although speech output may be used as another form of accessing mathematics, tactile learning is still the preferred mode of learning for VI learners and may not entirely be replaced by audio speech and lectures.

The accessibility of mathematics to VI learners holds a profound benefit for learners. Any effort to support these learners in empowering themselves to become competent in mathematics should be encouraged at all levels of education (DePountis et al., 2015; Derick, 2008; Mugo, 2015; Oira, 2017). One way of supporting these learners to achieve their educational goals and learn competitively with their sighted peers is through availing mathematics text in braille format and the use of assistive technology (Bitter, 2013). Assistive technology devices promote positive interaction between the teacher and the VI learners as both are actively participating as they work through curriculum content with a common goal (Mugo, 2015). Along with the above, incorporating assistive technology with instructional strategies improves learners' general performance (Mugo, 2015; Zhou, Ajuwon, Smith, Griffin-Shirley, Parker & Okungu, 2012).

2.7.2 The benefit of assistive technology for VI learners

The development of assistive technology has been embraced with a lot of enthusiasm as it is seen to provide independence to VI learners (Oira, 2016). Oira (2016) also clarifies that with the introduction of computers and other technological instruments, VI learners can access mathematics independently through auditory and enlarged text. Assistive technology acts as a compensatory mechanism to the loss of sight (Buhagiar & Tanti, 2013; Smith, Kelley, Maushak, Griffin-Shirley & Lan, 2009). The use of tools enhances the residual sight or strengthens other senses such as hearing to enable the VI learner to participate in education (Mulloy, Gevarter, Hopkins, Sutherland & Ramdoss, 2014). Smith (2008, maintains that assistive technology devices are a great equaliser for the loss of sight, and when harnessed in education, it provides instruments for VI learners to access information Mugo (2015) argues that technology affords VI learners the opportunity to think critically, as well as eliminating their barriers to learning. Assistive technology tools, if effectively integrated into the learning of mathematics, can reduce the tediousness of chains of mathematical calculation, allowing the learner to pay more attention to conceptual development (DePountis et al., 2015)

2.7.3 Summary

The usefulness of assistive technological devices should not be underestimated, whether at low-tech or high-tech device level. Assistive technology devices such as Perkins Braillers, a refreshable braille display, note-takers, large screen devices, smart braillers, audiobooks, smartphones and computers are used by learners to access and participate in constructing mathematics knowledge. The teacher uses a computer and its software to adapt the curriculum content in a format that is accessible to the VI learner. When assistive technology is integrated into the teaching of mathematics, it helps eliminate the barriers created by the loss of sight.

2.8 THEORETICAL FRAMEWORK

Teaching mathematics to VI learners depends on the skills that teachers have in adapting the curriculum content and using appropriate instructional approaches to teaching to help learners construct knowledge. Teachers are thus viewed as pivotal in the learning experience. The conceptual framework in this study is based on instructional approaches used, assistive devices used and the challenges encountered by the teacher in teaching mathematics to VI learners. From the literature, five approaches were identified in Section 2.1.7 to have potential in assisting VI learners to construct mathematics concepts. These teaching approaches are: the contextual approach, the scaffolding approach, the peer tutoring approach, the problem-solving approach and the use of manipulatives.

Not only are the approaches to teaching mathematics essential to the construction of mathematics knowledge, but assistive technology devices play a role as well. As Oira (2016) states, an increase in the use of assistive technology devices in education has transformed the instructional approaches used in teaching VI learners. Such devices have promoted independence among VI learners and improved their access to mathematics at a high level of learning. Incorporating assistive technology devices such as Perkins braillers, refreshable braille display, note-takers, large screen devices and Rubys enables VI learners' access to mathematics. Similarly, the use of technology such as a transformer HP to project and enlarge text for the partially sighted, and computer programs to translate text to braille and emboss sketches is vital.

Despite these, facilitating mathematics for VI learners is loaded with many challenges for the teacher (Maguvhe, 2015). As discussed in Section 2.1.3, these challenges are: a lack of necessary knowledge about learners, a lack of skills to teach learners, a lack of knowledge of braille code, being incompetent in technology, a lack of knowledge in braille, a lack of competence in computer literacy, inadequate skills to teach VI learners, inadequate resources and time constraints.

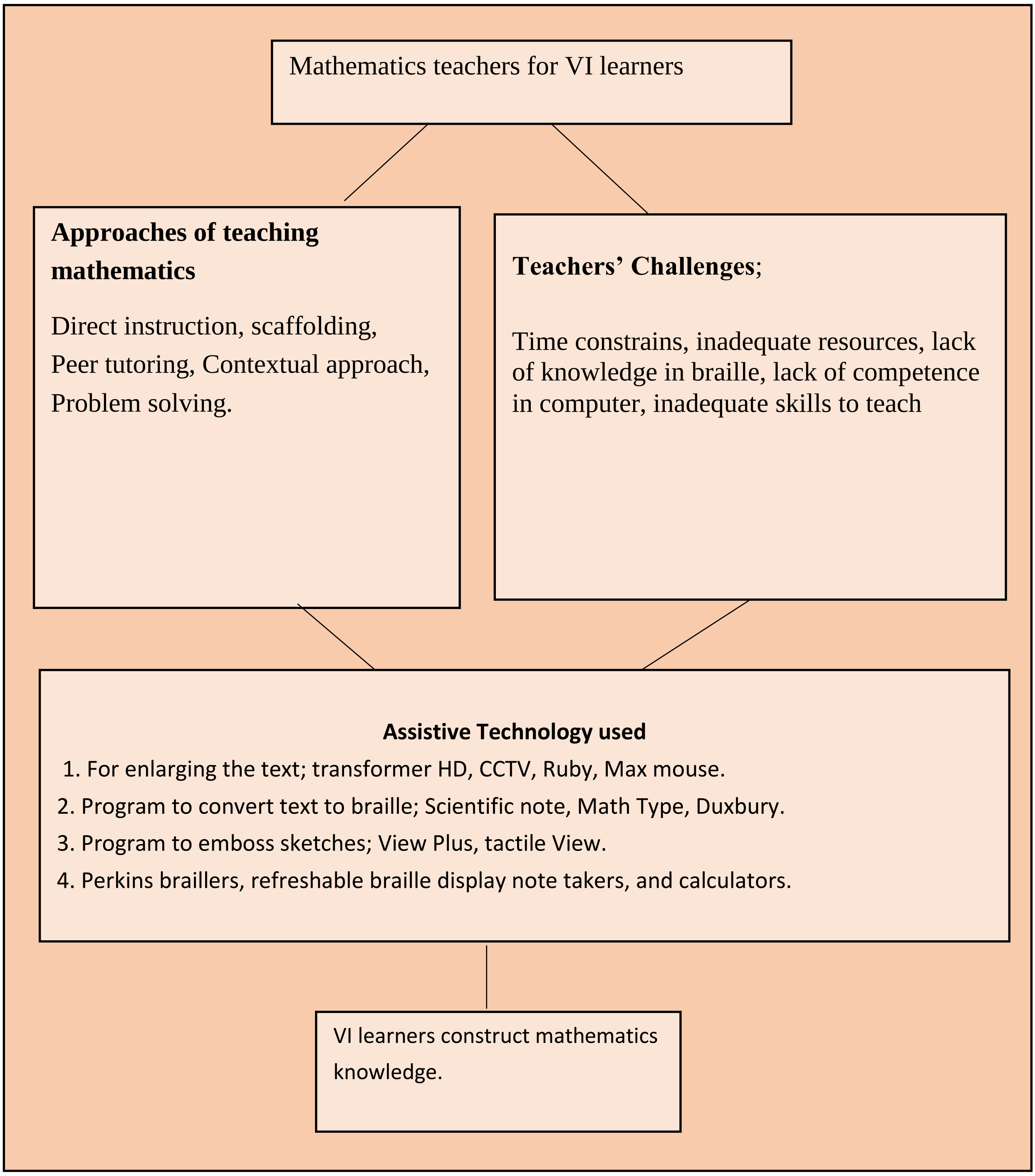


Figure 2.5: The challenges, approaches and assistive technology in teaching mathematics

This study is underpinned by the Constructivist Theory. Constructivism is a broad term widely used by philosophers, psychologists, and education (Woolfolk Hoy, 2000). This theory is grounded in the intellectual work of Dewey, Vygotsky, Piaget, and others (Bada & Olusegun, 2015). “In general, these proponents of constructivism believe that learners are actively involved in the construction of their own knowledge, and social interaction is important for their knowledge construction” (Woolfolk Hoy, 2000, p. 344).

From the above notion, it can be seen that Dewey criticises the traditional way of learning where standard subject content together with standard rules of conduct are emphasised (Ültanir, 2012). Dewey claimed that in traditional culture learning was passive, and teachers imparted their knowledge and skills to learners. He believed in active learning where learners construct knowledge by doing something rather than being spoon-fed knowledge (Pardjono, 2016). In his work, he proposed progressive learning where learners are perceived as active individuals perusing their learning through active participation rather than being filled with knowledge by the teacher. Dewey believed in self-disciplined and allowed democratic behaviour rather than embracing external behaviour full of rules (Ültanir, 2012). He believed that for learners to construct meaningful knowledge, teachers have to facilitate a conducive environment for active learning (Pardjono, 2016). This view of constructive learning is shaded with that of Piaget.

Piaget believed that learners acquire knowledge by active participation in the environment in which they live (Amineh & Asl, 2015). The interaction can be the actual manipulation of real objects or intellectually refining internal ideas (Harlow, Cummings & Aberasturi, 2007). Piaget believed that learners have mental structures called schemas through which knowledge is constructed. As learners encounter new experiences in their context, their thinking processes increase and need to be more organised. The new framework then develops to adapt to the changes. The process of adaptation occurs through assimilation and accommodation (Woolfolk Hoy, 2000). The process of assimilation takes place when new ideas cause a state of imbalance in the mind of the learner. To restore balance, they make sense of new knowledge by associating it with their prior knowledge (Harlow et al., 2007). In a situation where they are unable to associate it completely, learners build new schemas or frames to accommodate the new idea at a higher level. This change to the new schema is called accommodation (Bozkurt, 2017).

Although Piaget's philosophy of learning points to individual aspects of the construction of knowledge, social interaction is visible in his work. This is where learners who hold different views discuss these logically and embrace each other's opinion. The diverse views of learners may result in individuals re-establishing and reflecting on their thoughts (Bozkurt, 2017).

While Piaget's focus was mainly on individual construction of knowledge, Vygotsky's work was centred on socio-cultural aspects. He believed that individual cognitive development is shaped by activities of social interaction and cultural tools (Schreiber & Valle, 2013). He believed that learners initially construct knowledge in a social context before internalising it and using it individually (Amineh & Asl, 2015). For this reason, Vygotsky has been classified both as a social constructivist and as a psychologist (Woolfolk Hoy, 2000). The end of social learning is the benefit of the individual learner. Vygotsky believed that learners construct knowledge of the culture and the world if a more knowledgeable person guides them (Bozkurt, 2017). The role of the knowledgeable person is demonstrated in Vygotsky's concept of the Zone of Proximal Development (ZPD). The ZPD explains how scaffolding teaching helps the learner to understand the work they initially could not understand without guidance from an adult (Schreiber & Valle, 2013). The adult uses tools and cultural practices to motivate the learner towards generating new knowledge (Woolfolk Hoy, 2000).

2.8.1 Constructivism in education

Constructivism as a theory is significant in education as it mostly tries to explain how individual learners construct knowledge (Bada & Olusegun 2015). In constructivist learning, two notions are given preference: learning is an active phenomenon where learners participate actively in the acquisition of knowledge, and knowledge is socially and culturally constructed within a context (Ekpenyong, 2018). In simple terms, learners are actively involved in activities that lead to the construction of their knowledge. (Pardjono, 2016). The first perspective of acquiring knowledge stems from the Piagetian Cognitive Development Theory of learning, which focuses on the internal processes of learning (Amineh & Asl, 2015). Through participating in an activity, knowledge is constructed by building new ideas onto previously acquired knowledge. According to Pardjono (2016), the key to active learning can be summarised by four principals. These are:

- Active participation enhances the ability of learners to construct meaningful knowledge;

- Learners interact with physical materials in their environment;
- Learning is based on the individual needs of the learner; and
- Cooperative learning plays a role in knowledge construction.

The second notion is the Vygotskian perspective of learning, which emphasizes that learning is socially constructed (Bozkurt, 2017). This assumption stresses that learning is experienced when an individual participant in social activities is guided by an experienced member of the culture (Ekpenyong, 2018). These activities may include group discussions, problem-solving, mentoring one another and others. All of these influence the intellectual development of the learner and their understanding of the world around them (Ekpenyong, 2018).

Vygotsky further believed that at a given point of learning, the learner reaches a point where assistance is required. The learner may need structures, clues or even encouragement to keep on trying (Woolfolk Hoy, 2000). Vygotsky refers to this as a Zone of Proximal Development (Ekpenyong, 2018; Pardjono, 2016). In constructivist learning, the ZPD is achieved through scaffolding and peer tutoring, which are classroom approaches to teaching mathematics (Schreiber & Valle, 2013).

2.8.2 A constructivist's view of teaching mathematics

Traditional approaches to teaching mathematics focus on the transmission method, where teachers are viewed as knowledgeable people who transfer knowledge to passive learners.

The constructivist stance shifts learners from being passive receivers of knowledge form the learners who construct their own knowledge and are actively involved in their own learning. This paradigm shift has caused mathematics teachers to redefine their position to that of facilitators who tutor, stimulate and assist learners in constructing mathematics knowledge (Bada & Olusegun, 2015). According to Bozkurt (2017), meaningful facilitation is achieved when teaching experiences are contextualised so that the content is made meaningful to the learner. That is, the concepts to be taught are situated within the natural environment with which learners are familiar. According to Prideaux (2007), when learners relate mathematical ideas to life experiences, they assimilate the new content with prior knowledge, constructing new knowledge.

2.8.3 Constructivist approaches to teaching mathematics to VI learners

a) Contextual approach

From a constructivist perspective, VI learners construct mathematics concepts by actively participating in mathematics activities. In constructivist teaching, there is no transfer of knowledge from the teacher to the learner. The teacher facilitates mathematics lessons that encourage active participation. The curriculum content is contextualised to make sense of it for the VI learner rather than promoting memorisation. In this sense, the VI learners construct mathematics knowledge by assimilation, where new concepts are linked to prior knowledge (Bada & Olusegun, 2015). A contextual approach to learning creates an environment where the student takes responsibility for their construction of knowledge because it is meaningful to them.

b) Scaffolding and peer tutoring

In constructivist learning, mathematics teachers strive to increase learners' participation in the activities and motivate them to learn through the scaffolding and peer tutoring approaches (Ekpenyong, 2018). The teacher, or a more knowledgeable peer, guides the VI learner by giving clarity on concepts that cannot be understood without assistance. The teacher assists the VI learner by modelling the problem to the individual learner or the group, and then allowing the learner to practice. These approaches to teaching are grounded in Vygotsky's ZPD. The ZPD concept describes the difference between the actual mental age of the learner and the level of ability they can reach with the help of the teacher or a knowledgeable peer (Bozkurt, 2017).

c) The problem-solving approach

Constructivist learning encourages interactive learning where learners use their intellectual skills such as researching, metacognitive thinking and critical skills knowledge (Cirik, Çolak, & Kaya 2015). This means that they employ the problem-solving approach to construct knowledge. Problem-solving enables VI learners to break the problem into manageable steps as they work through the problem. Simply put, they apply Polyas's process for problem-solving. In instances where they are overwhelmed and do not know how to plan for and conduct the problem-solving steps, the teacher may offer a scaffold, or the problem can be solved as a group. Group or peer interaction enhances collaborative learning when solving a problem (Ekpenyong, 2018).

d) The direct learning approach

Even though constructivist teaching encourages high-level thinking in learners as the teacher guides them; there are some instances where direct instruction is inevitable in a class with VI learners. Given that VI learners are diverse in their needs, they need an occasion where the teacher models and explains mathematical concepts in a structured and clear format and then allows them to practice. This means that direct instruction and constructivist teaching work together as they supplement one another.

e) Manipulatives as a means to construct knowledge

The tactile activities that VI learners engage in when learning means that they are not passive but active learners. According to Sedaghatjou (2017), when VI learners manipulate an object in their environment, they deliberately move their figures to explore the object with a goal in mind. For example, a VI learner may touch a cylinder to experience the surface area. They aim to feel the whole surface. Manipulatives help the learner make connections between concepts and the concrete object. The constructivist teacher should make learning objects and activities available so that learners explore and experiment as they construct their knowledge (Ekpenyong, 2018).

2.9 CONCLUSION

This chapter aimed to review the relevant conceptual, theoretical and practical strategies in the teaching and learning of mathematics to VI learners. The learners access mathematics through the sense of touch and sound, which is a slower mode of learning as compared to that used by sighted learners. Teaching mathematics to VI learners has not been easy for many teachers as most teachers possess only a Bachelor’s degree that qualifies them to teach in mainstream education. They lack the skills to help learners construct mathematics knowledge. This includes a lack of proper training, braille literacy and technology competence, and they experience time constraints in covering the syllabus.

To help learners construct knowledge, teachers adopt varied instructional approaches to teaching mathematics such as contextual, scaffolding, peer tutoring, problem-solving and the use of manipulatives to meet the individual needs of the learners. However, facilitating mathematics for VI learners cannot be successful without the use of assistive technology devices, e.g. Perkins Braillers, a refreshable braille display, note-takers, large screen devices, smart braillers, audiobooks, smartphones and computers. Although some assistive devices are used by the teacher to modify the learning content to a format accessible to the VI learner, some tools are used by the VI learner as a compensatory mechanism for the loss of sight.

The Constructivist Theory was used as a lens to understand teaching strategies. Constructivists see learning as an active process where learners are actively involved in the construction of their own mathematical knowledge. This requires teachers to fill the position of a facilitator of learning activities.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 INTRODUCTION

The focus of this study was on the instructional strategies employed by mathematics teachers to assist visually impaired learners in constructing mathematics knowledge. The focus of the study was not on controlling and influencing the teachers' behaviour but to investigate events naturally as they happen. The study, as referred to in the problem statement and research questions in Chapter 1, aimed to understand the approaches used in the mathematics classroom, the assistive technology devices used and the challenges experienced by the teachers when teaching mathematics. This chapter describes the methodological approach used in this study. At the beginning of the chapter, the research paradigm is highlighted, followed by a description of the research methodology, which includes the research design and approaches, and the sampling and data collection techniques used in this study. Lastly, a discussion of the data analysis and ethical considerations is presented.

3.2 PARADIGMATIC PERSPECTIVE

The theory underpinning this study is the constructivist approach with interpretivism as the paradigm. The interpretivist paradigm explores the complexity of contextual phenomena intending to gain an in-depth understanding of the participants' viewpoints (Vosloo, 2014). It is a theory that seeks to understand and interpret the meaning of phenomena based on the perception of the participants (Maree, 2007). Embracing interpretivism in this study enabled the researcher to explore teachers' experiences of teaching mathematics to VI learners from their perspective and not the researcher's own experiences. Thanh and Thanh (2015) argue that an interpretive study is subjective rather than objective. Hence, this study's ontological assumption is subjectivity. In subjectivity, the researcher seeks to find out how humans perceive the world from a subjective point of view rather than an objective one (Ponelis, 2015). According to Hamilton and Corbett-Whittier, (2012), taking a subjective stance in research allows a researcher to gain insight into the participants' beliefs, attitudes, opinions and practices.

Interpretivism implies a qualitative study that embraces multiple realities (Creswell & Poth, 2017). In this study, multiple realities were exposed for each different participant using multiple data collection methods. The methods of data collection such as interviews, observations and document analysis, provide a holistic understanding of a situation (Creswell & Poth, 2017). The information in this study was collected through observing mathematics lessons as they were presented to VI learners, as well as conducting semi-structured interviews with the teachers in their natural setting.

3.3 RESEARCH DESIGN

In this study, the researcher employed a qualitative research design. A qualitative study seeks to explore, interpret and generate understanding about social interactions among individuals and their experiences as they unfold naturally (O'Brien, Harris, Beckman, Reed & Cook, 2014). It is an "approach that attempts to collect rich descriptive data with the intention of developing an understanding of what is being studied from the participants' perspective or experience" (Nieuwenhuis, 2010, p. 50). A qualitative research approach was valued in this study due to its ability to provide a quality and in-depth study as opposed to a broad scope of information (Maree, 2007). By using a qualitative research design, this study was able to explore in detail the instructional strategies used by mathematics teachers to help VI learners to construct mathematics knowledge. As Creswell and Poth (2017, p. 40) argue, a qualitative study is important when "a complex, detailed understanding of the issue" is to be established.

From the literature (Bayram et al., 2015; Kohanová, 2006; Maguvhe, 2015), it can be seen that teaching mathematics to VI learners is a challenge for teachers and needs to be understood in-depth. Qualitative studies provide an avenue to study in-depth, context-rich cases that lead to a full understanding of the phenomenon under study (Ponelis, 2015). By using a qualitative study, the researcher was able to collect data by observing and interviewing the teachers. The interpretation of the data collected revealed meaningful information to answer the questions posed in this study, this is further shown in Table 3.1.

Table 3.1: Summary of the methodology of the study

APPROACH	**DESCRIPTION**
Research design	Qualitative
Research approach	Case study
Primary research question	How can the instructional strategies used by mathematics teachers to facilitate VI learners' construction of knowledge be described?

Secondary question	1. What are the challenges experienced by mathematics teachers in teaching mathematics to VI learners in high school? 2. What are the instructional approaches used by mathematics teachers to help VI learners construct mathematics knowledge 3. Which assistive devices are used to enhance the acquisition of mathematics knowledge by VI learners
Participants	Two teachers teaching mathematics to Grades 9 and 10 VI learners
Data Collection Method	1. Classroom observation 2. Interviews with the teachers

3.3.1 Research approach

This study employed a case study approach to capture the teaching experiences of two mathematics teachers of VI learners at a high school. The use of a case study in qualitative research provides an opportunity for the researcher to focus on a small group with the intention of answering the research questions posed (Hamilton & Corbett-Whittier, 2012). In this study, a case study was established to understand the practice and process of the mathematics teacher in the context of teaching VI learners. In this particular case, the researcher intended to gain in-depth knowledge of the instructional strategies employed by Grades 9 and 10 mathematics teachers in teaching mathematics to VI learners. As Mills, Harrison, Franklin and Birks (2017) state, a case study is an effective inquiry into complex issues in their natural setting. In this case, the mathematics classroom of VI learners was the natural setting.

According to Louw (2015), a case study generates quality rather than a quantity of results. In this study, the case study provided an opportunity to observe the teachers' lessons and get first-hand information from their responses in the interviews. The data collected were extensive as they were drawn from more than one source (Creswell & Poth, 2017). However, the case study had limitations on generalisability because of the smaller sample and different contextual issues.

According to Maree (2007), a research site is a suitable and feasible place where research is conducted. It is “the field at the site where participants' experience the issue or problem under study” (Creswell & Poth, 2007, p 37). The research took place in a special needs school for blind and partially sighted learners in Gauteng. The school was purposively selected because it was the only special needs school for blind and partially sighted learners that offers mathematics at FET Phase level. Permission to access the site was obtained from the Gauteng Department of Education and the Principal of the school (see Addendum A).

3.3.2 Participants

Two teachers participated in this study. Table 3.2 provides the biographical data of the teachers.

Table 3.2: Biographical data of the participants

Teachers name	Teacher for Grade	Gender	Education level	Experience in teaching VI learners
Teacher 1	10	Male	BSc degree specialising in mathematics and PGCE certificate.	Over 30 years.
Teacher 2	9	Female	Post-graduate certificate in education.	Three years.

Teacher 1 is a male teacher teaching mathematics in Grades 10 - 12. He is the head of the mathematics, science and technology department. He has experience of over 30 years in teaching mathematics to VI learners. Academically, he holds a BSc degree specialising in mathematics, chemistry and physics, as well as a PGCE certificate in teaching methods. Teacher 1 was one of the founder teachers in establishing the teaching of mathematics, Physical Science and Life Science to blind and partially sighted learners at the FET phase in the school. During his 30 years career, he has received intense training on the methods of teaching mathematics to VI learners, which include transcribing and reading mathematics braille. He received his training from experienced teachers and has attended various workshops organised by the Department of Basic Education (DBE).

Teacher 2 is a female teacher who has been in a special needs school for three years. She holds a post-graduate certificate in education and has very limited experience in teaching mathematics to VI learners as she has received no formal training in working with VI learners. However, her proficiency in computer literacy has enabled her to learn the skill of translating text to braille and drawing and embossing diagrams with ease.

3.3.3 Sampling method

The participants in this case study were purposefully selected. Purposive sampling is a process broadly used in qualitative research for the selection of information-rich cases for the most effective study (Maree, 2007). According to Silverman (2000), purposive sampling should allow the researcher to choose a case because it illustrates some feature or process of the topic of interest.

The population of the study constituted all the high school mathematics teachers from the special needs school approached. A sample of two teachers was purposively selected from the entire population from whom data were generated. The criteria for selection was that the teacher should be teaching mathematics to Grades 9 or 10 VI learners at the special needs school for partially sighted and blind learners. There were three teachers teaching mathematics to Grade 9 and Grade 10, which was the focus of my study. The selection of participants was done using criteria-based case sampling. Criteria-based case sampling is a purposive method of sampling where participants providing the relevant information for the study are selected to generate data (Etikan, Musa & Alkassim, 2016). In this study, the two teachers selected were teaching high school mathematics to VI learners, which is an area of interest. It was important to understand the teaching strategies used by mathematics teachers in Grade 9 because it is a transition level to Grade 10.

The two teachers were willing to give correct information according to their experiences and professionalism. According to Palinkas, Horwitz, Green, Wisdom, Duan, and Hoagwood (2015), the participants for a study should not be forced to take part in the research but be willing and available to participate and communicate their lived experiences and opinion coherently and thoughtfully. The participants in this study were willing, on a voluntary basis, to be observed during their lesson presentations and to be interviewed face to face.

Eight Grade 9 learners participated in the study, 6 partially sighted and 2 profoundly blind. Likewise, there were eight Grade 10 learners who participated in the study, 6 partially sighted and 2 profoundly blind learners. Learners signed consent letters and parents were notified prior to the observations (See Addendum B). In case of any photograph taken, the learners' identities were concealed by covering their faces.

3.3.4 Data collection instruments

Conducting a qualitative study allowed me to use multiple sources of information to gain an in-depth understanding of the phenomenon under study (Creswell & Poth, 2016). This is to ensure that the study aspects are explored from multiple facets as opposed to only one (Baxter & Jack, 2008). This provides an opportunity to reflect on the study through different perspectives (Louw, 2015). According to Creswell and Poth (2016, p.73), multiple sources of information include, "Observations, interviews, audiovisuals material, and documents and reports." In this study, two sources of data were utilised; observation and interviews.

Observation

According to Maree (2007, p 83), "Observation is the systematic process of recording the behaviour patterns of participants, objects and occurrences without necessarily questioning or communing with them." Creswell (2016) suggests that observations require extraordinary skill from the researcher to identify and address the potential of the participants while also creating a good impression. In this case, the researcher acted professionally and focused on the instructional strategies employed by the teachers to help VI learners construct mathematics knowledge. All of the classroom observations were prearranged with the two teachers.

The researcher observed and video recorded six lessons from each class to gather information to answer the research questions. The six lessons According to McMillan and Schumacher (2010), tape recording, taking photos and a video recording of the observations offer accurate data for analysis. By watching the videotapes repeatedly, the researcher may be able to pick up details in the data that could have been overlooked otherwise. The researcher also used a prepared observation schedule (see Addendum C).

Interviews

After all the observations were completed, each participant was given a copy of the structured questions before the interviews commenced. The purpose of this was to allow them to prepare beforehand, especially in terms of the illustration of the use of computer programs.

Interviews were used in this study because observation alone could not have produced a quality study. As Patton (2015, p. 426) explains:

> *We interview people to find out from them those things we cannot directly observe and to understand what we have observed. We cannot observe feelings, thoughts, intentions and behaviours that took place at some previous point in time. We have to ask people questions about those things.*

Therefore, the second instrument used in this study was a semi-structured interview. Semi-structured interviews make use of predetermined questions to allow a framework of conversation during the interviews (Tanti, 2007). This structure provides an opportunity for the researcher to probe the respondents' responses with a variety of questions in line with the study. The response of the participants serves as a guide to identify emerging new knowledge (Maree, 2007). The interview questions focused on teaching approach, the technology to adapt mathematics content to accommodate VI learners and the challenges encountered by the teacher (see Addendum C).

3.3.5 The research procedure

The researcher commenced the study with the lesson observations. Six lessons for Grade 9 and Grade 10 classes were observed in a period of three weeks. Table 3.2 below illustrates the topic, Grade and dates when the classes were observed.

Table 3.2: The dates and topics observed for Grade 9 and Grade 10

Grade 9	Date	Topic	Grade 10	Date	Topic
Lesson 1	30/08/18	Factorising trinomials.	Lesson 1	5/09/18	Simple and compound.
Lesson 2	04/09/18	Simplifying trinomials.	Lesson 2	6/09/18	Compound interest.
Lesson 3	06/09/18	Functions.	Lesson 3	11/09/18	Calculating interest rate.
Lesson 4	11/09/18	Functions.	Lesson 4	12/09/18	Calculating interest rate.
Lesson 5	13/09/18	Calculating the gradient of a	Lesson 5	19/09/18	Finance, Timeline.

		linear graph.			
Lesson 6	18/09/18	Plotting a graph.	Lesson 6	20/18/18	Inflation.

The researcher observed lesson presentations to understand the approaches used by the teachers in teaching mathematics. The researcher also used observations to identify the assistive devices incorporated in the lessons. Lastly, the researcher observed to understand the challenges that these teachers encountered in teaching mathematics. Observations provided an opportunity for the researcher to listen, observe and experience the reality of teaching mathematics to VI learners. Observing classroom lessons provided an opportunity to gather first-hand information rather than basing the study on secondary data.

Since the researcher was a teacher at the same school, interviews were scheduled during free time and after school. The two teachers were asked the same questions in the same order. The respondents answered the questions in detail; however, whenever their free time was over, the researcher noted the unanswered questions and picked up from there in the follow-up interview time.

As the researcher was familiar with the two participants and the school, the researcher acknowledged the possibility of bias during interviews. Hence, she acted objectively and conducted interviews at a convenient time for the participants and in the natural setting of their classrooms, as well as the resource centre at the school.

The recording was done by taking notes as a preference of the participants. Only demonstrations on the use of assistive devices and computer programs were video recorded and transcribed. All of the notes and transcribed work were coded according to the prior identified themes and then analysed.

3.4 DATA ANALYSIS AND INTERPRETATION

Data analysis was based on the interpretivism philosophy that reality is constructed from people's subjective experiences of the external world (Levers, 2013). According to Maree (2007), the analysis of a qualitative study begins at the onset of data collection. The experiences, perceptions and views of the participants are taken into perspective during analysis (McMillan & Schumacher, 2010).

The data collected from each participant were organised, discussed and interpreted according to data collection methods. The data gathered from the observations were the first to be transcribed and analysed, followed by the data obtained from the interviews. The data were analysed inductively as categories emerged from the data (McMillan & Schumacher, 2010). The procedure for analysing data was derived from the three-stage stages suggested by Creswell (2007, p. 148):

> *Preparing and organizing the data (i.e., text data as in transcripts, or image data as in photographs) for analysis, then reducing the data into themes through a process of coding and condensing the codes, and finally representing the data in figures, tables, or a discussion.*

Similarly, Sargeant (2012) categorises qualitative data analysis into three stages, namely, deconstruction, interpretation, and reconstruction.

Deconstruction stage

Reconstruction involves breaking the data into small units to identify emerging themes (Sargeant, 2012). At this stage, the data are transcribed and organised for data analysis (Creswell, 2007). In this study, after the observation, the researcher transcribed the video recording into text. The researcher then read the transcript texts repeatedly to identify the emerging categories from the text. The same was repeated after the data were collected from the interviews.

Interpretation stage

According to Sargeant (2012), the interpretation stage involves attaching meaning to each sentence or phrase and grouping according to the sub-theme. This means reducing the data by coding or summarising the data into sub-themes (Creswell 2007). From both observation and interview data, the researcher grouped together with the sentences that lead to one sub-theme (see the sub-themes in Table 3.3).

Reconstruction stage

According to Sargeant (2012), reconstruction is the last stage of qualitative analysis. It involves putting the related codes together and explaining them broadly. Creswell (2007) explains that it is the last stage where data is portrayed in tables and discussed. From the categorised data, the researcher was able to identify the sub-themes that led to the main themes explored in order to understand the classroom approaches, assistive devices and computer programs incorporated into teaching VI learners, and the challenges experienced by these mathematics teachers. This is further shown in Table 3.3. below.

Table 3.3: Themes and sub-themes

Themes	Sub-themes
Challenges experienced by mathematics teachers	Lack of skills in braille. Time constraints. Lack of learners' support structure. Bulk braille books and missing information. Failure in technology.
Approaches	Contextual approach. Direct approach. Scaffolding. Peer tutoring. Problem-solving.
Assistive technology devices and computer programs	Devices used to enlarge text. View plus and tactile view programs. Scientific notebook and Math Type. Perkins braillers.

3.5 TRUSTWORTHINESS AND VALIDITY

Trustworthiness in a qualitative study is the confidence placed in the techniques used in collecting data, the data interpretation, analyses, and method used to guarantee a quality study (Connelly, 2016). Connelly argues that the criteria for achieving trustworthiness lie in credibility, dependability, confirmability and transferability, which are discussed further below.

3.5.1 Credibility

Credibility is the confidence one has in a study (Graneheim & Lundman, 2004). Credibility in a qualitative study is achieved through triangulation (Creswell, 2007; Maree, 2007).

Triangulation in a qualitative involves the use of more than one source of data collection (Hadi, & Closs, 2016). The researcher used interviews and classroom observations to achieve triangulation. McMillan and Schumacher (2010) find that the use of a multi-method strategy encourages the researcher to view the same topic from a different perspective. In this study, the use of classroom observations and teachers' in-depth interviews provided collaborated data. For example, observing the assistive technology used in class confirmed the data obtained from interviewing the teachers.

3.5.2 Dependability

Dependability refers to the consistency of the data over a period of time and can be enhanced by selecting participants with rich information to generate data (Connelly, 2016). During the study, I kept field notes of chronological time, place and participants involved in the study. I used quotes to make a point to avoid my personal interpretation in the analysis. Another way to enhance dependability was peer review. Peer review, also known as debriefing, is the critical analysis of the research processes by a person who is knowledgeable in the field of the study (Creswell & Miller, 2000). In this study, peer review was ensured at every phase of the study with advice and guidance during the proposal and chapter writing being provided by my supervisor and co-supervisor.

3.5.3 Confirmability

Confirmability is the degree to which there is consistency in the study (Connelly, 2016). Confirmability was achieved through triangulation. By using two participants and two data collection techniques, I could see similar results emerging from the different measuring tools. The video recordings provided confirmation of the observed data and were made available to my supervisor.

3.5.4 Transferability

According to Graneheim and Lundman (2004), transferability is the extent to which the data can be transferred to other settings. Although in a qualitative study, there is no generalisability of the findings, researchers support transferability (Connelly, 2016). Connelly further mentions that researchers concentrate on the participants' detailed responses together with a description of their context. In this study, transferability was enhanced by the selection of participants with experience in the field of study.

Validity, alternatively, is the degree to which an instrument measures what it is supposed to measure (Louw, 2015). According to McMillan and Schumacher (2010), validity answers the question: Do the researchers observe what they think they see? In this instance, validity is a measure of whether the findings represent the real events of the study. To enhance validity, the researcher paid attention to the data collection and analysis processes. During data collection processes, the efficiency of the data was enhanced through video recordings of all the observed lessons and photographs of the classroom illustrations and assistive technology devices. Repeated listening to the video recordings provided an understanding of the information that could have been omitted through note-taking.

3.5.5 Ethical considerations

Interacting with human beings or phenomena in the general environment gives rise to ethical issues (Mouton, 2001). As a qualitative researcher, I am aware of the ethical considerations and the standards expected by the University of Pretoria. In this regard, the research did not commence until I obtained written approval from the University of Pretoria ethics committee, Gauteng Department of Education and the principals of the school.

3.5.5.1 Informed consent

After gaining permission to commence the study, the researcher required signed informed consent from the participants. The researcher disclosed the aim and purpose of the study to the participants for the purpose of transparency. The participants were informed of the voluntary nature of participation and the choice to terminate their participation or to ask for a time-out during the interview.

3.5.5.2 Confidentiality and anonymity

According to McMillan and Schumacher (2010), the research site and the participant should not be identified in print. In the case of this study, the setting and the participants’ identity were not disclosed. The name of the special needs school was concealed and the teachers’ names remained anonymous as they were only referred to as Teacher 1 and Teacher 2. Confidentiality of participation was assured whereby the information acquired in this study, such as photos and videos, were not made available to anyone who was not directly involved in the study.

3.5.5.3 Caring and fairness

McMillan and Schumacher (2010) argue that some participants may experience humiliation and loss of trust during the study. In this incidence, caring and fairness plays an important role. Caring and fairness to both the researcher and the participants can be acquired through open discussions and negotiations. In this study, the researcher negotiated on the interview and observation times to promote fairness between herself and the participants.

3.6 CONCLUSION

The chapter explored five main ideas that concerned the methodology for this study. The chapter described the paradigm perspective, research design, data analysis and interpretation, validity and trustworthiness, and lastly, the ethical considerations of this study. The interpretivist paradigm was identified as the philosophy underpinning the research. This paradigm explores the complexity of contextual phenomenon intending to gain an in-depth understanding of the participants' perspective.

A qualitative research design was explored to provide a quality and in-depth study. This allowed the researcher to explore and interpret two data collection methods - observation and semi-structured interviews. In summary, the researcher gave an account of the procedures and processes involved in this qualitative study and how validity and trustworthiness were addressed. The chapter ends with the highlights of ethical considerations, with emphasis on the importance of informed consent, confidentiality and anonymity of the site and participants, and caring and fairness between the participants and the researcher.

CHAPTER 4 PRESENTATION OF THE FINDINGS

4.1 INTRODUCTION

In the previous chapter, the research paradigm, research design and a description of methodological techniques that were used in the study were discussed. This chapter presents the findings in line with the aim and objective of the study. The data for this study were gathered through observation and semi-structured interviews. All the results are presented in three categories as they emerged from the data analysis. The categories are organised to reflect the secondary questions in the study, namely:

1. What are the challenges experienced by mathematics teachers in teaching mathematics to VI learners in high school?
2. What are the instructional approaches used by mathematics teachers to help VI learners construct mathematics knowledge?
3. Which assistive devices are used to enhance the acquisition of mathematics knowledge by VI learners?

Two teachers of Grades 9 and 10 participated in this study. To ensure confidentiality and anonymity, the participants are referred to as Teacher 1 and Teacher 2 respectively.

4.2 THE CHALLENGES EXPERIENCED BY MATHEMATICS TEACHERS IN TEACHING MATHEMATICS TO VI LEARNERS.

The core of the data presentation is centred on the challenges experienced by mathematics teachers when teaching VI learners. Comprehensive data were gathered through observations and interviews. The data gathered through the observations are presented first, followed by the data gathered through the semi-structured interviews.

4.2.1 Teachers challenges from the observation

4.2.1.1 Teacher 1

From the six observed lessons, Teacher 1 was confident in teaching VI learners because of his vast experience spanning over 30 years. He actively involved all of the learners in the learning by asking them open-ended questions that promoted independent thinking. However, it was observed that he experienced some challenges during lesson presentations. The learners required personalise attention while working through an exercise and the teacher found it difficult to reach all the learners within a limited period.

Blind learners require assistance during a lesson, and may also be in need of another paper or correct volume of the braille book or diagram book. For example, in Lesson 3 a learner was observed to have requested a book during the lesson**.** This disrupted the lesson as the teacher had to pause teaching to attend to the learner first.

In Lesson 3, while the teacher was illustrating a mathematics concept, all the CCTV screens started blinking continuously. This technological failure had a negative impact on teaching because the partially sighted learners could not keep concentration as they were seen avoiding looking directly at the screen. The teacher then resorted to explaining concepts without illustration.

4.2.1.2 *Teacher 2*

From the observation, Teacher 2 experienced challenges in balancing the time spent explaining concepts to the partially sighted and the blind. She spent more time illustrating concepts on the CCTV, which partly benefited the partially sighted. In Lesson 1 and 2, one blind learner did not have his braille book open. He looked bored and did not follow the lesson in progression.

Although Teacher 2 tried to explain the concept of graphs, she found it difficult to communicate the ideas to the learners. For example, in Lesson 4, the teacher explained the steps to be followed when drawing a graph but when she asked learners to draw a graph, they expressed their frustration as they had not understood the concept. One learner said, "eeh!" While another exclaimed, "*ah wa, ma'am, we can't*." The learners then demanded more examples, however, the blind learners sat bored with nothing to do.

4.2.2 Teachers challenges from the interviews

Semi-structured interviews were another primary data gathering instrument that the researcher used in the study. The same interview questions were asked to the two teachers in the same order. When asked the question, '*What challenges do you encounter in teaching mathematics to VI learners?'* The response from the teachers regarding the challenges they experienced are presented below.

4.2.2.1 Teacher 1

Teacher 1 expressed his confidence in teaching mathematics to VI learners. However, he acknowledged the challenges he experienced in teaching the topic 'Euclidian geometry'. He claimed that Euclidean geometry could be challenging, especially when interpreting a sketch and proving angles using circle theories and converse theories. He expressed his sympathy for blind learners who tended to get entangled with all the many lines and angles on one page. It even became difficult for the teacher to explain. He further expressed his wish that the South African government would consider addressing the challenges of circle geometry at some stage, he said:

> *It is unfair towards the blind learner to be subjected to the same degree of difficulty when asking circle geometry. If for normal sighted kids, it can be a challenge to solve geometric proof, leave alone when it comes to blind learners. Surely, there must be some other field in the whole mathematics spectrum that we can venture in to enable the blind learner the same degree of competency and insight without these visual constraints.*

Another challenge that Teacher 1 expressed was "time constraints." The teacher said that the curriculum taught to VI learners is the same as that taught in mainstream education. He further stated that given their slow pace of learning, it is difficult to complete the syllabus. He complained that,

> *Even when the teachers have conquered the visual barriers that inhibit the VI learners from excelling in mathematics, they are still faced with the challenge of curriculum coverage, the pace at which you teach the blind learners is slower, and it becomes a battle to cover the syllabus on time. Sometimes you are forced by circumstances to be very crafty when it comes to your lesson preparation and planning within the time constraints.*

He revealed that mathematics teachers have resorted to offering ancillary services such as extra classes in the afternoon after normal teaching hours, monitoring learners' progress frequently, as well as regularly discussing learners' progress with their parents.

Teacher 1 indicated that very few parents are positive and give support to their children. Many of the parents do not attend school meetings and do not know what goes on in school.

He said, "*Most VI learners lack home support structures, which have a great impact on their learning.*"

Further still, Teacher 1 complained about the difficulties he experienced in making sketches for the blind learners, stating, "*It takes time to sketches and embossed diagrams.*"

Teacher 1 also complained about the challenge he experienced with braille books that have missing information and a diagram or information with errors in it. He mentioned that it falls to teachers to correct these errors.

Lastly, he expressed the frustration he felt when technology failed due to power and mechanical failure. He said that when technology fails, "*It becomes impossible for teachers to make sketches and translate print to braille for the blind learners.*"

4.2.2.2 Teacher 2

When asked, "*What challenges do you encounter in teaching mathematics to VI learners?*", Teacher 2 highlighted five main challenges that she experienced in teaching mathematics to VI learners. The first challenge was a lack of knowledge and skills in braille. Teacher 1 had not received any formal training in reading and transcribing texts to braille. She revealed that she found reading the learners' work difficult and had to rely on the learners to read back to her what they had written. However, she indicated that she was busy teaching herself and learning from other teachers.

The second challenge was teaching visual topics like measurements. Teacher 2 expressed,

> *Teaching topics on measurement is quite challenging. Some of the work in measurement involves drawing. However, blind learners cannot draw. They also find it difficult to read corners, angles etc.*

When asked, "*Mathematics is claimed to be abstract and its abstractness increase as you move high in the grade. Are there mathematics topics you skip when teaching VI learners?*", Teacher 2 acknowledged skipping most of the measurement topics, especially drawing and working with angles. She said, "*Working with small units, rulers, protractors etc. Measurement is the biggest challenge for VI learners. I do not teach them measurements.*"

The third challenge she experienced was the lack of students' self-motivation to learn mathematics. She expressed her concern for learners who did not take responsibility for and put effort into their work; hence, they struggled to understand even simple mathematics. She said,

> *Generally, Grade 9 learners struggle with mathematics, but they do not make any effort from their side to perform. For example, I give extra work every week for them to submit a week later. The papers come back empty, half-done or with no calculations at all. By not practising mathematics assignment topics given by the teacher, they lose on concept development*.

The fourth challenge mentioned during the interviews by Teacher 2 was the factor of time. She explained, "*Teaching mathematics to VI learners requires extended time above normal school hours*." She indicated that the VI learners were very slow in working through activities. They required her to explain two or three times for them to understand a concept. She also said, "*I have an extra class to help them with basic concepts and contents covered earlier in the year to enable them to practice and memorise."* Teacher 2 expressed her disappointment with some of the learners who had a negative attitude towards learning mathematics and did not attend extra classes.

The fifth challenge was the many volumes of braille books that are equivalent to one sighted learner textbook. For example, one sighted book is equivalent to 18 bulky books, eight activity books and ten diagram books. During the interview, Teacher 2 said that sometimes she found it difficult to assist blind learners with the correct volume that correlated with the sighted learners' copy, and even more difficult to locate a specific page for the activity. She said that more time was lost in this process.

In summary, the data collected from the classroom observations and teachers interviews indicated that these mathematics teachers experienced challenges in teaching VI learners. Teacher 1 found it difficult to teach circle geometry to blind learners. He suggested that another topic be substituted for circle geometry. Other challenges experienced were time constraints, missing information in braille books, a lack of support, difficulty sketching diagrams to be embossed in braille, and technological failures due to power and mechanical failure.

Due to limited experience, Teacher 2 had challenges in reading braille text. She acknowledged skipping measurement topics as these were challenging for blind learners. She expressed her frustration regarding the learners' negative attitude towards learning mathematics, the limited time she had with the voluminous curriculum, and the challenge of assisting blind learners with braille books.

4.3 Instructional approaches used by mathematics teachers to help VI learners construct mathematics knowledge

The core focus of the study was centred on the approaches that these teachers used in the classroom to help VI learners construct mathematics knowledge. The data collected from the observations and interviews were geared towards answering the secondary question: What are the instructional approaches used by mathematics teachers to help VI learners construct mathematics knowledge? Figure 4.2 provides the approaches identified in this study.

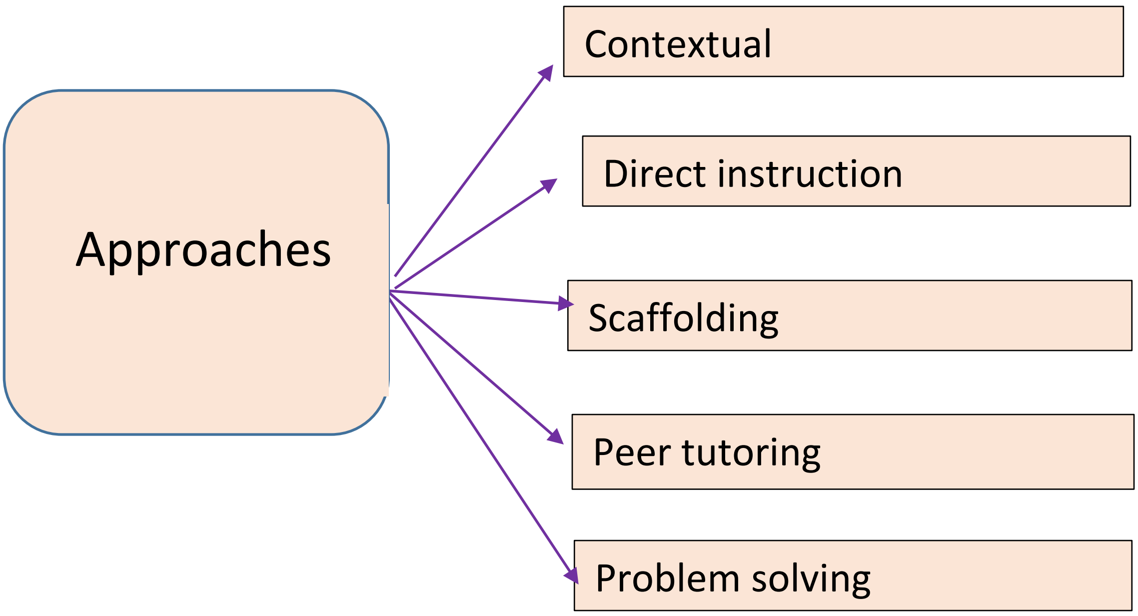


Table 4.1: The approaches used by the teachers in teaching VI learners

4.3.1 Instructional approaches identified from the observations

4.3.1.1 Teacher 1

a) Contextual

Teacher 1 used contextual learning in two of the six observed lessons. These were Lessons 1 and 3. In Lesson 1, he used the concept of a birthday to facilitate learning compound interest.

In his teaching, he guided the VI learners to calculate the initial amount of money Tshepo's father could have invested in the bank for his son from his 17th birthday to his 21st birthday if the accumulated amount was R9 867,46 having been compounded annually at the interest rate of 11% p.a.

In Lesson 3, contextualised learning was carried out using a scenario of an increase in the price of a loaf of bread from a local supermarket at a specific time. Teacher 1 explained, "*Inflation is for instance if you have the price of bread and you must work out what it should be over some time and what it used to be at a specific period.*" To instil the concept, he guided the VI learners to find how much they would pay for a loaf of bread at a local supermarket in 25 years' time if currently, the bread cost R9.40 at an inflation rate of 7% p.a.

b) Direct instruction

Direct instruction was not a dominant approach for Teacher 1 in teaching mathematics. However, he partially used it in Lesson 5 to explain the step-by-step procedure of solving a problem while the learners paid attention. He said,

> *When you deposit money into an account, life sometimes forces you to go and withdraw some of the money from that account because you need it for something. Sometimes you are lucky and win the lotto, and you want to add more money into your account. That is what happens. In other words, if you deposit money into the account over a period, sometimes you will subtract money from that account and sometimes add money into that account depending on circumstances. This is where timelines come in; what happens is - initially you deposit an amount into the account, and after a year you are forced to subtract or withdraw R2000 from the account. The amount you will have into left in the account is less than the amount which was initially in the account.*

After an intense explanation, he then used an example in the book to explain how to calculate the remaining balance in the bank after several transactions have taken place.

c) Scaffolding

Scaffolding as an approach to teaching mathematics to VI learners dominated all six observed lessons. In Lesson 1, Teacher 1 guided the learners to understand the concepts of simple and compound interest through a series of questions, for example, Teacher 1: *If your principal amount is R100, what do I mean by the principal amount?*

Learners: *the money that is deposited in the bank account.*

The teacher wanted learners to give a precise answer in the mathematical language. Hence, he clarified, *"that is the initial amount"*. He proceeded to evoke more responses from the learners using another example*, " for instance, if you deposit R100 into banking account after a year, what will happen to the R100?"* Another learner responded, *"It will increase."* Teacher 1 wanted to stimulate learners' prior knowledge, so he continued to probe for answers by asking more questions,

Teacher 1: Can you tell me by how much?

Learner: *R10.*

Teacher 1: *Why is it R10?*

Learner: *Is 10% of the principal amount*

Teacher 1 built on the learners' prior understanding of simple interest to introduce compound interest.

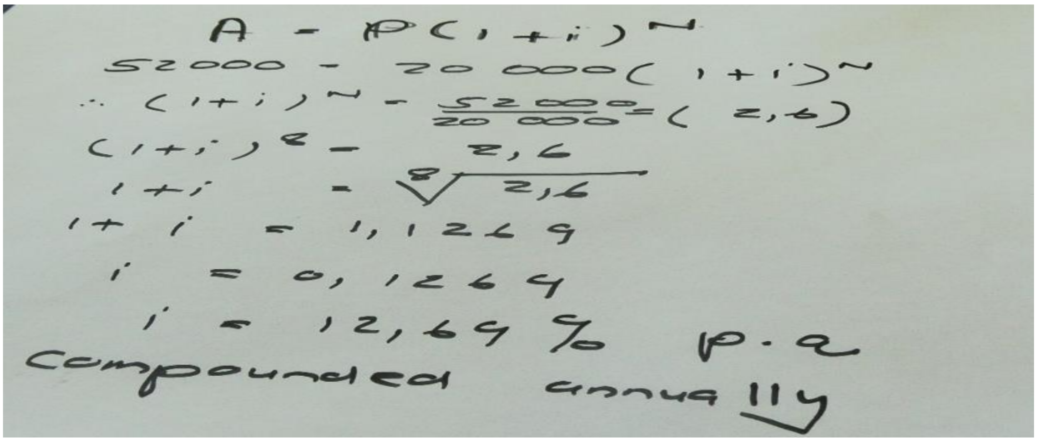
In Lesson 2, Teacher 1 explained to VI learners how to calculate for the interest rate, as in the following illustration:

$$52000 = 20000(1 + i)8$$

$$20000(1 + i)8 = 52000$$

$$(I + i)8 = 2{,}6$$

Later, he discovered that the learners had forgotten how to get rid of eighth by finding the 8^{th} root of 2.6. He paused to explain, "*to remove the eight, and you are going to get the 8^{th} root*." Teacher 1 spent time helping the blind learners to understand how to get the 8^{th} root using their scientific calculator (see detailed explanation in Section 4.2.8). Meanwhile, the other learners did not seem to understand the teacher's explanation, therefore, he used a simpler example: "*For instance, if you have* $x^3 = 27$ *what do we normally do to get the value of x?"* One learner answered, *"Something, times something, times something equal 27, which is three."* Teacher 1 then asked another follow-up question, "*What did you do to get three?"* The second learner responded, "*we get the cube root of 27."* Teacher 1 then clarified for them, *"Now, in this case, we don't use a cube root for some reasons, it is 8^{th} root…Even* *though it sounds weird, you do get something like 8th root*." An example of the exercise is provided in Photograph 4.1.



Photograph 4.1: Explaining the process of calculating the interest rate by finding the 8th root

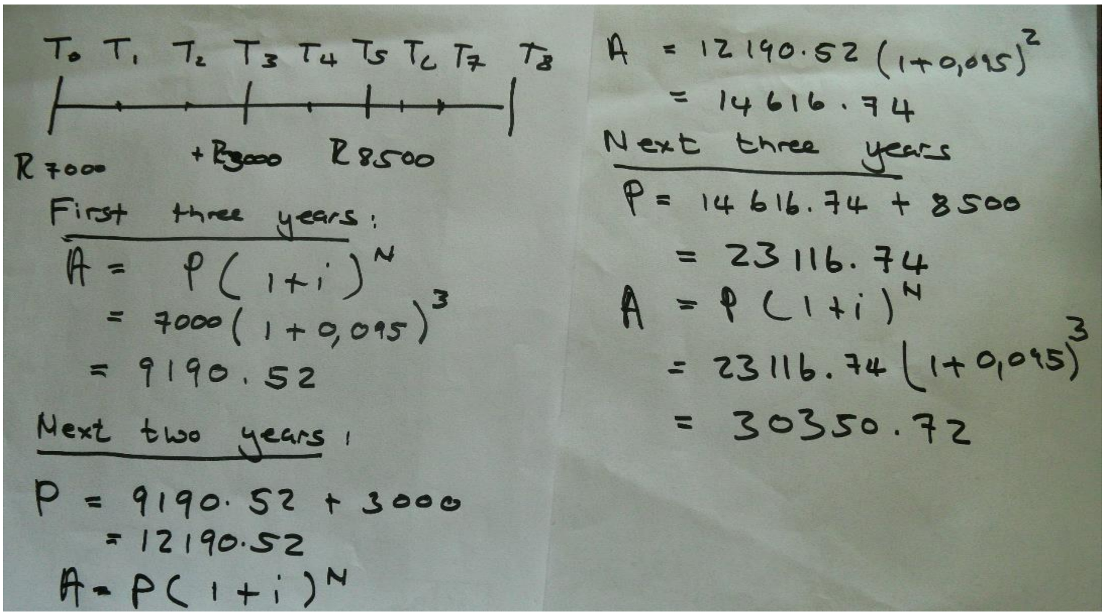
In Lesson 3, Teacher1 demonstrated how to calculate the original value of bread by using a compound interest formula $= p(1 + i)^n$ where substitution leads to $9.40 = p(1 + 0.07)^{25}$. He asked the learners to state the answer as it appeared in the textbook. The learners said it was equal to R 0.72, "*that means 72 cents for a loaf of bread*." Teacher 1 encouraged the learners to carry on with the exercise.

In Lesson 4, Teacher 1 repeatedly expressed the process used when calculating the percentage increase. He explained to the VI learners, *"First you get different of 6.81 and 9.60. In other words, you subtract from the initial amount and get the difference. Take the difference and divide by the initial amount and multiply the answer by 100%".* After he had repeated the statement verbally several times, Teacher 1 gave each learner a piece paper on which to practice. Later on, he gave them an exercise to complete using the same procedure.

In Lesson 5, Teacher 1 began the lesson by asking the learners to state the formulae used to calculate the population growth and the interest rate. After that, he read one problem from the learner's textbook:

> *A savings account is opened and R 7000 deposited. Three years later, R3000 is added to the savings account. Two years after the second deposit, the third deposit of R 8 500 is made. Calculate the total amount accumulated in the saving account after eight years if the interest paid is 9.5% p. A compounded annually.*

The blind learners followed the teacher reading from their braille books. Teacher 1 then drew a timeline and sub-divided it according to the transactions done on the account. Starting from the left side, he wrote R7000 under T0, skipped T1, T2 and wrote +R3000 under T3, skipped T4 and wrote R 8500 under T5. He then wrote nothing under T6, T7 and T8. The blind learners followed the example from their braille book. The sum is shown below in Photograph 4.2.



Photograph 4.2: Explaining how to solve a financial problem involving a timeline

Teacher 1 discussed the transaction with the learners under the headings: First three years, Next two years, and next three years, as seen above. The learners were then given an activity to reinforce the learned concept.

Lesson 6 was a continuation of the timeline topic previously covered in Lesson 5. Teacher 1 controlled the lesson through questions and answers to capture the learners' interest and evaluate their understanding. After reminding them that there could be scenarios where the amount in the account does not change but only the interest rate changes over time, he asked them to draw a timeline and subdivide it referring to the previous examples.

d) Peer tutoring

In all of the observed lessons, peer tutoring was only used in Lesson 3. Teacher 1 read a question on inflation as follows, *The average rate of inflation over the last ten years was 6.5%. The current price of a packet of 2.5kg white sugar is R21.50. Calculate the expected price of sugar in 10 years if the rate of inflation continued at the same level.*

He grouped the learners in twos and encouraged them to discuss the problem, but warned them not to talk about anything else but the work. He then moved around, assisting the struggling groups. He spent time with the blind learners listening and guiding them as they asked about problems they found difficult, as shown in Photograph 4.3 below.

Photograph 4.3: Teacher 1 helping blind learners construct mathematical knowledge during peer tutoring

e) Problem-solving

Although problem-solving skills were taught in all six of the observed lessons as a strategy of teaching mathematics, an in-depth approach to problem-solving was only developed in Lessons 5 and 6, where the Polya's step of problem-solving was followed. For example, in Lesson 5, Teacher 1 read aloud an example from a learner's book and summarised questions for learners to understand. He drew a timeline sketch and sub-divided it according to the transaction that was carried out on the account. He asked learners to choose the correct formula to use in solving the problem. Eventually, he gave them an exercise to do and went around evaluating their answers. The same procedure was repeated in Lesson 6.

4.3.1.2 Teacher 2

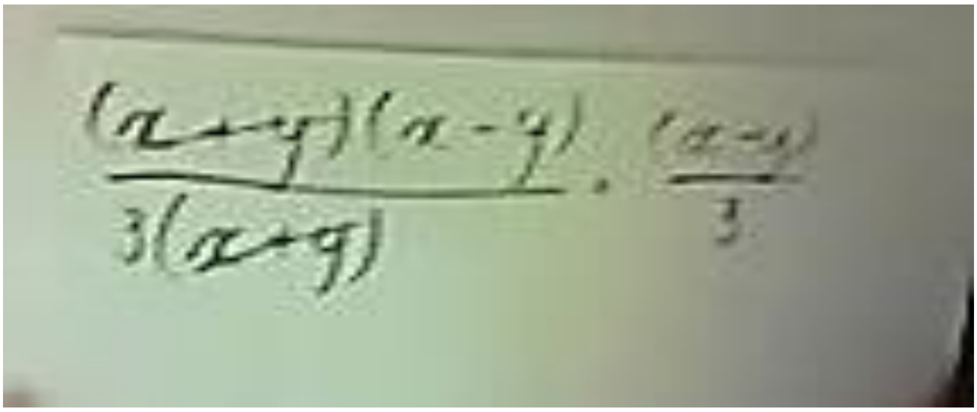
a) Contextual

Teacher 2 did not use contextual learning in any of the six observed lessons, although she could have used the idea of a gentle slope, steep slopes and staircase while teaching the gradient of linear graphs.

b) Direct instruction

Teacher 2 used direct instruction in five out of the six observed lessons. In Lesson 1 where she was teaching the factorisation of a trinomial, she explained how to factorize $x^2 + 5x + 6$. She explained, "*In your brackets you have (x + 2) and (x+3). If you multiply the 2 and the 3 you get your 6 at the end of your expression.*" After practising with several examples, she allowed each learner to simplify the trinomial in question. Blind learners followed the example from their braille books. Learners were given an activity to simplify a trinomial.

In Lesson 2, Teacher 2 explained how to simplify and cancel a fraction, as shown in Photograph 4.4.

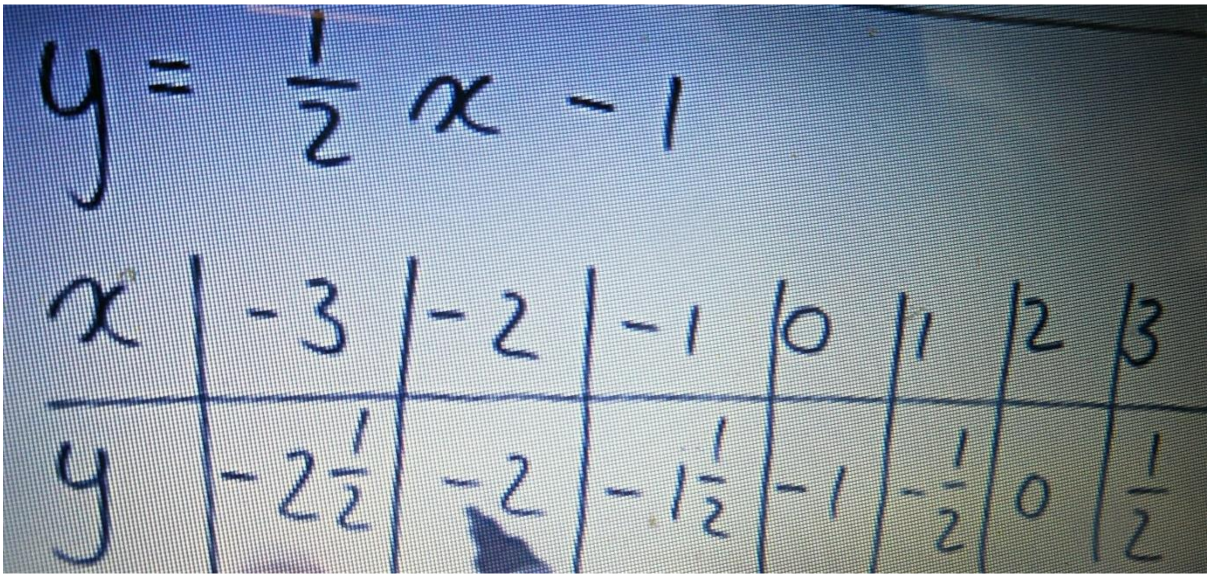


Photograph 4.4: Cancelling a denominator and numerator

In Lesson 3, Teacher 2 used an example to illustrate how to find the output when input is given. Afterwards, she provided an opportunity for learners to practice solving the value of the output given the formula $Y = \frac{1}{2}$ x $- 1$ using input values;$-3, -2, -1, 0, 1, 2$.

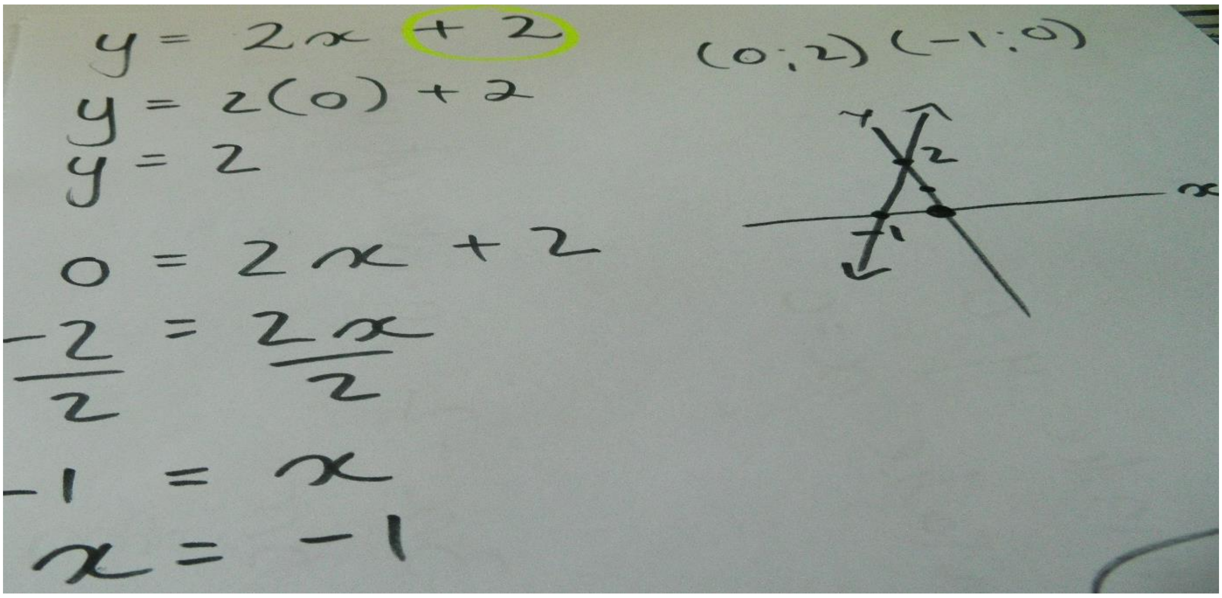
Since the blind learners could not draw the table, they completed the question by substituting for the x value in a linear form. $\left(\frac{1}{2} \times -2\right) - 1 = -2$. The teacher did not check their work.

After asking if everyone had completed finding the output value, she displayed the answers to the question on the CCTV screen and read the outcome loudly to benefit the blind learners, this is shown in Photograph 4.5.



Photograph 4.5: Answers to the equation $\boldsymbol{y = \frac{1}{2}\,x - 1}$

In Lesson 4, the teacher explains using two examples of how to calculate the ‘y’ and ‘x’ intercept given an equation. In the first example, $y = 2x + 2$. Teacher 2 calculated for the intercepts, stating, “*when you are to find* y*-intercept* $x = 0$ *when finding* x *intercept make*$=$ $0.$*”* She solved for the x and y-intercepts and plotted the graph as shown in Photograph 4.6.



Photograph 4.6: Plotting a graph: $\boldsymbol{Y = 2x + 2}$

From my observation, no support was given to the blind learners. Similarly, the partially sighted learners expressed their dissatisfaction and asked the teacher to give another example.

Example 2 was given as $2x + y = -1$. This was a different format from the first example, and the partially sighted learners seemed to be confused. She said, "*Remember the equation* $y = mx + c$, *so I'm going to sort my equation, so is going to be* $y = -2x - 1$. *Now it is in the form of* $y = mx + c$." She then calculated the value of the x- and y-intercept and plotted the second graph. She concluded by giving them a worksheet to complete.

In Lesson 5 and 6, Teacher 2 continued with the theme on functions. She expanded on the process of drawing a graph from the previous lesson and elaborated on calculating the intercept of the graph.

c) Scaffolding

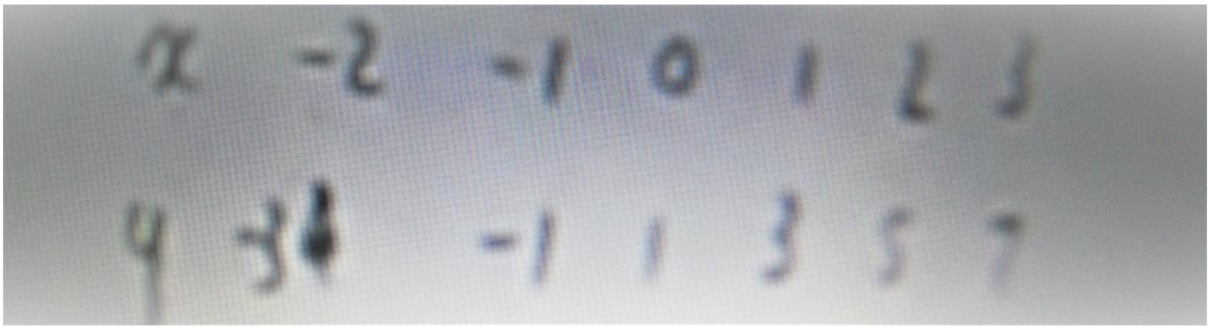
Scaffolding as an approach to teaching was utilised in five lessons. In Lesson 1, Teacher 2 guided the learners on how to simplify a trinomial that starts with a coefficient. She explained,

> *If you have* $2x^2 - 4x + 2$ *so before you can see your trinomial to factories, you need to take out the 2 from the* $2x^2 - 4x + 2$. *What is left is* $x^2 - 2x + 1$. *Therefore, you have 2 outside the brackets.*

Teacher 2 then asked a learner to follow the example in solving a similar equation: $3x^2 + 24x + 48$.

In Lesson 2, she moved around helping the learners, especially the blind learners on how to calculate the value of $\frac{x^2-9}{6x-18}$ by asking questions like "*What can you see on top?*" The learners were supposed to factorise the numerator using the difference between two squares and factorise the denominator by putting the highest common divisors outside the brackets. Then in the end, divide the fraction: $\frac{(x+3)(x-3)}{6(x-3)} = \frac{x+3}{6}$.

In Lesson 3, Teacher 2 guided the learners on how to calculate the output values given a formula for a linear graph and the input value. She explained, "*Given the equation* $y = 2x + 1$." The answers are shown in Photograph 4.7 below.

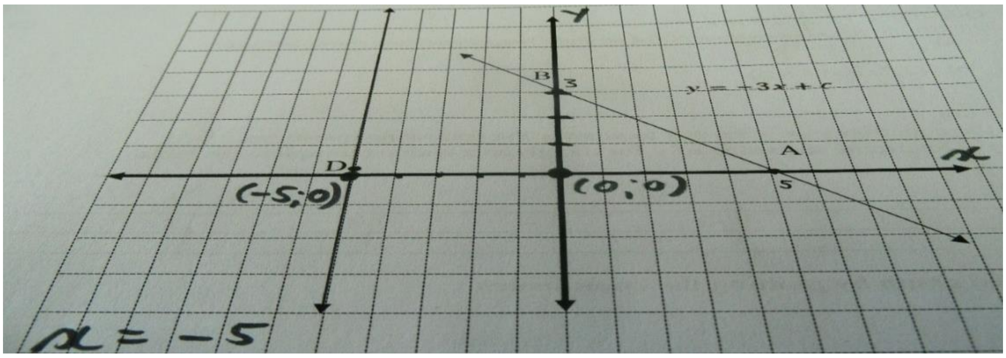


Photograph 4.7: Input and output value for the function $\boldsymbol{y = 2x + 1}$

Teacher 2 then explained, "*If x is -1,* $-1 \times 2 + 1 = 1$ *if x is 0,* $0 \times 2 + 1 = 1$*; if x is 1,* $1 \times 2 + 1 = 3$ *if x is 2,* $2 \times 2 + 1$ = *5 if x is 3,* $3 \times 3 + 1 = 10$."

During Lesson 4's presentation, the Grade 9 learners struggled to answer Question 1 of their assignment. Teacher 2 explained using a similar example of how the question should be worked out: $y = 3x - 3$. She told them, *"I'm going to use another question so that you can answer question 1. You need to state the gradient, y-intercept and x-intercept."* Referring to the equation, the teacher asked the learners to state the value of the gradient and the y-intercept. Then she reminded them how to substitute y with 0 to get the value of x . After the learners had given the correct responses, Teacher 2 encouraged them to carry on with the activity.

In Lesson 5, the VI learners had to find the value of c given the graph and the equation $y = 3x + c$. See Photograph 4.8 below.



Photograph 4.8: Liner graphs

Teacher 2 guided the learners, saying, "*You know that c is the place the graph cuts the y-axis."* Counting from the (0,0) point, she showed them that the graph cut the y-axis at three. Therefore, the equation is $y = 3x + 3$.

In Lesson 6, Teacher 2 explained by counting the spaces from (0,0). She stated, "*If that line is parallel to the y-axis you count horizontally in this case, the coordinate is* $(4,0)$*. Therefore the equation is* $x = -4$*.*" The blind learners followed by reading the coordinates on an embossed graph. Teacher 2 asked them to carry on with the activity as she walked around, guiding struggling learners.

d) Problem-solving

Problem-solving was taught in Lessons 3 and 4. In Lesson 1, only the basic concepts of problem-solving were mentioned when the factorisation of trinomials was taught. In this lesson, learners were to identify two factors whose product was equal to the constant, and the sum was equal to the coefficient of the middle variable. In Question 3 and 4, the process of finding the x- and y-intercept of a different equation and drafting the graphs was explained, and Polya's steps of problem-solving could be identified.

4.3.2 Instructional approaches identified from the interviews

During the interviews, when asked, "*what teaching approaches do you use to teach mathematics to the Visually Impaired learners?*" The teachers' responses were coded, as shown below.

Teacher 1

Teacher 1 mentioned three of the approaches. He said that the approaches used to teach mathematics to VI learners were the same as those used in mainstream education. He further explained, "*However, in my class, I normally divide my lesson into two slots to cater for both partially sighted and blind. The same concepts are conveyed to the learners at a different pace with different medium*." This dividing of lessons for the learners and explaining the concepts in pieces constitute direct instruction. For the category of scaffolding and peer tutoring, Teacher 1 mentioned that he worked one-on-one with blind learners and constantly monitored the development of concepts. He explained, "*In the areas they struggle, I give one-on-one support.*"

Teacher 2

During the interview, Teacher 2 mentioned two strategies for teaching mathematics out of the possible five approaches discussed in the literature and summarized in the conceptual framework. When she explained as follows:

> *After showing learners how to solve a problem, I try to use the majority of the time in class for the learners to be active and busy with mathematics, instead of me doing all the talking all the time.*

This is direct instruction, where the teacher explains the steps and lets learners practise the steps until they can construct their own understanding.

For the category of scaffolding, Teacher 2 had this to say, *"I lead them to solve problems so that they get the feeling of achieving, which in turn creates a sense of motivation."* Teacher 2 took on the role of a facilitator, evoking learners' thinking:

> *I try to get the learners curious on various topics so that they ask questions to understand". She explained, "I prefer for some cases the learners to solve a math problem, instead of me showing and spoon-feeding them*

4.3.3 Summary

Teacher 1 had received formal training in teaching mathematics to VI learners. He incorporated all five discussed approaches: the contextual approach, direct instruction, scaffolding, peer tutoring and problem-solving to meet the need of each learner. He actively involved all of the learners in the lesson. Teacher 2 had not received any formal training to teach mathematics to VI learners. In her lessons, she used three teaching approaches in the entire six observed lessons: direct instruction, scaffolding and problem-solving . She guided her learners toward the construction of knowledge of mathematics by explaining the concepts rather than allowing them to solve problems themselves.

4.4 ASSISTIVE TECHNOLOGY DEVICES USED TO ENHANCE THE CONSTRUCTION OF MATHEMATICAL KNOWLEDGE

Teachers who teach mathematics to VI learners use assistive technology to enhance their teaching. From the study, two types of assistive technology were identified: hardware tools that are tangible and software in the form of computer programs. Incorporating technology into teaching VI learners acts as a compensatory mechanism for the loss of sight (Buhagiar & Tanti, 2013). The researcher observed and interviewed the two teachers to discover the assistive devices used to accommodate and make mathematics accessible to VI learners. The categories identified are diagrammatically represented in Figure 4.1.

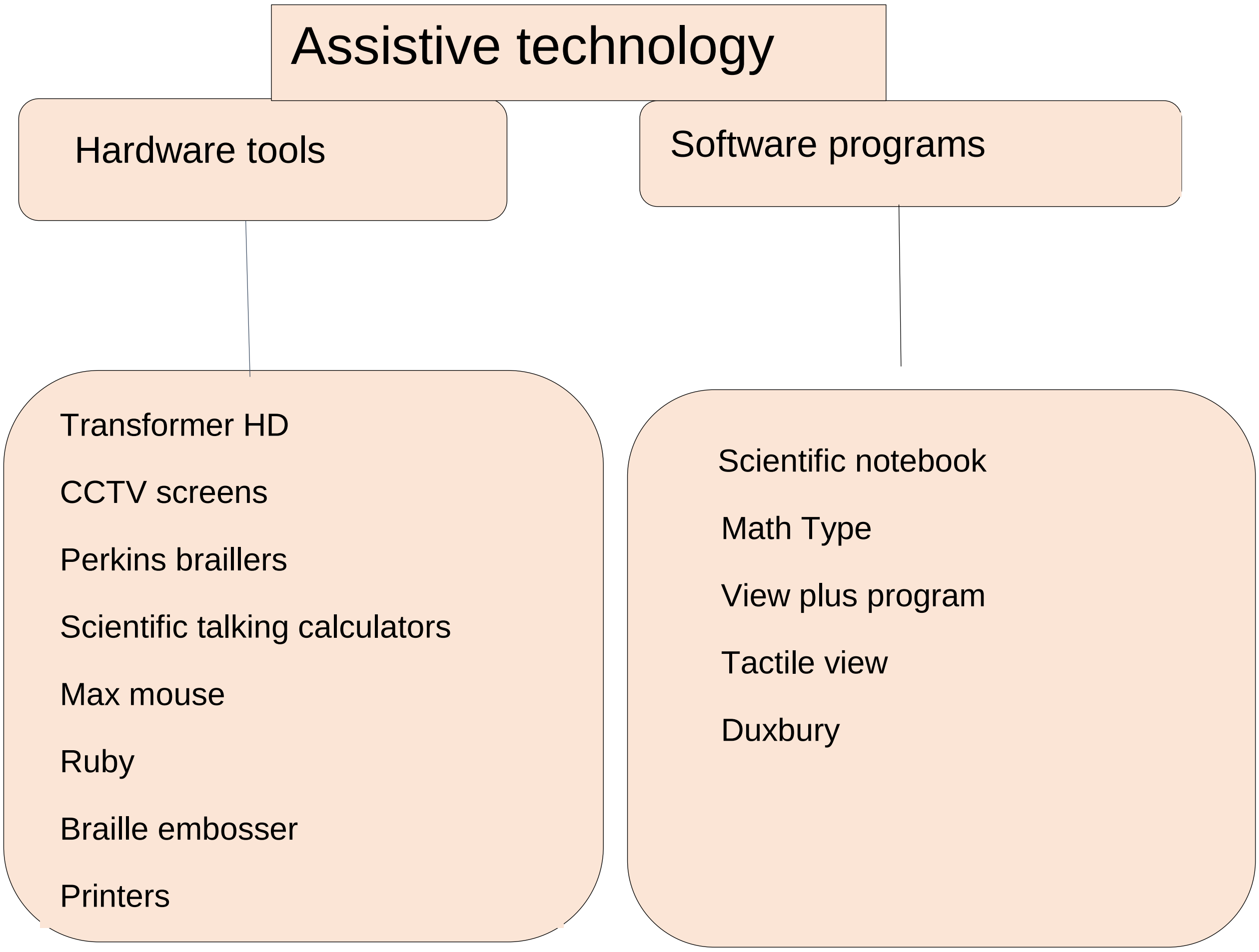


Figure 4.1: Assistive technology diagram

4.5 ASSISTIVE TECHNOLOGY DEVICES OBSERVED

There were two centres where most of the assistive technology devices were kept: one was in the classrooms, and the other was the teachers' resource centre. Both the teachers and learners used the devices kept in the classrooms. Those kept in the teachers' resource centre were strictly used by the teachers.

4.5.1 Hardware

Hardware tools were the physical, tangible devices used by both teachers and learners. Most of these were found in the classroom. Most of these were used to enlarge the text for partially sighted learners.

4.5.1.1 Hardware in Teacher 1 class

a) Transformer HD

A transformer HD is a high-performance electronic magnifier, which was used to magnify and project magnified text and diagrams onto the CCTV connected to it**.** In all of the six observed lessons, Teacher 1 used the Transformer HD to enlarge text and illustrations to the desired font for the learners. The Transformer HD is displayed in Photograph 4.9 below.

Photograph 4.9: Transformer HD for magnifying and projecting the teacher's illustrations and texts

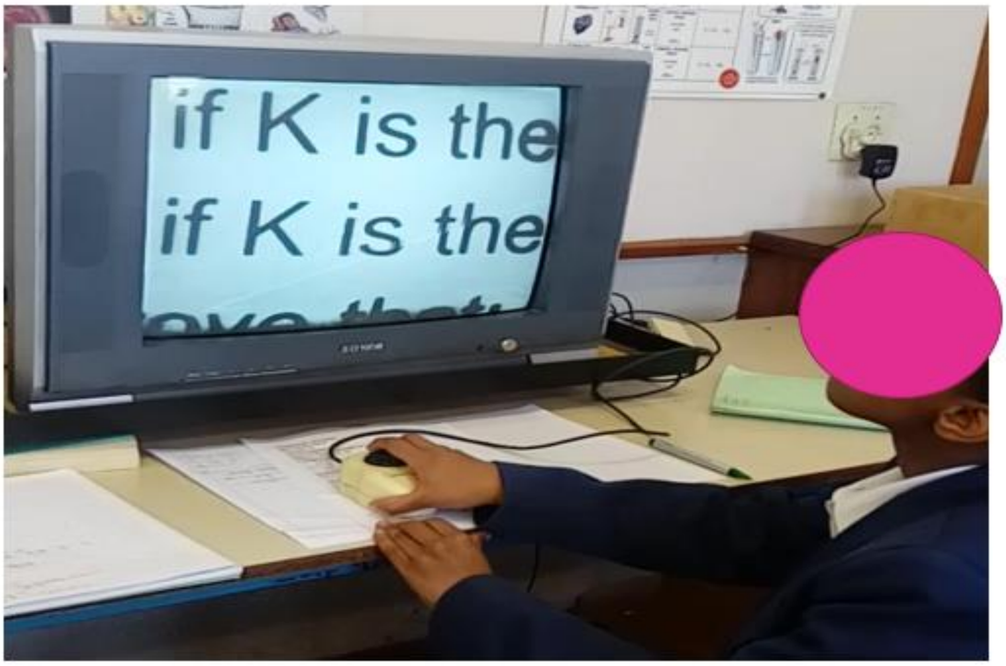
b) CCTV screen

In front of each seat was a mounted CCTV screen where the learners could see the teacher's enlarged illustrations. The partially sighted learners followed the teacher's examples in a font comfortable for their sight. See the general classroom appearance of the class together with CCTV screens in Photograph 4.10.

Photograph 4.10: CCTV screens in the Grade 10 class

c) A Max Mouse

A Max Mouse is a dynamic tool used by partially sighted learners to zoom in on mathematics text by dragging the mouse on the text and reading it on the CCTV screen. From my observation, only two screens in the Grade 10 class were fitted with a Max Mouse, as shown in Photograph 4.11.



Photograph 4.11: A partially sighted learner using a Max Mouse

d) Ruby

A Ruby is a hand-held device used to enlarge text. From the observations, the learners used a Ruby to read their textbook or a question paper that had not been enlarged. This is demonstrated below in Photograph 4.12.

Photograph 4.12: A Ruby magnifier

e) Perkins braillers

Perkins Braillers are simple tool with six keys and a space bar used by blind learners to write in braille (Bitter, 2013). From the observations conducted, there was a total of two blind learners in Grade 10. They used Perkins braillers to write classroom activities, assignments and homework (see Figure 2.2). Since the Perkins braillers are not to be moved from a classroom, they had other braillers in their hostels or at home for day scholars.

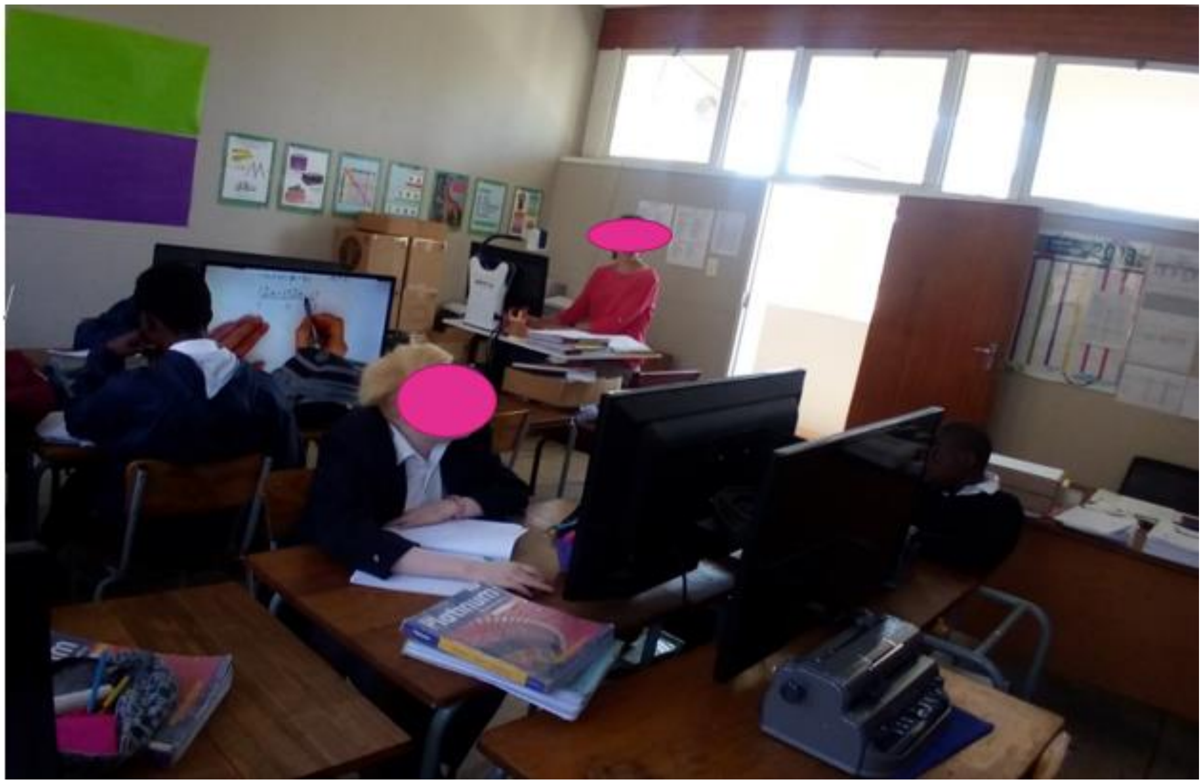
f) Scientific talking calculators and ordinary calculators

From the observations conducted, while the sighted learners used an ordinary scientific calculator to aid them to solve mathematical problems, the blind learners solved mathematical problems using talking calculators fitted with earphones.

4.5.1.2 Hardware in Teacher 2's class

a) Transformer HD

During teaching, Teacher 2 used a transformer HD to project her examples on the CCTV screens, which were modern flat screens. These made it possible for the partially sighted learners to access the mathematics in their desired font, as shown in Photograph 4.13 below.



Photograph 4.13: Transformer HD and flat screen CCTV screens

b) Perkins braillers

In Teacher 2's class, all of the blind learners had a brailled Platinum mathematics book that corresponded with the sighted mathematics book, as well as a Perkins brailler. The Perkins braillers were used to write activities in class.

c) Scientific talking calculator.

Although the talking calculators were seen in class, the blind learners did not use them in any of the observed lessons. This was because the teacher was teaching the topic of functions, which requires simple calculations.

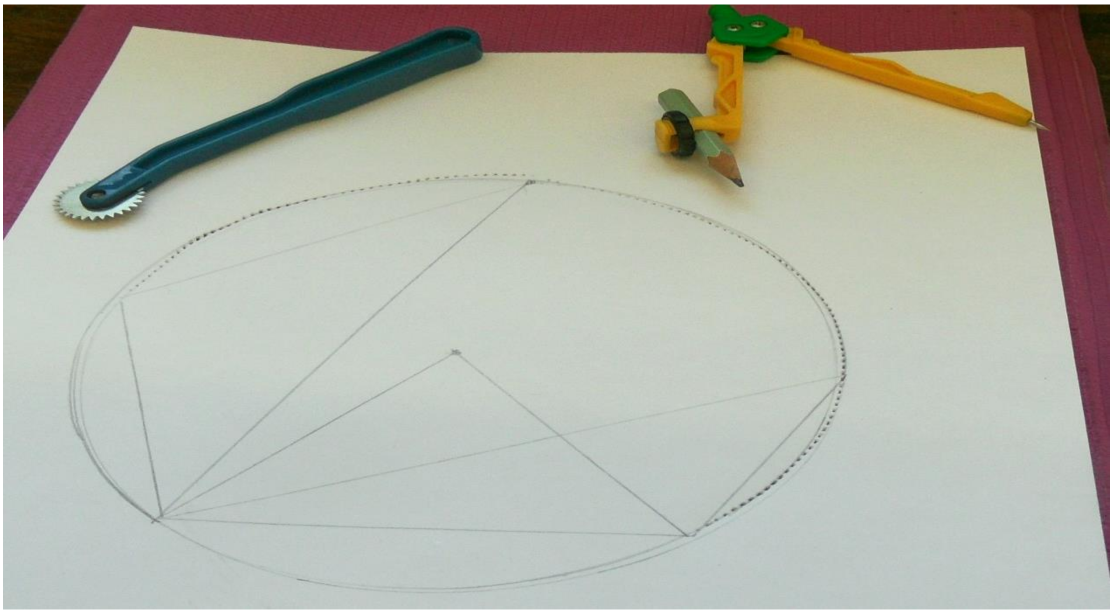
4.5.2 Hardware tools identified from the interviews

Hardware assistive devices were also identified during the interviews. When the teacher was asked about the assistive devices used to make mathematics accessible, the teachers explained in detail how the devices were used.

4.5.2.1 Teacher 1

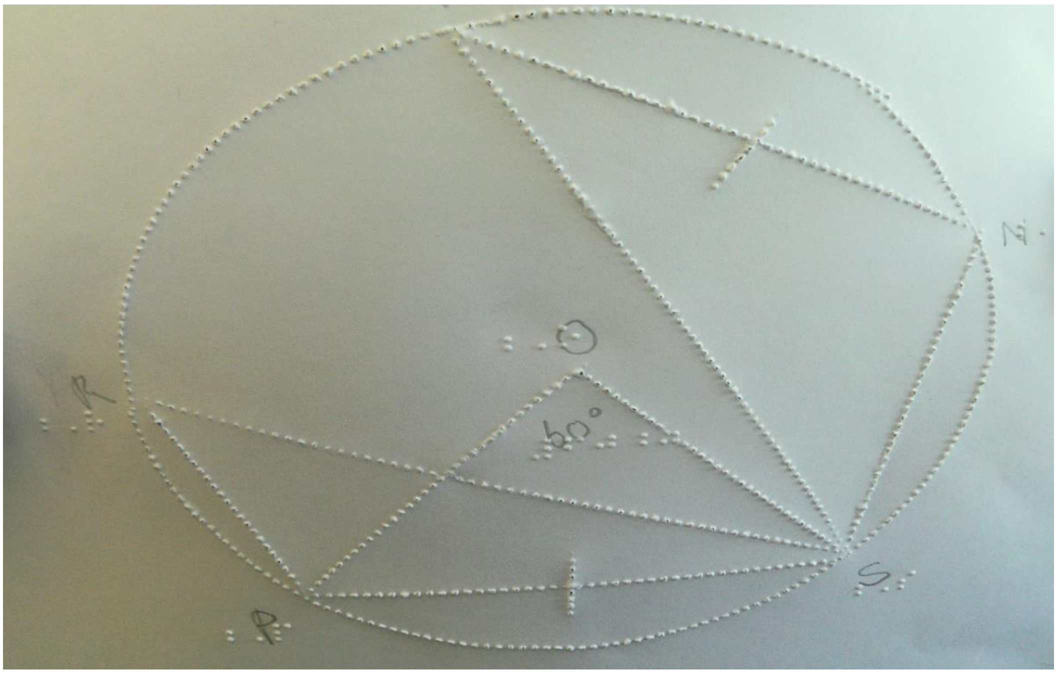
a) Dressing wheel

According to Teacher 1, a tracing wheel is a quick way of drawing a single sketch and converting it to a tactile one without using computer software (see Photograph 4.14).



Photograph 4.14: A tracing wheel used to draw tactile sketches

During the interview, Teacher 1 narrated how a sketch, like the one shown in Photograph 4.14, is drawn on paper with the aid of a ruler and a protractor. After that, tracing paper is used to poke dots along the drawn lines. The sketch is then turned over to the opposite side, which is more tactile, and inserted into a Perkins Brailler where all the subtitles and the degrees as labelled on the print diagram are brailled. The finished diagram is like the print copy but in braille format, as shown in Photograph 4.15.



Photograph 4.15: Tactile diagram for blind learners

b) Talking calculator

A scientific talking calculator has many features that go beyond the addition and subtraction of numbers in mathematics. During the interview, Teacher 1 demonstrated how blind learners successfully solved mathematics problems involving the compound interest formula using talking calculators. He began the interview by saying, "*Our school bought this talking calculator recently. This is a platinum XL calculator".* This is shown in Photograph 4.16.

Photograph 4.16: Talking scientific calculators

Teacher 1 further explained, "*It accommodates all the different calculations that are in the syllabus from Grades 10-12. In other words, you get all these trigonometrical calculations on* *the calculator."* He explained that it is a calculator perfectly suited for blind learners for all types of mathematical calculations in the FET phase at school. Teacher 1 gave an example of how the calculator is used in calculating compound interest. He calculated the interest rate ($1 + i)^8 = 2{,}6$. He explained that *"Scientific talking calculators don't have the function to handle this 8th root of 2,6 because we need to get the 8th root of 2,6. What I normally teach them is to raise* $2{,}6^{\frac{1}{8}}$. *According to the exponential law that says the 8th root should be equal to the power of* $\frac{1}{8}$*."* He said at this point, blind learners first solved for the value of $\frac{1}{8}$ using the calculator, which equals to 0.125. Teacher 1 would then write $1 + \mathrm{i} = 2{,}6^{0{,}125}$ And then, using the calculator, he calculated 2,6 to the power of 0,125 = 1,126864425… Then 1 + i = 1,1269. Then subtracting 1 from both sides, this resulted in i = 0,1269, which is equal to 12,69% per annum.

4.5.2.2 Teacher 2

Teacher 2 only mentioned talking calculators, Braille textbooks, Perkins braillers, and a camera with TV screens. No hardware devices were discussed in-depth during the interview with Teacher 2.

4.5.3 Software

When the teachers were asked how they translate text and diagrams to tactile the without compromising on the learning outcome, the use of software programs was the answer for both teachers. The software considered included a scientific notebook, Math Type, the View Plus program, tactile view, and Duxbury (DBT). Each teacher discussed in-depth the program he/she frequently used while mentioning, in brief, the programs less used.

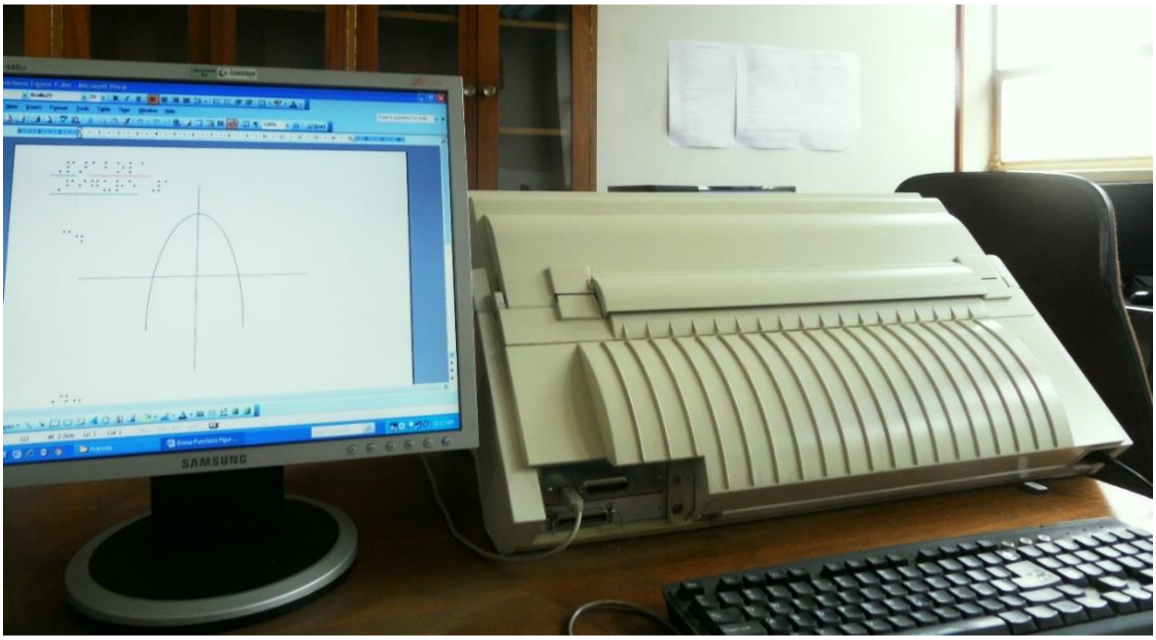
4.5.3.1 Teacher 1

a) View Plus

View Plus was the computer program that was used to draw graphical representation. Teacher 1 indicated that he used the View Plus computer program to make sketches, graphs, tables and other diagrams to be embossed. He drew a parabola on the computer and used the View Plus program to translate the text to braille. Opening a Word program with an already prepared sketch, he explained, *"The parabola graph is already sketched in a Word program.*

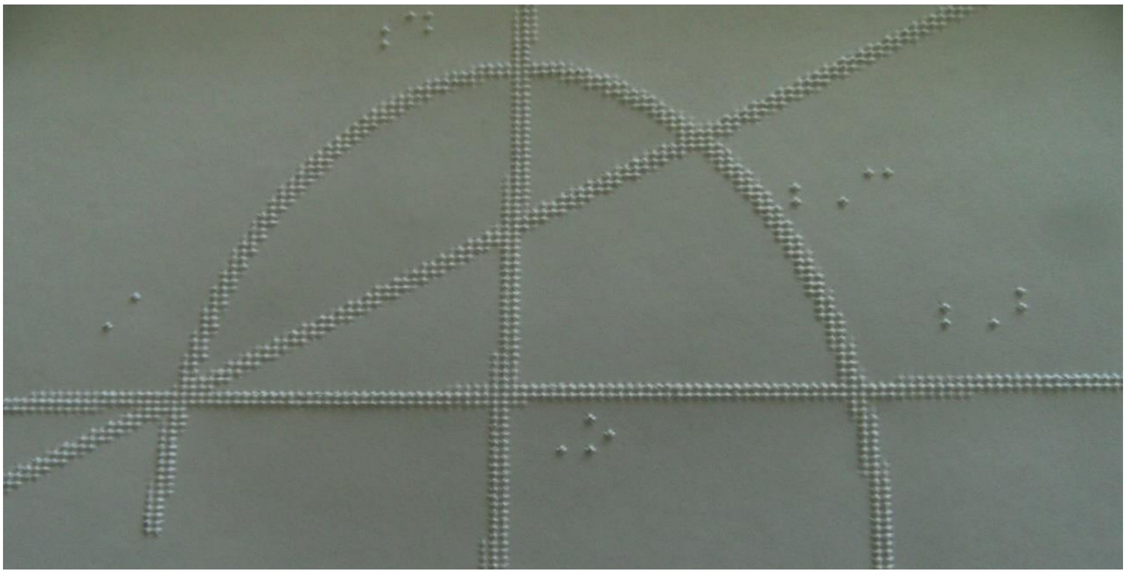
I have put on the subtitles already. In other words, what we need is to translate everything on the sketch."

He clicked on the program, and a list of icons popped up. He then clicked on View Plus for translation as shown in Photograph 4.17.



Photograph 4.17: Sketched diagram on the View Plus translator

After all subtitles on the sketch were translated and edited, the translated sketch was then printed in the tiger printer as shown in Photograph 4.18



Photograph 4.18: Embossed diagram from a Tiger printer

b) Tactile view software

Tactile view software is another computer program mentioned by Teacher 1 during the interviews. He explained as follows: "*Recently they introduced another computer programme called Tactile View software programs that help us in the process of creating diagrams and sketches in braille*." However, Teacher 1 did not demonstrate how it is operated.

c) Scientific notebook

During the interview, Teacher 1 explained how he translated printed text into braille. He said,

> *What I use for the text in mathematics is a software program known as a scientific notebook. The scientific notebook makes provision for all the different mathematical text, symbol and object that you can make use of in mathematics*

Teacher 1 opened a scientific notebook and pointed to the panel with the most mathematics symbols, shown below in Photograph 4.19.

Photograph 4.19: Mathematics panel compatible with the scientific notebook program

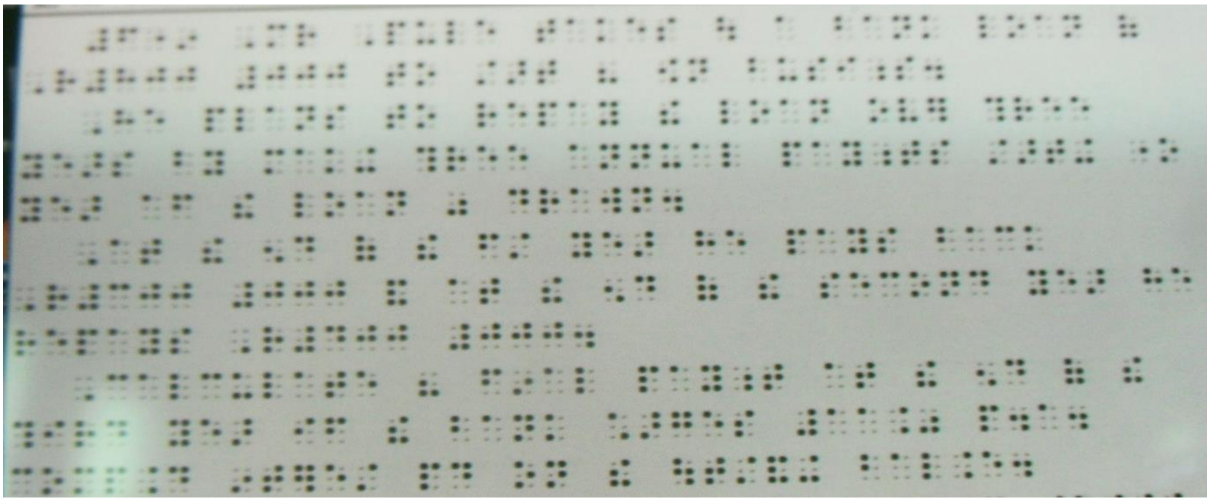
Teacher 1 opened a document that he had already set up for a Grade 10 assignment regarding loan repayments in financial mathematics. He explained while scrolling down the document:

> *If you look further down in the text, you can see that we make use of the normal formulae, like the compound interest formula:* $A = P(1+i)^n$ *simple interest*

formula $A = P(1 + in)$ *and the conversion of the different interest rates, from nominal to effective* $1 + i = \left(1 + \frac{i^m}{m}\right)^n$

He saved the document on the desktop and opened a program named DBT. He then stated, *"Duxbury is a computer program that helps us to translate any Word program into braille."* He opened the saved file using the Duxbury program and another panel popped up from which he chose UEB. UEB stands for "Unified English Braille", which is a type of braille code that was adopted in South Africa in 2004 (Cryer, Home & Morley Wilkins, 2013). He then clicked on the word translation code and explained, *"I am going to choose Grade 2 braille, which is contracted braille that has appropriate braille code used for blind learners in high school."*

Teacher 1 translated the whole assignment into braille by pressing the button marked translate, an example of which can be seen in Photograph 4.20.



Photograph 4.20: A translated braille text

d) Math Type and Braille Box

During the interview, Teacher 1 described Math Type as online computer software that is used to write mathematical algorithms and formulas that are to be converted to braille. However, he did not demonstrate how the program is used.

4.5.3.2 Teacher 2

Teacher 2 mentioned four software programs: Math type, scientific notebook, Tactile View, and View Plus. Apart from the tactile view program, she did not explain in detail how she used these programs.

a) Math Type and scientific notebook

Math Type and scientific notebook are the two software programs used by mathematics teachers to write mathematics problems to be translated to braille. Teacher 2 indicated that she did not use scientific notebook to write her work, but used the Math Type program, which is an online computer program with formulas and symbols that are used to write mathematical text.

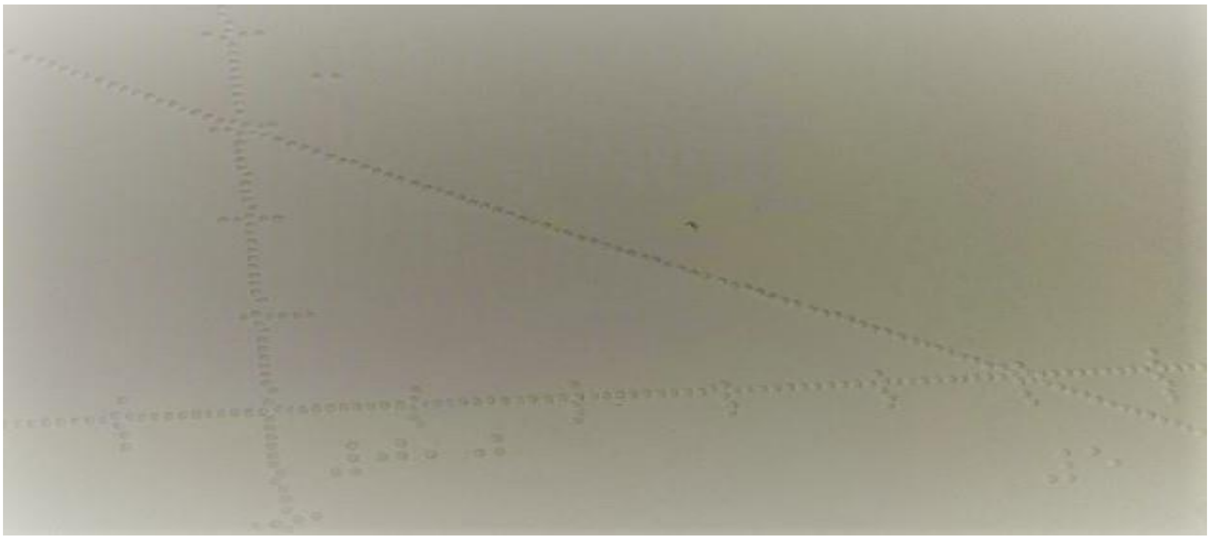
b) Tactile View and View Plus

Teacher 2 mentioned two computer programs that she used to draw and emboss mathematical diagrams, tables, maps and graphs. These were Tactile View, and View Plus. According to Teacher 2, she did not frequently use the View Plus program. Teacher 2 noted that she did not always do embossed sketches because they take time to draw. She also said that she sometimes explained the diagram and read the information on the diagram. She tried to make sure the learners understood a diagram by asking them to confirm that they did.

She briefly illustrated how to draw a linear graph in the Tactile View program. She drew a Cartesian plane with a y-axis and x-axis. Indicating the axis, she explained:

> *Then I mark on the graph the coordinates where the graph cuts the y-axis (0, 3) and cuts the x-axis at (5, 0). I will also put a marker for the origin where the x-axis and the y-axis are both zero. The sketch is now ready to be embossed in a braille box.*

This is shown in Photograph 4.21 below.



Photograph 4.21: An embossed linear graph

4.5.4 Summary

From the two teachers, hardware and software assistive technologies that help in teaching VI learners were identified. The hardwire devices constituted a Transformer HD, CCTV screens, Perkins braillers, scientific talking calculators, Max Mouse, Ruby, Braille embossers, printers, and braillers. Alternatively, the software programs were a scientific notebook, Math Type, the View Plus program, Tactile View, and Duxbury. While scientific notebook, Math Type and the Duxbury were the programs used to convert mathematics text to braille, the View Plus and Tactile View programs were used to produce tactile sketches.

4.5.5. Summary of data presented in the chapter

Data	Teacher 1	Teacher 2
Challenges experienced	1.Teaching circle geometry 2. time constraints 3. Lack of home support to the learners. 4. Technology failure. 5. Voluminous books for the blind and missing information	1.Teaching topic of measurements 2.lack of knowledge and skills in braille 3. Lack of students' self-motivation to learn mathematics. 3. many volumes of braille books that are equivalent to one sighted learner textbook
Approaches use in the teaching	Contextual approach, direct instruction, scaffolding, peer tutoring and problem-solving.	Direct instruction, scaffolding and problem-solving.

Technology used	Hardware: Transformer HD, CCTV screens, Perkins braillers, scientific talking calculators, Max Mouse, Ruby, Braille embossers and printers. The software programs were scientific notebook, the View Plus program and Duxbury	Hardware: Transformer HD, CCTV screens, Perkins braillers, scientific talking calculators, Braille embossers, printers and braille embossers. The software programs were Math Type, Tactile View, and Duxbury

4.6 CHAPTER CONCLUSION

This chapter presented the findings obtained from the classroom observations and in-depth interviews with the two teachers. It was apparent that these teachers teaching mathematics to VI learners in high school experienced various challenges. Teacher 1, who had skills and experience in teaching VI learners, knew how to overcome these challenges. From the investigation, five approaches were identified: contextual, direct instruction, scaffolding, peer tutoring and problem-solving. It is important to note that the approaches used in teaching mathematics to VI learners were not different from those used in the mainstream. However, the VI learners gained mathematical knowledge if the teacher made mathematics accessible to them. The accessibility of mathematics was made possible with the use of assistive technology. The transformer HD, CCTV, Max Mouse and a Ruby were used to enlarge the text to the desired font for the learners. Similarly, scientific notebook, Math Type, and Duxbury were used to convert text to braille, while the View Plus program and Tactile View programs were used to produce tactile sketches for learners.

CHAPTER 5 DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

This study aimed to investigate the instructional strategies used by mathematics teachers to help VI learners construct mathematics knowledge. The findings obtained from observing and interviewing two teachers for Grades 9 and 10 were presented in Chapter 4. In this chapter, the researcher aims to synthesise the findings based on the theoretical framework of this study, linking it to the literature review and the emergent results from the empirical investigation.

The discussion is centred on the three categories presented in Chapter 4. The challenges experienced by mathematics teachers in teaching mathematics to VI learners in high school, the instructional approaches used to help the VI learners construct mathematics knowledge, and the assistive devices used to enhance the construction of mathematics knowledge. The discussed facts will be used to answer the three secondary questions underpinning this study.

5.2 THE CHALLENGES TEACHERS EXPERIENCE IN TEACHING MATHEMATICS TO VI LEARNERS

VI learners have reduced visual or no visual sense and cannot process visual information to the same degree as a sighted individual (La Voy, 2009). For this reason, they require specialised assistance from their teachers to construct mathematics knowledge (Hassan & Salleh, 2017). Most teachers who teach mathematics to VI learners experience challenges (Maguhve, 2015). From the findings, the following challenges were presented.

5.2.1 Inadequate skills in teaching VI learners

Most teachers who facilitate mathematics in special needs schools for VI learners are only in possession of a Bachelor's degree to teach in mainstream education (Kapperman, Heinze & Skicken, 2010). They are not professionally equipped with the skills to teach VI learners. Most of these teachers have to develop skills from experience, in-service training and workshops.

From the findings, it can be seen that Teacher 1 had many years of experience in working with VI learners. He completely understood the intensity and attention required to support the blind learners in his class. Despite his experience in teaching VI learners at FET phase, he still experienced challenging moments in class. He voiced the challenges that he encountered in teaching the topic '*circle geometry*'. He said that when teaching circle geometry, "[The] *Blind learner tends to get entangled with so many lines and angles on one page; it becomes difficult for a teacher to explain the concept to them."* Although he found it challenging to teach this topic, he explained that he took time and required different approaches to help the blind learners understand geometry. As Buhagiar and Tanti (2013) state, a lack of skill and experience in teaching blind learners may result in difficulties teaching some topics like geometry, which is occasionally omitted. From the findings, Teacher 2 had not received any formal training to teach VI learners. During the interview, she expressed her discomfort in teaching some of the measurement topics, stating, "*I find it difficult to teach topics on measurement, and it is quite challenging*." Teacher 2 said that she did not teach some topics in measurement to the blind learners.

According to Rule et al. (2011), unskilled and inexperienced teachers find teaching mathematics to VI learners to be very challenging. Teacher 2 had limited experience in teaching mathematics to VI learners. From the observations, it could be seen that she experienced challenges in facilitating sketching graphs. Even after repeated illustration to the learners, they could not draw a graph when asked to do so.

The interview revealed that these Grade 9 learners were not motivated to learn mathematics and had cultivated a negative attitude towards mathematics. Teacher 2 indicated that the learners did not take responsibility and made little effort in their work; hence, they struggled to understand even simple mathematics.

5.2.2 Lack of a home support structure

The study revealed that the parents or guardians of the learners in this study often did not give home support to VI learners**.** Teacher 1 expressed his disappointment in not being able to work together with the parents of the VI learner in guiding them academically and morally. He said, "*These children need home intervention program to boost them in this competitive world."* Teacher 2 complained about the frequent incomplete homework and assignments from the learners after a weekend with their parents or guardians. She stated, "*I give extra work every week for them to submit a week later. The papers come back empty, half-done or with no calculations at all."*

5.2.3 Lack of skills in using braille

According to Gulley, Smith, Price, Prickett, and Ragland (2017), VI learners underachieve in mathematics, partially because they experience a crisis in using braille. From the findings for Teacher 1, on the one hand, it can be seen that he was skilled and experience in reading and translating braille and worked through braille work confidently. Teacher 2, on the other hand, experienced difficulty reading the learners' braille work because she did not receive formal training in braille. She could not read Level 2 braille and could not introduce new braille to the learners as they appeared in a new topic. During the interview, Teacher 2 said that she found it "*challenging to read braille even assist the blind learners with the correct booklet."*

5.2.4 Time constraints

Teacher 1 expressed his frustration with the time constraints on teaching mathematics to VI learners. He claimed that the scope of the curriculum content for every term was so broad that he found it very challenging to cover it within the recommended period of 4.5 hours per week for mathematics. He said, *"Sometimes you are forced by circumstances to be very crafty when it comes to your lesson preparation and planning within the time constraints*." During the interview, he mentioned that sketching and embossing graphs, tables and other illustration consumed a lot of time during class. This is because blind learners require an extra explanation of the meanings of certain concepts represented on sketches, such as graphs or diagrams, which is time-consuming.

Similarly, Teacher 2 explained that the drawing of graphs and tables for blind learner took time. In addition, the learners were very slow to learn, "*…you need to explain facts 3-4 time before they understand."* She also said that the demand to cover the curriculum had forced her and others to offer extra lessons in addition to the regular teaching hours.

One of the reasons why teaching mathematics to VI learners takes time is the modality through which they learn. As discussed in Section 2.11, blind learners' tactile modality of learning is slow since reading mathematics with figures involves touching one character at a time in comparison to getting a general view as is done with sighted individuals (Mugo 2015). Accordingly, the writing and reading of braille material take longer than the writing and reading of standard text (Bitter, 2015).

5.2.5 Bulk braille books and missing information

The findings further revealed that the braille books used by blind learners are bulky and many in number compared to the one for sighted text. Teacher 1 explained that some diagrams and other important information were omitted in the braille books. This disadvantages blind learners as these books should be consistent with sighted mathematics textbooks. Teacher 2 indicated that there were many volumes of braille books, and sometimes "*it is difficult to know which volume of the braille book to use and which page is the right page for the exercise.*" She gave an example of the Platinum mathematics Grade 9 learners' books, which has eight big brailed booklets, and ten diagram booklets, totalling 18 booklets.

5.2.6 Failure of technology

Assistive technology is important in the learning of mathematics by VI learners as it helps minimize their barriers to learning (Mugo (2015). Therefore, their availability improves the quality of teaching, and their unavailability causes a challenge for the teacher. The assistive technology devices available in the school were sufficient for the teaching of mathematics to VI learners. However, the challenge for these teachers arose when there was a failure in these tools' operation**.** From the observation in one lesson, Teacher 1 resorted to oral teaching when the CCTV screens could not work correctly during the lesson. During the interview, he expressed the challenges he faced when he wanted to emboss sketches and the tiger printer was not working.

In the case of Teacher 2, she said, "*Sometimes we experience a challenge when the computers and the printers are faulty.*" This means that the blind learners sometimes did not have work to read.

5.3 THE INSTRUCTIONAL APPROACHES USED BY MATHEMATICS TEACHERS TO HELP VI LEARNERS CONSTRUCT MATHEMATICS KNOWLEDGE

As earlier stated in Section 2.3, VI learners are a heterogeneous group with individual needs and interests in learning. Hence, there is no single approach to teaching that is appropriate for all VI learners (Rule et al., 2011). These authors further find that the approach chosen is determined by the experience the teacher has and whether the chosen approach to help the VI learners construct knowledge is appropriate and effective.

The approaches used to teach mathematics to the VI learners in this school did not significantly differ from those used in mainstream education (Hassan & Salleh, 2017; Rule et al., 2011). From the findings, the approaches used in facilitating mathematics with the VI learners are summarised in Table 5.1 according to the preference of each teacher.

Table 5.1: A summary of the approaches used by the teachers

1. Contextual			**2. Direct instruction**		
	Teacher 1	Teacher 2		Teacher 1	Teacher 2
Lesson 1	**Yes**	**No**	Lesson 1	No	Yes
Lesson 2	**No**	**No**	Lesson 2	No	Yes
Lesson 3	**Yes**	**No**	Lesson 3	No	Yes
Lesson 4	**No**	**No**	Lesson 4	No	Yes
Lesson 5	**No**	**No**	Lesson 5	yes	Yes
Lesson 6	**No**	**No**	Lesson 6	No	No
3. Scaffolding			**4. Peer tutoring**		
Lesson 1	Yes	Yes	Lesson 1	No	No
Lesson 2	Yes	Yes	Lesson 2	No	No
Lesson 3	Yes	Yes	Lesson 3	Yes	No
Lesson 4	Yes	Yes	Lesson 4	No	No
Lesson 5	Yes	Yes	Lesson 5	No	No
Lesson 6	Yes	No	Lesson 6	No	No
5. Problem-solving					
Lesson 1	No	No			
Lesson 2	No	No			
Lesson 3	No	Yes			
Lesson 4	No	Yes			
Lesson 5	Yes	No			
Lesson 6	yes	No			

Focusing on constructivism as the philosophy that underpinned this study, it follows that when interpreting the results, one has to keep in mind that constructivism gives the teacher the freedom to explore any teaching/learning approach to use in his/her teachings to the benefit of the learner. This may influence the type of approach that a teacher prefers for a particular class, topic and individual needs and interest.

Teacher 1 made use of five approaches where applicable. These were contextual, scaffolding, direct instruction, and peer tutoring, problem-solving approach. Teacher 2 used three approaches: direct teaching, scaffolding, and to some extent, problem-solving. She did not use authentic and peer tutoring in her teaching.

5.3.1 Contextual approach

The use of the contextual approach in a lesson enables learners to connect new concepts to their immediate environment and construct their knowledge (Louw, 2015). Teacher 1 contextualised learning to a limited degree. In Lesson 1, he discussed a question in the context of a birthday. In Lesson 3, Teacher 1 explained the calculation of inflation on the cost of bread from a local supermarket 25 years ago and in 25 years to come. From the examples given, the VI learners were able to connect the new knowledge to familiar events. Building new ideas onto already known situations allows learners to construct meaning about what they are learning by building onto prior knowledge. As a result, they take ownership of the new experience (Louw, 2015; Rule et al., 2011; Wadlington & Wadlington, 2008).

Although Teacher 2 had the opportunity to implement contextualised learning, she did not use the contextualised approach.

5.3.2 Direct approach

The direct instructional approach allows the teacher to explain a concept step-by-step and it allows learners to practise until mastery is attained (Wadlington & Wadlington, 2008). From the observations, it can be seen that Teacher 1 occasionally used direct teaching to explain the new concepts in detail before allowing the learners to practice the taught skills. He systematically posed questions that motivated the learners to think attentively about the mathematics content, while at the same time he constantly monitored the development of concepts and skills. For example, in Lesson 5, Teacher 1 systematically explained how to calculate the amount left in the bank after multiple transactions of deposits and withdrawals had taken place. He actively involved learners by asking probing questions, which in turn led to a positive attitude in learning. They enthusiastically worked throughout the activity and they presented their ability to solve mathematics problems.

Similarly, Teacher 2 used a direct approach in Lessons 3, 4 and 5. In Lesson 3, she used this approach in explaining how to solve for the output value given the input and the equation of the linear graph. Some learners solved the equation for input value without a problem while others experienced problems and could be seen staring at the screen without working out the problem. Teacher 2 did not notice that the learners were frustrated and did not engage in solving the problem because she spent time working out the correct answers to the question instead of walking around to observe what the learners were doing. She later displayed the correct answers on the CCTV screens and clarified how each value was calculated. In Lesson 4, Teacher 2 explained the process of calculating the $x-$ and $y-$intercepts given the equation of the linear graph. Lastly, in Lesson 5, Teacher 2 gave a direct explanation of how to draw a linear graph. Teacher 2 then gave them a worksheet with an exercise on graphs to complete. It was difficult for the learners to draw the graph.

Based on the findings, Teacher 1 actively involved the VI learners in learning while Teacher 2 used the traditional method. She taught traditionally with very little attention to the blind learners in her teaching. Therefore, it can be concluded that direct teaching can only benefit VI learners if they are actively involved in the construction of new knowledge.

5.3.3 Scaffolding approach

Both teachers used a scaffolding approach to teach mathematics to VI learners. In Lesson 1, Teacher 1 carefully selected simple examples that were well known to the learners to explain the process of solving simple interest. Once he thought that the concepts were well understood, he introduced and worked with a compound interest formula $A = P(1 + in)$ and later allowed learners to follow the method to complete their activity on compound interest while he observed and guided those who were struggling. It is clear that Teacher 1 scaffolded learning through simple to complex tasks and handed over the responsibility to learners to practice the skill, but he remained attentive to the concept development of the learners. This type of approach aligns with scaffolding, as seen in the research of Bakker, Smit and Wegefif (2015). In Lesson 2, Teacher 1 built on the learners' prior knowledge to explain calculating the interest rate. Later in the lesson, he discovered that learners were struggling to calculate problems involving exponents as found in the compound interest formula. At this point, he changed his focus from solving the problem and explained the same concept using a different example that was easy to understand, i.e. he explained how to solve for the eighth root of a number by practising solving the cube root of a number, which was familiar to the VI learners. In these lessons, the teacher applied the scaffolding approach at a second hierarchical level, as found by Anghileri (2006). At this level, there is an interaction between the teacher and learners through explaining, reviewing and restructuring problems. In Lessons 3, 4, 5 and 6, Teacher 1 facilitated learning through interactive instruction. The VI learners were allowed to be actively involved in the learning activities to construct their own understanding of the mathematics concepts being covered.

In the interview, Teacher 1 affirmed using direct teaching as he said he normally divided the learning content into small sub-topics for easy teaching to blind and partially sighted learners.

In the case of Teacher 2, the research finding revealed that she guided the learners to solve a problem involving trinomials with or without a coefficient. Teacher 2 spent a significant amount of time working out examples while allowing the learners to choose which factorising method was appropriate to factorise the denominator and the numerator. At the end of the lesson, the learners appeared to have understood these concepts from the responses they gave to their teacher. This type of scaffolding resembles what Oira (2014) finds about scaffolding as coaching the learners in the correct ways of solving problems through demonstrating the concept until they understand (see Section 2.3.5).

Furthermore, the interview revealed that Teacher 2 used direct teaching. She explained that after repeatedly showing learners how to work out a solution, she always gave them work on which to practice.

5.3.4 Problem-solving

According to Rule et al. (2011), the use of problem-solving as an approach to teaching increases an understanding of mathematics concepts while minimising memorisation. Teacher 1 used problem-solving in Lesson 5 and Lesson 6. That facilitation of learning in these lessons mirrored the problem-solving steps as identified by Polya (see Section 2.3.8). For example, in Lesson 5, Teacher 1 read aloud the problem to be solved and helped the VI learners understand its context. He then illustrated the content on a timeline diagram for the partially sighted learners. The blind learners followed the teacher’s illustration from the embossed diagram in their books. Later on, the teacher discussed with the learners the appropriate formulae to use. Later, all of the learners were actively involved in solving the problem. The teacher went around to oversee the process and help the learners reflect on their solution. The use of problem-solving encouraged critical thinking among the learners as they reflected on their work.

Teacher 2 attempted to teach through problem-solving in Lesson 3 and Lesson 4, but she did not follow the entire step as recommended by Polya. Her intention in using problem-solving skills was to explain to the learners the procedure of calculating the $x -$ and $y -$intercept and then draw a graph.

5.3.5 Peer tutoring

Teacher 1 used peer tutoring to a limited degree. In the interview, he expressed an idea of facilitating learning one-on-one to give more support. In Lesson 2, he paired the learners into groups of twos, read the question to them and encouraged them to discuss and compare answers. At first, the peers were not actively engaged in their discussions as the instruction seemed unclear to them. Later on, Teacher 1 intervened by visiting each group and assisting them where necessary. This increased peer interactions as they were informed of what they were expected to do. The pairing of the peers was not done according to intellectual levels but rather proximity to each other. The disadvantage of this pairing was that the blind learners did not get an opportunity to work with sighted learners since they did not sit next to each other.

The findings showed that Teacher 2 did not use peer tutoring in her class; neither did she individualise her teaching, even when she had an opportunity to do so.

5.3.6 The use of manipulatives

Neither of the two teachers used manipulatives as an instructional approach. However, in Lesson 5 and 6, Teacher 1 used pictures of a timeline when teaching the 'Timeline' topic in financial mathematics. The blind learners read embossed timeline diagrams in their braille book. In the case of teacher 2, she gave an embossed graph to blind learners in Lesson 4. However, she could have also given them wiki sticks, and embossed a Cartesian plane to plot their own graphs.

5.4 ASSISTIVE TECHNOLOGY DEVICES USED IN TEACHING MATHEMATICS

Section 2.4.2 shows that assistive technology devices in teaching mathematics to VI learners acts as a compensatory mechanism for the loss of sight (Buhagiar & Tanti, 2013; Smith et al., 2009). The data collected indicated that a significant number of hardware and software computer programs were available and accessible for the teaching of mathematics. While most of the hardware devices were used to enlarge the text for the partially sighted, software programs were used to translate the text to braille and make tactile sketches. From both the observations and interviews, the following devices were identified as listed in Table 5.2.

Table 5.2: The hardware and software program identified

Hardware	How it was used
Transformer HD	The teacher uses the Transformer HD to project his illustrations on the learners' CCTV screens.
CCTV screens	Magnifies text for partially sighted learners.
Talking calculators	Used by blind learners to perform calculations.
Perkins braillers	Used by blind learners to take notes and complete assignments.
Braille books	Used by blind learners to access the same content as the sighted learners in braille format.
A Ruby Max mouse	A handheld device that was used by the partially sighted learners to read text. It zooms in on mathematics text on a screen.
Software programs	
Math type and scientific notebook	These were used by the teachers to type mathematics symbols and formulas.
Tactile View program	Sketching diagrams that were embossed in a braille box.
View Plus program	A sketching diagram that was embossed in a tiger printer.
Duxbury computer program	Used by the teachers to translate text to Unified English Braille (UEB).

5.4.1 The hardware devices that enlarge mathematics text

a) Transformer HD

Partially sighted or low vision learners have diminished vision that hinders them from processing visual information like normal sighted learners do (La Voy, 2009). Therefore, the learning material has to be enlarged to a comfortable font for each learner during mathematics experiences. From the findings in this study, both teachers used a transformer HD connected to CCTV screens to enlarge the text and illustrations. Teacher 1 had an old model Transformer HD and used it to project illustrated mathematics examples onto the CCTV. This assistive device could reduce or enlarge the font size of the text and sketches as the learners desired with the press of a button. Teacher 1 wrote normally on the paper under the transformer HD, and every partially sighted learner could read the text with the adjusted magnification.

Teacher 2 used a modern transformer HD that had many functions. It could enhance contrast, which works for individual partially sighted learners and could be connected to a laptop. The most used features on the Transformer HD was to adjust the magnification of the text on the learners' screens for comfortable accesses of mathematics content.

b) CCTV screens

The partially sighted learners relied on the CCTV screens to read the magnified mathematics content. The Grade 10 learners used the old model screen, while the Grade 9 learners had wide, modern flat screens that could be changed to a preferred background screen colour.

c) Ruby magnifier

The partially sighted learners whose sight was so poor that they could only read well from font 18 and above used a handheld magnifier called a Ruby. The devices gave the partially sighted learners the flexibility of reading an enlarged text in the textbook or see detailed sketches at their preferred time and place by simply placing the device on top of the text. This promoted independence in completing homework and assignments. The use of a Ruby was observed in the Grade 10 class (see Photograph 4.12). Additionally, the device had a built-in LED light that enhanced the lighting on the screen. Therefore, it could be used in rooms with dim light.

d) Max mouse

The Max mouse is a dynamic device that is used to zoom in and zoom out of text by dragging the mouse on a written text. From the observations, a Grade 10 magnified and displayed the text on the CCTV screen (see Photograph 4.11). The font of the text could be adjusted for the partially sighted learners to read.

5.4.2 Hardware devices used by the blind learners to write mathematics

Blind learners can participate in classroom activities, complete mathematics tasks independently and achieve academic goals just as sighted learners do if given assistive devices to use. In this study, the assistive devices used by the blind learners to access mathematics were Perkins braillers, talking calculators and other materials.

a) Perkins braillers

Perkins braillers were the tools used by blind learners in all of the observed lessons to write exercises, assignments, take notes and any other content that needed to be jotted down. The braillers used by Grade 9 and 10 learners were the old model, which is believed to be durable and produces quality braille. Perkins braillers make mathematics accessible and promote the independence of blind learners, as confirmed by Smith (2008) in literature.

b) Scientific talking calculators

From both the observations and interviews for the two teachers, scientific calculators were valued for blind learners just like the standard calculator is for the sighted. The calculators have an inbuilt speech synthesizer that speaks out when any key is pressed. The Grade 10 blind learners used talking calculators as the primary instrument for calculating more advanced problems in financial mathematics quicker and more accurately. This made mathematics learning easier as they focused on concept development rather than tiring themselves with mental computations. Additionally, the devices allowed them to operate independently in their homework and assignments.

To avoid the discomfort of noise from the talking calculators, all of the observed calculators were fitted with headphones so that the sound was only heard by each learner. The calculators also had volume adjustment buttons for lowering and switching off the sound.

5.4.3 Software programs used to convert mathematics content to braille

Blind learners read braille by feeling with the tips of their fingers. Changing the curriculum content to accommodate them requires the desired text to be translated into braille. Translating mathematics text requires special programs, such as those discussed in Section 2.4. This refers to programs that can encode all mathematical symbols and formulae. Two computer programs were found to be useful in adapting curriculum content. These were: Scientific Notebook and Math Type.

a) Scientific Notebook

The Scientific Notebook is a computer program with built-in mathematical symbols and formulae. Therefore, it has great potential for all mathematics algorithms to be written (see Section 4.2.3). Teacher 1 translated his mathematics text through this program. From his explanation, it can be seen that when any mathematical text was written in a scientific notebook, the content could be translated using the UEB braille program known as Duxbury. After all the text had been translated, the translated text was embossed in a Braille Box.

Teacher 2 did not make use of the Scientific Notebook program. Instead, she preferred to use Math type, which was equally as good.

a) Math Type

Math Type is an online computer program with symbols, operations and formulae that are used to write mathematical text (see Section 4.3.1). Teacher 1 preferred the Scientific Notebook program and did not use Math Type.

Teacher 2 indicated that in her class the mathematics text was written in the Math Type program and translated into UEB braille, after which the embossed braille text was similar to the original text.

5.4.4 Software programs used to create tactile sketches

Tactile View and View Plus were the computer programs used to sketch graphs, diagrams and other illustrations. Teacher 1 sketched graphs in the View Plus program and embossed them in the Tiger printer. View Plus, together with the Tiger printer produced high-quality tactile sketches, which were quality texture for the blind learners (see Photographs 4.17 and 4.18). However, the program was complex to use and required time and experience.

Teacher 2 used the Tactile View program, which was easy and quick to use for sketches. However, the produced sketches were not of a high quality, but good enough to be useful for the blind learners (see Photograph 4.21).

5.5 CONCLUSION

The study started with a discussion of the challenges experienced by teachers when teaching mathematics to VI learners. The discussed challenges were: inadequate skills in teaching VI learners, a lack of skill in using braille, time constraints, bulk braille books and missing information, a lack of home support structure, and failure of technology. Experienced and trained teachers were found to use different approaches to help the VI learners construct mathematics knowledge. The study identified the approaches that could be successfully used as direct instruction, scaffolding, contextual learning, peer tutoring and problem-solving.

From the discussion, both the teachers used assistive technology to adapt and modify the curriculum to accommodate all VI learners. From the observation, the Transformer HD, Ruby and Max mouse were the hardware tools used to enlarge the text to a comfortable font for the partially sighted learners. The Scientific Notebook, Math Type and Duxbury computer programs aided in translating mathematics text to braille, while View Plus and Tactile View were found to be essential in producing tactile diagrams.

CHAPTER 6 SUMMARY OF THE FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

6.1 INTRODUCTION

This study aimed to investigate the instructional strategies used by mathematics teachers to help VI learners construct mathematics knowledge. The data collected from classroom observations and semi-structured interviews were recorded in Chapter 4. The findings from the empirical investigation were linked to the literature and theoretical framework and discussed in Chapter 5. In this chapter, the research questions will be answered, the limitations of the study identified, and recommendations for future research topics suggested. Thereafter, the implications and the reflection on the study will be presented.

6.2 SUMMARY OF THE STUDY

The purpose of the study was to explore the strategies used by mathematics teachers to help VI learners construct mathematics knowledge. The focus was on understanding the challenges experienced by mathematics teachers, their classroom approaches, and the assistive technology devices they used to teach VI learners. The main research question for the study was: How can the instructional strategies used by mathematics teachers to facilitate VI learners' construction of knowledge be described? To meet the objectives of this inquiry, three secondary questions were explored. These were:

1. What are the challenges experienced by mathematics teachers in teaching mathematics to VI learners in high school?
2. What are the instructional approaches used by mathematics teachers to help VI learners construct mathematics knowledge?
3. Which assistive devices are used to enhance the acquisition of mathematics knowledge by the VI learners?

To answer each of these questions, the researcher will synthesise and summarise the discussion of the findings as discussed in Chapter 5.

6.3 SUMMARY OF THE FINDINGS

6.3.1 Challenges experienced by the mathematics teachers

Most teachers who teach mathematics to VI learners possess a Bachelor's degree in mathematics that allows them to teach in mainstream education (Louw, 2015; Hassan & Salleh, 2017; Maguhve, 2015). Therefore, they experience challenges when they have to teach in a special needs school with VI learners. The study's findings showed that inadequate skills in teaching VI learners, a lack of skills in using braille, time constraints, a lack of learners' home support structure, and a failure in technology were some of the challenges encountered by these mathematics teachers.

Teacher, 2 had no formal training and little experience in teaching VI learners. From my observations, she struggled to teach the topic on graphs to the partially sighted. Additionally, during the interview, she expressed the frustration that she experienced in teaching the topic of 'measurements' to blind learners. This was contrary to the findings of Teacher 1, who had formal training in teaching VI learners and had over 30 years' of teaching experience. Teacher 1 created opportunities for all learners to constructively participate in the lesson. Even with the challenging topic of 'circle geometry', he found alternative methods of teaching it so as not to disadvantage the blind learners.

According to Kapperman et al. (1997), teachers who teach mathematics to VI learners are expected to introduce new braille code to the learners as they appear in the text. It is clear that a lack of knowledge in braille poses a great challenge to teaching (Bayram, 2014). Teacher 2 could not read the learners' braille work and found it difficult to assist the blind learners to open the correct page in the braille book that corresponded with the sighted copy.

Accordingly, due to the slow nature of learning by VI learners (see Section 2.1.1), both teachers expressed the pressure they experienced in covering all of the content in the syllabus satisfactorily. Another challenge the teachers encountered was the many braille booklets that were equivalent to one sighted textbook and the missing information in the braille books. Further still, a lack of home support structure was a challenge. Teacher 1 expressed his disappointment in parents who did not work with him to support the VI learners academically.

Lastly, there were instances where assistive technology occasionally failed due to power outages or mechanical failure. Failure in technology disrupts the lesson. From one of the observations, when the CCTV screens in Teacher 1's class were not working properly, the teacher resorted to talking without illustrations for the partially sighted.

6.3.2 Instructional approaches used by mathematics teachers

The analysed data revealed that five constructivist approaches were used to help learners construct mathematics knowledge. The identified approaches were: contextual, direct instruction, peer tutoring, scaffolding and the problem-solving approach (see Section 2.3). According to the literature, there is no single approach to teaching mathematics that is deemed perfect for all teachers (Louw, 2015). The choice of an approach to be used in facilitating the construction of knowledge depended on these teachers' skills and experience in teaching the VI learners and the influence the approach would have on the construction of knowledge (Rule et al., 2011).

Analysing the approaches, as presented in Table 5.2, the preferred approach to facilitating mathematics to VI learners was scaffolding. A possible explanation could be the fact that scaffolding is a constructivist approach that is interactive and provides the teacher with an opportunity to guide and support the VI learner to achieve his/her potential. As Noriega and Zambarano (2011) argue, scaffolding provides an opportunity for learners to understand classroom activities that they could not understand before without support. Furthermore, scaffolding enables learners to be actively involved in the lesson and construct their knowledge as the teacher assumes the role of a facilitator (Bozkurt, 2017).

Apart from the scaffolding approach, another constructivist approach used by the two teachers was direct instruction. While Teacher 1 used direct instruction only twice in his teachings, Teacher 2 utilised it in all five observed lessons. She explained the concept systematically then gave the learners activities to practice.

Another constructivist approach used by the two teachers, but to a limited degree, was problem-solving. Problem-solving increases the ability to construct mathematics knowledge while reducing memorisation (Rule at el., 2011). From this finding, it was clear that Teacher 1 taught problem-solving, according to Polya's (1957) steps of problem-solving.

6.3.3 Assistive devices used to enhance the acquisition of mathematics knowledge by VI learners

As already discussed in Section 2.4.2, the use of assistive technology devices in teaching mathematics to VI learner acts as a compensatory mechanism for the loss of sight (Buhagiar & Tanti, 2013; Smith et al., 2009). Additionally, the use of assistive devices in teaching mathematics to VI learners provides independence for the learner and helps to eliminate barriers to learning (Mugo, 2015). In this study, four categories of assistive technology devices were identified (see Table 5.1). These were: assistive technology devices used to enlarge text, the assistive technology used by blind learners (braille and talking calculators), the assistive technology used to change the text to braille, and the assistive technology used to emboss diagrams. In this study, a Transformer HD, CCTV, Max mouse and Ruby were the assistive technology devices used to enlarge text.

Perkins braillers and scientific talking calculators were the assistive devices used by blind learners to access mathematics. Perkins Braillers were used to take notes and write the tasks given by the teacher. Scientific talking calculators were used to calculate taxing problems and to check the accuracy of their answers.

Two computer programs, Math Type and Scientific Notebook, together with the Duxbury braille translator, were used to translate the mathematics text to braille. The mathematics text was typed in Math Type or Scientific Notebook and then translated to braille by the Duxbury braille translator program. Thereafter, the translated work was embossed into braille through a braille box embosser. The braille format made it possible for blind learners to access the same curriculum content as sighted learners.

View plus and Tactile View were the computer programs that produced embossed sketches. In addition, a simple tracing wheel could also be used to make a single tactile diagram without the use of computer programs (see Photograph 4.14).

6.4 CONCLUSIVE REMARKS CONCERNING THIS STUDY

Blind learners have limited or no sight input in their construction of knowledge. Teachers facilitating learning for these learners require extra skill other than their general Bachelor's degree. From the study, it emerged that teachers teaching mathematics to VI learners experience challenges because they lack formal training to teach in special needs schools.

The results from the investigation showed that the approaches used to teach mathematics in mainstream schools could be adapted and used in special needs schools with VI learners. The experience and formal training of those teaching in special needs schools play a significant role in the choice of the approach to use to help VI learners construct knowledge. These approaches were: contextual, direct instruction, peer tutoring, scaffolding, and the problem-solving approach.

Transforming the mainstream curriculum content to make it accessible for VI learners is made possible with the use of assistive technology. The technology is used to enlarge the text to accommodate the partially sighted learners. In the case of blind learners, the text is converted to braille while sketches are made tactile. Assistive devices provide opportunities for VI learners to achieve educational goals competitively alongside sighted learners.

6.5 IMPLICATION OF THE FINDINGS

Teaching mathematics to VI learners requires a skilled and experienced teacher to adapt the curriculum and choose the appropriate approach to facilitate learning. Teacher 1, who had formal training and experience in teaching mathematics to VI learners, involved all of his learners in learning. He varied his approach to teaching, and the learners seemed to understand the lessons.

Alternatively, Teacher 2, who had no formal training and limited experience in teaching mathematics to VI learners, experienced challenges in teaching. Her learners did not get the concept of sketching a graph. From the study it can be deduced that for special needs schools with VI learners to introduce mathematics at FET phase, all mathematics teachers should be equipped with the necessary skills to teach these learners. This can be done through organising separate in-service teacher training and workshops for mathematics teachers who teach VI learners. Currently, the workshops that these teachers attend are mainly for the benefit of those in mainstream education.

6.6 RECOMMENDATIONS FOR THE FUTURE

The national government, through the Ministry of Education Science and Technology, should open vocational training centres to equip teachers with the necessary skills to teach VI learners. These will motivate potential teachers in another special needs school for the blind to teach mathematics to blind learners at FET phase in their respective schools.

My research was broad in covering three themes: the challenges experienced by the teachers, the approaches used, and the assistive technology in their classrooms. For future studies, in-depth research of each of these themes should be conducted to understand in detail how teachers should facilitate the construction of mathematics by VI learners in high school.

Many South African special needs schools do not offer mathematics to VI learners at FET phase level. The foundation of learning mathematics at primary level should be emphasised because it influences the attitude and ability of learners to learn mathematics at a higher level.

6.7 FINAL REFLECTIONS

I am glad that I did my research on this topic. It has developed and improved my practice of teaching mathematics to VI learners at the high school level. Through the literature review and experiences in the field, I understand more about the VI learners, their needs and emotions. I have experienced the challenges that these teachers encountered while teaching mathematics, and the ways of overcoming these challenges. I have understood the approaches used in facilitating mathematics to VI learners and the many assistive technologies in the market that can be used to mediate learning.

From the study of the literature, I discovered that very little research has been done on teaching mathematics to VI learners in South Africa as compared to other countries. More resources and attention should be directed to this category of learners because they can achieve more than we believe.

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ADDENDA

Addendum A:

- Re: Approval in Respect of Request to Conduct Research
- GDE Approval letter
- Ethics Committee approval letter

Addendum B:

- Request for permission to conduct research in your school
- Request for your participation in the study
- Permission to be present during the research
- Parents' notification letter

Addendum C:

- Semi-structured interview questions
- Observations checklist used during lesson presentation

ADDENDUM A

Approval in Respect of Request to Conduct Research

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the DistricUHead Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

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Making education a societal priority

Office of the Director: Education Research and Knowledge Management

7th Floor, 17 Simmonds Street, Johannesburg, 2001

Tel: (011) 355 0488

Email: Faith.Tshabalala@gauteng.gov.za

Website: www.education.gpg.gov.za

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.
2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.

3 A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.

4. A letter/ document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.

5 The Researcher will make evety eff01t obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be pena[ised in any way.

6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.

7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.

8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.

9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.

10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.

11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.

12. On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.

13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.

14. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

……………………………………………………………

Ms Faith Tshabalala
Acting Director: Education Research and Knowledge Management

DATE: . aq oe/aøŽ&……………………

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Office of the Director: Education Research and Knowledge Management

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Website: www.education.gpg.gov.za

GDE research approval letterer

GAUTENG PROVINCE

Department: Education

REPUBLIC OF SOUTH AFRICA

814141112

GDE RESEARCH APPROVAL LETTER

Date:	24 August 2018
Validity of Research Approval:	05 February 2018 — 28 September 2018 2018/258
Name of Researcher:	Liaga M.M
Address of Researcher:	287 Bootes street
	Waterkloof Ridge
	0181
Telephone Number:	012 460 2621 072 187 4651
Email address:	mary.liaga@yahoo.com
Research Topic:	Classroom instructional strategies employed by mathematics teachers in teaching visually im aired learners.

Type of qualification	Masters
Number and type of schools:	One Secondary School
District/s/HO	Tshwane West.

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Faculty of Education

Ethics committee approval letter

Ethics Committee 16 August 2018

Ms Mary Liaga

Dear Ms Liaga

REFERENCE: SM 18/05/02

We received proof that you have met the conditions outlined. Your application is thus **approved**, and you may start with your fieldwork. The decision covers the entire research process, until completion of the study report, and not only the days that data will be collected. The approval is valid for two years for a Masters and three for Doctorate.

The approval by the Ethics Committee is subject to the following conditions being met:

1. The research will be conducted as stipulated on the application form submitted to the Ethics Committee with the supporting documents.
2. Proof of how you adhered to the Department of Basic Education (DBE) policy for research must be submitted where relevant.
3. In the event that the research protocol changed for whatever reason the Ethics Committee must be notified thereof by submitting an amendment to the application (Section E), together with all the supporting documentation that will be used for data collection namely; questionnaires, interview schedules and observation schedules, for further approval before data can be collected. Noncompliance implies that the Committee's approval is null and void. The changes may include the following but are not limited to:
   - Change of investigator,
   - Research methods any other aspect therefore and,

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- Participants.

The Ethics Committee of the Faculty of Education does not accept any liability for research misconduct, of whatsoever nature, committed by the researcher(s) in the implementation of the approved protocol.

Upon completion of your research you will need to submit the following documentations to the Ethics Committee for your

Clearance Certificate:

- Integrated Declaration Form (Form D08), • Initial Ethics Approval letter and,
- Approval of Title.

Please quote the reference number **SM 18/05/02** in any communication with the Ethics Committee. Best wishes

Prof Liesel Ebersöhn
Chair: Ethics Committee
faculty of Education

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ADDENDUM B

Request for permission to conduct research in your school

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Faculty of Education

Mrs M Liaga

278 Bootes Street,

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Pretoria 018

Mary.liaga@yahoo.com

Cell. 072187651

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN YOUR SCHOOL

Dear Principal

I am a Master's student at the University of Pretoria, Faculty of Education. The topic of my study is "Classroom instructional strategies employed by mathematics teachers to teach visually impaired learners." My study aims to identify the specific teaching instructional methods that can be utilised by mathematics teachers to make mathematics accessible to VI learners in high school. This will further allow teachers to identify ways of adapting and modifying the mathematics curriculum content into an accessible format. Finally, this study will help to establish the challenges encountered by mathematics teachers in teaching mathematics to VI learners in high school.

I intend to collect data for my study via semi-structured interviews and observations. The participants will be 2 teachers who are currently teaching mathematics to VI learners in Grades 9 and 10. The interviews will be conducted at a time and venue convenient to and preferred by the participants. Class observations will be done during normal class periods in the school setting. I intent to have two interviews that will last one hour each for each of the mathematics teachers, and six classroom observations each lasting 30 minutes for each of the two grades.

The normal teaching and learning routine will not be disturbed. The interview sessions will be audio taped, while lesson observation sessions will be videotaped.

Teacher participation is voluntary, and they can withdraw at any time should they wish to discontinue as participants. The identity of the school and all participants will be protected at all times using passwords. Only my supervisor and I will know which school and which teachers were involved in the research. The information provided by the participants will strictly be for the research purposes only.

I hereby seek your permission to conduct this study in your school and commit to provide feedback to the school in the form of a written report upon the successful completion of my Master’s degree programme. For any questions before or during the research, please feel free to contact me. Kindly confirm your acceptance by filling in the attached consent form.

Thank you in anticipation for your cooperation.

Yours sincerely

____

Name of student: Mary M. Liaga

Contact number for student: 0721874651

E-mail of student: mary.liaga@yahoo.com

____

Name of supervisor: Dr Sonja Van Putten

Contact number of supervisor:--

E-mail of supervisor: ---

I hereby grant consent to Mrs. Liaga to conduct her research at this school for her Master's Degree programme. Mrs Liaga has permission to video record the Grade 9 and 10 mathematics lessons as well as to capture audio records of the interviews with the Grade 9 and 10 mathematics teachers for use in her study.

School principal's name: ___________________________

School principal's signature: ________________________

Date: ____

Email address: ____

Request for your participation in study

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Faculty of Education

Mrs M. Liaga

278 Bootes Street,

Waterkloof Ridge Pretoria 0810

Cell. 072187651

Mary.liaga@yahoo.com

REQUEST FOR YOUR PARTICIPATION IN STUDY

Dear Mr/Miss/Mrs_____

I am a Master's student at the University of Pretoria, faculty of Science Mathematics and Technology. I will be conducting research to investigate classroom instruction strategies employed by mathematics teachers to teach mathematics to visually impaired (VI) high school learners. My study aims are:

- To identify the teaching instructional approaches that can be utilised by mathematics teachers to make mathematics accessible to VI learners in high school.
- To identify ways of adapting, modifying and transforming visual mathematics content to make it accessible for VI learners.
- To establish the challenges encountered by mathematics teachers in teaching mathematics to VI learners in high school.

I intend to collect data for my study via semi-structured interviews and observations. The interviews will be conducted at a time and venue convenient to and preferred by you. I intend to have two interview sessions that will last one hour each. Class observation will be done during normal class period in the school setting. I intend to observe six 30 minute mathematics sessions for each class observation.

The normal teaching and learning routines will not be disturbed. The interview sections will be audio recorded, while lessons observation sessions will be video recorded. Participation in this study is voluntary, and participants can withdraw from the study at any time. The identity of the school and all participants will be protected at all times using passwords. Only my supervisor and I will know which teachers participated in the research. The information provided by the participants will be strictly for research purposes.

I hereby seek your consent and participation in this study as a mathematics teacher to VI learners. After the successful completion of my Master's degree, I commit to provide feedback to the school in the form of a written report.

Yours sincerely

20/08/2018

Researcher: Mrs. Liaga M. Mary Date

23/08/2018

Supervisor: Dr Van Putten Date

Kindly confirm your acceptance by filling in the attached consent form.

Thank you in anticipation for your cooperation.

I hereby grant consent to Mrs M. Liaga to conduct her research in my class. Mrs Liaga has permission to video record my mathematics lessons and audio record the interviews. During interview sessions, I will answer the questions posed to me to the best of my Knowledge. Teacher's name: ____________________________

Signature: _________________________ Date: ___________________________

Email address: _______________________

Presence during research

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Mrs M. Liaga

278 Bootes Street, Waterkloof Ridge,

Pretoria,

Mary.liaga@yahoo.com

Cell: 0721874651

PRESENCE DURING RESEARCH

Dear Student

I am enrolled for a Master's degree programme in the department of Science Mathematics and Technology at the University of Pretoria. I intent to investigate classroom instruction strategies employed by mathematics teachers to teach mathematics to visually impaired learners.

As part of my investigations, I will observe some mathematics lessons during normal class period. During those observations, I will film your mathematics teacher presenting his/her lessons. This implies that I will be present during your mathematics lessons but will not be teaching you. You will participate in your mathematics lessons as usual. I will stand in a position where my focus will only be on your teacher and his/her activities.

The video recordings will only be used for my studies. The video recordings will be confidential and only accessible to me and my supervisor. You are welcome to contact me at any time should you have any questions regarding this research.

Yours sincerely

23/ 08/ 2018

Researcher: Mrs. Liaga M. Mbulika — Date

Supervisor: Dr Van Putten   Date; 23/08/2018

I hereby consent to having Mrs Liaga present in my mathematics class and acknowledge that I understand that she will be video recording my teacher.

Student name: ___________________________

Signature: ________________________

Date: _________________________

Grade ______________

Parents' notification letter

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14 August 2018

PARENTS' NOTIFICATION LETTER

Dear Sir/Madam

I am currently enrolled for a Master's degree in Mathematics Education at the University of Pretoria. My research is aimed at investigating how teachers teach mathematics to visually impaired high school learners.

This is to inform you that your son/ daughter_____ is a learner in the classroom where I intend to collect data by observing and recording the teacher's classroom instruction strategy. I will observe your child's mathematics teacher during six of their lessons. I will video record these lessons, as it will help me to have an accurate record of the teacher's classroom practice. When video recording the lesson, I will focus on the teacher and not on the learners in the class. The video recordings will be taken from the back of the class and I will only film the teacher. All video recordings will be password protected and will only be used for my Master's degree.

Both the children and the teacher are ensured of being treated with confidentiality and anonymity at all times, and only my supervisor and I will have access to the recordings. The data collected will only be used for academic purposes.

Yours sincerely

_____________ Date _____20/08/2018_____

Mrs. Mary Liaga

Supervisor ____  Date 23/08/2018

ADDENDUM C

Semi- structured Interview Questions

Good morning / afternoon / evening,

My name is Mrs Mary Liaga

The purpose of this interview is to gather information about your experiences in teaching VI learners. I would like to discuss with you the classroom instruction you employ in teaching mathematics to grade10/learners and the challenges you experience. Thank you very much for your time in advance!

1. What is your highest qualification?

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2. How long have you been teaching Mathematics to VI in grade 10/9?

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3. Did you receive formal or informal training to teach mathematics to VI learners? Give more details.

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4. What other learning area besides mathematics do you teach?

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5. What learning resources do you use in the Teaching mathematics to VI learner?

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6. Do you consider the resources sufficient for you, other teachers and for the learners?

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7. How do you use Assistive devices in teaching mathematics to VI learners

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8. What challenges do you experience as a teacher in the use of the Computer Software for teaching/learning of mathematics?

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9. Is there difference between the mathematics curriculum content taught in special school like your institution and that of the main stream?

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10. How do you modify the mainstream curriculum to make it accessible to the Visually Impaired learners without compromising on the learning outcome? Illustrate how you 1. Convert print text to braille and 2. Sketches to embossed tactile sketch.

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11. Mathematics is claimed to be abstract and its abstractness increase as you move high in the grade. Are there mathematics topics you skip when teaching VI learners?

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12. What teaching approaches do you use to teach mathematics to the Visually Impaired learners?

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13. What challenge do you encounter in teaching mathematics to VI learners?

Observations checklist used during lesson presentation

Observations check list used during lesson presentation

Date____________ Time ____________Grade__________

Topic____

Aspects to be observed	**Blind**	**Sighted**
Size if the class		
Books available		
Assistive technology used in the lesson		
Programmes used to emboss diagrams, charts and graphs		
Adapted teaching materials available: Embossed sketches enlarged materials and brailed pieces.		
The direct approach in the teaching of mathematics concepts and learners involvement.		

Use of contextual learning. The teacher uses examples from the immediate environment. Involvement of all learners.	
Learning in small groups or peer tutoring. Teachers support	
Use of scaffolding approach to teaching mathematics. The learner's participation	
Steps followed in problem-solving approach. Learners participation	
The use of manipulatives material in the lesson.	
Challenges experienced by the teacher during the lesson presentation.	