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Teaching mathematics to oral hearing impaired learners in an inclusive environment

by

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A dissertation submitted in fulfilment of the requirements for the degree

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Declaration

I declare that the dissertation, which I hereby submit for the degree **Magister Educationis (MEd)** at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Linda le Hanie

28 September 2017

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Ethics statement

The author, whose name appears on the title page of this dissertation, has obtained, for the research described in this work, the applicable research ethics approval. The author declares that she has 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*.

Linda le Hanie
28 September 2017

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ABSTRACT

Inclusive education came into the spot light with the World Conference on Special Needs Education: Access and Quality, held in Salamanca, Spain in June 1994. The problem investigated in this study is how teaching oral hearing impaired learners in an inclusive school affects the classroom practice of the mathematics teacher as teaching-and-learning expert. In this study, the term *hearing impaired* refers to learners with a bilateral, moderate to profound hearing loss who have hearing aids and/or cochlear implants. These learners communicate orally, in other words, they have developed spoken language and do not communicate using sign language.

The study focused on the classroom practice of three teachers in three different phases, namely the Intermediate Phase (Grade 4-6), the Secondary Phase (Grade 7-9) and the Further Education and Training phase (Grade 10-12) and explored how they teach mathematics to Hearing Impaired (HI) learners in an inclusive school. A qualitative research approach was followed and the research design was an exploratory case study. The data was collected in an inclusive school that includes oral HI learners which was purposefully chosen due to its model of inclusion where oral HI learners attend the same classes and lessons as their hearing peers.

Three data collection instruments were used, namely semi-structured interviews, lesson observations and documentation analysis. The data was analysed deductively according to the themes reflected in the conceptual framework. The conceptual framework was based on ten practices mathematics teachers should apply when teaching HI learners (Easterbrooks & Stephenson, 2006), but through the lens of the mathematics teacher as teaching-and-learning expert and the language factors in teaching mathematics to HI learners. The research revealed that not all teachers who teach at an inclusive school truly understand the concept of inclusion and that continuous training is a pre-requisite for inclusion to be successful.

Key words: Inclusive education; hearing impaired; mathematics; teaching and learning; language factors.

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To Whom It May Concern

Re: Certification of Editing –Master's Dissertation in Education

This letter serves to confirm that Linda le Hanie submitted a Master's Dissertation to myself for editing. The dissertation is entitled, '**TEACHING MATHEMATICS TO ORAL HEARING IMPAIRED LEARNERS IN AN INCLUSIVE ENVIRONMENT**'.

The following aspects were edited:

- Spelling
- Grammar
- Consistency of layout
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Should you have any further queries, please do not hesitate to contact me.

Kind regards,

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LIST OF ABBREVIATIONS

FET........ Further Education and Training

HI………. Hearing Impaired

IP………. Intermediate Phase

LP……… Language Proficiency

PTI……… Professional Teacher Identity

SP………. Senior Phase

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Chapter 1

Introduction and contextualisation

1.1 Introduction

Teaching, we say, is the passageway through which all education reforms must travel if they are to make it through the classroom door and, ultimately, improve students' learning (Stigler, 1999, p.xi).

Inclusive education came into the spot light with the World Conference on Special Needs Education: Access and Quality, held in Salamanca, Spain in June 1994. During the abovementioned conference, a framework for action on special needs education was adopted, with the guiding principle that "schools should accommodate all children regardless of their physical, intellectual, social, emotional, linguistic or other conditions" (UNESCO, 1994, p.6). This framework was adopted by 92 countries and influenced local legislation. In response, section 5(1) of the South African Schools Act, 1996 (Act 84 of 1996) states that "[a] public school must admit learners and serve their educational requirements without unfairly discriminating in any way".

1.2 Background

In the Report on the Implementation of Education White Paper 6 on Inclusive Education (2015) the Department of Basic Education mentions that attitudes should be changed across the system and a commitment to an inclusive education system was necessary. For it to be achieved, training on a large scale as well as the monitoring thereof should be in place. The Gauteng Department of Education's Disability Right Policy (2014), quotes the broad definition of disability that was approved by the South African Cabinet as the

> loss or elimination of opportunities to take part in the life of the community, equitably with others that is encountered by persons having physical, sensory, psychological, developmental, learning, neurological or other impairments, which may be permanent, temporary or episodic in nature, thereby causing activity limitations and participation restriction with the mainstream society (p.7).

The disability in question is hearing loss. It is important to distinguish between *deaf*, *Deaf* and *hearing impaired*. Easterbrooks (1997) refers to the federal definition of *deaf* as people with a hearing loss which "adversely affects educational performance and which is so severe that the child is impaired in processing linguistic (communication) information through hearing, with or without amplification (hearing aids)"(p.2). The term *Deaf* with a capital 'D' refers to people with a hearing loss identifying with the Deaf Culture where they make use of sign language for communication (Padden & Humphries, 1988). *Hearing impaired* is a term that is used inconsistently. Some people use it to refer to those who are hard of hearing, while others use it to refer to all degrees of hearing loss (Easterbrooks, 1997). In this study, the term *hearing impaired* will be used to refer to learners with a bilateral (in both ears) moderate to profound hearing loss and who have hearing aids and/or cochlear implants. These learners communicate orally, in other words, they have developed spoken language (Clark, 2007) and do not communicate using sign language.

1.3 Rationale

I started my teaching career in 2001 after completing a Higher Education Diploma in Natural Sciences with mathematics, chemistry and physics as majors. During the first seven years of my teaching career, my main focus was on teaching mathematics to high school learners in Grade 8 – 11 in a mainstream school. From 2008 - 2016 I taught at an inclusive private primary school where I was responsible for Grades 6 and 7 mathematics. This inclusive school accommodates a small number of Hearing Impaired (HI) learners who learn alongside their hearing peers in an inclusive environment, from now on called 'an inclusive school'.

I empathised with the HI learners since I have a unilateral hearing loss myself from contracting mumps at the age of nine, which resulted in me becoming profoundly deaf in my left ear. I understood something of the frustration that the HI learners experienced and therefore I made it my mission to assist those learners to learn mathematics using a spoken language. The aim at the inclusive school is not to teach and communicate with HI learners using sign language, but to make a difference in deaf education by teaching the HI learners a spoken language in order for them to communicate orally.

The nine years at the inclusive school have taught me that with the correct input, favourable conditions and a lot of hard work, the HI learners can achieve their goals. It also revealed that if a learner cannot communicate clearly due to certain barriers, one cannot assume that that learner does not have the required mental ability. Im and Kim (2014) found that low achievement with regard to HI learners is mainly due to poor literal ability and not a low intellectual ability. At the end of 2014, one of the first HI learners to whom I taught mathematics in Grade 6 and 7, got a distinction for mathematics in Grade 12 and is currently studying engineering at a local university.

I realised, especially when teaching mathematics, that it is possible for the HI learners to keep up with the rest of the class when the calculations are demonstrated on the board. The HI learners have a better understanding of what to answer if they see the questions in comparison with the teacher posing questions orally (Liu, Chou, Liu & Yang, 2006). However, problems arise with the explanation of new principles and the use of unfamiliar vocabulary. Learners suffer if mathematics concepts are not “introduced and explained in oral language that moves from ordinary language that students already understand to the more technical language that they need to develop for full understanding of the concepts” (Schleppegrell, 2007, p.156).

For success to be achieved with the HI learners, I had to undergo continuous training in the methodology of teaching HI learners, and had to adapt my manner of teaching to focus specifically on the language used, for example, clarifying words and rephrasing the instructions where necessary. This lies at the base of the research.

1.4 Problem statement

The World Conference on Special Needs Education: Access and Quality, held in Salamanca, Spain in June 1994 brought about a more prominent focus on inclusive education. The result is the recognition of the need for continued professional teacher development in order to implement inclusive education successfully (Department of Basic Education, 2015). The problem addressed in this study is how teaching oral HI learners in an inclusive school affects the classroom practice of the mathematics teacher as a teaching-and-learning expert.

1.5 Purpose of the study

The purpose of the study is to explore how mathematics teachers teach mathematics to oral HI learners in an inclusive school, with the focus on their teaching-and-learning. The ultimate goal of the study is to hopefully make a contribution towards improving the quality of teaching and learning in South African mathematics classes in an inclusive school.

1.6 Research questions

The following primary and secondary research questions guided the study:

Primary research question

How do mathematics teachers teach oral hearing impaired learners in an inclusive environment?

In order to answer the primary question, the following secondary research questions were asked:

Secondary research questions

1. How can the classroom practices of the mathematics teachers as teaching-and-learning experts be described?
2. What are the language factors that need to be considered when teaching mathematics to hearing impaired learners?

1.7 Methodological considerations

The research paradigm that underpinned this study is social constructivism which recognises that "all knowledge is constructed and based upon not only prior knowledge, but also the cultural and social context" (Botha, 2011, p.69). Interpretivism is also sometimes referred to as constructivism (Nieuwenhuis, 2016). This study is subjective in nature with the ontological assumption of *idealism*. Nieuwenhuis (2016) described idealism when he stated that "reality is only knowable through the human mind and through socially constructed meanings" (p.58). The assumption of epistemology relates to how things can be known - how one can discover and disclose truths or facts or physical laws, if they do exist (Nieuwenhuis, 2016). The emphasis in this study is on the point of view of the insider (participant) and not on the point of view of the outsider (researcher).

A qualitative research approach was followed in order to answer the research questions as the study is concerned with "specific meanings, emotions and practices that emerge through the interactions and interdependencies between people" (Hogan, Dolan & Donnelly, 2009, p.4). Nieuwenhuis (2016) remarks that all qualitative research is naturalistic, meaning it focuses on natural settings where interaction occurs.

The research design is an exploratory single case study. Simons (2009) defined a case study as "an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, programme or system in real life context. It is research-based, inclusive of different methods and is evidence-led" (p.21).

This study focuses on the classroom practices of three teachers in three different phases, namely the Intermediate Phase (IP) (Grade 4 - 6), the Secondary Phase (SP) (Grade 7 - 9) and the Further Education and Training phase (FET) (Grade 10 - 12) and explores how they teach mathematics to HI learners in an inclusive school. All three of the teachers teach at the same private inclusive school in Gauteng, South Africa and were purposefully chosen. The teachers chosen to participate from the SP and FET are the ones with the most experience in teaching mathematics at the specific inclusive school. The teacher chosen from the IP is the one teaching the highest grade in the phase and with the most experience in teaching in an inclusive school.

The data was collected at an inclusive school that admits oral HI learners - in other words HI learners using spoken language to communicate. Three data collection instruments were used, namely interviews, lesson observations and document analysis. There were two semi-structured interviews per teacher. One interview took place before the observation of any lessons and the second interview after the observation of the second lesson. Two lessons per teacher were observed. Interview schedules and observation schedules were used. Documentation in the form of preparation files and/or recent class tests were also collected and analysed. ATLAS.ti 7 was used to analyse the data deductively according to the categories/themes reflected in the conceptual framework (see Figure 2.2). The conceptual framework was based on ten practices mathematics teachers should apply when teaching HI learners (Easterbrooks & Stephenson, 2006), but through the lenses of the mathematics teacher as teaching-and-learning expert as well as the language factors that need to be considered when teaching mathematics to oral HI learners in an inclusive school.

To ensure validity, four of the eight validity strategies Creswell (2014) mentions were used, namely triangulation (the usage of different data sources); member checking (my understanding and interpretation of the interviews was taken back to the participants to confirm accuracy); rich, thick descriptions (to convey the findings) and clarification of bias (for instance how my interpretation of the findings is shaped by my background).

In order to maintain confidentiality and anonymity, a pseudonym was assigned to each participant. To ensure that the study adhered to the research ethics requirements, permission was obtained from the Ethics Committee at the University of Pretoria. Consent was given by the private school's director and principals, the mathematics teachers as well as the parents of the learners. The learners had to give assent themselves.

1.8 Concept clarification

Since there are various definitions of the concepts in literature, as discussed in the literature review, it is necessary to clarify the concepts in the context of this research and how they will be used in this study:

Deaf (capital 'D')	People with a hearing loss identifying with the Deaf Culture and using sign language for communication (Padden & Humphries, 1988).
deaf (lowercase 'd')	People with a hearing loss that affects educational performance and causes impairment in processing linguistic information through learning, with or without hearing aids (Easterbrooks, 1997).
Hard of hearing	Refers to a hearing loss where there may be enough residual hearing that an auditory device, such as a hearing aid or FM system, provides adequate assistance to process speech (University of Washington, 2017).
Hearing impaired	For the purpose of this study, refers to learners with a bilateral moderate to profound hearing loss and who have hearing aids and/or cochlear implants and communicate orally.
Inclusion	All learners get support. Developing of good teaching strategies so all the learners can benefit (Department of Education, 2001).
Integration	Learners have to fit into a particular system or be integrated into an existing one (Department of Education, 2001).
Oral	Learners communicating with spoken language and not using sign language.
Soundfield	A soundfield system consists of a wireless microphone and one or more loudspeakers which amplify the teacher's voice around the class (The Dynamic SoundField benefits leaflet, 2010). The system continuously measures the classroom's noise level and automatically optimises its own configuration, ensuring speech remains loud and clear (Brochure Roger Dynamic SoundField, 2016).

1.9 Possible contributions of the study

Since the World Conference on Special Needs Education: Access and Quality, held in Salamanca, Spain in June 1994, there is a more prominent focus on inclusive education worldwide. This study is an attempt to make a contribution to the understanding and execution of inclusive education in South Africa, particularly relating to mathematics teaching.

1.10 The structure of the dissertation

The dissertation consists of five chapters. The introduction and contextualisation constitute this first chapter. Chapter 2, consists of the literature review and conceptual framework, and provides an in-depth analysis and synthesis of the relevant literature and explains the conceptual framework on which this study is based. In Chapter 3 the methodology used in this study is explained. The selection of the participants, research site, data collection instruments, and data analyses procedures are discussed, as well as the trustworthiness of the study and ethical considerations. Chapter 4 consists of the presentation and analyses of the findings based on the data obtained. The findings are discussed and supported by the literature review and conceptual framework. The research questions are also answered. Chapter 5 contains the conclusions and implications as well as a chapter summary, concluding remarks concerning the study, recommendations and limitations of the study, and lastly a final reflection on the study.

What follows is the chapter outline (Table 1.1) of the dissertation.

Table 1.1: Chapter outline

Chapter 1	**Introduction and contextualisation** • Introduction • Background • Rationale • Problem statement • Purpose of the study • Research questions • Methodological considerations • Concept clarification • Possible contributions of the study
Chapter 2	**Literature review and conceptual framework**
Chapter 3	**Research design and methods** • Research paradigm and assumptions • Research approach and design • Research site and sampling • Data collection techniques • Data analysis strategies • Quality assurance criteria • Ethical considerations
Chapter 4	**Presentation and discussion of the findings** • Data collection process • Data analysis strategies • Information regarding the participants • Discussion of themes • Findings, trends and explanations
Chapter 5	**Conclusions** • Chapter summary • Significance of the study • Limitations of the study • Implications of the study

Chapter 2

Literature review and conceptual framework

This chapter commences with the clarification between two concepts, namely **inclusion** and **integration**. A subsequent discussion of **Professional Teacher Identity (PTI)** addresses expert teacher as well as teacher knowledge. The three PTI categories from Beijaard, Verloop and Vermunt (2000) are considered, where after **teaching-and-learning practices for HI learners** based on Easterbrooks and Stephenson's (2006) ten practices a mathematics and science teacher should use when teaching HI learners, are discussed. The **language factors in teaching mathematics for HI learners** are then addressed under the headings of language and learning, mathematics register, language proficiency and language factors for HI learners. The last part of the chapter consists of the conceptual framework and a discussion of how it was generated by linking the two themes, namely **mathematics teacher as teaching-and-learning expert** and **language factors in teaching mathematics for HI learners** to the adapted practices from Easterbrooks and Stephenson (2006). The adapted practices assigned to the theme of **mathematics teacher as teaching-and-learning expert** are: the role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancement of visual organisers and use of technology. The adapted practices assigned to the theme of **language factors in teaching mathematics to HI learners** are language of instruction: mathematics to language of instruction; and mediating textbooks and documentation.

2.1 Inclusive Education

In answer to the question 'What is inclusive education?', the Department of Education's White Paper 6 on Special Needs Education (2001) lists a few characteristics of inclusive education and training. For instance, inclusive education and training entails that the participation of all learners in the culture and the curricula of educational institutions is maximised and barriers to learning are uncovered and minimised. The Department of Education also acknowledges that some learners may need more focused and specialised forms of support in order to be able to reach their full potential. They conclude that inclusive education and training systems can provide different levels and kinds of assistance to learners and teachers.

In order to enhance the understanding of the implication of inclusion, the Department of Education distinguishes in White Paper 6 between mainstreaming or integration, and inclusion (See Table 2.1 below).

Table 2.1: The difference between 'Mainstreaming' or 'Integration', and 'Inclusion'

'Mainstreaming' or 'Integration'	'Inclusion'
Learners have to fit into a particular system or are integrated into an existing one.	Acknowledges differences among all learners and builds on similarities.
Give some learners extra support in order to be able to fit into a 'normal' classroom routine.	All learners get support. Developing of good teaching strategies so all the learners can benefit.
Focus is on learners to change and not the system.	Focuses on adaptation of the system to overcome barriers that prevent learners from reaching their potential.

Find below an expansion of the three differences between mainstreaming or integration and inclusion as seen in Table 2.1 (Department of Education, 2001).

2.1.1 Mainstreaming or integration

- *Learners have to fit into a particular system or are integrated into an existing one*. The emphasis falls on getting learners with special needs to fit into a particular kind of system or to accommodate them in an existing system.
- *Give some learners extra support in order to be able to fit into a 'normal' classroom routine*. In this case the extra support comes from specialists who assess and diagnose the learners. They can also prescribe technical interventions such as the placement of learners in programmes.
- *Focus is on learners to change and not the system*. If the learner does not change, they might not fit into a certain system.

2.1.2 Inclusion

- *Acknowledges differences among all learners and builds on similarities.* Inclusion recognises and respects learners' differences. It focuses on building on the similarities of the learners.
- *All learners get support. Developing of good teaching strategies so all the learners can benefit.* In order for the full range of learning needs to be met, support will be given to learners, educators and the system. It includes the development of good teaching strategies.
- *Focuses on adaptation of the system to overcome barriers that prevent learners from reaching their potential.* For the full range of learning needs to be met, there should be adjustments made in the classroom.

2.1.3 Barriers to learning

White Paper 6 recognises that the curriculum is one of the most significant barriers to learning for learners with a disability. The barriers arise from different aspects of the curriculum such as the content; the language of instruction; the methods and processes used; the pace of teaching; and learning materials and equipment that are used. The Department of Education subsequently recommends that the process of learning and teaching should be flexible enough to accommodate different learning needs and styles.

If the barriers can be overcome, the HI learners might have a brighter future with more possibilities. A subject like mathematics can contribute to their future.

> For deaf and hard of hearing students in particular, a strong mathematics education may be a determining factor in their future, providing professional choice and increasing opportunities for advancement. It is the responsibility of educators to prepare students to meet these challenges by providing a mathematics education that fosters competence. (Pagliaro, 1998, p.22).

2.1.4 Summary of Inclusive Education

In summary, the inclusion of learners with a disability is about creating opportunities for participation in educational institutions and by minimising barriers to learning. As was illustrated in Table 2.1 the main requirement for inclusion to occur is that the system must change, whereas in the case of mainstreaming or integration, the learner must change in order to fit in.

2.2 Professional Teacher Identity

As mentioned earlier, the focus of this study is on how mathematics teachers teach mathematics to oral HI learners in an inclusive school. In other words, how do the teachers as teaching-and-learning experts address the inclusion of HI learners. Part of the discussion includes topics such as professional teacher identity (PTI); expert teacher; teacher knowledge; and the three categories of PTI from Beijaard et al. (2000). Concluding the section is an examination of teaching-and-learning practices based on ten practices a mathematics and science teacher should use when teaching HI learners according to Easterbrooks and Stephenson (2006).

2.2.1 Introduction

During their research, Beijaard, Meijer and Verloop (2004) found different definitions for PTI or even no definition in some studies. Still, they propose four essential features of PTI. In the first instance, they mention that it is a dynamic, ongoing process reflecting on experiences. Secondly, PTI indicates both the person and the context. In the third place they are of the opinion that PTI consists of sub-identities and that these sub-identities do not clash - they are well balanced. Lastly PTI implies action, as it is not considered as something teachers have, but something that they use in order to make sense of themselves as teachers.

There are three factors, according to Beijaard et al. (2000), which influence a teacher's perceptions of their PTI, namely teaching context; teaching experience; and the biography of the teacher. *Teaching context* refers to the classroom ecology and school culture whereas *teaching experience* indicates knowledge bases that are rich and well-organised. The last factor, *biography of the teacher*, includes age, critical incidents, events, and other relevant factors such as looking up to a previous teacher.

Beijaard et al. (2000) state that teachers determine their PTI from how they see themselves as subject matter experts, pedagogical experts, and didactical experts. The knowledge teachers have relates to being a *subject* expert. Being a *pedagogical expert* involves ethical and moral features, i.e. nurturing the learner, whereas a *didactical expert* focuses on planning, execution, and evaluation of lessons, i.e. teaching and learning (Beijaard et al., 2000).

2.2.2 Defining expertise

Hoffman (1998) proposes that at a cognitive level, expertise can be defined in terms of three factors, namely its development, experts' knowledge structures, and experts' reasoning processes. When defining *expertise according to cognitive development*, Hoffman (1998) states that it is not the same as intelligence.

> The development of expertise involves a progression from a superficial and literal understanding of problems (a qualitative mark of the cognition of novices) to an articulated, conceptual, and principled understanding (a qualitative mark of the cognition of experts). The accumulation of skills based on experience and practice are the key, not maturational processes or time per se. Hence, two experts in a given domain can be of quite different ages, and it makes more sense to speak of developmental levels than stages. (Hoffman, 1998, p.3-4)

Hoffman (1998) remarks, when elaborating on *expertise according to knowledge structure*, that there is a difference between expert knowledge and novice knowledge, not only in its organisation but also in its extent and claims that it was shown empirically that experts draw more complex conceptual distinctions than novices. Murphy and Wright (1984) are of the opinion that although the concepts used by experts and novices might have similar structures, the experts' concepts tend to be more differentiated and clustered more tightly.

The last factor, *experts' reasoning processes*, refers to basic reasoning strategies. Hoffman (1998) mentions that experts and novices reason in different ways - in the case of problem solving, experts will spend more time in forming a conceptual understanding of the problem than novices and will generate representations that are conceptually richer and more organised than those produced by the novices. Hoffman (1998) also highlights that experts will use abstract representations of the problem relying on a deep knowledge, whereas novices will use "hastily formed concrete (that is superficial) problem representations" (p.8).

The defining of expertise above was with regard to any domain. In the next section, the definition of expert teacher is addressed.

2.2.3 Defining expert teacher

A heuristic five-stage model of exemplary performance was developed by Berliner (1994) to show how an individual moves from being a novice teacher to being an expert teacher. The figure below (Figure 2.1) is a representation of the model based on the five-stage model of Berliner. The *Expert* level, at stage 5, is where individuals can intuitively grasp situations and can sense the appropriate response in non-analytic and non-deliberative ways. They have the ability to react without thinking.

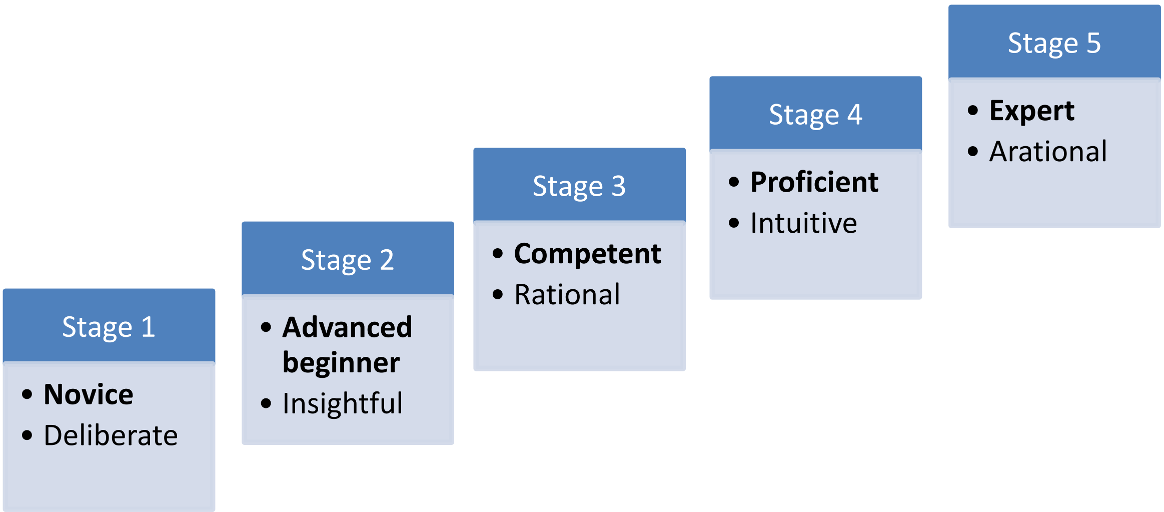

Figure 2.1: Berliner's (1994) heuristic five-stage model of exemplary performance (Adapted)

In another article Berliner (2001) shares that when analysing and numerically coding teachers' classroom lessons and transcripts obtained from interviews with the teachers, trained observers and analysts hypothesised 13 prototypical features of an *expert teacher*. According to them, an expert teacher:

- Uses knowledge better;
- Has extensive pedagogical content knowledge as well as deep representations of subject matter knowledge;
- Has better problem solving strategies;
- Has better adaptation of goals for diverse learners and better skills for improvisation;
- Has better decision making abilities;
- Creates more challenging objectives;
- Creates a better classroom climate;

- Can read cues from students better, thus has a better perception of classroom events;
- Has greater sensitivity to context;
- Can monitor learning and gives better feedback to learners;
- Tests hypotheses more frequently;
- Has a greater respect for learners; and
- Shows more passion for teaching.

Berliner (2001) mentions propositions that are only derived from studies of teaching expertise. He comments that, as proved by more than one research programme, expert teachers are mainly proficient in their own domain and in specific contexts; and they are more opportunistic and flexible in their teaching than novices (Berliner, 2001). Berliner (2001) also notes that expert teachers believe their experience and subject matter knowledge give them the necessary autonomy to choose the content and pedagogy in their domain of expertise.

2.2.4 Teacher Knowledge

Fenstermacher (1994) in *The Knower and the Known: The Nature of Knowledge in Research on Teaching*, is of the opinion that four questions can be formulated from teacher knowledge literature, namely

- What is known about effective teaching?
- What do teachers know?
- What knowledge is essential for teaching?
- What produces knowledge about teaching? (p.3)

In the end Fenstermacher leaves the readers with a research challenge: “The challenge for teacher knowledge research is not simply one of showing us that teachers think, believe, or have opinions, but that they know. And even more important, that they know that they know” (p.53).

Clandinin and Connelly (1996) go further and add a fifth question to Fenstermacher’s four questions, namely: “How is teacher knowledge shaped by the professional knowledge context in which teachers work?” (p.24). They are also of the opinion that for each of Fenstermacher’s four questions, the answers might well be “it depends” (p.29) and they believe that the challenge Fenstermacher left his readers with, as mentioned above, is not the most important challenge for teacher knowledge research.

> It is true, of course, that the imposition, via the sacred theory/practice story, of knowledge from research on the four questions has led teachers to devalue their professional knowledge. But this has led in turn to necessary deceptions as teachers obscure their knowledge by saying one thing and doing another. The telling and living of cover stories may give the impression that teachers do not know that they know. But they do. (Clandinin & Connelly, 1996, p.28)

Clandinin and Connelly (1996) agree that Fenstermacher's four questions were effectively the drive behind the research on teaching literature, but that there is a wide spread sense that this literature did not develop into much. They feel that practical reality was dramatically exceeded by practical expectations and they also admit that an understanding of teachers' personal practical knowledge, against the background of teachers' professional knowledge landscapes, is heading in a new direction. Clandinin and Connelly (1996) are of the opinion that there is a need for new questions and feel that new productive researchable questions might emerge from new ways of imparting a professional life in schools.

Ball, Lubienski and Mewborn (2001) remark that questions relating to the knowledge teachers need to have, how it affects their teaching, and how they can be assisted to develop it have been in the spotlight for more than four decades. Shulman (1987) emphasises that the understanding by a teacher of what is to be learned and how it is to be taught are necessary for teaching to begin.

At the base of this understanding lie seven categories of knowledge according to Shulman (1987). The seven categories are:

- Content knowledge;
- General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organisation that appear to transcend subject matter;
- Curriculum knowledge, with a particular grasp of the materials and programmes that serve as 'tools of the trade for teachers';

- Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding;
- Knowledge of learners and their characteristics;
- Knowledge of educational contexts, ranging from the workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures; and
- Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds. (Shulman, 1987, p.8)

For decades content knowledge (also referred to as subject knowledge) and to a lesser extent, pedagogical knowledge have been the focus of research into teacher knowledge and learning (Johnson, 2017). Researchers focussed on the investigation of teachers' knowledge of mathematics in the 1960's and since then teachers' mathematical knowledge has been a much discussed problem with regard to the improvement of mathematics teaching and learning (Ball et al., 2001). Osana, Lacroix, Tuckehr and Desrosiers (2006) suggest that "pre-service professional development include an increased emphasis on mathematics content knowledge as well as expert modelling of the identification of deep conceptual principles at the heart of the mathematics curriculum" (p.347).

2.2.5 PTI Categories

"We teach in order that others may learn" (Orton & Frobisher, 2002, p.11). As discussed in Section 2.2.1 above, Beijaard et al. (2000), state that teachers determine their PTI from how they see themselves as subject experts, pedagogical experts, and didactical experts. Schoenfeld and Kilpatrick (2008) offer a provisional framework consisting of a set of dimensions of proficiency in teaching mathematics. The researcher is of the opinion that this framework has elements applicable to all three categories of PTI mentioned by Beijaard et al. (2000). The dimensions stated in the provisional framework of Schoenfeld and Kilpatrick (2008) are:

- Knowing school mathematics in depth and breadth;
- Knowing students as thinkers;

- Knowing students as learners;
- Crafting and managing learning environments;
- Developing classroom norms and supporting classroom discourse as part of teaching and understanding;
- Building relationships that support learning; and
- Reflecting on one's practice. (Schoenfeld & Kilpatrick, 2008, p.2)

Table 2.2 is a representation of how I see the merging of the three categories of Beijaard, et al. (2000) and the dimensions of proficiency in teaching mathematics of the provisional framework of Schoenfeld and Kilpatrick (2008).

Table 2.2: The merging of the categories of PTI mentioned by Beijaard et al. (2000) and the dimensions of proficiency in teaching mathematics in the provisional framework of Schoenfeld and Kilpatrick (2008).

<table>
<tr><th>PTI categories</th><th>Subject expert</th><th>Pedagogical expert</th><th>Didactical expert</th></tr>
<tr><td rowspan="2">Dimensions of proficiency</td><td rowspan="2">• Knowing school mathematics in depth and breadth</td><td>• Knowing students as thinkers
• Knowing students as learners
• Building relationships that support learning</td><td>• Reflecting on one's practice</td></tr>
<tr><td colspan="2">• Developing classroom norms and supporting classroom discourse as part of teaching and understanding
• Crafting and managing learning environments</td></tr>
</table>

2.2.5.1 Subject expert

For the purpose of this section, the dimension under subject expert will be discussed, namely *knowing school mathematics in depth and breadth*. This dimension correlates with one of Shulman's categories of knowledge, i.e. *content knowledge*. According to Shulman (1986) content knowledge refers to the amount and organization of knowledge per se in the mind of teachers. When explaining the provisional framework consisting of a set of dimensions of proficiency in teaching mathematics, Schoenfeld and Kilpatrick (2008) are of the opinion that proficient mathematics teachers' knowledge of school mathematics is both broad and deep.

> It is broad in that such teachers have multiple ways of conceptualizing the current grade-level content, can represent it in a variety of ways, understand the key aspects of each topic, and see connections to other topics at the same level. It is deep in that such teachers know the curricular origins and directions of the content - where the mathematics has been taught and where it leads to - and they understand how the mathematical ideas grow conceptually. (Schoenfeld & Kilpatrick, 2008, p.2).

When having this kind of knowledge, proficient teachers can prioritise and organise content so that learners can get acquainted with big ideas instead of losing them in a lot of detail. This knowledge also gives the teachers the ability to respond with flexibility to questions raised by the learners (Schoenfeld & Kilpatrick, 2008). Ball (1988) believes that to be able to teach mathematics effectively, teachers must understand mathematics themselves. She is also of the opinion that the exact knowledge of mathematics includes more than mathematical statements or formulas. It requires language that goes beyond simple mathematical representation. According to Ball (1988) reasons and relationships form part of explicit knowledge: being able not only to explain why, but also to relate particular ideas or procedures to others within mathematics.

Hill, Rowan and Ball (2005) found that learners' mathematics performance can be improved by increasing the teachers' mathematical knowledge. They also propose that efforts should be made to enhance teachers' mathematical knowledge through content-focused professional development in order to improve learners' mathematical performance. Teachers should be assisted by faculty and professional developers in developing knowledge of mathematics that "goes beyond the understanding needed for everyday nonprofessional functioning" (Hill, Schilling & Ball, 2004, p.27), as then they will be prepared for the tasks encountered.

Three contributions researchers made over the years on content knowledge have been pointed out by Hill et al. (2004). The first is refocusing researchers' attention on the centrality of the subject and subject knowledge in teaching. The second one is reverting attention back to disciplines and their structures as a basis for theorizing about what teachers should know. The last one refers to the knowledge expert teachers have regarding content and how they apply this subject knowledge in their teaching. Yet, Hill et al. (2004) are of the opinion that complete understanding about the organization and structure of subject knowledge in different disciplines and what these structures suggest for teaching are still lacking. Schoenfeld and Kilpatrick (2008) emphasise that mathematical knowledge forms the backbone of mathematics teaching proficiency.

2.2.5.2 Pedagogical expert

Beijaard et al. (2000), refer to a pedagogical expert as someone who relates to ethical and moral features i.e. nurturing of the learner, whereas Van Putten (2011) describes a pedagogical expert as a “Carer” (p.61). She mentions that caring forms the basis of the relationship the teacher has with the learners and vice versa, which leads to the support of learners in their non-cognitive development (Van Putten, 2011). This correlates with Table 2.2 where a pedagogical expert is described as one who:

- Knows the students as thinkers;
- Knows the students as learners; and
- Is able to build relationships that support learning.

The pedagogical expert knows how students think and learn. Orton and Frobisher (2002) point out that the emphasis when learning mathematics in recent years was placed more on the desirability of understanding and less on repeating remembered routines and demonstrating certain basic skills. Skemp (1976) advocates two kinds of understanding mathematics. The first one is *relational* and the second one is *instrumental*. When referring to *relational understanding*, Skemp clarifies it as “knowing both what to do and why”, whereas *instrumental understanding* can be simplified as “rules without reasons” (Skemp, 1976, p.20). Cai and Ding (2015) remark that mathematical understanding has been viewed dually: as the process of achieving understanding, but also as the result of having achieved understanding.

Orton and Frobisher (2002) state that the reason learners struggle to understand mathematics is because of its abstract nature, which might lead to learners disliking and ultimately rejecting mathematics. They made the suggestion that teachers need to adopt teaching methods that assist learners to move smoothly from the relatively concrete to the relatively abstract, and that this must happen at all stages of their mathematical education.

In order for learners to be able to successfully study mathematics, they must understand concepts, which is challenging since concepts cannot be learned without intellectual effort. This intellectual effort should happen frequently over a long time (Orton & Frobisher, 2002). Orton and Frobisher (2002) also remark that the learner's own individual efforts are usually required to construct understanding, as some things are best understood when the learners have worked it out by themselves. This does not imply that the learners can make progress only on their own, and therefore making the teacher obsolete, as the teacher has contributions to make. It is, for example, the responsibility of the teacher to create an environment in which learning with understanding is possible (Orton & Frobisher, 2002).

Although the teacher as pedagogical expert, in other words carer, is a PTI category, it is not the focus of this study and thus will not be discussed further. However, the two overlapping dimensions as seen in Table 2.2 will be discussed under the next section on didactical expert, namely developing classroom norms and supporting classroom discourse as part of teaching and understanding, as well as crafting and managing learning environments.

2.2.5.3 Didactical expert

A didactical expert, according to Beijaard et al. (2000), is someone who focuses on teaching and learning, thus a teaching-and-learning expert. Although *reflecting on one's practice* (Table 2.2) is part of being a teaching-and-learning expert, together with the overlapping dimensions of *developing classroom norms and supporting classroom discourse as part of teaching and understanding* and *crafting and managing learning* (Table 2.2), being a teaching-and-learning expert consists of much more.

Cockcroft (1982) points out that mathematics teaching at all levels should include opportunities for "exposition by the teacher; discussion between teacher and pupils and between pupils themselves; appropriate practical work; consolidation and practice of fundamental skills and routines; problem solving, including the application of mathematics to everyday situations; and investigational work" (p.71). Below is a discussion of Cockcroft's list as I have divided it between the two overlapping dimensions.

Developing classroom norms and supporting classroom discourse as part of teaching and understanding

- *Exposition by the teacher*

Orton and Frobisher (2002) note that exposition seems to be very efficient in big classes where learners processed everything simultaneously and in the same way. The teacher determines the tempo and with careful planning ensures the delivery of the whole curriculum. Exposition seems to be economical with regard to effort, as much of what is conveyed consists of routines (Orton & Frobisher, 2002). Cockcroft (1982) acknowledges that exposition by the teacher has always been a fundamental ingredient in the classroom but pleads that teachers should respond to answers given by the learners, whether it is right or wrong as it can lead for both teacher and pupil to worthwhile discussion and increased awareness of specific misunderstandings or misinterpretations. Orton and Frobisher (2002) state that there is currently consensus that exposition and practice do not have to be the only methods used, as they alone are not sufficient to promote learning most effectively.

- *Discussion between teacher and learners and between learners themselves*

Good mathematics teachers should have the ability to say what they mean and mean what they say (Cockcroft, 1982). When there are opportunities to talk about mathematics, to explain and discuss results and to test hypotheses, Cockcroft (1982) believes that such ability will be developed. Question and answer sessions can be a great opportunity for discussion as the learners should be encouraged to express their thoughts more clearly where they come into contact with the thoughts of others (Orton & Frobisher, 2002). With group discussions, learners get the opportunity to learn to take turns, to listen to their peers and to receive fair criticism (Orton & Frobisher, 2002).

Simonson (2011) explains how a Grade 6 expert teacher guided the learners to discover the algorithm of determining whether a fraction converts to a terminating decimal or a repeating decimal all by themselves, and remarks that they will definitely remember it better than just memorising steps. In other words, the learners' own discovery cause them to now understand how to determine whether a fraction converts to a terminating decimal or a repeating decimal. Straker (1993) laments that learners struggling with mathematics are usually given more pencil and paper practice instead of participating in discussions which would be so much more valuable. Teachers should guard against such actions. Cai and Ding (2015) found that Chinese teachers in their study strongly argued against offering learners procedures instead of engaging learners in exploring the reason. The Chinese teachers also focused on strategies such as reinventing a concept, verbalising a concept, and using examples and comparisons for analogical reasoning to achieve mathematical understanding (Cai & Ding, 2015). The teacher in Simonson's (2011) study did just that.

Cockcroft (1982) is of the opinion that the correlating topics at primary and secondary level should be presented so that the learner will see the relationships. "Pupils need the explicit help, which can only be given by extended discussion, to establish these relationships; even pupils whose mathematical attainment is high do not easily do this for themselves" (Cockcroft, 1982, p.72).

- *Problem solving, including the application of mathematics to everyday situations*

A fundamental part of mathematics is the ability to solve problems. Cockcroft (1982) mentions that problem solving refers to the ability to apply mathematics to a variety of situations. He stated that the first step of problem solving is translating the problem into appropriate mathematical terms. The teacher needs to assist the learners in understanding how to apply the concepts and skills being learned in order to solve problems. These problems might occur in familiar as well as unfamiliar situations (Cockcroft, 1982). The teacher should be aware that for many learners this will require a vast amount of discussion and oral work before even easy problems can be done in written form (Cockcroft, 1982). Orton and Frobisher (2002) emphasise that problems force children to think, to recall relevant prior knowledge and use it, and to be creative in a modest way.

Crafting and managing learning environments

- *Appropriate practical work*

Cockcroft (1982) states that practical work is crucial for the development of mathematics at the primary phase and that it is too often assumed that there is no need for it in the secondary phase - which is not the case. According to Orton and Frobisher (2002) there are many who believe that not enough practical work is being done in primary school, especially with the older learners. They also argue that the pressure through the curriculum as well as the expectations of parents is the reason for moving too quickly from the concrete to the abstract. Orton and Frobisher (2002) consider practical work as a valuable vehicle for assisting pupils to construct meaning. Practical work is not only needed by low attaining learners, but beneficial to all learners. However, Cockcroft (1982) points out that the type of activity, amount of time spent on it and the amount of repetition that is required will vary according to the needs and attainment of pupils.

- *Consolidation and practice of fundamental skills and routines*

It is important that learners receive the opportunity to practice skills and routines which have been acquired as well as consolidating those with the ones they already possess in order to use it when solving problems or doing investigational work (Cockcroft, 1982). The amount of practice varies in different levels of learners. Cockcroft (1982) also remarks that practicing fundamental skills is not by itself sufficient to develop the abilities to solve problems or to investigate - these matters need separate attention.

- *Investigational work*

Cockcroft (1982) notes that investigation is necessary to be able to solve problems in many fields. He argues that many teachers think it is similar to a project, an extensive piece of work that will take a long time to complete - maybe in a group or individually. This is not necessarily the case. Investigations can be short and do not have to be difficult. Learners can get the same result or a variety of results as seen in the following examples: "make up three subtraction sums which have 473 as their answer" (Cockcroft, 1982, p.74) or "exploring square numbers" (Orton & Frobisher, 2002, p.31). Investigations might lead to class discussions and a teacher should be willing to follow some false trails by not telling the class too quickly that the trail leads nowhere. Cockcroft (1982) is of the opinion that if the outcome of the investigation is not discussed, much of the value of an investigation can be lost. Orton and Frobisher (2002) submit that if a learner does not respond to an investigation as a challenge, there is no use for it.

2.2.6 Teaching-and-learning practices for HI learners

As mentioned in Section 2.1 above, the focus of inclusion in an inclusive school is on the school that has to change and not on the learner that needs to change in order to fit in. Although the teaching of HI learners in an inclusive school challenges the teachers' way of teaching, Vermeulen, Denessen and Knoors (2012) found that the teachers only made minor changes in their teaching-and-learning practice of HI learners and that they rather opted to give the learners a modicum of additional individual support.

Easterbrooks and Stephenson (2006) suggest ten practices a mathematics and science teacher should use when teaching HI learners. The ten practices are: teacher as content specialist; specialised content vocabulary; authentic, problem-based instruction; critical thinking; the teacher as skilled communicator; active learning; visual organisers; use of technology; instruction through the primary language; and mediating textbooks. A discussion of the first eight practices will follow now. The last two practices - instruction through the primary language and mediating textbooks - will be discussed in Section 2.3 below under language factors in teaching mathematics to HI learners.

2.2.6.1 The role of the teacher as content specialist

Easterbrooks and Stephenson (2006) recommend in their research that teachers teaching deaf or hard of hearing learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching. Lang and Pagliaro (2007) state that teacher education programmes and professional development coordinators are responsible for organising workshops and other assistance in order to help teachers acquire workable strategies to increase their skills and their familiarity of the content. This is necessary so that the learner's ability to unpack concepts and words from long-term memory can be enhanced.

2.2.6.2 Specialised content vocabulary

Specialised content vocabulary, as explained by Easterbrooks and Stephenson (2006) can lead to the increasing of "content comprehension and promote group discussions and opportunities for self-expression on specific topics" (p.394). HI learners lag behind their hearing peers in the critical area of vocabulary knowledge and they will benefit from repeated exposure to vocabulary (Luckner & Cooke, 2010). Luckner and Cooke (2010) subsequently suggest that teachers should use a portion of their regular lesson to expand vocabulary, repeat new words in different contexts, practice vocabulary instruction and spend enough time on using new vocabulary in various contexts. The teachers should apply the suggestions in discussions, writing, and reading in order to make the HI learner independent vocabulary learners (Luckner & Cooke, 2010). Orton and Frobisher (2002) recommend that learners should create their own dictionary of mathematical vocabulary as this will force the learners to think very hard about definitions and meanings.

2.2.6.3 Incorporation of real-world problems and critical thinking

Although Easterbrooks and Stephenson (2006) have these two practices as two separate ones, in my experience they overlap. For the purpose of the study the two practices have therefore been combined.

Real-world problems present opportunities to use traditional mathematical concepts from various branches of mathematics in meaningful ways (Pagliaro & Kritzer, 2005). Real-world story problems include chart reading, organising of information and to be able to use more difficult mathematical operations than arithmetic story problems (Carter & Dean, 2006). "Problems force children to think, to recall and use relevant prior knowledge, and to be creative in a modest way" (Orton & Frobisher, 2002, p.20). Pagliaro and Kritzer (2005) found that real-world problems engage learners of all ability levels, but unfortunately teachers consider the concepts too complicated for the HI learners and do not include the problems in instruction.

In the study done by Kelly, Lang and Pagliaro (2003), they found that mathematics teachers teaching deaf and hard of hearing learners, focus more on practicing exercises than on true problem-solving situations. The teachers also tend to avoid the more cognitively challenging aspects of word problem solving, resulting in inadequate time spent on in-depth aspects of problems as well as analysing solution strategies. Kelly et al. (2003) argue that the teachers' focus on the understanding of the problem may logically be attributed to meeting the HI learners' generally lower language abilities. This happens as the teachers have the perception that language is the primary barrier to the HI learner's ability to solve word problems successfully.

Although drill and practice are important in mathematics, the learners' thinking abilities need to be extended. The learners should be guided to learn how to think beyond the basics, to a problem-solving and higher-order-thinking approach (Easterbrooks & Stephenson, 2006). As reported by Kelly et al. (2003), the teachers of HI learners place relatively less focus on developing their critical thinking, reasoning, synthesis of information and other essential skills needed for effective problem solving. Pagliaro and Kritzer (2005) are of the opinion that teachers should have higher expectations overall for HI learners. It is important that teachers provide the HI learners with opportunities to think.

2.2.6.4 The role of the teacher as a skilled communicator

Easterbrooks and Stephenson (2006) concluded that a teacher's ability to communicate is an imperative component of effective instruction. Liu, Chou, Liu, and Yang (2006) acknowledge that a challenge faced by the teachers of HI learners is "to overcome the communication barrier" (p.151). Vermeulen et al. (2012) found that teachers teaching HI learners in an inclusive school in the Netherlands adapted their communication to the needs of the learners. The lack of vocabulary hinders learners' ability to learn words independently of context. In subjects such as mathematics, science and social studies, the learners are required to learn new words that represent unknown concepts (Luckner & Cooke, 2010). Lang and Pagliaro (2007) are of the opinion that the HI learner's understanding, performance, and ultimately achievement in mathematics are likely to increase if the instruction of the teacher takes the HI learner's cognitive organisation and development into consideration. When demonstrating procedural models for problem solving, as reported by Mousley and Kelly (1998), the teachers should provide detailed step-by-step explanations in spoken as well as written form and should make use of "pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation" (Lang & Pagliaro, 2007, p.459). Teachers should also keep in mind that HI learners who are frustrated with their communication may be unhappy and have behavioural problems in the classroom (Braeges, Stinson & Long, 1993).

2.2.6.5 Active learning

This practice refers to active learning principles applied by the teachers in order to enhance concept mastery. Easterbrook and Stephenson (2006) mention that "minds-on, active learning requires students who are deaf or hard of hearing to apply critical thinking skills when this kind of learning is used in the teaching of mathematics and science concepts; this in turn, ensures greater understanding and comprehension" (p.392). According to Orton and Frobisher (2002) there are many who believe that not enough practical work is being done in the primary schools, especially with the older learners. They also state that the pressure from the curriculum as well as the expectations of parents are the reason for the moving from the concrete to the abstract being hurried. "Practical work is a valuable vehicle for assisting pupils to construct meaning" (Orton & Frobisher, 2002, p.19).

2.2.6.6 Enhancement of visual organisers

The enhancement of visual organisers is where teachers make use of visual aids such as graphs, charts and maps. Lang and Pagliaro (2007) emphasise the importance for mathematics teachers to prepare sufficiently in order for their learners to benefit from the education. Nickson (2008) explains that "the tangible properties of the physical objects help pupils to store up mental structures which contribute to the development of mathematical concepts and their understanding" (p.19). If the teachers teach new mathematics concepts and vocabulary, they should make use of pedagogy that builds on prior knowledge and contexts that link the concept or word to a picture explaining the meaning. Ineffective teaching often occurs when teaching happens only by verbal exposition (Orton & Frobisher, 2002).

Gravemeijer (1997) calls the use of structured materials in mathematical learning into question and proposes a summary of three main shortcomings of manipulatives as aids to learners' mathematical learning. The shortcomings are:

- when using manipulatives, learners do not necessarily develop an insight into the mathematical concept being taught so that they understand it;
- although learners might have grasped the concept, they might not know how and when to use it when solving problems; and
- the learners' own experience is not being reflected by using manipulatives and the learners' informal knowledge and strategies, are being ignored.

2.2.6.7 Use of technology

Pagliaro (1998) recommends that "technology should be available and used as a tool to expand instruction and enhance understanding and knowledge" (p.27). She also mentions that the availability of the internet and innovative software gives learners the opportunity to have better access to information in written as well as visual form. It is important that this technology should be located in the classrooms and not in laboratories and that it should be appropriate to grade level and subject matter (Pagliaro, 1998).

Experiments done by Liu et al. (2006) show that student participation in learning activities was increased by the use of highly interactive communication through a wireless network. It is called WiTEC (wireless technology-enhanced classroom) and is a combination of Tablet PC's, a wireless network and applicable software. They found that more HI learners responded to the teacher's questions with WiTEC and that without WiTEC most of the HI learners could not respond to the teacher when they were only asked questions orally. The reason for this is that the learners knew how to answer the teacher's question, but they did not know what the teacher was asking. Once the teacher wrote down the questions, the learners were able to speak the answers one after another. Therefore the styli of the Tablet PCs in the WiTEC environment functionally assisted oral teaching. It made the questions asked by the teacher more understandable which resulted in less questions being asked by the teacher. It also enhanced the efficiency of teacher-student interaction and encouraged students' participation in teaching and learning activities (Liu et al., 2006).

2.2.7 Summary of the PTI of the mathematics teacher

In summary, when discussing the topic of the PTI of the mathematics teacher, several concepts were addressed, namely teacher expert, teacher knowledge as well as PTI categories with a focus on the didactical expert i.e. teaching-and-learning expert. It concluded with the discussion of the teaching-and-learning practices for HI learners.

2.3 Language factors in teaching mathematics to HI learners

This section focuses on the language factors when teaching mathematics to hearing and HI learners. Topics under discussion include language and learning, mathematics register, language proficiency and the language factors specifically for HI learners. The remaining two practices of Easterbrooks and Stephenson (2006) that a mathematics teacher should use when teaching HI learners, namely instruction through the primary language and mediating textbooks will also be discussed.

2.3.1 Language and learning

Language is used when communicating ideas and thoughts. The words in language are "labels for concepts and ideas, so it is difficult to separate issues of language from issues of learning" (Orton & Frobisher, 2002, p.53). More than forty years ago, Aiken (1972) wrote a paper on language factors relevant to learning mathematics and declared that it is not only linguistic abilities that have an influence on the performance in mathematics, but also that mathematics is a specialised language itself.

Sénéchal, Ouellette and Rodney (2006) reckon that a better vocabulary might result in better comprehension as it provides the building blocks for higher order thinking skills, and Johnson (2001) comments that it is essential for learning any subject to learn its vocabulary. According to Carter and Dean (2006) the accuracy of mathematical definitions is often the deciding factor between an unsure and clear understanding and that mathematics teachers should therefore be prepared for vocabulary exploration. They also remark that "reading comprehension is an essential component of successful problem solving which is the primary goal of mathematics lessons" (Carter & Dean, 2006, p.144).

Orton and Frobisher (2002) found that new words, associated with new ideas when teaching mathematics should be introduced carefully and the meaning should be discussed extensively. Learners should be given the opportunity to say, write and use the words or phrases in relevant contexts. They caution that teachers should not assume that there will be no further difficulty with particular words, no matter how carefully they have been introduced, because regular use in context is essential too (Orton & Frobisher, 2002). They also suggest that the teachers do all they can to motivate learners not to be reluctant in using new mathematical words with the precision intended.

Language can interfere and obstruct the learning of mathematics, according to Orton and Frobisher (2002), as mathematicians decided to "adopt a particular word or combination of words" (p.54) that might be known or unknown to the learner. Orton and Frobisher (2002) expand on their argument by explaining that some of the language used in mathematics consists of "Mathematical English" and "Ordinary English" (p.54). They have used "real numbers" (p.54) as an example. *Numbers* in "real numbers" are classified as *Mathematical English* where *real* was taken from *Ordinary English*. Orton and Frobisher (2002) made the remark that it may not always be mathematical words causing confusion and creating difficulty, but also ordinary words. "The language of mathematics involves a very large vocabulary, including many everyday words as well as the inevitable specialist terminology, sometimes referred to as the mathematics register" (Orton & Frobisher, 2002, p.54).

2.3.2 Mathematics register

Khisty (1993) uses the term 'talking mathematics' which refers to using language to create mathematical meanings and that learners learn the language of mathematics from their peers and teachers who are actively using it. A big challenge in the mathematics class though, is for the teacher to guide the learners "to move from everyday, informal ways of construing knowledge into the technical and academic ways that are necessary for disciplinary learning in all subjects" (Schleppegrell, 2007, p.140). Halliday (1978) highlights the linguistic challenges of mathematics teaching with his discussion of the *mathematics register*.

> A set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings. We can refer to a 'mathematics register', in the sense of the meanings that belong to the language of mathematics (the mathematical use of natural language, that is: not mathematics itself), and that a language must express if it is being used for mathematical purposes. (Halliday, 1978, p.195)

Schleppegrell (2007) refers to the work of some researchers that have described the "linguistic features of the mathematics register that construct this technical discourse" (p.141) and create a table (Table 2.3) with regard to multiple semiotic (meaning-creating) systems that construct knowledge and grammatical patterns.

Table 2.3: Features of the classroom mathematics register

Multiple semiotic systems	***Grammatical patterns***
• Mathematics symbolic notation	• Technical vocabulary
• Oral language	• Dense noun phrases
• Written language	• *Being* and *having* verbs
• Graphs and visual displays	• Conjunctions with technical meanings
	• Implicit logical relationships

Below is a discussion of the features of the classroom mathematics register as seen in Table 2.3.

2.3.2.1 Multiple semiotic systems

Multiple semiotic systems refer to meaning-creating systems that construct knowledge. For example, “mathematics symbolism can be used to describe relationships of parts to whole, and to construct trends and patterns of continuous covariation that cannot be presented as precisely in natural language” (Schleppegrell, 2007, p.141).

O’Halloran (1999) mentions that *visual representations*, such as graphs and diagrams, can represent information contained in the mathematics symbolism through means that language cannot. He gives the example in terms of a trigonometry problem. The problem used a diagram of a man standing on a cliff looking down on a river. The man would like to calculate the width of the river by using a rope and equipment that measures angles. The contextual information was provided by language while the pattern of relationships between the entities was described by mathematical symbolism. The diagram provided a connection between the material world (a cliff and river) and the mathematical processes formed in the problem – a connection that was discussed in the classroom. The “mathematical discourse is multi-semiotic because it involves the use of the semiotic resources of mathematical symbolism, visual display and language” (O’Halloran, 1998, p 361). Schleppegrell (2007) concludes that the written language, the mathematics symbolic statements, the visual representation, and the oral language work together to construct meaning during the interaction between teacher and students when discussing the problem.

2.3.2.2 Grammatical patterns

Mathematics not only contains technical vocabulary such as *sum* or *fraction*, but also words used in ordinary language (Schleppegrell, 2007). These ordinary words have a specific mathematical meaning and include terms such as *place, borrow* and *product*. Schleppegrell (2007) also suggests that it may be easier to learn the new vocabulary that is centrally mathematical than learning the technical meanings for words that students already know in other contexts.

Another grammatical pattern is *dense noun phrases*. An example of such is “the volume of a rectangular prism with sides 8, 10 and 12 cm” (Veel, 1999, p.197). These dense noun phrases contribute to entangled complex meaning relationships in the questions the learners have to solve. Schleppegrell (2007) mentions that explanations in textbooks are so dense that the teacher has an important role in assisting learners to learn to connect the symbols, diagrams and technical language.

Sfard, Nesher, Streefland, Cobb & Mason (1998) explains that natural or everyday language is limited describing mathematical notions and gave the example of "a fourth of a number decreased by 5" (p.42) and mentions that although it appears to be part of natural language it is an ambiguous expression as it can be written as either $\frac{1}{4}(n - 5)$ or as $\frac{1}{4}n - 5$. It has different meanings from a mathematical point of view and formal notation is the only way to distinguish between the meanings. "To talk mathematically means in part to be able to formulate expressions in a way that will distinguish between the two meanings and this cannot be accomplished without formal notation" (Sfard et al., 1998, p.42-43).

Being and *having* verbs are a challenge when it comes to their grammatical features. *Being* might refer to the category, while *having* might refer to the properties (Schleppegrell, 2007). For instance, an isosceles triangle (*being*) indicates a triangle with two equal sides (*having*). If a learner does not understand the difference, they might not be able to answer the questions correctly.

The precise and technical meanings of c*onjunctions* used in ordinary language are another challenge as they often "link clauses in complex ways, with variations presenting similar meanings" (Schleppegrell, 2007, p.145). Schleppegrell (2007) gives the examples of *if*, *when*, and *therefore* and states that they are used in precise ways in word problems and in developing theorems and proofs.

Even though the features of the mathematics register (Table 2.3) can be seen as separate elements, they are always used in interaction with each other in the learning and teaching of mathematics (Schleppegrell, 2007). She also believes that a strategy for engaging and supporting learners' learning can be to focus on the features of the language through which mathematics is constructed.

> By helping students recognise how mathematics is constructed in multi-semiotic and grammatical resources, teachers can support students' development of the technical construal of knowledge that has to be achieved for mathematics learning. The technical construal is important for them to perform well on assessments, but the development of the mathematics register has to build from oral language that

> moves from the everyday to the technical … the construction of knowledge about mathematics depends on the oral language explanations and interaction of the teacher. (Schleppegrell, 2007, p.147)

Learning mathematics and the language of mathematics is a challenge for all learners, even more so for learners who do not have opportunities outside the school environment to use the academic language (Schleppegrell, 2007). One suggestion Lemke (2003) makes is that teachers should "at all stages repeatedly make it explicit for students how mathematical expressions and mathematised visual representations can be translated partially, but never completely, into natural language statements and questions" (p.25). He also urges teachers to expose learners to out-of-school settings and practices where people are using mathematics in order for a better understanding.

2.3.3 Language proficiency

Language proficiency (LP) refers to the "ability to effectively communicate in the target language" (Dippenaar, 2004, p.7), in other words to be able to use the four skills, namely reading, writing, speaking and listening as mediating tools. Many researchers claim LP as "one of the most important factors of successful learning in all subject matter education" (Im & Kim, 2014, p.1396). LP is not only applicable to the teacher, but also to the learners.

LP or the lack thereof is a reality all over the world. In 2003, Malaysia implemented a new language of instruction policy with the effect that the medium for mathematics and science instruction changed to English. With the new system, the mathematics and science teachers' responsibilities included the role of teachers of English for academic purposes. This had the effect that the mathematics and science teachers had to improve their own proficiency in English to be able to cope with the demands of teaching in English (Tan, 2011).

In South Africa, Evans and Cleghorn (2010) observed some Afrikaans-speaking student teachers, who were teaching Grades R - 3 in English in two urban educational settings. English was not the student teachers' mother tongue, and the researchers were concerned with the outcome. Teachers' difficulties in using English for instructional purposes are evidenced by what they observed in the example below.

Example:

The student teacher is revising shapes and colours. She intends teaching the word 'oval' but gives a wordy explanation of something egg-shaped. Her elicitation question to the learners is, 'Where do we also find eggs?' She had intended that learners point to other oval shapes in the class however the result is that a learner appropriately answers, 'In the shop'. The teacher simply responds with an emphatic 'No'.

Response:

> The example illustrates linguistic insecurity involving two interrelated instructional predicaments: poor oral expression (not necessarily the same as proficiency) results in miscommunication and misunderstanding, while this inability to express one's thoughts fluently has resulted in missed opportunity for incidental learning and, no doubt, a bewildered learner. (Evans & Cleghorn, 2010, p.144)

A big concern regarding LP is in what ways teachers can effectively attend to children's needs if they lack linguistic security in the language of instruction? (Evans & Cleghorn, 2010). The learners' success depends on the teacher's language proficiency. Therefore, a learner may not experience success if a teacher is not proficient in the medium of instruction (Dippenaar & Peyper, 2011).

For learners to improve their LP in mathematics, they should be encouraged to "produce extended discourse in mathematics classrooms, engage in discussion about the language through which word problems are constructed, and practice the writing of mathematics concepts in authentic ways" (Schleppegrell, 2007, p.156).

2.3.4 Language factors for HI learners

Deafness Foundation (Victoria) and Deaf Children Australia (2005) state that learners with normal hearing start school with mostly well-developed speech and language, as they acquired it effortlessly since birth when they listen and overhear people around them. They also have a well-developed general knowledge base. In comparison to their hearing peers, HI learners generally find it more difficult to acquire language as well as general knowledge. Table 2.4 presents a comparison between hearing and HI learners with regard to their speech, language and communication (Deafness Foundation [DF] & Deaf Children Australia [DCA], 2005).

Table 2.4: Speech, language and communication comparison between hearing and HI learners.

Normal hearing learners	HI learners
Well-developed speech and language when starting school.	Might start school with delays as they find it more difficult to acquire language.
Listening and overhearing since birth results in acquiring language effortlessly.	Limited exposure to incidental learning and overhearing since birth might result in delays at school.
General knowledge usually well developed.	Difficulty in acquiring general knowledge.
Can use questions and discussions to expand their language and general awareness.	Lack of language and general knowledge is not a reflection of their potential or ability.
	Might understand words in a sentence, in written and spoken language, but not the full meaning of the sentence.
	Might struggle to say some words or monitoring loudness or pitch of their own voices. This is not a reflection of their intelligence.

HI learners have less opportunity to learn how a language system works and it is more challenging for them to acquire new vocabulary, concepts and expressions (DF & DCA, 2005).

Teachers can assist HI learners in the following manner to understand spoken messages if they did not follow what has been said (DF & DCA, 2005):

- *Repeating:* Repeat what has been said. Either by the teacher or by other learners.
- *Rephrasing:* Say things in a different way. Simplify the message.

Teachers should also be willing to explain what is meant and give more information. In ensuring that HI learners are on par, the teacher can ask them a question so that they can demonstrate their understanding (DF & DCA, 2005).

2.3.5 Language practices for teaching HI learners

The two remaining practices when teaching mathematics to HI learners, as discussed by Easterbrooks and Stephenson (2006), are the instruction through the primary language and mediating textbooks.

2.3.5.1 Instruction through the primary language

The main focus here is that teachers should use the student's first language in providing science and mathematics concepts before assessing competence in English (Easterbrook & Stephenson, 2006). In this case the primary language refers to sign language. Easterbrook and Stephenson (2006) also mention that there is evidence in the literature that indicates better academic performance in the content areas when teachers instruct learners in their primary language.

2.3.5.2 Mediating textbooks

The practice of mediating textbooks addresses the difference between the language abilities of the child and the language demands of the textbooks. Schell (1982) mentions that mathematics' reading material is the most challenging content area material to read as it has "more concepts per word, per sentence and per paragraph than any other area" (p.544). It also involves abstractions, specialised symbols and technical terminology. For learners, therefore, to be able to make meaningful interpretations, they must have considerable content knowledge. The teacher should be aware that HI learners find it difficult to solve written mathematics problems (Pau, 1995). This practice is a chronic problem that teachers of HI learners must address in order to ensure access to grade-level content in mathematics. One way to achieve this is by making use of scaffolding techniques, in other words including visual prompts, graphic organisers and lower-level reading materials (Easterbrooks & Stephenson, 2006).

Another way may be addressing the level of readability of particular materials. Orton and Frobisher (2002) list some factors which need to be taken into account when determining the level of readability. It includes the following:

- Length of words, sentences and paragraphs;
- Complex words and other symbols; and the
- Use of pictures, diagrams, graphs. For example when talking about a trapezium, it is easier remembering the meaning when looking at the visual representation.

2.3.6 Summary of language factors in teaching mathematics

In summary, when discussing the topic of language factors in teaching mathematics, a few concepts were addressed, namely language and learning, mathematics register, language proficiency and language factors for HI learners. Lastly the two remaining practices a mathematics teacher should use when teaching HI learners (Easterbrooks & Stephenson, 2006) were discussed, namely instruction through the primary language and mediating textbooks.

2.4 Conceptual framework

For the conceptual framework (Figure 2.2), the two themes discussed from the sub-questions, have been used as a basis. The ten practices a mathematics and science teacher should apply when teaching HI learners (Easterbrooks & Stephenson, 2006) were then adapted where necessary according to the researcher's own experiences. They were then issued to the applicable theme by the researcher herself.

The original ten practices were: teacher as content specialist; specialised content vocabulary; authentic, problem-based instruction; critical thinking; the teacher as skilled communicator; active learning; visual organisers; use of technology; instruction through the primary language; and mediating textbooks. Although Easterbrooks and Stephenson (2006) had incorporated real-world problems and critical thinking as two separate practices, I combined them for the purpose of the study, because in my experience the practices overlap. The practice of active learning was adapted to *active teaching-and-learning principles* as I included the teachers' involvement by repeating words or phrases and by positioning themselves in such a way that the HI learners are able to lip-read (DF & DCA, 2005).

For the purpose of this study, instruction through the primary language was adapted to *language of instruction: mathematics to language of instruction*. Not only will the focus be on the language of instruction, but also on the use of the mathematics register - in other words changing between mathematical language and natural language. DF and DCA (2005) suggested that if a learner struggles to understand what is being said, the teacher should say it in a different way. It is called *rephrasing*. Lastly, mediating textbooks was changed to *mediating textbooks and documentation*. For the purpose of the study, documentation such as tests and worksheets were also analysed and not just textbooks.

The themes have been connected to one another to indicate the collaboration required in order to answer the main research question, namely, '**How do mathematics teachers teach oral hearing impaired learners in an inclusive environment?'**

The practices of the role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancement of visual organisers and use of technology were included in the first theme, namely, **the mathematics teacher as teaching-and-learning expert**. The practices of language of instruction: mathematics to language of instruction; and mediating textbooks and documentation were assigned to the theme of **language factors in teaching mathematics to HI learners**.

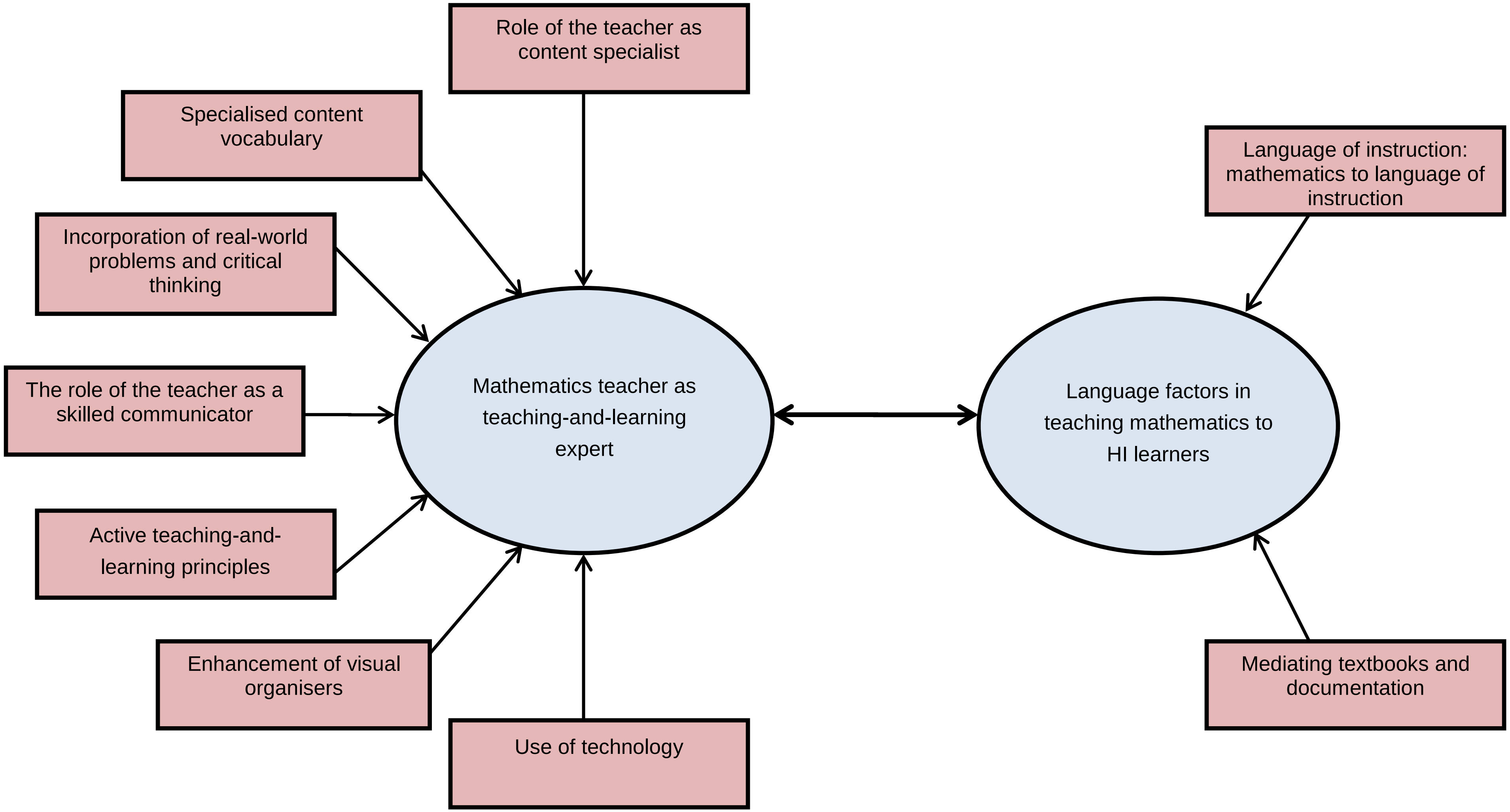

Figure 2.2: Conceptual framework

2.5 Chapter summary

In this chapter I started by discussing the difference between **inclusion** and **integration**. I then dissected **PTI** and addressed topics such as expertise and teacher expert, teacher knowledge as well as the three categories of PTI, namely subject expert, pedagogical expert and didactical expert. The last part concluded with the discussion of teaching-and-learning practices for HI learners based on the ten practices a mathematics teacher should use when teaching HI learners (Easterbrooks & Stephenson, 2006). When discussing the topic of **language factors in teaching mathematics to HI learners** there were a few concepts addressed, namely language and learning, mathematics register, language proficiency and language factors for HI learners. The section ended with a discussion of the remaining two practices from Easterbrooks and Stephenson (2006). The final part of the chapter consisted of the **conceptual framework** with a discussion of the adapted practices from Easterbrooks and Stephenson (2006) as well as the connection between the themes and the practices. The two themes were **mathematics teacher as teaching-and-learning expert** and **language factors in teaching mathematics to HI learners.** The adapted practices assigned to the theme of **mathematics teacher as teaching-and-learning expert** were: the role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancement of visual organisers; and use of technology. The adapted practices assigned to the theme of **language factors in teaching mathematics to HI learners** were language of instruction: mathematics to language of instruction; and mediating textbooks and documentation.

Chapter 3

Research design and methods

3.1 Introduction

In this chapter the chosen research paradigm will be discussed as well as the assumptions through which the researcher views the world. The rationale for choosing qualitative research as the approach and exploratory case study as the design for this research will also be explained. The research site, sample selection and data collection techniques are described in detail followed by the data analysis strategies. At the end of the chapter there are discussions of critical issues such as trustworthiness and validity of the study and also the applicable ethical considerations.

3.2 Research paradigm and assumptions

According to Holden and Lynch (n.d.), researchers decided to apply the same successful objectivist approach of the natural sciences to social sciences. From this, subjectivism arose and critics realised that both sciences are divergent (Holden & Lynch, n.d.). Holden and Lynch (n.d.) refer to Easterby-Smith, Thorpe and Lowe who labelled the different approaches as positivism and phenomenology while Hughes and Sharrock used the words positivism and interpretivism.

Gitchel and Mpofu (2012) refer to other researchers stating that there are predominantly two paradigms in which social science is positioned, namely qualitative and quantitative. Different assumptions are made by both the paradigms. For instance, qualitative research "is based on the belief that knowledge is a subjectively constructed reality and widely distributed among communities of knowers, each of whom has a personal, but equally valid interpretation of reality" (Gitchel & Mpofu, 2012, p.59). On the other hand the quantitative approach is based on the assumption of objective existence of reality, in other words "whatever exists can be objectively measured and valid conclusions about it reached by observers" (Gitchel & Mpofu, 2012, p.59).

3.2.1 Research paradigm

The research paradigm that underpinned this study is social constructivism which suggests that "all knowledge is constructed and based upon not only prior knowledge, but also the cultural and social context" (Botha, 2011, p.69).

3.2.2 Paradigmatic assumptions

The nature of the study is based on three assumptions, namely ontological, epistemological and methodological assumptions. Ontology and epistemology have a direct effect on the choice of methodology (Holdyn & Lynch, n.d.). This study is subjective in nature with the ontological assumption of *idealism*. Nieuwenhuis (2016) described idealism when he said "reality is only knowable through the human mind and through socially constructed meanings" (p.58). The assumption of epistemology relates to "how things can be known - how truths or facts or physical laws, if they do exist, can be discovered and disclosed" (Nieuwenhuis, 2016, p.67). The emphasis in this study is on the point of view of the insider (participant) and not on the point of view of the outsider (researcher). The point of view of individuals who are being investigated needs to be understood and their frame of reference shared. The "understanding of individuals' interpretations of the world around them has to come from the inside, not the outside" (Cohen, Manion & Morrison, 2011, p.19). An ideographic methodological preference was demanded.

3.3 Research approach and design

Table 3.1 below provides the structure of the research design and methodology to be used. It has been adapted from the one Botha (2011) used in her thesis. Below the table the research approach and design are discussed in detail.

Table 3.1: Structure of research design and methodology

Research approach	**QUALITATIVE**
Research design	Exploratory case study According to Thomas (2015), when doing a case study you will be focusing on one "thing" and that thing might be "a person, a group, an institution, a country, an event, a period in time or whatever" (p.3). This case study consists of three mathematics teachers teaching mathematics to HI learners in an inclusive school as a group.

Research method	Semi-structured interviews (2 per teacher) Observations (2 lessons per teacher) Documentation such as tests, worksheets and planning Recordings of interviews and lessons	
Primary research question	**How do mathematics teachers teach oral hearing impaired learners in an inclusive environment?**	
Secondary research questions	**Question 1** How can the classroom practice of the mathematics teachers as teaching-and-learning experts be described?	**Question 2** What are the language factors that need to be considered when teaching mathematics to HI learners?
Objectives of the secondary questions	To explore the determining factors of a mathematics teaching-and-learning expert.	To explore the language factors that need to be taken into consideration when teaching HI learners.
Participants	Three mathematics teachers from three different phases (IP, SP and FET), teaching HI learners in an inclusive school.	
Data collection techniques	• Two observations per teacher with the same mathematics class on different days. All the observations will be videotaped. • Two semi-structured interviews per teacher: one interview before any lessons and one after the observation of the second lesson. Audio-tape recordings of the interviews will be made. • Documentation collected: Tests, worksheets and planning.	
Techniques per question	Observations Interviews Documentation	Observations Interviews Documentation
Data analysis	**Deductive approach for data analysis** • Establish units of analysis of the data • Create a 'domain analysis' • Use ATLAS.ti 7 to analyse the video and audio data as well as the documentation • Establish relationships and links between the domains • Making speculative inferences • Summarising	

3.3.1 Research approach

A qualitative research approach was followed in order to answer the research questions as the study concerned "specific meanings, emotions and practices that emerge through the interactions and interdependencies between people" (Hogan, Dolan & Donnelly, 2009, p.4). Nieuwenhuis (2016) made the remark that "all qualitative research is naturalistic, that is, it focuses on natural settings where interaction occurs" (p.53).

Creswell (2014) mentioned basic characteristics of qualitative research namely, "natural setting, researcher as key instrument, multiple sources of data, inductive and deductive data analysis, participants' meanings, emergent designs, reflexivity, holistic account" (p.185-186). Find below an explanation of each characteristic.

- *Natural setting*: Researchers collecting data in the natural setting of the participants and also have face-to-face interaction with the participants.
- *Researcher as key instrument*: Researchers themselves are the ones gathering the information, without tending to rely on questionnaires.
- *Multiple sources of data*: Researchers make use of multiple forms of data gathering techniques such as interviews, observations and documentation analysis. In order to make sense of all the information, they categorise it into different themes.
- *Inductive and deductive data analysis*: Researchers build their themes from the bottom up organising the information into more abstract units. Once having a comprehensive set of themes, the researcher looks back at the data and themes deductively to determine whether additional information needs to be gathered.
- *Participants' meanings*: The researcher tends to learn the meaning of the problem through the eyes of the participant and not the meaning the researcher themselves brings to the research.
- *Emergent designs*: The initial plan for research is not set in stone; it might change as the researcher has to learn about the problem from the participants' point of view.
- *Reflexivity*: The researcher reflects on how their role in the study as well as their personal background might influence their interpretation and shape the direction of the study.
- *Holistic account*: The researcher tries to create a complex picture of the issue under study.

Looking back at the research approach, the basic characteristics of qualitative research mentioned by Creswell (2014) were applied, with the only exception that a deductive data analysis with using the researcher's own conceptual framework indicating the themes was done.

3.3.2 Research design

When choosing a qualitative research design, Creswell (2014) recommended that researchers choose between narrative, phenomenology, ethnography, case study and grounded theory. I chose to make use of a case study.

Simons (2009) defined a case study as "an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, programme or system in a real life context. It is research-based, inclusive of different methods and is evidence-led" (p.21). Van Wynsberghe and Khan (2007) proposed a more precise definition for case study research, one that reconciles various definitions. They described a case study as a "transparadigmatic and transdisciplinary heuristic that involves the careful delineation of the phenomena for which evidence is being collected" (Van Wynsberghe & Khan, 2007, p.80). By *transparadigmatic* they meant that a case study is relevant regardless of the chosen research paradigm. When they mentioned *transdisciplinary* they suggested that a case study does not have a specific disciplinary orientation, in other words it can be used in science, fine arts and humanities research, for example. Van Wynsberghe and Khan (2007) also explained *heuristic* as "an approach that focuses one's attention during learning, construction, discovery, or problem solving" (p.81). They made the remark that there are several heuristics involved in case study research and these heuristics serve to continually focus one's attention on the phenomenon for which evidence is collected (Van Wynsberghe & Khan, 2007). According to Thomas (2015), when doing a case study you will be focusing on one "thing" and that thing might be "a person, a group, an institution, a country, an event, a period in time or whatever" (p.3). Thomas (2015) also made the remark that a case study is "about the particular rather than the general" and he is of the opinion that "you cannot generalise from a case study" (p.3).

The focus of this study is to explore and describe the way in which mathematics teachers teach mathematics to oral HI learners in an inclusive school. As Nieuwenhuis (2016) states, "the objective of exploratory research is to identify key issues and key variables and to gain greater understanding of a phenomenon, a group of people or social setting" (p.55).

3.4 Research site and sampling

The research site is an inclusive private school in Gauteng, South Africa. It consists of a primary and high school where oral HI learners are taught alongside their hearing peers. The school was purposefully chosen due to its model of inclusion, where oral HI learners attend the same classes and lessons as their hearing peers. Each class consists of an optimum of 25 learners of whom a maximum of four learners might be hearing impaired.

Non-probability sampling was used in order to create an in-depth description with the focus on purposive sampling. The sample consists of three mathematics teachers from this private inclusive school: one teaching HI learners in the IP (Grades 4-6), one teaching in the SP (Grades 7-9), and one teaching HI learners in the FET phase (Grades 10-12). The applicable HI learners were either Afrikaans or English speaking.

A possible disadvantage of the planned sampling is the limited amount of available teachers. In the IP (Grades 4-6) there are three teachers; in the SP (Grades 7-9) there are also three teachers while in the FET phase (Grades 10-12) there are only 2 possible teachers. The teachers teaching the highest grade with the most experience were chosen. Another disadvantage is the limited number of HI impaired learners taking mathematics and not mathematical literacy as a subject in Grades 10-12. Currently there are only 3 HI learners in the FET phase taking mathematics.

3.5 Data collection techniques

According to Creswell (2014) the qualitative forms of data can be placed into the following main categories:

- Qualitative observations
- Qualitative interviews
- Qualitative documents
- Qualitative audio and visual materials

3.5.1 Data collection process

For this study, data was collected through observations, semi-structured interviews and document analysis from the teacher's planning, tests and worksheets. Video recordings were made of the observations, while audio recordings were made of the interviews. Kersting (2008) suggests that the analysis of video recordings can be used not to measure teacher knowledge, but as a tool to improve the teachers' teaching and their students' learning.

Figure 3.1 represents the data collection process for the observations and interviews.

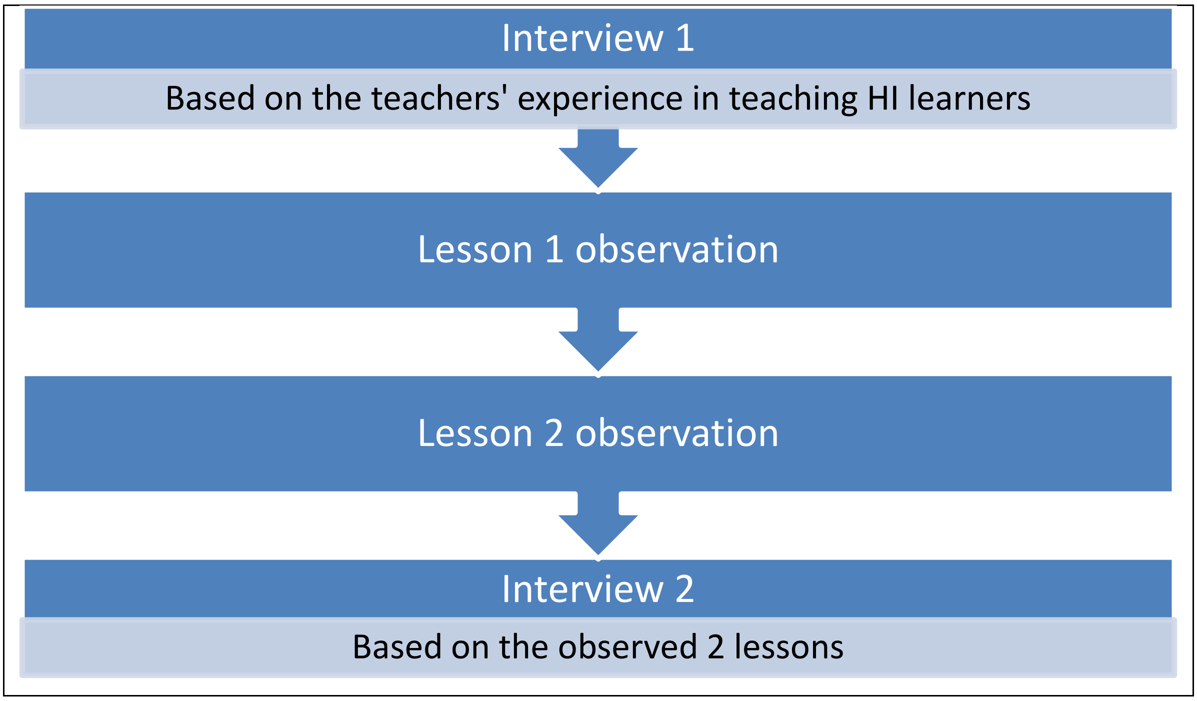

Figure 3.1: The data collection process

3.5.2 Observations

Creswell (2012) states that observation is "the process of gathering open-ended, first-hand information by observing people and places at a research site" (p.213). Two mathematics lessons of each teacher were observed, each time with the same class with the same HI learners. Even though the observations did not take place on consecutive days, the topics of both lessons were still the same. The focus of the observations was on the practices needed in order to teach HI learners in an inclusive school. This included teaching-and-learning practices as well as language factors. In assisting with the data analysis of the observations, the lessons were video-taped and transcribed afterwards. Field notes were made regarding any unexpected valuable data that had emerged. Classroom observations are essential since learners' participation contribution and interaction with the teacher and content easily change the dynamics of a lesson and lead to valuable data that can be collected.

3.5.3 Interviews

Nieuwenhuis (2016) defined an interview as "a two-way conversation in which the interviewer asks the participant questions to collect data and to learn about the ideas, beliefs, views, opinions and behaviours of the participant" (p.92-93). Open-ended (unstructured), semi-structured, and structured interviews are the three types of interviews in qualitative research (Nieuwenhuis, 2016). Some advantages of interviews include easy administration; non-verbal cues that can be accessed; the participant that can be identified by the interviewer, unlike when using questionnaires; and the interviewer can ensure that all the questions are answered (Seabi, 2012). In this study two semi-structured interviews[1] per teacher were conducted: one before the lessons were observed and one after the observation of the second lesson. Audio recordings of the interviews were made and the tape recordings were transcribed verbatim and coded afterwards by myself. Table 3.2 below provides clarification of the character of the interviews (Adapted from Botha, 2011)

Table 3.2: Clarification of the character of the interviews

INTERVIEW 1 A semi-structured interview conducted prior to any lessons observed	**Purpose of the interview** To obtain information on the mathematics teacher's experience in teaching HI learners in an inclusive school.
	Examples of the content of interview questions • Teachers' adaptation of lessons due to HI learners in class • Challenges teachers face when teaching HI learners • Addressing the challenges when teaching HI learners
INTERVIEW 2 A semi-structured interview conducted after both lessons were observed	**Purpose of the interview** To discuss the observed lessons as well as certain aspects in it.
	Examples of the content of interview questions • The planned outcomes of the lessons • The adaptation of certain aspects of the lessons due to the HI learners in class

3.5.4 Documentation

Documents can be defined as a record of an event or process (McCulloch, 2004) and it is a valuable source of information in qualitative research (Creswell, 2012). The teachers'

[1] See Appendix E and F

planning was used as documentation in the proposed research as well as tests and/or worksheets. The analysis of the documentation was done with the conceptual framework as a basis. The focus was to identify the applicable categories of the conceptual framework in the documentation provided by the teachers with the focus on the language factors when teaching mathematics to HI learners.

All three of the above data collection techniques were used in collaboration to make sense of the reality and the complexity of the phenomenon, in other words the exploration of how mathematics teachers teach mathematics to oral HI learners in an inclusive school.

3.5.5 Summary of data collection techniques

Table 3.3 is a summary of the data collection techniques used with their advantages and limitations as incorporated and adapted from Creswell (2014).

Table 3.3: Qualitative data collection types, options, advantages and limitations

Data collection types	Chosen option within types	Advantages of the type	Limitations of the type
Observations	Complete observer - the researcher observed without any participation.	• First-hand experience • Recording of data as it occurs • Unusual aspects can be noticed • Useful in exploring topics difficult for participant to discuss.	• Researcher may be experienced as intrusive. • Private information, not for reporting, may be observed. • Researcher may have limited observing skills. • Some participants may present special problems in gaining rapport.
Interviews	One-on-one and face-to-face, in-person.	• Allows researcher control over the line of questioning. • Participants can provide background	• Provides indirect information filtered through the views of the interviewee. • Researcher's presence

		information.	may bias responses. • Not all people are equally articulate and perceptive.
Documents	Private documents - preparation files including tests and worksheets.	• Can be assessed at a convenient time for the researcher. • Represents information to which participants have given attention. • As written evidence, it saves a researcher the time and expense of transcribing.	• Not all people are equally articulate and perceptive. • May be protected information unavailable to the public or for private access. • Requires transcribing or optically scanning for computer entry. • Materials may be incomplete. • The documents may not be authentic or accurate.
Audio-visual materials	• Video recordings of lessons • Audio recordings of interviews	• It is creative in that it captures attention visually. • Provides an opportunity for participants to share their reality directly.	• May be difficult to interpret. • The presence of an observer may be disruptive and affect responses.

3.6 Data analysis strategies

"Data analysis should be done in a way that reflects integrity and that is unbiased and scientific" (Maree, 2012, p.227). Qualitative data is usually put into similar themes or categories (Di Fabio & Maree, 2012). Di Fabio and Maree (2012) refer to Ryan and Bernard who said:

> Analysing text involves several tasks: (1) discovering themes and subthemes, (2) winnowing themes to a manageable few (i.e. deciding which themes are important in any project), (3) building hierarchies of themes or code books, and (4) linking themes into theoretical models. (Di Fabio & Maree, 2012, p.139)

Creswell (2014) urges researchers to look at qualitative data analysis as "following steps from the specific to the general and as involving multiple levels of analysis" (p.196). For this purpose Creswell's (2014) suggested seven-step analytic strategy was adapted for this study:

Step 1: *Organising and preparing the data for analysis* - Interviews and observations were transcribed and translated where necessary, field notes typed up and the sorting and arranging of the data into different types took place.
Step 2: *Reading and looking at the data* - A general overview of the information as well as time to reflect on its overall meaning were part of this step.
Step 3: *Coding of the data* - Predetermined codes from the conceptual framework (Figure 2.2) have been used to set up a qualitative codebook (Table 3.4) and grouped into code families (Table 3.5) and the raw data was coded using a deductive approach. The transcriptions of the observations as well as the given documentation from each participant were coded in the ATLAS.ti 7 computer program which allows for codes to be easily accessed, sorted and merged.

Table 3.5: List of Code Families and their Members

Code Family	Codes
Mathematics teacher as teaching-and-learning expert	• Role of the teacher as content specialist • Specialised content vocabulary • Incorporation of real-world problems and critical thinking • The role of the teacher as skilled communicator • Active teaching-and-learning principles • Enhancement of visual organisers • Use of technology
Language factors in teaching mathematics to HI learners	• Language of instruction: mathematics to language of instruction • Mediating textbooks and documents

Step 4: *Generating descriptions and themes* - Themes from the two interviews per participant were analysed for each case.
Step 5: *Representation of description and themes* - Narrative passages and tables were used to convey the information.
Step 6: *Interpretation of the findings* - Lessons learned were the researcher's personal interpretation.

Although exploratory qualitative studies tend to be primarily inductive (Nieuwenhuis, 2016), I made use of a deductive approach as set out in the conceptual framework (Table 2.2). Certain conclusions were made from the analysis and are discussed in chapter 5.

Table 3.4: Codebook used in the deductive approach

Code info	Comment
Active teaching-and-learning principles	For enhancement of concept mastery. Practical work is a valuable vehicle for assisting learners to construct meaning.
Enhancement of visual organisers	Visual aids such as graphs, charts and maps. When teaching new concepts and vocabulary, teachers should make use of pedagogy that builds on prior knowledge and contexts that link the concept or word to a picture explaining the meaning.
Incorporation of real-world problems and critical thinking	Real-world problems present opportunities to use traditional mathematical concepts from various branches of mathematics in meaningful ways. Include chart reading and the organising of information. The learners should be guided to learn how to think beyond the basics, to a problem-solving and higher-order-thinking approach. It is important that teachers provide the HI learners with opportunities to think.
Language of instruction: mathematics to language of instruction	Teachers should provide mathematics concepts using the learner's first language before competence is assessed in another language. (The primary language might refer to sign language.) Also focus on the use of the mathematics register - in other words changing between mathematical language and natural language (Rephrasing).
Mediating textbooks and documentation	The difference between the language abilities of the learner and the language demands of the textbooks, tests and worksheets. Level of readability includes the length of words, sentences and paragraphs; complex words and other symbols; and the use of pictures, diagrams, graphs. For example when talking about a trapezium, it is easier remembering the meaning when looking at the visual representation.
Role of the teacher as content specialist	Teachers teaching HI learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching.
Specialised content	HI learners lag behind their hearing peers in the critical area of vocabulary knowledge and they will benefit from

vocabulary	repeated exposure to vocabulary
The role of the teacher as skilled communicator	Lack of vocabulary hinders HI learners' ability to learn words independently of the context. Teachers should make use of pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation.
Use of technology	Technology should be available and used as a tool to expand instruction and enhance understanding and knowledge.

3.7 Quality assurance criteria

Trustworthiness, validity and reliability are criteria of quality assurance considered in this qualitative research study. The Hawthorne and Halo effect as well as the Dunning-Kruger effect were also kept in mind.

3.7.1 Trustworthiness of the study

Di Fabio and Maree (2012) made the remark that in qualitative research, “validity is also referred to as trustworthiness in terms of the credibility, confirmability, transferability, dependability and authenticity of a study” (p.139).

Factors that affect the trustworthiness of the study are the small number of participants, the small number of lessons observed as well as the limited documentation received from the participants.

3.7.2 Validity and reliability of the study

Creswell (2014) made a distinction between qualitative validity and qualitative reliability when he stipulated that for qualitative validity “the researcher checks for the accuracy of the findings by employing certain procedures” (p.201) and qualitative reliability refers to a consistent approach. The core of validation “lies in the open and transparent nature of the research procedures, and in leaving a clear ‘audit trail’ of decisions and interpretations made during the course of the research process” (Nieuwenhuis, 2016, p.122). Maxwell (1992) pointed out that “if qualitative studies cannot consistently produce valid results, then policies, programs, or predictions based on these studies cannot be relied on” (p.279). To ensure validity, four of the eight validity strategies Creswell (2014) mentioned were used, namely triangulation; member checking; rich, thick descriptions; and clarification of bias.

Triangulation refers to the usage of different data sources (Creswell, 2014), while member checking refers to the submission of transcripts to the participants in order to correct errors of fact (Nieuwenhuis, 2016). Rich, thick descriptions were used to convey the findings and lastly in order to clarify any bias, I, as an example, indicated how my interpretation of the findings was shaped by my background. In order to enhance validity I avoided seeking answers to support my preconceived ideas and I maintained objectivity as much as I could. The study focused especially on interpretative validity as well as descriptive validity. During the interviews, all the teachers were asked the same questions and after the interviews, they were given a summary of my interpretation of their answers in order for them to verify or change their answers. In order to enhance the reliability of the study, the approach was kept approach consistent.

3.7.2.1 The Hawthorne effect

Seabi (2012) made the remark that the Hawthorne effect (also known as placebo) refers to “the distortions in behaviour that occur when participants change their behaviour because they are being observed” (p.86). During the data collection stage, the Hawthorne effect was taken into consideration as it might occur where teachers perform differently due to being observed. To reduce this effect, two lessons per teacher with the same class were observed. I emphasised the fact that I was not there to criticise. To further enhance the trustworthiness of the observations, the lessons were video-taped and the interviews, audio-taped.

3.7.2.2 The Halo effect

“The halo effect is generally defined as the influence of a global evaluation of individual attributes of a person” for example “nice people tend to have nice attributes and less nice people have less nice attributes” (Nisbett & Wilson, 1977, p.250). Lewis-Beck, Bryman and Liao (2003) said that the halo effect describes the “global impact of a likeable personality, or some specific desirable trait, in creating biased judgments of the target person on any dimension” (p.451). Even though I had been the HoD for one of the participants up to the end of the previous year, I tried to distance myself from him and analysed his actions objectively. To enhance the trustworthiness of the data analysis, I avoided the tendency to seek answers that would have supported my preconceived ideas.

3.7.2.3 The Dunning-Kruger effect

The Dunning-Kruger effect implies the occurrence where it is difficult to recognise one’s own limitations (Kruger & Dunning, 1999). Kruger and Dunning (1999) are of the opinion that “people tend to hold overly favourable views of their abilities” (p.1). This effect was taken into consideration but I also kept in mind that my own bias should not influence the interpretation of the data.

3.8 Ethical considerations

The most common ethical criteria mentioned in the ethics section of a dissertation, according to many researchers (Morgan & Sklar, 2012), are informed consent, confidentiality, anonymity, protection from harm and access to results. Consent was given by the private schools’ director and principals, the mathematics teachers as well as the parents of the learners. The learners gave assent themselves. The limited amount of available teachers was taken into consideration and dealt with in the most ethical way possible. The teachers were not forced to participate in the planned study and they had the assurance that they would be protected. In order to accomplish confidentiality and anonymity, a pseudonym was assigned to each participant.

The ethical considerations of working with disabled learners were taken into account due to the smaller sample size. The small number of HI learners in a private inclusive school is a vulnerable population and was addressed with all the ethical requirements. Video recordings were not made with the HI learners' faces visible – only the teacher's face.

General ethical principles that apply to dissertation writing according to APA General Principals are beneficence and non-maleficence; fidelity and responsibility; integrity; justice and lastly respect for people's rights and dignity (Elias & Theron, 2012). To ensure that the study adhered to research ethics requirements, permission was obtained from the Ethics Committee at the University of Pretoria.

3.9 Conclusion

In this chapter the research paradigm, namely social constructivism, with an interpretivism position was discussed. A qualitative research approach with an exploratory case study as a research design was used. The research site was a private inclusive mainstream primary and high school where oral HI learners learn alongside their hearing peers. The school is situated in Gauteng, South Africa. The sample consisted of three mathematics teachers - each teaching in a different phase (IP, SP and FET). Two observations per teacher were used to explore how teachers teach HI learners in an inclusive school. The two interviews took place, one before the observation of the first lesson and the other one once both lessons were observed. The teachers' planning, tests and worksheets were also analysed. ATLAS.ti 7 was used to analyse the video and audio data. Lastly the trustworthiness of the study as well as the ethical considerations that were taken into consideration were discussed. The following chapter consists of the results of the study as well as a discussion thereof.

Chapter 4

Presentation and discussion of the findings

4.1 Introduction

In this chapter the data collection process[2] and the data analysis strategies[3] will be looked at again while the coding of the data will be described in detail. Based on my conceptual framework (as seen below in Figure 4.1) the findings from each participant were thematically presented and discussed, related to the literature and used to explain the identified trends. The two themes were 1) mathematics teacher as teaching-and-learning expert; and 2) language factors in teaching mathematics to HI learners. Each theme consisted of practices based on the ten practices a mathematics teacher should use when teaching HI learners (Easterbrooks & Stephenson, 2006) as sub-themes allocated to them and can be seen in Figure 4.1.

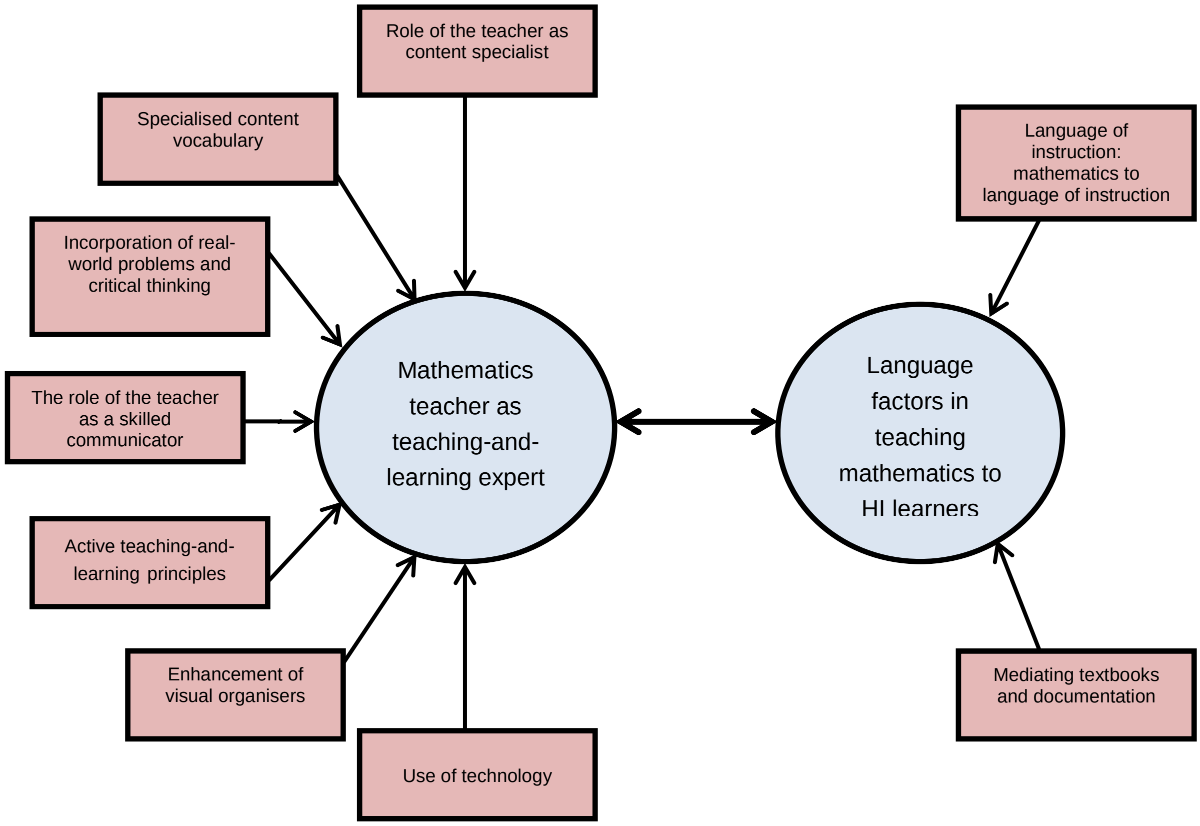

Figure 4.1: Conceptual framework

[2] For more detail see Section 3.5: Data collection techniques.
[3] For more detail see Section 3.6: Data analysis strategies.

The research questions were:

Primary research question

How do mathematics teachers teach oral hearing impaired learners in an inclusive environment?

Secondary research questions

1. How can the classroom practice of the mathematics teachers as teaching-and-learning experts be described?
2. What are the language factors that need to be considered when teaching mathematics to HI learners?

4.2 Data collection process

The data collection took place during May 2017 at a private inclusive school in Pretoria, consisting of a primary and high school. The director of the school was initially contacted and the study was discussed with him and their participation was requested. He referred me to the principals of the primary and high school. Once a meeting was held with them, they gave me permission to contact the possible participants. Three possible participants[4] were identified and contacted - Bob in the primary school and Rose and Dina in the high school. Each one of them received an invitation and consent letter. During the data collection period I communicated and made arrangements directly with each of them.

The data collection process[5] of two interviews and two observations per participant was adhered to. The first interview was held before any observations, while the second interview took place sometime after the second observation. The duration of the interviews varied from ten minutes to nearly half an hour and the interviews were conducted after school hours or during a free period. The first interview was based on the teachers' experience, while the second one was based on the observed two lessons.

Bob was observed with a Grade 5 class[6]. The primary school usually has periods of 50 minutes each. The first lesson observed with Bob, was on a day the learners had concert practice time during school hours, therefore the duration was nearly 40 minutes. On the day

[4] Pseudonyms were used for ethical purposes

[5] The data collection process is discussed in Section 3.5: Data collection techniques.

[6] See Section 3.4: Research site and sampling.

of the observation of Bob's second lesson, there was no concert practice, so the duration was 50 minutes. Rose's two lessons with the Grade 8's were approximately 35 minutes each, as was the first Grade 10 lesson of Dina. The second lesson of Dina was a double period with the scheduled duration of one hour, but she came late, so the lesson was effectively 46 minutes.

In Table 4.1 a timeline is given indicating the dates all three participants' lessons were observed and interviews conducted.

Table 4.1: Timeline of the data collection process

Data gathering instrument	Participant[7]	Date in 2017
Interview 1	Dina	18 May
Interview 1	Rose	18 May
Lesson 1	Rose	22 May
Lesson 1	Dina	23 May
Lesson 2	Rose	24 May
Lesson 2	Dina	25 May
Interview 2	Dina	25 May
Interview 2	Rose	25 May
Interview 1	Bob	26 May
Lesson 1	Bob	26 May
Lesson 2	Bob	31 May
Interview 2	Bob	31 May

The participants also gave me some documents in the form of worksheets, tests, exams and copies of textbook pages. None of them had written lesson plans. They followed the applicable textbooks strictly.

4.3 Data analysis strategies

The study's deductive approach and analytic strategies are discussed in Chapter 3[8]. Only the transcribing and coding of the data will be discussed in this section. The inclusion and exclusion criteria for coding the data are also discussed and presented in table form.

[7] Pseudonyms were used to protect the participants' true identities.

[8] See Section 3.6: Data analysis strategies.

4.3.1 Transcribing the data

The video and audio-taped data was transcribed verbatim to text and translated to English where the data was in Afrikaans. Where certain Afrikaans vocabulary was essential, the word/s were kept as part of the translation. Care was taken not to interpret the data already during the transcribing phase. All hand-written field notes as well as insights that were thought of afterwards which had not been noted were typed on a template form. Uncertainties that emerged were addressed by watching the recordings of the lessons or listening to the audio recordings again. Transcripts of the interviews were sent to the participants for member checking. Only Bob made one correction to what he said in the interview. Transcripts of the observations were read afterwards to ensure true adherence to the actual observations. Documents received from the participants that were not in digital form were scanned.

4.3.2 Coding of the data

In coding the data, a deductive approach based on the conceptual framework[9] was used. According to the conceptual framework two themes, namely 1) mathematics teacher as teaching-and-learning expert and 2) language factors in teaching mathematics to HI learners were identified and set up as code families. Codes were ascribed based on the practices a mathematics and science teacher should use in teaching HI learners (Easterbrooks & Stephenson, 2006) as the members of the families (Table 4.2) in which the raw data was analysed.

Table 4.2: List of Code Families and their Members

Code Family	Codes
Mathematics teacher as teaching-and-learning expert	• Role of the teacher as content specialist • Specialised content vocabulary • Incorporation of real-world problems and critical thinking • The role of the teacher as skilled communicator • Active teaching-and-learning principles • Enhancement of visual organisers • Use of technology
Language factors in teaching mathematics	• Language of instruction: mathematics to language of instruction

[9] See Section 2.4.

to HI learners	• Mediating textbooks and documents

By using the software program ATLAS.ti 7, the transcripts were coded according to a set of pre-determined themes. The data was analysed according to two themes, namely 1) the mathematics teacher as teaching-and-learning expert; and 2) language factors in teaching mathematics to HI learners. Sub-themes for each of these themes were created using ATLAS.ti 7. Networks for these sub-themes were created afterwards where the connections between the different codes assigned to the families were indicated.

4.3.2.1 Theme 1: Mathematics teacher as teaching-and-learning expert

The seven sub-themes from the adapted practices a mathematics and science teacher should apply in teaching HI learners (Easterbrooks & Stephenson, 2006) that were ascribed to the theme of mathematics teacher as teaching-and-learning expert were:

- Role of the teacher as content specialist;
- Specialised content vocabulary;
- Incorporation of real-world problems and critical thinking;
- The role of the teacher as skilled communicator;
- Active teaching-and-learning principles;
- Enhancement of visual organisers; and
- Use of technology

All data was collected from the observations, interviews and documentation. While coding, another code emerged from the data that is associated with **specialised content vocabulary**, namely *Tutorials and individual sessions. Tutorials and individual sessions* refers to additional assistance to HI learners. *Tutorials* focus on subject content and vocabulary while *individual sessions* focus on vocabulary and spoken language. Two additional codes emerged from the data associated with **active teaching-and-learning principles**, namely *Repeating* and *Preventing lip-reading*. *Repeating* refers to the teacher repeating what some learners said in order for the HI learners to follow conversations and explanations. *Preventing lip*-reading contradicts with sufficient **active teaching-and-learning principles**, as the teacher stands in such a way or in such a place that the HI learner cannot use lip-reading to assist his or her hearing. While coding, another code emerged from the data that is associated with **enhancement of visual organisers**, namely *Gestures*. *Gestures* indicates that the teacher uses parts of his or her body to help explain what is being said. It might be a phrase or just a word. *Gestures* is not sign language.

Table 4.3 is an abstract from the codebook in ATLAS.ti 7 with a description of each of the sub-themes and the other emerging themes.

Table 4.3: Mathematics teacher as teaching-and-learning expert: sub-themes and descriptions

Sub-theme	Description
Role of the teacher as content specialist	Teachers teaching HI learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching.
Specialised content vocabulary	HI learners lag behind their hearing peers in the critical area of vocabulary knowledge and they will benefit from repeated exposure to vocabulary.
Incorporation of real-world problems and critical thinking	Real-world problems present opportunities to use traditional mathematical concepts from various branches of mathematics in meaningful ways, including chart reading and organising of information. The learners should be guided to learn how to think beyond the basics, to a problem-solving and higher-order-thinking approach. It is important that teachers provide the HI learners with opportunities to think.
The role of the teacher as skilled communicator	Lack of vocabulary hinders HI learners' ability to learn words independent of context. Teachers should make use of pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation.
Active teaching-and-learning principles	For enhancement of concept mastery. Practical work is a valuable vehicle for assisting learners to construct meaning.
Enhancement of visual organisers	Visual aids such as graphs, charts and maps. When teaching new concepts and vocabulary, teachers should make use of pedagogy that builds on prior knowledge and contexts that link the concept or word to a picture explaining the meaning.
Use of technology	Technology should be available and used as a tool to expand instruction and enhance understanding and knowledge.
Additional themes	**Description**
Tutorials and individual sessions	Additional assistance to HI learners. Tutorials focus on subject content and vocabulary while individual sessions focus on

	vocabulary and spoken language.
Repeating	Teacher repeats what a learner said, or even what the teacher said themselves in order for HI learner to be able to follow conversations or explanations.
Preventing lip-reading	HI learner unable to read lips due to teacher's position.
Gestures	Using parts of body to help explain what is being said. Might be a phrase or just a word.

Using ATLAS.ti 7, networks of the code families were created and the mathematics teacher as teaching-and-learning expert's network is illustrated in Figure 4.2. The broken line arrows (in red) indicate the different practices being linked to the code family: **mathematics teacher as teaching-and-learning expert** while the solid line arrows indicate a certain link between the sub-themes and other emerging codes.

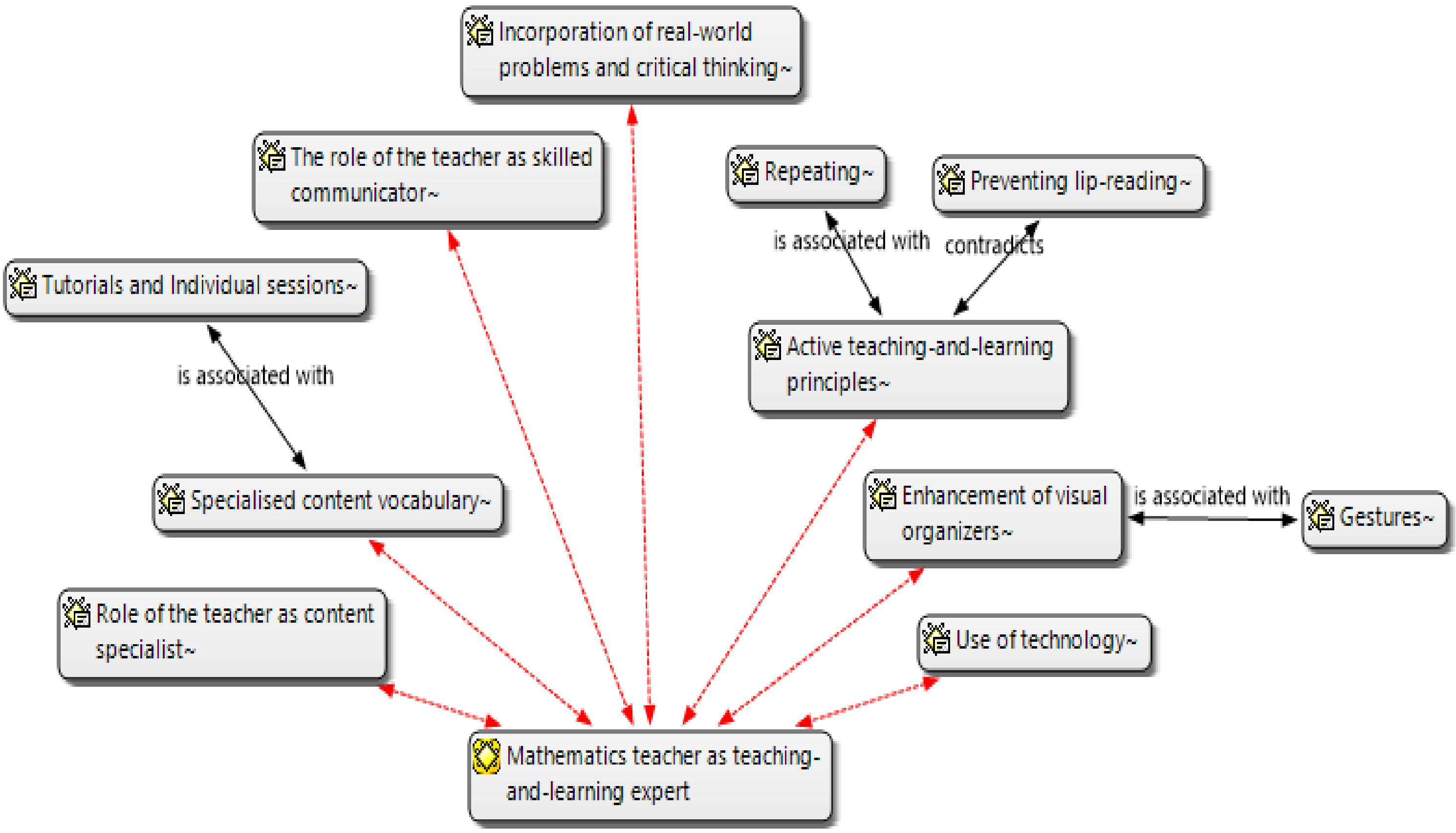

Figure 4.2: Mathematics teacher as teaching-and-learning expert

4.3.2.2 Theme 2: Language factors in teaching mathematics to HI learners

The two sub-themes from the adapted practices a mathematics and science teacher should apply in teaching HI learners (Easterbrooks & Stephenson, 2006) that were ascribed to the theme of language factors in teaching mathematics to HI learners were:

- Language of instruction: mathematics to language of instruction; and
- Mediating textbooks and documentation.

The data was collected from the observations and the received documentation. While coding, another code emerged from the data that is associated with **language of instruction: mathematics to language of instruction**, namely *Rephrasing. Rephrasing* indicates that the teacher puts phrases or words in other words or simpler language. It also relates to mathematics register - in other words changing between mathematical language and natural language. *Rephrasing* helps the HI learners to overcome the language barrier.

Table 4.4 is an abstract from the codebook in ATLAS.ti 7 with a description of each of the two sub-themes and the other emerging theme.

Table 4.4: Language factors in teaching mathematics to HI learners: sub-themes and descriptions

Sub-theme	Description
Language of instruction: mathematics to language of instruction	Teachers should provide mathematics concepts using the learner's first language before competence is assessed in another language. (The primary language might refer to sign language.)
Mediating textbooks and documents	The difference between the language abilities of the learner and the language demands of the textbooks. The level of readability includes the length of words, sentences and paragraphs; complex words and other symbols; and the use of pictures, diagrams, and graphs. For example when talking about a trapezium, it is easier to remember the meaning when looking at the visual representation.
Additional themes	**Description**
Rephrasing	Using other, easier, more common (natural) language to explain a phrase or word. Relates to the mathematics register.

Using ATLAS.ti 7, networks of the code families were created and the language factors in teaching mathematics to HI learners' network are illustrated in Figure 4.3. The broken line arrows (in red) indicate the two different practices being linked to the code family: **language factors in teaching mathematics to HI learners** while the solid line arrow indicates a certain link between the sub-theme **language of instruction: mathematics to language of instruction** and the emerging code.

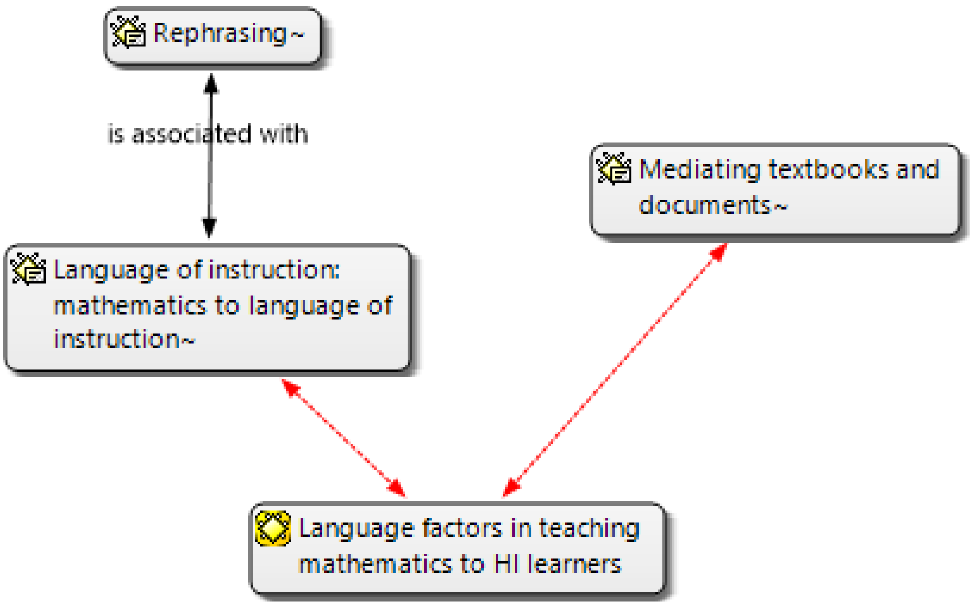

Figure 4.3: Language factors in teaching mathematics to HI learners

4.3.2.3 Inclusion criteria for coding the data

Table 4.5 is a summary of the inclusion criteria used for coding the data.

Table 4.5: Inclusion criteria used for coding the data

MATHEMATICS TEACHER AS TEACHING-AND-LEARNING EXPERT	
Code (Sub-theme) info	**Description**
Role of the teacher as content specialist	Teachers teaching HI learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching.
Specialised content vocabulary	HI learners lag behind their hearing peers in the critical area of vocabulary knowledge and they will benefit from repeated exposure to vocabulary.
Incorporation of real-world problems and critical thinking	Real-world problems present opportunities to use traditional mathematical concepts from various branches of mathematics in meaningful ways, including chart reading and organising of information. The learners should be guided to learn how to think beyond the basics, to a problem-solving and higher-order-thinking approach. It is important that teachers provide the HI learners with opportunities to think.
The role of the teacher as skilled communicator	Lack of vocabulary hinders HI learners' ability to learn words independent of context. Teachers should make use of pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation.
Active teaching-and-learning principles	For enhancement of concept mastery. Practical work is a valuable vehicle for assisting learners to construct meaning.
Enhancement of visual organisers	Visual aids such as graphs, charts and maps. When teaching new concepts and vocabulary, teachers should make use of pedagogy that builds on prior knowledge and contexts that link the concept or word to a picture explaining the meaning.
Use of technology	Technology should be available and used as a tool to expand instruction and enhance understanding and knowledge.

Additional themes	**Description**
Tutorials and individual sessions	Additional assistance to HI learners. Tutorials focus on subject content and vocabulary while individual sessions focus on vocabulary and spoken language.
Repeating	Teacher repeats what a learner said, or even what he or she said him or herself in order for HI learner to be able to follow conversations or explanations.
Preventing lip-reading	HI learner unable to read lips due to teacher's position.
Gestures	Using parts of body to help explain what is being said. Might be a phrase or just a word.
LANGUAGE FACTORS IN TEACHING MATHEMATICS TO HI LEARNERS	
Code (Sub-theme) info	**Description**
Language of instruction: mathematics to language of instruction	Teachers should provide mathematics concepts using the learner's first language before competence is assessed in another language. (The primary language might refer to sign language.)
Mediating textbooks and documents	The difference between the language abilities of the learner and the language demands of the textbooks. Level of readability includes the length of words, sentences and paragraphs; complex words and other symbols; and the use of pictures, diagrams, and graphs. For example when talking about a trapezium, it is easier to remember the meaning when looking at the visual representation.
Additional themes	**Description**
Rephrasing	Using other, easier, more common (natural) language to explain a phrase or word. Relates to the mathematics register.

4.3.2.4 Exclusion criteria for coding the data

In the process of coding the observations and documentation, some of the discourse, activities and documentation were not relevant to the study and did not form part of the conceptual framework, while others were inaudible. These were excluded when the data was coded. During the interviews some participants did not always stick to the question being asked and elaborated on irrelevant topics. The exclusion criteria as well as examples of excluded text are listed in Table 4.6 below.

Table 4.6: Exclusion criteria for coding the data

Exclusion criteria	Examples of text excluded from coding
Interruptions	Teachers attending to people knocking on the door. Learners asking to go to the bathroom.
Incidents during the observation when I could not hear what was said.	This occurred when the teacher attended to individual learners at their desks or when a learner answered a question or asked something and I could not hear. During one lesson construction took place outside and the grinder made a big noise. Some of the data was inaudible during the transcription.
The interviewee going off topic during the interview.	***Tell me more about yourself, the places where you've taught and how many years' experience you have as a mathematics teacher.*** *… I studied at Potchefstroom; the initiation started on the Sunday and I received admission on the Thursday. I always tell the children that I cried myself into university because my father said that I could not go and study. But OK, by hook or by crook I went and studied at Potchefstroom…*
Spelling mistakes on PowerProint presentation.	Three-dimensional spelled in Afrikaans as *Dried**e**mensioneel.*
Elaboration on irrelevant topics	*I must tell you, it really, it was an eye opener for me. I do not think of learners with hearing loss the same way I did last year. I think a person becomes more used to it. And I have Hendrik who gets 80%. I have Truman who gets 100%. So, the only learner that I am really concerned about is Jay. But Jay is only lazy, because Jay can speak very well. And he can actually hear very well too, but he is just too lazy.*

4.4 Information regarding the three participants

The next section contains biographical information regarding the three participants Bob, Rose and Dina. It also includes some background information regarding the observed lessons. Pseudonyms were used to protect the participants' identities.

4.4.1 Bob

Bob is a 40 year old male with 15 years' experience as a primary school mathematics teacher in a public school as well as the private inclusive school. Over the years he has taught mathematics to Grades 4-7, with the most experience, however, with Grade 5 learners. Of the seven years he has been teaching in the private inclusive school, he has taught mathematics for five years. Apart from his Higher Education Diploma, he also achieved a Further Diploma in Education, an Advance Certificate in Education as well as a BEd Honours degree in Education management.

The two lessons I observed were with the Grade 5 Afrikaans class consisting of 23 learners. Three of the learners were HI. The theme of the lessons was three-dimensional shapes.

4.4.2 Rose

At age 50, Rose is the oldest of the three participants with 25 years' of experience as a mathematics teacher in public as well as private schools. Over the years she has taught mathematics to Grades 4-12 learners with the focus mainly on Grades 11 and 12. She has taught mathematics Grades 11 and 12 at the private inclusive school since 2014. This year she was responsible for Grades 8, 11 and 12 mathematics. Apart from achieving a BSc degree, she also obtained an Honours degree in physics as well as the Higher Education Diploma.

I observed Rose's two lessons with her Grade 8 Afrikaans class. The class consists of 20 learners of which only one was an HI learner. The theme of the lessons was exponents with the focus on determining the products as well as simplifying exponents in fraction form. During both of the lessons, Rose only marked homework calculations. No new work was explained. On the day of the second observation, there was construction taking place just outside her classroom and the grinding made it difficult to hear during the lesson.

4.4.3 Dina

Dina has a Baccalaureus Educationis (BEd) degree for Intermediate and Senior phase with majors in mathematics and technology. She is 35 years old with 13 years' experience in teaching mathematics Grades 8-11 at different public schools all over the country. She had her own mathematics centre for Grades 8-12 learners at her house for six months before relocating with her family to Pretoria. Since July 2016, she has been a staff member of the private inclusive school. For the second half of 2016 she was responsible for Grades 11 and 12 Mathematical Literacy. She is currently teaching mathematics to Grades 9 and 10 at the private inclusive school.

The theme of the two lessons observed was trigonometric functions. The outcomes, according to her, were to identify the different trigonometric functions, to draw them, and to be able to answer questions based on those functions. The Grade 10 English class she taught consists of 30 learners, two of whom are HI.

To summarise: The most relevant information appears in Table 4.7 below:

Table 4.7: Biographical information of the three participants

	Bob	Rose	Dina
Age (years)	40	50	35
Qualifications	• HED • Further Diploma in Education • BEd Hons Education management • Advance Certificate in Education	• BSc • Hons in Physics • HED	• BEd (Intermediate and senior phase)
Mathematics teaching experience (years)	15	25	13
Mathematics teaching experience for HI learners (years)	5	3,5	1

4.5 Theme 1: Mathematics teacher as teaching-and-learning expert

In this section the findings are presented and discussed from the observations, interviews and documentation analysis of Bob, Rose and Dina. All discussions on the sub-themes **role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancement of visual organisers; and use of technology** were structured strictly according to the specific order of the sub-themes (codes) as indicated in Table 4.5[10] The additional codes *tutorials and individual sessions, repeating, preventing lip-reading* and *gestures* are discussed under the relevant sub-themes.

The language of all quotes from Dina has not been edited. Since Bob's and Rose's classes were conducted in Afrikaans, the quotations were translated into English. Background information regarding the observed lessons of the participants is given. At the end of the section is a summary of this section in table form similar to Table 4.5.

4.5.1 Bob as teaching-and-learning expert

4.5.1.1 Role of the teacher as content specialist

The focus in the role of the teacher as content specialist is that teachers teaching HI learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching (Easterbrooks & Stephenson, 2006). As Bob did not study special needs education, but an ordinary teaching qualification, his knowledge of the content of mathematics is supposed to be sufficient.

On two occasions, however, Bob did not give the correct vocabulary and/or definition and might have confused some learners. This might be due to a slip of the tongue, or it might be due to a lack of content knowledge. See the two examples below:

The first example where Bob did not use the correct vocabulary was with the discussion of the cylinder. He said it did not have angles *(hoeke[11])*, while he was supposed to say that it did not have vertices *(hoekpunte[12])*.

[10] Table 4.5 is discussed under Section 4.3.2.3: Inclusion criteria for coding the data.

[11] Afrikaans word *hoeke* translated to angles.

[12] Afrikaans word *hoekpunte* translated to vertices.

B: *Elme[13], come. Choose the cylinder*. (Elme walks to the front and selects the correct shape) *Yes? Good. Tell me,* (Bob asks Elme) *how many vertices does it have?*

L: *None, sir.*

B: *Huh? None? Why not?*

L: *Because it is round.*

B: *It is round; it does not have* ***angles*** **(hoeke).** *Good, how many ehm ...edges does it have?*

As angles are ***hoeke*** in Afrikaans and vertices ***hoekpunte***, the close correlation might have influenced the incorrect repetition by Bob.

In the second example, Bob did not expand on the learners' definition of an isosceles triangle:

B: *Good, and explain to Shantelle what is an* ***isosceles triangle[14]****.*

L: *All the edges are the same length.*

B: *Explain to Steph, Jani.*

L: *All the edges are the same length.*

B: *Ok thank you. Quickly explain to Piet* (points with hand to Carel and walks closer to them).

L: *All the edges are the same length.*

B: *Did you hear?*

Never, as can be seen above, did Bob correct the definition of an isosceles triangle. The learners gave the definition of an equilateral triangle. He had the learners repeat it to one another without explaining what they were saying and the application of it.

4.5.1.2 Specialised content vocabulary

As HI learners lag behind their hearing peers in the critical area of vocabulary knowledge, they will benefit from repeated exposure to vocabulary (Luckner & Cooke, 2010). During the first lesson, Bob focused on the vocabulary of: side, edge, angles *(hoeke)*, vertices *(hoekpunte)* and faces. There were eight occasions on which he mentioned one or more of

[13] Pseudonyms were used for all the names.
[14] Researcher's own emphasis.

the new vocabulary as the HI learners would benefit from repeated exposure to it. Unfortunately he never wrote the words on the board as a visual aid. He only said the words.

During the second lesson, Bob recapped the vocabulary of side, edge, angles, vertices and faces and applied it to different three-dimensional shapes in a PowerPoint presentation. He also wanted the learners to understand the difference between two-dimensional and three-dimensional. He focused on the HI learners when he talked about the different dimensions, as can be seen in the extract[15] below:

B: *Good. First one shows* (Slide 1 of PowerPoint has the word spelled like: Dried**e**mensioneel[16]) *the word three-dimensional has the word three in it. Do you see that? Three...Why do you think three? Ivan?*

L: *Three dimensions.*

B: *Three dimensions. Do you remember when we did two-dimensional shapes, Shantelle* (HI learner) *we said it had two dimensions. What are those two dimensions? Can you remember Shantelle what a two-dimensional shape must have, what a two-dimensional shape must have? I think it was in the class test too?*

(Class *Yes Sir*).

B: *Who got it right? Let's see* (learners raise their hands) *So now you know. And Steph* (HI learner)*? Why not Steph? Kayli, ag Jani here next to you is going to say, so you, you both must now look at her* (indicating to two of the HI learners to look at Jani).

L: *Breadth and length.*

B: *What did she say?* (looks at Shantelle a HI learner).

L: *Breadth and length.*

B: *Steph, what did she say?*

L: *Metre[17] and length.*

B: *Not metre. Length. Breadth and length. Now what is it Steph? What is breadth and length? Explain it to me* (Steph only looks at Bob).

[15] Translated from Afrikaans to English.

[16] Spelling error in title. It is supposed to be Dried**i**mensioneel.

[17] *Breedte* is Afrikaans for breadth and *meter* is the Afrikaans for metre. The HI learner heard *meter* instead of *breedte* in Afrikaans as it sounds similar.

Even though the one HI learner repeated it incorrectly and Bob corrected him, it is evident that he did not know what and why they were repeating the words. He could not explain what they were saying.

Tutorials and individual sessions

Bob explained that every morning from 7:00 - 7:30 they have tutorials with the HI learners. “It is basically what you can call…eh … re-teaching, but it is more of a repetition of the work being dealt with in class that day or work you know the learner doesn’t understand yet that we maybe did the previous day”. The HI learners would attend the tutorials in groups and Bob uses the time for example to let them write the answers of sums on little white boards. The boards are then put up in the air so that he can quickly see who is on par and who is not. He is of the opinion that the tutorials give them more time to ensure that concepts are grasped and captured. Clark (2007) mentions that a learner should get support by special subject teachers rather than by specialists in deaf education.

In the afternoons from 13:30 until 14:00 the teachers usually get two, sometimes three HI learners for 10 minute individual sessions each. During that time they will work one-on-one and focus more on language. Bob mentioned that he would bring in mathematical vocabulary such as *descending order,* the words used in tests like *define, describe* and *calculate* and explain to the HI learners what they mean.

During the second lesson, Bob referred to the tutorials when he talked to one of the HI learners in Grade 5:

> ***B**: Now, Shantelle, you get … this year what we are going to teach you, two different types of pyramids. One with a square base... What does a square base mean? Do you know?* (still talking to Shantelle – she does not know) *I will..., I will tomorrow morning, when we have the tutorials, ask you all these questions again to see if you were listening today. Ok? Ok. So you must listen carefully.*

4.5.1.3 Incorporation of real-world problems and critical thinking

During the two lessons observed with Bob, he used real-world problems in his explanation as it presented opportunities to use traditional mathematical concepts from various branches of mathematics in meaningful ways (Pagliaro & Kritzer, 2005). The example below[18] refers to the net of a three-dimensional shape:

[18] Translated from Afrikaans to English.

B: *What do we call that thing of the cube?* (points with laser to net on the board)
(It is not clear if HI learner #1 is answering him).
Tell him again. (Talks to HI learner #2).

***L**: A net.*

***B**: Tell me,* (Looks at the HI learners #1 and #3).
What is a net? (Touches HI learner #2 on the shoulder – he stands half slanting to her back). *Explain to me what is a net.*

***L**: Eh…you form the shape.*

***B**: Yes, it is the same as this one, such as the......pattern. I don't really do needlework, but I know there are women who always fold the patterns up and then you cut. So this is the pattern you fold in order to fold that block. A pattern. Does your mom do needlework?* (looks to HI learner #1, but another girl answers in the confirmatory) *and then she cuts the pattern out and then she makes the pants and the legs and other stuff. That type is the pattern to make it possible to fold the cube* (Points to picture on PowerPoint presentation). *Do you understand?* (Asks the class). *Good, what is nice about that patterns, now you can count, Ivan, how many faces does this cube of mine have?*

Bob wanted to ensure that the HI learners understood what a net was. He compared it with needlework and a pattern used to make pants. It is not clear if HI learner #1 and #3 understood his comparison. HI learner #2 was on par and understood what a net was.

Opportunities for critical thinking should be provided by the teachers (Pagliaro & Kritzer, 2005). Learners should be guided to learn how to think beyond the basics. Bob gave the learners a challenge and even though it might not seem to be a mathematical problem-solving and higher-order-thinking approach, it definitely challenged them. Their challenge was to create songs about three-dimensional shapes. He first taught them an English song for the sphere for example. It was: "Sphere, sphere, what's your clue? You look like a soccer ball I kick with my shoe". The learners were tasked to write their own song with their own rhyme on the characteristics of three-dimensional shapes.

4.5.1.4 The role of the teacher as skilled communicator

HI learners' lack of vocabulary hinders their ability to learn words independent of context (Luckner & Cooke, 2010). Teachers should therefore use pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation

(Lang & Pagliaro, 2007). Following is an example[19] of how Bob introduced new concepts and words, in this case not with a pictorial representation, but with concrete manipulatives. The learners had to construct a triangular pyramid using matches and prestik. He had one learner's triangular pyramid in his hands when he started the explanation.

B: *Good, let me help you. If you look, this is which shape?*
(He again raises a learner's shape into the air and looks at the class. He points only to a triangular face of the three-dimensional shape).
(Some learners say *two-dimensional*, others *three-dimensional* and others *triangle*).
B: *A two-dimensional triangle. What does it do here?* (Points to angles)
An angle and an angle and an angle. (Points to triangle's three angles)
But now, now I...if I place these sticks on top it has a triangle here and it has a triangle there, and it has a triangle here and a triangle below, (Points at triangular faces of three-dimensional shape) *now I cannot call these things angles* (hoeke)[20] *anymore, because each triangle makes an angle where the angles come together let us call this a vertex* (hoekpunt)[21]. *Do you understand this?*
(Class reacted with a *Yes, Sir*).
B: *What do we call these sticks?* (referring to matches making the edges of the three-dimensional shape) *Let us first look at the two-dimensional if we had a triangle. What do we call these?* (Indicating to sticks/matches of the triangle representing the sides of the two-dimensional shape)
L: *Sides*
B: *A side. Do you agree? How many sides does this triangle have?*
(Class reacts with *three*).
B: *Three. But now if we build a three-dimensional shape, now we have more than one triangle. Am I right?* (Builds pyramid again). *Here is a triangle with a side. Here is a triangle with sides* (Points at sides). *Now we cannot call them sides anymore, because each triangle has sides that come together. What must we call it now? Who knows?* (He looks to the right).
L: *Side* (kant)[22]
B: *Uh - uh*[23]
L: *A side* (sykant)[24]

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[19] Translated from Afrikaans to English.
[20] Translated from *hoeke* in Afrikaans.
[21] Translated from *hoekpunt* in Afrikaans.
[22] Original Afrikaans word.
[23] Indicates incorrect answer.

***B**: Uh - uh*

***L**: Edge*

***B**: (snaps fingers excitedly) *Let us quickly stand and do a ....'yes-yes-yes!'**

(Learners stand up and do a '*yes-yes-yes!*').

***L**: A side.* (Talks while learners take their seats).

***B**: No, you are not listening.* (Walks to a HI learner). *What did he say do we call this?*

***L**: An edge side.* (rand kant)[25]

***B**: Uh - uh*

An edge. (Bends low to bring his face to her eye level).

What do we call it, Ina[26]? (Walks to the middle where Ina is seated).

***L**: An edge.*

***B**: What do we call it, Merco?*

***L**: An edge.*

***B**: Now why do we call it an edge and not a side? Reinhardt?*

***L**: Because it has more than one side, sir.*

***B**: More than one side. There where the sides meet.*

Bob got the answers he was looking for from the learners with his communication skills. The HI learners could see what he explained as he used manipulatives to introduce new vocabulary.

4.5.1.5 Active teaching-and-learning principles

During the first interview with Bob, he mentioned that he initially received training from the Head of Training on site to assist him in teaching HI learners. Even though Bob did not mention it in his interviews, I am aware that the training was not just a once-off. It is continuous and it does not matter how experienced a teacher might be, the Head of Training does class visits and gives feedback in order to improve the teachers' skills.

Below are examples[27] Bob had to focus on when teaching HI learners:

- "In our training, a lot of emphasis was placed on that you must not turn your back on the learners when you are working on the board. Ehm… in the beginning it was a challenge, because if you are writing on the board, you turn your back on the learners. If you talk so that the learners can see your lips. Ehm… you must not walk

[24] Original Afrikaans word.

[25] Original answer in Afrikaans.

[26] Pseudonyms used for names of learners.

[27] Translated from Afrikaans to English.

around too much. At other schools, they want you to walk around, but when you work with HI learners in your classroom, you need to focus on it so that they can see your face at all times".

- "You need to repeat a lot. …repetition is always good, but you have to repeat more than usual".
- "And you need to ask now and then, ehm… listen, what did I say? Do you understand?"
- "You cannot just write a method on the board and expect from them to understand where it comes from … 'if you multiply with 10, why do you just put a zero'?. And explain a bit more why".
- "They struggle to see things visually …. Meaning you need to work more practical, more visual".

Bob also made a remark that the HI learners' arithmetic is not always on par. He also stated he felt their multiplication tables and division tables are a bit better if they get support from home. In his second interview, Bob mentioned that one needs to practice mathematics. He experienced that the tempo the HI learners are working at, is slower than normal and feared that the tempo he is talking at might cause HI learners to miss things.

In addressing the challenges the teachers were facing, Bob made some suggestions:

- "Be more practical. Pack things out for them. Sometimes it looks weird, but you can even use pencils from their pencil case to explain by saying, ok, you have this amount of pencils on the one side, in order for them to experience it more practical, then, then they understand better".
- "Visit HI learners more often to say ok, I will sit with you for 2 or 3 minutes in a lesson, if the other learners are working, to see if they are on par with what you have explained".
- To improve the tempo - "give them a certain amount of time to complete something".

There are some differences when having HI learners in a class compared to another school without them, but Bob felt that "if you teach properly, then you need to make minimal adaptations - to achieve success with them".

Both of Bob's two lessons on three-dimensional shapes were full of active learning. He made use of active learning principles in a clever way to enhance concept mastery. Bob started off his first lesson by giving each Grade 5 learner some prestik and matches. Their task was to create the pyramid he showed them by using the prestik and matches.

Later in the lesson the learners had to do activities in groups. There were five stations with different activities each. After six or seven minutes the learners were supposed to rotate to the next station. At the first station, the learners had to construct a three-dimensional shape from its net. Each one in the group had to choose the net of a different shape. The second station had marshmallows, toothpicks and kebab sticks and the learners had to create a three-dimensional shape they picked from a pile using the marshmallows and different kinds of sticks. At the third station the learners received straws, prestik and paint. The idea was that they used the straws for the edges and the prestik for the vertices. The paint was there to paint the faces of the shapes It was not clear what they were supposed to paint if the straws and prestik only gave them a structure. Unfortunately, I was not there for the follow-up lesson in order to see how Bob resolved this problem.

The fourth station had a guessing game. The learners had to take turns being blindfolded. The other learners had to choose a three-dimensional shape and give it to the blindfolded learner. That learner then had to touch and feel the shape and described to the others how many edges, vertices and faces it had. He or she also had to provide the name of the shape. At the fifth group, the learners played a memory game. There were cards with pictures as well as cards only with the names of the shapes. Bob not only gave them cards with three-dimensional shapes on it, but he also mixed it up with two-dimensional shapes. Another challenge was that the written words were in English and not in Afrikaans like the specific Grade 5 class was.

During the second lesson, Bob recapped the characteristics of the three-dimensional shapes. He also taught them some songs he got from Pinterest[28] in helping to remember some of the characteristics. An example is the one for the square based pyramid: “Pyramid, pyramid, what’s your clue? You look like the house the Egyptians walk through”. The learners had to sing and make gestures in helping to remember the connections.

Bob also used the opportunity in the second lesson to call on learners to pick a specific, requested shape from a pile in the front of the classroom. The learners could not wait to be picked and have a turn to show off their knowledge.

[28] A website where people can upload images and other media content.

Repeating

During both of Bob's observed lessons, he repeated 69 times what someone else said, or what he himself said over a period of 86 minutes, but 36 times he did not repeat answers of the learners. Below is an example of Bob repeating what a learner said:

> ***Girl***
>
> It is a pyramid with a triangular base.
>
> ***Bob***
>
> Beautiful! A pyramid with a triangular base.

Preventing lip-reading

Bob's position in class was such that only once during each of the observed lessons could the HI learners not see his face. He has truly mastered the skill of facing the learners in order for them to be able to use lip-reading as an aid to hearing.

4.5.1.6 Enhancement of visual organisers

Bob introduced the theme of three-dimensional shapes by using plenty of visual organisers such as plastic models of the shapes, matches and prestik as well as marshmallows and different types of sticks[29]. To explain the difference between *angle* and *vertex* as well as between *edge* and *side* for example, Bob built on their prior knowledge and used prestik and sticks to first show the learners an ordinary triangle with angles and sides. Then he added three other triangles to create a triangular based pyramid and indicated to them that where there were sides overlapping, it was now called an edge, and where angles of the different triangles came together, it was called a *vertex*[30]. He captured the essence again by doing the same with two A4 papers. The learners overall understood the difference between an angle and vertex as well as an edge and a side.

When explaining a triangular prism, he walked over to his desk and presented the learners with a calendar from a local pharmacy. They could see that the three-dimensional shapes were all around us in our daily lives. He also used the calendar to show them the faces of the shape as it was not only a structure. He pointed out the fact that although the ends of the calendar were open, those were also faces.

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[29] Refer to Section 4.5.1.5 for explanation of the activities.

[30] Take note the lesson was translated from Afrikaans to English.

Gestures

Bob used gestures in both lessons to assist with his explanations. In the first lesson Bob told the learners of the swimming pool that was built at his house. He used gestures to explain to the learners how he indicated to the contractor the required rectangular shape of the pool. The pool was 25 m long and he told them he wanted to take on Chad le Clos, so he must practice his freestyle. He gestured the freestyle movement. He also explained to the learners that when choosing between the words height and depth, depended on the observer's position: whether inside the pool and looking up, or outside the pool and looking down. Each time he used gestures.

When Bob taught the learners the songs for some of the characteristics of the three-dimensional shapes[31] he used gestures for enhancing the relevance of the association. For example when he taught them the song of the pyramid[32] he adopted an Egyptian pose. Another example is the song of the sphere: "Sphere, sphere, what's your clue? You look like a soccer ball I kick with my shoe". He demonstrated the kicking of a ball.

4.5.1.7 Use of technology

During both of the lessons I observed of Bob, he was wearing a Roger inspiro Soundfield connected to a Roger Dynamic SoundField. It is a wireless microphone that not only transmits the sound directly to the hearing aids of a HI learner, but it is also linked to the soundfield. The Dynamic SoundField benefits leaflet (2010) informs that "a soundfield system consists of a wireless microphone and one or more loudspeakers which amplify the teacher's voice around the class" (p.1). In this case there is only one loudspeaker in the classroom. The Roger Dynamic SoundField transmits sound digitally, "automatically alternating frequencies in order to eliminate potential interference with existing Wi-Fi or Bluetooth networks. The system continuously measures the room's noise level and automatically optimises its own configuration, ensuring speech remains loud and clear" (Brochure Roger Dynamic SoundField, 2016, p.3).

In his second lesson, Bob made use of a PowerPoint presentation while explaining three-dimensional shapes. He also used a laser to indicate on the presentation while elaborating on three-dimensional shapes. Bob did not hesitate to use technology to look for assistance while preparing. He mentioned to the learners that he got the songs on certain three-dimensional shapes on Pinterest.

[31] See Section 4.5.1.5.
[32] See Section 4.5.1.5.

4.5.2 Rose as teaching-and-learning expert

4.5.2.1 Role of the teacher as content specialist

The focus on the role of the teacher as content specialist is that teachers teaching HI learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching (Easterbrooks & Stephenson, 2006). As Rose did not study special needs education, but a BSc degree followed by a teaching diploma, her knowledge of the content of mathematics is supposed to be more than sufficient. During the observations of the lessons, there were no occasions where her content knowledge was challenged as she just marked homework calculations.

4.5.2.2 Specialised content vocabulary

As HI learners lag behind their hearing peers in the critical area of vocabulary knowledge, they will benefit from repeated exposure to vocabulary (Luckner & Cooke, 2010). On a number of occasions during the observations, Rose corrected the learners' way of speaking. Find examples below:

- ***R**: Must I say 2 minus 1? Not 2 from 1?*

- ***L**: Ma'am I said 2x 3 over 4, 2x 3.*
  ***R**: 2x to the power of three. Read correctly.*

- ***L**: 4 is 2.*
  ***R**: Not 4 is 2; 4 divided by 2.*

- ***L**: And then you minus with a square 3. You …*
  ***R**: Just 3. You minus the power with 3. You don't say square. Square is a little two.*

Tutorials and individual sessions

Rose mentioned that she has a tutorial with the Grade 8 HI learner once a week and that it is then one-on-one. During that time she can quickly see if there are any problems. Two problems she identified were that the HI learner was weak with her multiplication tables and that her combinations were not what they are supposed to be. The tutorials were the ideal time to focus on the problems. Rose also said that during the tutorials she would use pre-teaching by teaching the HI learner in advance what would be done the coming week. This she did not only with the HI learner in Grade 8, but also the one in Grade 11:

> *It works wonderful, because then the eyes sparkle, we know exactly what is happening and I also see this with my Grade 11 learner. It is wonderful. I often pre-teach him. So I can with him, he is really clever, so in a morning, I can do 3, 4 lessons in advance - do I with him and it works wonderfully with him. Then he knows already what we will be doing in class, but again, any learner will benefit if they receive pre-teaching.*

Rose saw the Grade 8 HI learner for individual sessions the previous term. She stated that in the individual sessions they did not focus on subjects. They expanded the HI learner's general knowledge and worked on vocabulary. As the HI learner achieved higher marks in mathematics than in English, they rather focused on languages. Rose tried to improve the Grade 8 HI learner's English[33] by looking at English newspaper articles, reading them and working on them.

4.5.2.3 Incorporation of real-world problems and critical thinking

Little evidence was observed where Rose presented the learners with opportunities to use traditional mathematical concepts from various branches of mathematics in meaningful ways. Below are two questions from tests[34] that were the nearest she came to linking to real-world problems.

Example 1:

> *A man is standing on a diving board 3m above the surface of the swimming pool. He dives a total distance of 6,5m. What should be the minimum depth of the swimming pool?*

Example 2:

> *In 16 of the 20 rugby matches he played, Danie scored. The percentage matches he scored in are*
>
> *A. 16%*
> *B. 8%*
> *C. 80%*
> *D. 160%*

[33] Take note the Grade 8 HI learner's mother tongue is Afrikaans.
[34] Translated from Afrikaans to English.

Rose gave the learners opportunities for critical thinking. Even though it did not happen during the observations, it happened in worksheets and class tests[35]. Below are two examples of critical thinking required from the learners. Example 1 came from a class test where the learners had to apply their knowledge while Example 2 was a question from a worksheet.

Example 1:

Write down your own **(i) numerical** and **(ii) geometrical** sequences up to five terms.

Example 2:

There are mistakes in every one of the following calculations.

(i) Explain what is wrong.

(ii) Explain how it is supposed to be done.

(iii) Do the calculation correctly on the empty folio handed out to you.

$$2 \times 3\frac{3}{5} - \frac{4}{5}$$
$$= 2 \times \frac{18}{5} - \frac{4}{5}$$
$$= 2 \times \frac{18}{5}$$
$$= \frac{36}{10} - \frac{4}{5}$$
$$= \frac{36}{10} - \frac{8}{10}$$
$$= \frac{28}{10}$$
$$= \frac{14}{5}$$

4.5.2.4 The role of the teacher as skilled communicator

For the purpose of this study **the role of the teacher as skilled communicator** is linked to the lack of vocabulary that hinders the HI learners' ability to learn words independent of context (Luckner & Cooke, 2010). The teacher should therefore make use of pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation (Lang & Pagliaro, 2007).

[35] Translated from Afrikaans to English.

As both of the lessons observed with Rose were spent on marking homework, no new concepts were introduced and there was no clear evidence of **the role of the teacher as skilled communicator**. The only evidence found, was in presentation slides of previous lessons Rose gave me as part of the documentation analysis. Figure 4.4 and Figure 4.5 are two of the slides[36] she did with the Grade 8 class. The slides contain evidence of procedures and written notes.

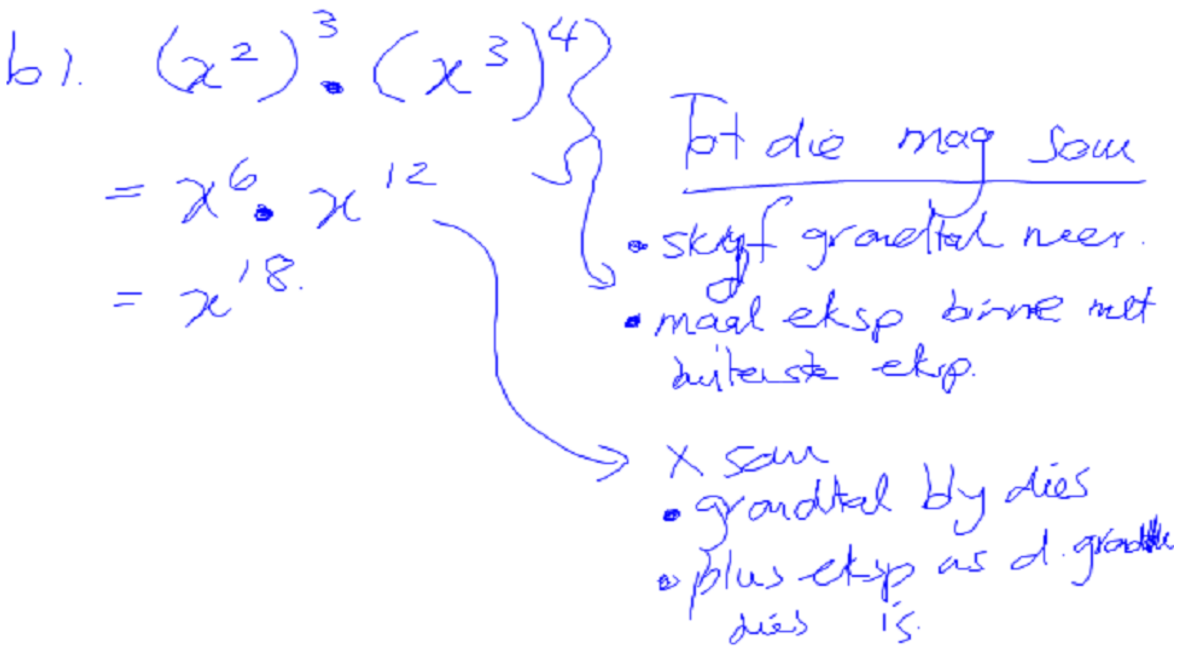

Figure 4.4: Evidence A of previous explanation of doing exponent calculations.

On the right hand side of the slide, are the steps and notes written in Afrikaans. When translated into English it will be:

<u>'To the power of' - sums</u>

- Write down the base.
- Multiply exponents inside with exponent outside.

X sum

- Base stays the same.
- Add the exponents if the bases are the same.

[36] Original slides in Afrikaans.

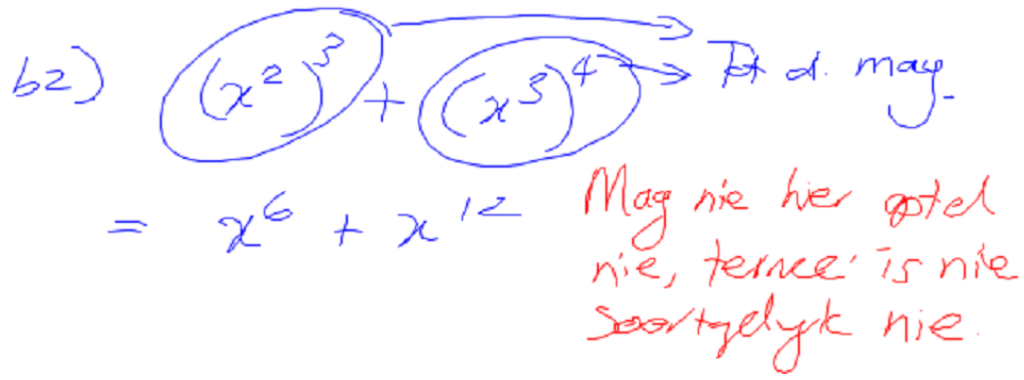

Figure 4.5: Evidence B of previous explanation of doing exponent calculations.

The note written in red can be translated as: *May not add here, these are not like terms.*

4.5.2.5 Active teaching-and-learning principles

Although Rose had spent three and a half years at the inclusive school and received plenty of in-house training, she mentioned in her first interview that *"I don't really teach in another way, because it is inclusive. The only thing one tends to do is to turn your back on the learners when talking and writing on the board"*[37]*.* Her answer to the question in the second interview of what she had to adapt due to the HI learners in her class, was that she never adapted her lessons. She was of the opinion that "*Because, remember our learners were brought up in the primary school, so it is inclusive education. In other words I feel the only thing that needs be adapted here, is our technology".*

During the first interview while discussing whether a HI learner will know when he or she does not understand, Rose made the remark that as a teacher

> *You have to have an opportunity for the learners to work in class so that you can see what he does; otherwise you will not know that he didn't hear correctly. So it is that participation or you have to ask him a question so that he can answer in order for you to see whether he understood. So every time there needs to be an opportunity. Or you must ask him questions that he needs to answer. Or he needs to do written work. You have to see from his feedback whether he heard what you have said.*

Rose mentioned in the second interview that she does not rush through the work, as she would not be able to say that the learners mastered the work.

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[37] Translated from Afrikaans to English.

The two lessons I observed of Rose were lessons in which she just marked calculations. She asked a learner by name to tell her the steps of the calculations of the specific sum and then she would write it on the whiteboard as the learner gave the answers. Those were the only opportunities observed where the Grade 8 learners were actively involved.

Repeating

During both of Rose's observed lessons, she repeated 55 times what someone else said, or what she herself said over a period of 70 minutes. See the following examples[38]:

- "Especially if there is a minus in front, because a minus changes my sign. Because a minus multiplied with something changes it".
- "Ok, what did we do first when we did the previous calculation and we had powers? What did we do first?"
- **Girl:** ...and then at the bottom is just a 2.
  Rose: 2. There you go.

Preventing lip-reading

During the first interview with Rose, she mentioned[39] that one thing a teacher tends to do is to "turn your back on the learners when talking and writing on the board". She also stated "so we have to focus on it not to turn our backs to the learners when talking, because they want to see your face" and "it is only good manners, to look at someone while talking to them".

What Rose said during the interview contradicts with what was observed during the lessons. During the first lesson there were 74 incidents where Rose turned her back on the learners while talking, either when writing on the board or just looking at it to follow what a learner said and making a remark. During the second lesson it happened 63 times.

As a result, the HI learner struggled to use lip-reading as an aid in order to assist in hearing.

4.5.2.6 Enhancement of visual organisers

During the first interview with Rose, she told me that mathematics teachers write a lot on the board. Both of Rose's lessons were just the marking of homework calculations. She constantly used the Mimio computer program as the interactive whiteboard. All the sums were written on the board and done in steps. Once there was no more space to write, she would open another slide and continue with the marking of the sums. At one point during the

[38] Translated by the researcher from Afrikaans to English.
[39] Quotations translated from Afrikaans to English.

second lesson, she used different colours on the board in order to show the rules of exponents.

Gestures

Most of the gestures Rose made were facial expressions. She either nodded her head if a learner answered correctly, or she made a face as indication that the learner was on the wrong track. Other gestures that she made:

- Once she looked at a learner with a tilted head to what the learner had to answer as indication that the learner made an incorrect comment.
- She also pulled up her shoulders to emphasise that 1 multiplied by 1 stayed 1 and will not make a difference to an answer.
- At two instances she indicated the answers with her fingers, namely two and four.
- In her question to a learner how to multiply fractions with each other, she made horizontal movements with her hands to indicate one should multiply the numerators with each other and then the denominators with each other.

4.5.2.7 Use of technology

During both of the lessons it was observed that Rose was wearing a Roger Touchscreen Mic connected to a Roger Dynamic SoundField. It is a wireless microphone "capable of transmitting simultaneously to Roger receiver wearers and soundfield listeners" (Brochure Roger Dynamic SoundField, 2016, p.4). The Dynamic SoundField benefits leaflet (2010) informs that "a soundfield system consists of a wireless microphone and one or more loudspeakers which amplify the teacher's voice around the class" (p.1).

Rose was the only teacher using an interactive whiteboard with the Mimio computer program. Although she mainly used it as a type of whiteboard with whiteboard markers, she informed me during the second interview that she saves each lesson's slides. Thus, if a learner is absent, she can just e-mail the slides done that day to him or her. If there is a query or question from the learners about a previous slide, she can just open it up, where in the case of an ordinary board and markers she would not be able to do so once the board was cleaned.

4.5.3 Dina as teaching-and-learning expert

4.5.3.1 Role of the teacher as content specialist

The focus on the role of the teacher as content specialist is that teachers teaching HI learners should possess specific training, experience and certification in the content knowledge of the subjects they are teaching (Easterbrooks & Stephenson, 2006). As Dina did not study special needs education, but a degree in education with mathematics and technology as majors, her content knowledge is supposed to be sufficient. However, in her second interview she mentioned that after 13 years of teaching, there are things that she only understood this year for the first time, for example the concept of $\boldsymbol{f}(\boldsymbol{x})$ in trigonometric diagrams. See conversation below:

***D**: And I will tell you, honestly, like I told you before, this really is my weakness. It feels for the first time that this year I am comfortable and ok.*

***I**[40]: Understand it yourself.*

D: *Understand it myself. In 13 years…*

I: *Why, would you say?*

D: *The f of x is the y.*

I: *Yes, but why only this year?*

D: *I don't know, maybe because I had such a mental block, I just did what I was supposed to do. For example this exercise 14 I did with them, previously, I would have … 'ok…we just do one, then we are done'. While I felt this time that we had to do all of it.*

4.5.3.2 Specialised content vocabulary

As HI learners lag behind their hearing peers in the critical area of vocabulary knowledge, they will benefit from repeated exposure to vocabulary (Luckner & Cooke, 2010). Although Dina repeated words or phrases 72 times during her two observed lessons, not all of that repetition enhanced content vocabulary. The following example is an indication of this.

***D**: Ok, exactly. Guys, when you work with tan, you do not have an amplitude. Why not?*

(Class murmuring)

***D**: There is no wave. Guys, give me more?*

(Class murmuring)

***D**: There is no crest. Ok, there is no crest. But for those of us who's Afrikaans, what is the meaning of crest?*

(Class murmuring *Bakkie op, bakkie af*[41])

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[40] Words said by interviewer.

[41] Words in Afrikaans she used to explain *crest* by making gestures indicating the curves of a bowl.

D: ***Bakkie op***[42] *… ok no, that doesn't make sense either. There is no …* (indicate with hands) *maximum and no minimum. Right. I didn't hear you, sorry.*
Ok, so this one goes to infinity. Ok, now … that means that we will not be able to determine the range of a (show on board) *by using maximum minus minimum. Ok, right. So let's then go to the tan graph. Quickly tell me guys, the original tan graph, what is different from this one to the original tan graph?*

The phrase *bakkie op, bakkie af* does not expand the vocabulary of the HI learners. They need to be able to identity with the correct vocabulary.

Tutorials and individual sessions

To improve the vocabulary and spoken language of the HI learners, they attend tutorials and individual sessions. The HI learners in the high school have a mathematics tutorial once a week for 40 minutes where special attention is given. Dina, for example, has the Grade 10 HI learners for tutorials on a Friday morning and uses the time to catch-up on the week's work, or to pre-teach work coming the following week.

Dina mentioned that the individual sessions are in the afternoons and that she did "weird" English words[43] in the first term with a specific HI learner.

4.5.3.3 Incorporation of real-world problems and critical thinking

The only evidence found where Dina touched on real-world problems, was the question a learner asked her with regard to trigonometric functions. See conversation below:

L: *Ma'am, can I ask you a question? Where will you actually use this in life?*

D: *Ah, I was waiting for that. I actually went and googled it. Ok, so I will actually quickly tell you what is this good for. Ok, guys, the question was where will we use this in real life? Ok, so as I told you before, if you are going to take mathematics and not math lit, it is because you are going to study an extremely difficult course at university, right? That requires you to get 70 % for your maths, ok. So where will you use this? So guys, you will...I will show you on GeoGebra, but if I increase the value that multiplies with tan, to a big number. What happens to tan, then it eventually become like a straight line. Because if you think back to straight lines, you had* $y = mx + c$*, right? What was the m?*

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[42] Researcher's emphasis.

[43] The HI learner she did it with, are English.

***L**: Gradient.*

***D**: The gradient. Tan, guys, is which to the x and y and r? What over what?*

(Class murmuring)

***D**: y over x, right? Now guys, the gradient is also y over x. The gradient, if you do the gradient, I don't know whether you did it like this in grade 9; so gradient is delta y over delta x* (writes formula on board)*. Did you do that last year?*

(Class murmuring)

***D**: Ok, so it just means that…* Wat is 'n verandering in y in Engels?[44] (Talks to the assistant, Mike)

(Class *The change*)

***D**: The change. Thank you. So guys, this is the change of y divided with the change of x. So this is the same as tan* (indicates to formula on board) *when you will have y over x. So by having a gradient is to determine the slope of a roof. To determine the slope if you build a road.*

***L**: … Bob the builder ...*

(Class laugh)

***D**: If you are a civil engineer and you have to decide on granite floors and the* (Indicating. Struggling to get word)*... gradient of those. Ok, so that is where you use tan. It's actually the tangent, which means that it is a, a ....*raaklyn[45]*. It touches, but it is straight. Ok, so if you have a circle for example* (draws on board while talking)*, and there's a straight line, that will be like a tangent. Having a slope.*

Later in the discussion:

***D**: So it's about building, determining slopes, determining gradients. Guys, if you build a house, and you have a certain height for your wall, you can only build your roof as high as the walls can carry. So, then you will use the gradient to determine the height and also the slope of your roof. Ok, I can see that some of you are looking at me like ... uh?...ok?* (Makes facial expression)

(Class murmuring and laughing)

***D**: Right, I get that. Ok guys, can we go back to the question?* (Wiping explanation off the board that doesn't have anything to do with textbook question) *Ok, let's quickly... are your textbooks open on page 99?*

(Class *eh uh*)

[44] Talks in Afrikaans to her assistant. She wants to know what the *change in y* in English is.

[45] Afrikaans word for tangent.

***D**: Right.*

(Writing something on board that she wiped out. HI learner sitting in the front wants to know something. She goes to his desk. Seems like she's explaining again if you build a wall ... with regard to slope).

***D**: Right, guys, let's quickly have a look at the questions at hand.*

In the section above, Dina emphasised that the work at hand was about building and slopes. She gave some kind of a summary when she said "*if you build a house, and you have a certain height for your wall, you can only build your roof as high as the walls can carry. So, then you will use the gradient to determine the height and also the slope of your roof".* She realised that the learners did not really understand, so she carried on with their homework.

It is a pity that Dina did not spend adequate time on the theme under discussion, as it was a golden opportunity to expose the learners to real-life situations and even challenge them in determining the slope in an example.

It is important that learners get the opportunity for critical thinking and are guided by the teacher to learn how to think beyond the basics, to a problem-solving and higher-order-thinking approach (Easterbrooks & Stephenson, 2006). Teachers cannot just ask a challenging question and then without reasonable thinking time, provide the answer. Unfortunately this was the case in the example below:

D: *...Equals to ... what equals to infinity?*

(Class *The range*)

***D**: The range. So what does that then mean? If the range is to infinity and to negative infinity* (Making gestures with hands). *What does that then mean?*
That there is no amplitude. Oh, ok. Right guys.

Dina asked a question requiring critical thinking from the Grade 10 learners. However, she gave the answer herself. The opportunity, unfortunately, was not maximised.

4.5.3.4 The role of the teacher as skilled communicator

HI learners' lack of vocabulary hinders their ability to learn words independent of context. Teachers should therefore use pedagogy that builds on prior knowledge and context and relates the new concept or word to a pictorial representation.

As the observed lessons consisted of doing and marking questions from the textbook, no new concepts and words were introduced. Below is an example, however, of how Dina's communication skills[46] were challenged by a learner when asked about the relevance of the work in life.

***L**: Ma'am, can I ask you a question? Where will you actually use this in life?*

***D**: Ah, I was waiting for that. I actually went and googled it. Ok, so I will actually quickly tell you what is this good for. Ok, guys, the question was where will we use this in real life? Ok, so as I told you before, if you are going to take mathematics and not math lit, it is because you are going to study an extremely difficult course at university, right? That requires you to get 70 % for your maths, ok. So where will you use this? So guys, you will...I will show you on GeoGebra, but if I increase the value that multiplies with tan, to a big number. What happens to tan, then it eventually become like a straight line. Because if you think back to straight lines, you had* $y = mx + c$, *right? What was the m?*

***L**: Gradient.*

***D**: The gradient. Tan, guys, is which to the x and y and r? What over what?*

(Class murmuring)

***D**: y over x, right? Now guys, the gradient is also y over x. The gradient, if you do the gradient, I don't know whether you did it like this in grade 9; so gradient is delta y over delta x* (writes formula on board)*. Did you do that last year?*

(Class murmuring)

***D**: Ok, so it just means that…* Wat is 'n veranderlike in y in Engels?[47] (Talks to the assistant, Mike)

(Class *The change*)

***D**: The change. Thank you. So guys, this is the change of y divided with the change of x. So this is the same as tan* (indicates to formula on board) *when you will have y over x. So by having a gradient is to determine the slope of a roof. To determine the slope if you build a road.*

***L**: … Bob the builder ...*

(Class laugh)

***D**: If you are a civil engineer and you have to decide on granite floors and the* (Indicating. Struggling to get word)*... gradient of those. Ok, so that is where you*

46 Dina's mother tongue is Afrikaans. She taught in English.
47 Talks in Afrikaans to her assistant.

*use tan. It's actually the tangent, which means that it is a, a ....*raaklyn[48]*. It touches, but it is straight. Ok, so if you have a circle for example* (draws on board while talking)*, and there's a straight line, that will be like a tangent. Having a slope. Yes?* (Looking at learner asking a question)

Up to this point, Dina was lacking skills in communicating what she read on the internet. She had an idea of what to explain, but could not explain it in such a way that the learners understood, even though she used some gestures. Apart from writing the formula $m = \frac{\Delta y}{\Delta x}$ on the board, she did not make use of any pictorial representation to show the context of what was being explained. It was as if she just wanted to tell the learners that they had to have more than 70% for mathematics to be able to go and study *"an extremely difficult course*[49]*"* and that engineers will use it. She even used Afrikaans words twice while explaining as she was not prepared enough to be familiar with the required English words. During the second interview with Dina, she made a remark *"I don't do lesson plans, because I know what I must do. So I know if I am not good at something, then I make sure I prepare for it"*[50]. It could be seen that she was prepared for a question like this, but not well prepared enough.

The discussion continued.

***L**: Ma'am, what do you mean by change in y?*

***D**: Ok, guys, if I can take you back to Grade 9 when you drew a straight line graph. The good old days...* (Talks while writing on board - draws axis and straight line with positive *y* intercept and negative *x* intercept). *Ok, and there's your straight line* (indicates to line on board). *Now, will this slope be positive or negative?*

(Class murmuring)

***D**: Positive, because this is increasing, right? So let's take that this is 3, and this is -2* (making dots on y and x-axis respectively)*. So what will the slope then be? The m-value? It's a positive gradient, right, so I moved 1, 2, 3* (counting while moving from y intercept to origin)*, the change in y. 1, 2* (counting while moving from origin on x-axis and writing on board - substituting it in $y = mx + c$) *Ok? Then that will be x and where it intercepts the y axis I'll find my c-value. Ok, so that will be the equation of this straight line. Where this* (circles m-value) *can also represent tan,*

48 Afrikaans word.

49 Dina's words.

50 Translated from Afrikaans.

because it's y over x. Ok, so that's totally off topic, but eh ... did I answer your question? (Talks to learner)

***L**: Uh eh*

During the above section of the discussion, it was noted that Dina felt more comfortable with what was being asked. Although the knowledge applicable to the question asked was more familiar to her and she used more pictorial representations[51], her explanation did not really answer the question of the learner.

The discussion continued.

***D**: So it's about building, determining slopes, determining gradients. Guys, if you build a house, and you have a certain height for your wall, you can only build your roof as high as the walls can carry. So, then you will use the gradient to determine the height and also the slope of your roof. Ok, I can see that some of you are looking at me like ... uh?...ok?* (Makes facial expression)

(Class murmuring and laughing)

***D**: Right, I get that. Ok guys, can we go back to the question?* (Wiping explanation off the board that doesn't have anything to do with textbook question) *Ok, let's quickly... are your textbooks open on page 99?*

(Class *eh uh*)

***D**: Right.*

(Writing something on board that she wiped out. HI learner sitting in the front wants to know something. She goes to his desk. Seems like she's explaining again if you build a wall ... with regards to slope).

***D**: Right, guys, let's quickly have a look at the questions at hand.*

In the section above, Dina emphasised that the work at hand was about building and slopes. She gave some kind of a summary when she said "*if you build a house, and you have a certain height for your wall, you can only build your roof as high as the walls can carry. So, then you will use the gradient to determine the height and also the slope of your roof".* She realised that the learners did not really understand, so she carried on with their homework. The HI learner in the front called her to his desk. His question was unfortunately inaudible, as was Dina's completed answer to him, but it was clear that she explained again about the

[51] Dina drew graph on whiteboard and indicated procedure using it.

roof of the building and that it had to do with the work they were doing. Although she asked if he was ok with her reply, it was not clear that it was indeed the case.

4.5.3.5 Active teaching-and-learning principles

Although Dina had spent only one year at the inclusive school, she initially received training from the Head of Training on what the implications of teaching HI learners in an inclusive school are. It was discussed in her interviews with me.

Below are remarks[52] Dina made with regard to the implications of teaching HI learners:

- "I think I speak slower".
- "I think I make more eye contact".
- "If I explain something then I will not only explain it one way, I will also explain it a longer more detailed way".
- I am "looking differently at the instructions I give".
- "I do not only tell the homework, I also write it on the board".
- "I also explain much more with my hands".
- "Visual".

She commented that she had to bring in more visuals but mentioned that this was the first year she actually had the technology at her disposal for presenting work more visually.

Dina's two lessons consisted of trigonometric functions: to draw them and to be able to answer questions based on those functions. The learners were actively involved when the questions were explained on the board and they could give some answers. Dina seldom called for a specific learner to answer. Most of the times she asked the question and then waited for any response from anybody. Calculators were used to determine the applicable co-ordinates of the graphs.

Repeating

During both of Dina's observed lessons, she repeated overall 72 times what someone else said, or what she herself said over a period of 83 minutes. Most of the times she repeated her own phrases. See the following examples:

- "Rienie asked me about the reflection, quickly write this down".
- "It stretched. It stretched".
- "They say that the diagram represents two graphs. Two graphs".

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[52] Translated from Afrikaans to English.

- “Ninety. Tiisetso says ninety”.
- “Ok, guys, let's quickly do the last question. Let's quickly do the last question”.

Preventing lip-reading

During Dina’s first lesson there were 21 incidents where she turned her back on the learners while talking, while it happened 27 times during the longer second lesson. It happened when she was talking while writing on the board or even walking around in the class. This made it difficult for the HI learners to be able to do lip-reading.

4.5.3.6 Enhancement of visual organisers

Dina used a computer program named GeoGebra to create the trigonometric functions visually and project them onto the whiteboard. When explaining the trigonometric functions, the projected graphs on the whiteboard played a cardinal role. Time and again she would focus the learners on the visual representation of the functions in order to be able to answer the questions. She would also write the answers on the board with a whiteboard marker while explaining.

One example in which the visual representation worked well was the question to determine graphically the values of $x \in [0°\,; 360°]$ for which: $f(x) \geq g(x)$, where $f(x) = 2\,cos\,x$ and $g(x) = -\cos\,x$. She used a blue whiteboard marker to highlight $f(x)$ and a red whiteboard marker to highlight $g(x)$. The learners clearly saw where the blue graph was above the red graph and were able to answer the question with her guidance.

Another example applicable to the same two graphs, was when the learners had to determine the values of k where the graph of $y = -\cos x + k$ will not cut the x-axis. Once she quickly drew the x-axis with a whiteboard marker on the board, Dina went to the computer and moved the graphs up in order for the learners to be able to understand the question. The learners saw that there will be a time that the specific graph will not intersect the x-axis and with her guidance they got to the answer. She also moved the graph down and the learners could see that there will be two answers for the value of k.

Gestures

In Dina’s second interview, she told me that because she was teaching HI learners, she would often make use of gestures for example when telling the homework, she would indicate the exercise number with her hands as well as the questions to be done. At the end of Dina's second lesson when she gave the learners their homework, she gestured the exercise and number, just like she told me she was doing.

The theme of Dina's lessons was trigonometric functions and she made use of gestures a couple of times, for instance when:

- Talking about the reflection about the x-axis or not;
- The range is to infinity and to negative infinity;
- Talking about maximum and minimum;
- Explaining whether the a-value indicated a shift of the graph, or that the graph was stretched out; and
- Asking whether the graph shifted up or down.

4.5.3.7 Use of technology

During both of the lessons that were observed with Dina, she was wearing a Roger Touchscreen Mic connected to a Roger Dynamic SoundField. Dina made use of a projector in both observed lessons. She used a computer program named GeoGebra to draw the trigonometric functions and project them onto a white board for assistance in explaining. The learners were urged to use their calculators as an aid to calculate the co-ordinates of the functions. Dina also created and administrates a WhatsApp group for the class. During the first lesson she made the remark that she sent a WhatsApp to inform the learners that the class test of the following day was postponed. The learners had homework instead. Unfortunately one of the HI learners did not have data on his phone and therefore did not receive the message.

4.5.4 Summary of participants as teaching-and-learning experts

Table 4.8 is a summary of the three participants' background and as teaching-and-learning experts.

Table 4.8: Summary of the three participants' background and as teaching-and-learning experts.

PARTICIPANTS	BOB	ROSE	DINA
BACKGROUND			
Qualifications and experience	Higher Education Diploma as well as a Further Diploma in Education. Achieved an Advance certificate in Education as well as a BEd Honours degree in Education management. Has 15 years' experience in teaching mathematics at primary school level of which five years are with HI learners in an inclusive school.	BSc as well as honours in Physics. Also achieved the Higher Education Diploma. Has 25 years' experience in teaching mathematics (Grades 4-12 over the years) of which three and a half years are with HI learners.	BEd degree for Intermediate and Senior phase with mathematics and Technology as majors. Has 13 years' experience as a mathematics teacher for Grades 8-11. Had a mathematics centre at her house for six months. Has taught HI learners now for one year.
MATHEMATICS TEACHER AS TEACHING-AND-LEARNING EXPERT			
Role of the teacher as content specialist	• Bob did not study special needs education, but an ordinary teaching qualification. • Mathematics content knowledge is supposed to be sufficient. • Used incorrect vocabulary once. • Did not give correct explanation of *isosceles triangle*.	• Rose did not study special needs education, but a BSc degree followed by a teaching diploma. • Mathematics content knowledge is supposed to be more than sufficient. • No evidence of content knowledge being challenged.	• Dina did not study special needs education, but a degree in education with mathematics and technology as majors. • Mathematics content knowledge is supposed to be sufficient. • She mentioned that after 13 years of teaching, there are things that she only understood this year for the first

			time, for example the concept of $f(x)$.
Specialised content vocabulary	• Repeated the new vocabulary many times, but did not write it on the board as a visual aid. • Evident that HI learners struggled with vocabulary. They did not understand what was meant by two dimensions.	• Corrected learner's way of speaking. E.g. $2x^3$ is 2x to the power of three (and not as learner just said 2x 3)	• Not all of words and/or phrases repeated are content vocabulary. • *Bakkie op, bakkie af* instead of crest.
Tutorials and individual sessions	• Tutorials in mornings from 7:00 - 7:30. Do mainly re-teaching - more of a repetition of the previous day's work. • Individual sessions from 13:30 - 14:00, 10 minutes per learner. Bob will focus on vocabulary such as *descending order, define, describe* and *calculate.* • Reminded HI learner in class of following day's tutorial.	• Will work on problem areas during tutorials - multiplication tables for instance. • Does pre-teaching as well. • Individual sessions to improve Grade 8 HI learner's English (as she is Afrikaans).	• 40 minutes once a week mathematics tutorial. • Used time to catch-up on past week's work or pre-teach for coming week. • Did "weird" English words with HI learner in first term. Not applicable to mathematics.

Incorporation of real-world problems and critical thinking	• Compared the net of a three dimensional shape to a pattern for pants. Unfortunately it was not with manipulatives, but just verbal. • Challenged the learners to write their own songs on the characteristics of three dimensional shapes.	• Not observed during lessons, but visible in worksheets and class tests. • E.g. Word problems. A man diving from a diving board. • E.g. Learners had to analyse a calculation with its answers.	• Missed a golden opportunity to expose the learners to real-life problems. Did not spend adequate time on real-world problems and critical thinking. • Asked questions that require critical thinking, but unfortunately gave the answers herself.
The role of the teacher as a skilled communicator	• Used manipulatives to guide HI learners in trying to master new words, such as *edge* (and not *side).*	• There was little evidence of this theme as the lessons observed were marking of homework.	• Although she prepared for a question of where it will be used in real life, her communication skills were lacking and the learners struggled to follow her.
Active teaching-and-learning principles	When teaching HI learners: • Do not turn back on learners when working on the board. They should be able to lip-read. • Repeat more than usual. • Ask HI learners what was being said and if they understood. • Do not just write a method on the	• Rose does not teach in another way as it is inclusion. • She admitted she never adapt her lessons due to HI learners. • She focused on not turning her back to the class when writing on the board. • HI learners should have an	The effect of teaching HI learners on her: • Speaks slower. • Makes more eye contact. • Will explain something in more than one way. • Explains much more with her hands. • Use visuals more.

	board and expect HI learners to understand where it comes from. Explain more. • HI learners struggle to see things visually. Do more practical, visual work. • Visit HI learners more often during a lesson to check on them. • To improve their tempo, give HI learners a certain amount of time to complete something. • Let learners make use of manipulatives to create three-dimensional shapes. • Had five stations where groups had to do something to help with concept mastering.	opportunity to work in class so that the teacher can monitor them. • Learner participation in marking calculations.	• Looks differently at instructions she is giving. • Learner participation in marking calculations. • Learners used calculators as an aid.
Repeating	• Repeated what a learner said or even he himself said 69 times during both observations over a period of 86 minutes.	• Repeated what a learner said or even she herself said 55 times during both observations over a period of 70 minutes.	• Repeated what a learner said or even she herself said 72 times during both observations over a period of 83 minutes.
Preventing lip-	• Mastered the skill of not turning	• Turned her back on the learners	• Turned her back on the learners

reading	his back on the learners while talking. HI learners could see his face for the biggest majority of the time.	when writing on the board and talking simultaneously. During the two lessons it happened 74 times during the first lesson and 63 times during the second lesson.	when writing on the board and talking simultaneously. During the two lessons it happened 21 times during the first lesson and 27 times during the second lesson.
Enhancement of visual organisers	• Used shapes learners made to explain new concepts. • Used real-life objects to enhance understanding of vocabulary.	• Made use of interactive whiteboard to write calculations on.	• Projected graphs on whiteboard. • Used colour to assist learners in understanding. • Moved graphs up and down as part of explaining.
Gestures	• Used gestures in songs to emphasise characteristics of three-dimensional shapes. • Explained new vocabulary with gestures where applicable.	• Used gestures that mainly indicated a right or a wrong answer. • Where applicable, used hands to show method.	• Indicating homework with hands. • Indicating possible translations of graphs as well as maximum and minimum.
Use of technology	• Was wearing a Roger inspiro Soundfield connected to a soundfield. • Made use of a PowerPoint presentation. • Did research on Pinterest.	• Was wearing a Roger Touchscreen Mic connected to a soundfield. • Used an interactive whiteboard. • E-mailed slides to absent learners.	• Was wearing a Roger Touchscreen Mic connected to a soundfield. • Used GeoGebra and projector to create graphs. • Learners used calculators for determining co-ordinates. • Class is on a WhatsApp group.

4.5.5 Discussion of mathematics teachers as teaching-and-learning experts

In the next section, the findings of the study of the mathematics teacher as teaching-and-learning expert are discussed according to the sub-themes, namely, role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancement of visual organisers; and use of technology[53].

4.5.5.1 Role of the teacher as content specialist

Neither of the participants studied special needs education. All three of them have the necessary qualifications required to teach the classes that they do. Still there were two occasions where Bob used incorrect vocabulary and/or did not give the correct definition of a concept. During Rose's lessons there was no evidence of her content knowledge being challenged as she only marked homework sums with the class. After 13 years, Dina understands certain concepts for the first time, for instance $\boldsymbol{f}(\boldsymbol{x})$. Although she had many years' experience, having to explain it by giving more information, for the HI learners (Knuckey, 2005) might have resulted in her grasping certain concepts herself for the first time.

4.5.5.2 Specialised content vocabulary

Luckner and Cooke (2010) suggest that teachers should use a portion of their regular lesson to expand vocabulary, repeat new words in different contexts, practice vocabulary instruction and spend enough time on using new vocabulary in various contexts. When observing the participants of my study, I found that Bob repeated new vocabulary many times as part of the lesson and not as a portion of the lesson especially structured for the expansion of vocabulary. Dina on the other hand repeated many phrases, but not all of them were repetition of content vocabulary. The only evidence where Rose was focused on the content vocabulary was when she corrected learners that spoke incorrectly. All three of the participants on the other hand, use their tutorials and individual sessions as opportunities to expand the vocabulary of the HI learners and all three of them applied rephrasing.

Tutorials and individual sessions

All three of the participants mentioned that they conduct tutorials and individual sessions. They do post-teaching and pre-teaching in the tutorials. While Rose and Dina focused

[53] See Table 4.3 under Section 4.3.2.1.

mainly on the English language during the individual sessions, whether for an Afrikaans learner or not, I found that Bob used the individual sessions for enhancing of mathematical vocabulary, such as concepts asked in tests, for instance the definitions of words like *define*, *describe* and *calculate* in a test.

4.5.5.3 Incorporation of real-world problems and critical thinking

Pagliaro and Kritzer (2005) are of the opinion that real-world problems engage learners of all ability levels, but unfortunately teachers consider the concepts too complicated for the HI learners and do not include them in instruction. None of the three participants were able to incorporate real-world problems effectively. Bob wanted to ensure that the HI learners understood what a net was. He compared it with needlework and a pattern used to make pants. The comparison would have more power if he did not just tell the learners, but if he had a real pattern to show them the application of a net in the real world. There was no challenge given to the learners. Dina had an opportunity to expose the learners to it, but did not spend adequate time on it. Rose on the other hand did not attend to it in either of her two observed lessons. She only addressed it superficially in a worksheet.

In the study done by Kelly, Lang and Pagliaro (2003), they found that mathematics teachers teaching deaf and hard of hearing learners, focus more on practicing exercises than on true problem-solving situations. The teachers also tend to avoid the more cognitively challenging aspects of word problem solving. In the study, it was found that both Bob and Dina addressed critical thinking slightly during their lessons. Bob's challenge was not compulsory where as Dina did not spend adequate time on it and gave the learners the answers herself. There was no evidence of the learners being challenged to think critically in Rose's class; however, there was evidence of a question in a worksheet where the learners had to think critically.

4.5.5.4 The role of the teacher as skilled communicator

The three participants had different outcomes with regard to being a skilled communicator. There was no evidence in Rose's lessons that she was a skilled communicator as she just marked homework in both lessons and did not relate new concepts to a pictorial representation. Dina, on the other hand, was prepared for the specific question of where the work will be used in real life, however, her communication skills were lacking and the learners struggled to follow her. She did not make use of pictorial representation to explain the concepts. Bob was the only one of the participants that used manipulatives to teach the new vocabulary and his communication skills were evident.

4.5.5.5 Active teaching-and-learning principles

DF and DCA (2005), gave hints in their book *Are you being heard? Information and Teaching tips for teachers of students with a hearing loss.* Although all three of the participants received initial training, the only factor that correlates with DF and DCA (2005), and what they are well aware of not to do, is not to write on the board and talk at the same time. Dina and Rose mentioned it during their interviews, but both of them still wrote on the board while talking during their lessons. During Bob's lessons, on the other hand, he never wrote on the board while talking, as he had a PowerPoint presentation and practical activities.

Compared to Bob who made use of manipulatives to create three-dimensional shapes and other group activities, Rose and Dina's learners were actively involved in marking calculations. Dina's learners were active using the calculators as an aid. Although Orton and Frobisher (2002) stated that there are many who believe that not enough practical work is being done by the older learners in the primary school, it is now evident that the high school learners are doing even less practical work in comparison to primary school learners.

Repeating

In the study it was found that Bob, Rose and Dina repeated many times what was being said during the lessons, either what learners said or what they themselves said. It assisted the HI learners to follow conversations and explanations better.

Preventing lip-reading

Although Bob mastered the skill of not turning his back on the learners while talking, both Rose and Dina turned away many times when writing on the board and talking at the same time. DF and DCA (2005) made the remark that teachers should also be aware that there are some words difficult to lip-read, for instance 'mother' and 'brother' appeared to be the same and a word like 'coke' is invisible.

4.5.5.6 Enhancement of visual organisers

All three of the participants made use of visual organisers. Bob used the shapes made by the learners as well as real-life objects to enhance understanding of the vocabulary. Rose's visual organiser consisted of an interactive whiteboard where Dina used the projector and her computer to project the graphs onto the board. DF and DCA (2005), gave the hint of using visuals such as mind maps, graphic organisers, flow charts, tables, diagrams, pictures and objects as a teaching strategy.

Gestures

DF and DCA (2005), made the recommendation to avoid unnecessary distracting hand movements when speaking. The gestures Bob made were in assistance of explaining certain concepts and new vocabulary and not distracting. Dina's hand movements were helping to indicate possible translations where Rose only made gestures that mainly indicated a right or a wrong answer.

4.5.5.7 Use of technology

Technology is an empowering tool that can assist teachers in expanding learners' engagement in learning as well as in promoting more equitable access to the general curriculum for all learners (Michaels & McDermott, 2003). All three of the participants were wearing state of the art Roger Soundfield technology to assist the HI learners with the best possible sound quality. They also used their projectors either for a PowerPoint presentation, an interactive whiteboard or just the projection of a graph to be discussed.

4.6 Theme 2: Language factors in teaching mathematics to HI learners

In this section the findings from the interviews, observations and documentation of Bob, Rose and Dina will be presented and discussed. All discussions on the sub-themes **language of instruction: mathematics to language of instruction;** and **mediating textbooks and documents** are strictly according to the specific order of the sub-themes (codes) as indicated in Table 4.6[54] The additional code *rephrasing* is discussed under the relevant sub-theme.

The language of all quotes from Dina's observations have not been edited. Since Bob's and Rose's classes were conducted in Afrikaans, the quotations were translated into English. All of the interviews were translated as they were in Afrikaans. Background information regarding the observed lessons of the participants is given. At the end of the section is a summary of this section in table form similar to Table 4.4.

4.6.1 Bob: language factors in teaching mathematics to HI learners

4.6.1.1 Language of instruction: mathematics to language of instruction

[54] Table 4.6 is discussed under Section 4.3.2.3: Inclusion criteria for coding the data.

There were incidents during Bob's two lessons where mathematics concepts were not provided in the HI learners' primary language:

- One of the group work activities was to play a memory game where the names of two-dimensional and three-dimensional shapes were typed in English and not in Afrikaans, as Afrikaans is the primary language of the HI learners.
- The songs Bob taught them with regard to some characteristics of the three-dimensional shapes were in English.

Not using the HI learners' primary language might result in confusion for the HI learner.

Rephrasing

Bob rephrased certain phrases or words on nine occasions during the two observed lessons when he changed the wording to make it simpler. Find below examples of the original text in Afrikaans and then the translated version[55].

- *"Hierso sê hulle, benoem die driedimensionele vorms. Wat is sy naam, wat is sy naam...hoe kan ons nou sy naam hê?"*

  Translated:

  "Here they say, name the three-dimensional shapes. What is its name, what is its name....how can we have its name?"

- *"Goed en dit is as dit 'n plat vorm is. Twee dimensioneel".*

  Translated:

  "Good and that is if it is a flat shape. Two-dimensional".

In the next example, Bob referred to the net of a shape.

- *"Daai tipe is die patroon om die kubus te kan vou".*

  Translated:

  "That type is the pattern to make it possible to fold the cube".

4.6.1.2 Mediating textbooks and documents

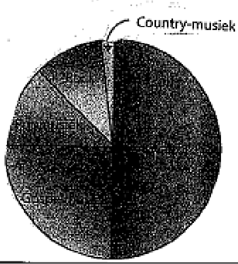
In the textbook the learners have, there are keywords and their definitions in blocks. The language of textbooks is not the only challenge a HI learner might face when talking about mediating textbooks. Tests and exams are also a challenge as can be seen in the example

[55] Translated by the researcher from Afrikaans to English.

in Figure 4.6[56] of the class test Bob set. Questions where they have to fill in the correct word as part of a sentence are challenging for HI learners, as their language abilities are not necessarily on par with the hearing learners.

Vraag 7: Bestudeer die sektor diagram en voltooi die sinne deur die oop spasies in te vul.

Dit is 'n ....diagram. Dit toon die .... van verskillende graad 5-leerders. .... Van die leerders hou van kwaitomusiek. 'n .... van die leerders hou van gospelmusiek. Een .... van die leerders hou van popmusiek. Die oorblywende leerders hou van .... en .... musiek. Die modus van die data is ....



[8]

Figure 4.6: An example of a language challenged question in a test.

The above question can be translated as:

Question 7: Study the sector diagram and complete the sentences by filling in the open spaces.

This is a ……………………………… diagram. It indicates the …………………………. of different Grade 5 learners' ……………………………………. Some of the learners like kwaito music. A ………………….. of the learners like gospel music. One …………….. of the learners like pop music. The rest of the learners like …………………………… and ………………………………… music. The mode of the data is …………………………..

Another challenging question for the HI learners from a class test was[57]:

- A 2D shape has 2 dimensions. What do we call the dimensions[58]?

Although the question above seemed to be straight forward, the HI learners did not understand what was being asked, as can be seen from two HI learners' answer sheets.

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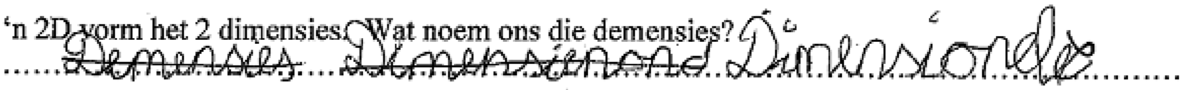
[56] An extract from the Afrikaans test.

[57] Translated from Afikaans.

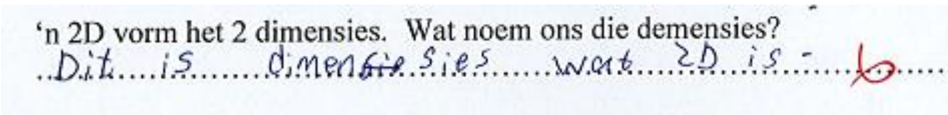
[58] In the Afrikaans test, the word was spelled incorrectly.

Example 1:


‘n 2D vorm het 2 dimensies. Wat noem ons die demensies?

In example 1, the HI learner just re-writes the word *dimensional* after crossing it out twice before.

Example 2:


‘n 2D vorm het 2 dimensies. Wat noem ons die demensies?

Dit is dimensies wat 2D is

The example 2, the HI learner did not answer the question. The translated answer of the learner is: *It is dimensions that are 2D.*

The HI learners’ language ability is less than the ability required to answer the question.

4.6.2 Rose: language factors in teaching mathematics to HI learners

4.6.2.1 Language of instruction: mathematics to language of instruction

Rose’s language of instruction was mainly pure. There was one incident in the first lesson and one incident in the second lesson where she indicated that the calculations were done correctly by using the German word “Wunderbar”. She also used the word “right” a couple of times as an interjection while teaching the Afrikaans Grade 8 class.

Rephrasing

Rephrasing words or phrases into simpler, more common language, assists the HI learner in understanding what is being said. Rose did just that on three occasions during the observed lessons. Find below the original text in Afrikaans and then the translated version[59].

- *“As jy die teller deel deur die noemer, is die antwoord 1. Dit wat jy bo het gedeel deur dit wat jy onder het, dan is die antwoord 1”.*

  Translated:

  “If you divide the numerator with the denominator, the answer is 1. The things you have above divided by the things you have at the bottom; then the answer is 1”.
- *“Maar ons gaan elke som mooi rustig deurgaan. Ons is nie haastig nie, né?”*

[59] Translated by the researcher from Afrikaans to English.

Translated:

"But we are going to go through each calculation slowly (*rustig*)[60]. We are not in a rush, hey?"

- *"Kom ons gaan net eers onder die lyn werk. Vergeet dat daar 'n bo die lyn is. Vergeet van die teller, werk net in die noemer nou vir my".*

  Translated:

  "Let's just work underneath the line first. Forget that there is something at the top. Forget about the numerator, just work with the denominator".

In the document analysis, one place was found in a test where rephrasing was used:

- *"Skryf die verhouding (verwantskap) tussen die getalle in die ry in woorde".*

  Translation:

  Write down in words the ratio (relation) between the numbers in the sequence.

4.6.2.2 Mediating textbooks and documents

In tests Rose set, some questions[61] were found that might be quite challenging for the HI learners due to the complexity of the given sentences:

- *'n Sekere getal is 'n faktor van 72, is minder as 72 en is 'n* ***tweesyfer*** *getal. Die getal is deelbaar deur die som van die syfers, maar is nie deelbaar deur die produk van die syfers nie. Wat is die getal?*

  Translation[62]: A certain number is a factor of 72, it is less than 72 and is a two-digit number. The number is divisible by the sum of the digits, but is not divisible by the product of the digits. What is the number?

- *Dui aan of die volgende stellings WAAR of ONWAAR is. Indien die stelling ONWAAR is, skryf die stelling oor sodat dit WAAR sal wees. Onderstreep die gedeelte van die stelling wat jy verander.*

  1.1. Wanneer magte met mekaar vermenigvuldig word, dan bly die grondtalle dieselfde en die eksponent van die verskillende grondtalle word bymekaar getal.

---

60 Original Afrikaans word.

61 As from the Afrikaans tests.

62 Translation done by the researcher.

Translation[63]: Say whether the following statements are TRUE or FALSE. If a statement is FALSE, rewrite the statement in such a way that it becomes TRUE. Underline the part of the statement you have changed.

1.1 When powers are being multiplied with one another, then the bases stay the same and the exponents of the different bases are added.

4.6.3 Dina: language factors in teaching mathematics to HI learners

4.6.3.1 Language of instruction: mathematics to language of instruction

Although Dina's mother tongue is Afrikaans, she taught the Grade 10 English class mathematics. There were a couple of incidents where she used the Afrikaans words in case of a lack of the correct English words:

- "bakkie op, bakkie af" - To indicate the movement of creating a sine or cosine's wave.
- "It's actually the tangent, which means that it is a, a … *raaklyn*".
- "Sorry for it being so *deurmekaar* this morning".
- "They are my *witbroodjies*"

She also once emphasised something by saying it will "*altyd* be like that".

Rephrasing

During the lessons, Dina rephrased words or phrases into simpler, more common language, assisting the HI learner in understanding what is being said. Below are three of the 11 examples[64]:

- "Ok, guys, you can also translate this to 'increasing y-values'. So from which point ... from which point does my y-values get bigger?"
- "The graph is increasing .... getting more ... getting higher .... having a positive slope..."
- "So by touching, it also cuts."

In the first interview, Dina mentioned[65] that she rephrased the Grade 11 mathematics Literacy paper at the end of the previous year by:

- "Cutting the sentences to a maximum of five words".
- "Beginning a sentence in a new line".

---

[63] Translation done by the researcher.

[64] Translated from Afrikaans to English.

[65] Translated from Afrikaans to English.

- "Typing the sentence out and making it shorter".
- Using "synonyms".

4.6.3.2 Mediating textbooks and documents

When marking the homework from the textbook with the learners, Dina read what the learners were supposed to do, for example:

- $\boldsymbol{g(x)} > f(x)$[66]

  She told them: "Ok, right let's go on …. For which values of x is the *g*-graph bigger than the *f*-graph?"

- **For which values of x is $g(x) \geq f(x)$?**

  Dina handled this question by saying: "where's the $g(x)$bigger or equal to the $f(x)$?"

Dina did the interpretation of the symbols in both cases herself

4.6.4 Summary of participants' language factors in teaching mathematics to HI learners

Table 4.9 is a summary of the participants' language factors in teaching mathematics to HI learners.

[66] Typed in bold indicates questions from the textbook.

Table 4.9: Summary of the three participants' language factors in teaching mathematics to HI learners

PARTICIPANTS	BOB	ROSE	DINA
LANGUAGE FACTORS IN TEACHING MATHEMATICS TO HI LEARNERS			
Language of instruction: mathematics to language of instruction	• Taught Grade 5 Afrikaans class. • Songs of characteristics of three-dimensional shapes in English. • Names of two and three-dimensional shapes of memory game in English.	• Language of instruction mainly pure. • Sometimes used "Wunderbar" and "Right" in the Afrikaans class as interjections.	• Taught Grade 10 English class. • Sometimes used Afrikaans words or sayings instead of English ones.
Rephrasing	He did it nine times during the lessons. E.g. "Good and that is if it is a flat shape. Two-dimensional".	She did it three times during the lessons and once in a test. E.g. "Let's just work underneath the line first. Forget that there is something at the top. Forget about the numerator, just work with the denominator".	She did it 11 times during the lessons. E.g. "The graph is increasing.... getting more ... getting higher.... having a positive slope... ahh"
Mediating textbooks and documentation	• Challenging questions in the class test for the HI learners.	• Challenging language-based questions in the tests.	• She did interpretations in the textbook of symbols herself when marking answers.

4.6.5 Discussion of participants' language factors in teaching mathematics to HI learners

In the next section, the findings of my study of language factors in teaching mathematics to HI learners are discussed according to the two sub-themes, namely, language of instruction: mathematics to language of instruction and mediating textbooks and documentation[67].

4.6.5.1 Language of instruction: mathematics to language of instruction

Teachers should provide mathematics concepts using the learner's first language before competence is assessed in another language (Easterbrook & Stephenson, 2006, p.391). The analysis of the study showed that only one of the three teachers used pure language, namely Rose. She only made use of interjections that were certain words in English and German while teaching. On the other hand Bob had a group activity and an optional homework assignment where English words were used while he was teaching an Afrikaans class. While Dina was teaching and explaining it was evident that she sometimes had to rely on the Afrikaans word to express herself. Her mother tongue is Afrikaans and she taught in English.

Rephrasing

It was found that all three of the participants used opportunities to rephrase phrases in order to simplify the language. This enhanced the understanding of the HI learner. DF and DCA (2005) suggested that to assist communication, the teacher should say things in a different way.

4.6.5.2 Mediating textbooks and documents

Mediating textbooks referred to the difference between the language abilities of the learner and the language demands of the textbooks. Learners perform better when documents feature highly pictorial content and simplified language is used (Diebold & Waldron, 1988). The study provided evidence that Bob and Rose used challenging language-based questions in some tests. Dina, the other participant used the textbook questions, but she herself made the interpretations of the given symbolic questions in the textbook.

[67] See Table 4.4 under Section 4.3.2.2.

4.7 Findings, trends and explanations

Before the findings, trends and explanations applicable to the themes are discussed, two additional findings that came to light, namely the Understanding of inclusion and Additional help for HI learners, will be discussed first.

- **Understanding of inclusion**

As discussed in Section 2.1 the difference between *Inclusion* and *Integration* in a nutshell is that with *inclusion*, the system must change while *integration* indicates that the learner must change. When asked in the first interview whether the teacher needs to teach in a different way now that there are HI learners in the class and what the challenges were, Bob immediately gave a list of things that he had to focus on and change once he started teaching at the inclusive school. Bob understood that for inclusion, the system had to change. Rose on the other hand explicitly told me that she does not teach in another way, as it was inclusion. It was clear that she was talking about *integration* as that was when the learner had to change and not the system. Dina, with only one year of experience at an inclusive school named things she had already changed and was focussing on. From this, it is possible to conclude that Rose, with her 25 years' experience teaching mathematics, did not understand inclusion and was not really willing to change her methods after so many years in the trade. Bob, with his 15 years' experience as a mathematics teacher five years' of which were in an inclusive school showed an understanding of inclusion and adapted his ways according to the training he received, as did Dina.

- **Additional help for HI learners**

All three of the participants gave additional assistance to the learners when they were doing tutorials and individual sessions. They were seeing their HI learners once a week for a mathematics tutorial, where they used the opportunity to pre-teach once the HI learner showed he or she understood the work previously done. During the individual time, Rose and Dina would focus on vocabulary expansion in languages as a subject, while Bob would use the time to focus on mathematical vocabulary and possible exam questions.

An analysis of the discussions on themes 1 and 2 was done and resulted in the following summary in which the findings, trends and explanations are laid out.

- **Communication skills**

All three of the teachers were aware not to turn their backs on the learners while talking and writing on the board simultaneously. Bob executed it perfectly, while Rose and Dina on the other hand were so into writing the steps and answers on the board, that both of them turned their backs on the learners on numerous occasions while explaining or writing, thus preventing the HI learner from being able to lip-read. Bob, Rose and Dina made use of repetition during their lessons. They all repeated at some time what another learner said or what they themselves said or asked. They also took the opportunities to rephrase, or made use of easier language explaining the work. Bob quite often made use of gestures, bringing his words to life, without it being distracting. Dina's gestures assisted her explanations of what was required from the learners, while Rose's gestures barely had anything to do with the work, instead they consisted of facial expressions most of the time. Both Bob and Rose often called the learners by name when looking at them to answer a question, while Dina asked the questions mostly to the whole class and they answered in a murmuring resulting in a chaotic undertone.

- **Active, visual learning**

Although Orton and Frobisher (2002) stated that there are many who believe that not enough practical work is being done by the older learners in the primary school, it can now be seen that the high school learners are doing even less practical work in comparison to the older primary school learners. It is understandable that Bob's topic, namely three-dimensional shapes, lent itself to more visual, active learning. The learners in Dina's class were encouraged to use their calculators to help them determining the co-ordinates as part of being active. On the other hand were the learners in Rose's class participating in explaining the way their homework calculations were done. All three of the participants made use of a computer and projector. Bob had a PowerPoint presentation, Dina used GeoGebra, and Rose was the only one to use the interactive whiteboard program called Mimio.

- **Real-world problems and critical thinking**

These parts of mathematics have definitely been neglected by all three of the teachers. Rose took her time marking the homework for the whole duration of both of the observations and never came across, nor created opportunities to challenge the learners with real-world problems and critical thinking while explaining. Bob gave a non-compulsory challenge for critical thinking where the learners could write songs about the characteristics of the three-dimensional shapes. Dina on the other hand, had a great opportunity to challenge the learners to critical thinking in real-world problems when she was asked where one will ever use trigonometric graphs in real life. Unfortunately she could not make the best of it. She only explained roughly and did not use the opportunity to do a real calculation to determine the slope for instance and make it *alive* for the learners. I experienced a trend with all three of the participants that they do not have the time nor do they want to spend adequate time on critical thinking and were not prepared enough for it.

4.8 Conclusion

In this chapter, the data collection process that took place in a private inclusive school in Gauteng during May 2017. I had three participants, each teaching mathematics in a different phase was discussed. Data was collected by means of two interviews and two observations as well as document analysis. The first interview was held before any observations took place, while the second one took place after the observations of both lessons. The focus of the first interview was on the experience of the teacher, while the second one was on the two lessons observed. A deductive approach to coding the data based on the adapted practices a mathematics and science teacher should apply in teaching HI learners was adopted (Easterbrooks & Stephenson, 2006) to which the raw data was analysed. In this chapter the data of the three participants was presented and the findings were discussed on the basis of a literature control. Lastly trends were identified and possible explanations for the trends were given.

In Chapter 5 the research questions are answered, and the research study is reflected on and conclusions from the case study are drawn. The limitations and significance of the study are also discussed and recommendations for further research are made.

Chapter 5

Conclusions

5.1 Introduction

This chapter is used to provide a summary of the previous four chapters and to answer the research questions that guided the study. I reflect on the research as to what I could have done differently and my interpretation of the adapted practices a mathematics teacher should apply in teaching HI learners is reviewed (Easterbrooks & Stephenson, 2006). This is followed by the conclusions, recommendations and limitations of the study.

5.2 Chapter summary

In Chapter 1, the research study was introduced and contextualised. The purpose of the study was to explore how mathematics teachers teach mathematics to oral HI learners in an inclusive school, with the focus on their teaching-and-learning. The problem and the rationale for the study were discussed. The research questions were formulated and the methodological considerations as well as the possible contributions were discussed.

Chapter 2 presented a detailed analysis of the findings in the relevant literature as well as the conceptual framework on which the study is based. Discussions on inclusive education; PTI categories (Beijaard et al., 2000) with a focus on the didactical expert i.e. the mathematics teacher as teaching-and-learning expert; and the language factors in teaching mathematics to HI learners followed. The conceptual framework which is based on the adapted practices a mathematics teacher should apply in teaching HI learners (Easterbrooks & Stephenson, 2006), was then discussed.

A description of the qualitative methodology used in this study was presented in Chapter 3. Social constructivism as the research paradigm was discussed and the nature of the study as subjective and idealism was presented. This was an exploratory case study. Observations were used to explore the determining factors of a mathematics teaching-and-learning expert as well as the language factors that need to be taken into consideration when teaching HI learners. Interviews were used to determine why teachers do what they do in class and documentation was analysed. ATLAS.ti 7 was used to analyse the video and audio data.

Lastly, the trustworthiness of the study and ethical considerations that were taken into consideration were addressed.

Chapter 4 briefly reports on the data collection process, presents and discusses the findings and lastly identifies trends and possible explanations for those trends. ATLAS.ti 7 was used to analyse the data. When coding the data, a deductive approach for the adapted practices a mathematics teacher should apply in teaching HI learners was used (Easterbrooks & Stephenson, 2006), namely: the role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancement of visual organisers; use of technology; language of instruction: mathematics to language of instruction; and mediating textbooks and documentation. The presented findings from the data obtained through class observations, interview recordings and documentation received of the different categories are provided in Table 4.2. The findings were then related to the findings in the literature and trends were identified and subsequently explained.

5.3 Summary of the participants

The following table (Table 5.1) regarding the three participants' background information, the teacher as teaching-and-learning expert and the language factors in teaching mathematics to HI learners was prepared to facilitate the summary of the participants.

Table 5.1: Summary of participants' information (Adapted from Botha, 2011)

Keys:

Mathematics teacher as teaching-and-learning expert: Evident: ✓ Somewhat evident: ● Not evident/sufficient: ✘

Language factors in teaching mathematics to HI learners: Sufficient: ✓ Somewhat sufficient: ● Not evident/sufficient: ✘

Paragraph numbers in the thesis are indicated in brackets.

Background information	Bob	Rose	Dina
Age	40	50	35
Experience as a mathematics teacher (years)	15	25	13
Years teaching mathematics for HI learners	5	3,5	1
Mathematics teacher as teaching-and-learning expert			
Role of teacher as content specialist	✓ (4.5.1.1)	✘ (4.5.2.1)	● (4.5.3.1)
Specialised content vocabulary	✓ (4.5.1.2)	● (4.5.2.2)	● (4.5.3.2)
Incorporation of real-world problems and critical thinking	✘ (4.5.1.3)	✘ (4.5.2.3)	✘ (4.5.3.3)
The role of the teacher as a skilled communicator	✓ (4.5.1.4)	● (4.5.2.4)	● (4.5.3.4)
Active teaching-and-learning principles	✓ (4.5.1.5)	● (4.5.2.5)	● (4.5.3.5)
Enhancement of visual organisers	✓ (4.5.1.6)	✘ (4.5.2.6)	● (4.5.3.6)
Use of technology	✓ (4.5.1.7)	✓ (4.5.2.7)	✓ (4.5.3.7)
Language factors in teaching mathematics			
Language of instruction: mathematics to language of instruction	● (4.6.1.1)	✓ (4.6.2.1)	● (4.6.3.1)
Mediating textbooks and documentation	✘ (4.6.1.2)	● (4.6.2.2)	● (4.6.3.2)

5.3.1 Sub-question 1: How can the classroom practice of the mathematics teachers as teaching-and-learning experts be described?

To answer this question, the teacher as teaching-and-learning expert was described according to the sub-themes in the conceptual framework; namely the role of the teacher as content specialist; specialised content vocabulary; incorporation of real-world problems and critical thinking; the role of the teacher as skilled communicator; active teaching-and-learning principles; enhancements of visual organisers; and use of technology.

Role of the teacher as content specialist and specialised content vocabulary

As Bob was the teacher with the most years' experience in teaching mathematics to HI learners he was the one with the most training and it was evident that he applied what he had learnt. Rose on the other hand, might have been the one with the most experience in teaching mathematics, but she did not understand what inclusion meant and was reluctant to change her old ways. The Dunning-Kruger effect[68] came to light in this case. Dina, the new-comer to inclusive education with only one year's experience, showed her willingness to learn and to apply the newly gained knowledge.

Going beyond the classroom

The sub-theme that exposed a gap in the teachers' classroom practice was the incorporation of real-world problems and critical thinking. Although Bob and Dina tried to address it, it was not sufficiently done and thus leaves room for improvement. This correlates with other studies as Pagliaro and Kritzer (2005) are of the opinion that real-world problems engage learners of all ability levels, but unfortunately teachers consider the concepts too complicated for the HI learners and do not include them in instruction. Kelly, Lang and Pagliaro (2003) found that mathematics teachers teaching HI learners focus more on practicing exercises than on true problem-solving situations. The teachers also tend to avoid the more cognitively challenging aspects of word problem solving.

Active, visual learning

Bob, teaching the Grade 5 learners and the one with the most experience, used many active learning principles hand in hand with visual organisers. Although the theme of the lessons, namely, three-dimensional shapes, contributed to an active lesson with plenty of visual organisers, he was prepared for it. Lang and Pagliaro (2007) state that it is very important for

[68] See Section 3.7.2.3

mathematics teachers to prepare sufficiently in order for their learners to benefit from the education as “the tangible properties of the physical objects help pupils to store up mental structures which contribute to the development of mathematical concepts and their understanding” (Nickson, 2008, p.19). As Rose’s lessons consisted of marking homework, she gave each learner an opportunity to be actively part of the lesson when calling his or her name to answer. Dina seldom addressed a specific learner. Her learners were actively involved by answering the questions in a bundle, which caused a chaotic undertone.

Use of technology

All three of the participants made use of various types of technology. As they are teaching at the same school including HI learners, all the classes were issued with the Roger Dynamic Soundfield to enhance sound quality. Additionally Bob, Rose and Dina used other types of technology. Bob and Dina made use of social networks in the form of Pinterest and WhatsApp groups respectively, while Rose used the Mimio interactive program. Dina also used another software program to assist her in drawing functions, namely GeoGebra.

5.3.2 Sub-question 2: What are the language factors that need to be considered when teaching mathematics to HI learners?

To answer this question, the language factors in teaching mathematics to HI learners were described according to the sub-themes in the conceptual framework, namely language of instruction: mathematics to language of instruction; and mediating textbooks and documentation.

Language of instruction: mathematics to language of instruction

In a study done by Vermeulen et al. (2012), they found that teachers teaching HI learners in an inclusive school in the Netherlands adapted their communication to the needs of the learners. All three of the participants in this study showed sufficient or somewhat sufficient communication skills as required to teach HI learners. Bob mastered the technique, while Rose made use of pedagogy that builds on prior knowledge and context and kept her language of instruction pure. Dina was an Afrikaans teacher teaching the English class and needs to improve her language proficiency.

Mediating textbooks and documentation

When it came to the written presentation of mathematics in textbooks or tests and exams, there was room for improvement. All three teachers adhered strictly to their textbooks. As their textbooks are not written for HI learners, there lacked rephrased words or sentences and the level of readability was too high for the HI learners. It was evident from the data that Rose and Dina were addressing this issue to some extent. The reason for them focussing on it and not Bob, might be the fact that they are teaching high school learners that need to be able to write a standardised rephrased paper by the end of Grade 12.

5.4 What is the value of the study's findings for inclusive education?

This study was an attempt to make a contribution to the understanding and execution of inclusive education in South Africa with reference to mathematics.

- My research revealed that not all teachers who teach at an inclusive school truly understand the concept of inclusion.
- Continuous training is a pre-requisite for inclusion to be successful.
- Mathematics teachers in an inclusive school are reluctant to engage in real-world problems and critical thinking with the HI learners.

5.5 What would I have done differently?

During the data presentation stage, I realised that valuable communications between the teacher and the learners were lost when I could not hear the conversation. With the insight of hindsight, a research assistant could have been employed to video-tape all the sessions as I was known to the participants.

Another aspect that could have been done differently was to include teachers from other inclusive schools as part of the study. It would have been valuable to investigate how teachers within a different setting and with different training, teach mathematics to HI learners.

5.6 Conclusions

Some conclusions regarding the mathematics teacher as teaching-and-learning expert and the language factors in teaching mathematics to HI learners follow:

Mathematics teacher as teaching-and-learning expert

- Not all teachers truly understand the implications of inclusion.

- Coming to an inclusive school with many years' experience at ordinary mainstream schools, may result in difficulty adapting to an inclusive environment.
- The teachers evade the incorporation of real-world problems together with critical thinking.
- Although the high school teachers were aware not to turn their backs on the class while talking and writing on the board, it still occurred on numerous occasions.
- Levels of active learning principles differ between primary and high school teachers.
- It is challenging to use visual organisers often, as it takes a lot of preparation time.
- All three teachers made use of technology in various ways.

Language factors in teaching mathematics to HI learners

- Teachers often repeated what other learners or even themselves said.
- Rephrasing occurred during the lessons.
- Not all the teachers kept their language of instruction pure.
- Textbooks, tests and exams still consisted of challenging language for the HI learners.

5.7 Recommendations for further research

Several aspects of the teaching of mathematics to oral HI learners in an inclusive environment require further research in order to make inclusion work. These include investigation into:

- The outcome of a standardised rephrased Grade 12 mathematics final exam.
- The training and preparation of teachers teaching in an inclusive school.

5.8 Limitations of the study

Data was gathered from a very small number of teachers teaching mathematics to HI learners in an inclusive school and generalisation of the results is impossible. However, generalisation was not an aim of the study. I am truly aware that different researchers may interpret the data differently. My perspective is bound by space, time, personal experience and previous connections to the specific school. The possibility that subjectivity may have influenced the findings cannot be ruled out.

I attempted to enhance the credibility and trustworthiness of the study through triangulation by using observations, interviews and document analysis at different stages of the data collection process. I emphasised to the teachers that I was interested in the uniqueness of each teacher and my purpose was not to criticise them and report their performances in class to their superiors. The same interview schedules, including the same questions in the same sequence for all interviewees were used.

5.9 Last reflections

The past three years have been a time of accelerated growth and learning for me, both professionally and personally. I hope that my findings will contribute to teacher training and theory and that this study will contribute to the building of a successful inclusive education system.

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Appendices

Appendix A: Letter of consent to the Director/Principal of the school

Mrs. L. le Hanie
545 Stephan road
Magalieskruin
0182
linda@zikedish.com
Cell: 072 2909 478

20 February 2017

Dear Sir/Madam

Request to conduct research

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 oral hearing impaired learners in an inclusive environment. I hereby request permission to use your school for my research.

The data collection process will be as follows:

- Three mathematics teachers from three different phases (intermediate, senior and FET) teaching mathematics to hearing impaired learners in an inclusive environment will be requested to participate.
- Two lessons per teacher with the same mathematics class will be observed. It will also be videotaped in such a way that only the teachers' faces will be seen. I will not be in direct contact with the learners. The learners will be present in the class during the observations together with the researcher. No learner will be identified or visible in the video. The learners as well as the parents/guardians will receive a letter of informed consent for the video recording of the lessons.

- Two semi-structured interviews per teacher are also requested, one interview before the first lesson and one after the second lesson. The first interview will be based on the teachers' experience of teaching hearing impaired learners, while the second interview will be based on the observed lessons. The interviews will be conducted outside school hours at a time and place convenient for the teacher. Audio recordings of the interviews will be made.
- Lastly, I would like to have access to documentation in the form of the teachers' preparation files.

Only my supervisor and I will have access to the video and audio recordings which will be password protected. The data collected will only be used for academic purposes. All data collected with public funding may be made available in an open repository for public and scientific use.

All participation is voluntary. Confidentiality and anonymity will be guaranteed at all times. After the successful completion of my Master's degree, I will give feedback to the school in the form of a written report. For any questions before or during the research, please feel free to contact me.

If you are willing to allow me to conduct research at your school, please sign this letter as a declaration of your consent.

Yours sincerely

__________________________ __________________________

Researcher: Mrs. L. le Hanie Date

__________________________ __________________________

Supervisor: Dr. S. van Putten Date

I hereby grant consent to Mrs. L. le Hanie to conduct her research at this school for her Master's research. I also give consent to Mrs. L. le Hanie to video record the lessons and audio record the interviews.

School director/principal's name: ___________________________

School director/principal's signature: ________________________

Date: ____

Email address: ____

Contact number: _______________________________________

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Appendix B: Letter of consent to the mathematics teacher

UNIVERSITEIT VAN PRETORIA
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Faculty of Education

Mrs. L. le Hanie
545 Stephan road
Magalieskruin
0182
linda@zikedish.com
Cell: 072 2909 478

5 May 2017

Dear Sir/Madam

Letter of consent to the mathematics teacher

You are invited to participate in research aimed at investigating how teachers teach mathematics to oral hearing impaired learners in an inclusive environment. The research will be reported in my Master's dissertation at the University of Pretoria. I would like to invite you to participate in this study's data collection phase by being observed teaching the same mathematics class for two lessons. You will be interviewed before the first lesson and after the second. You will also be asked to allow me access to your preparation files/documents.

The data collection process will be as follows:

- Mathematics teachers teaching mathematics to hearing impaired learners in an inclusive environment are invited to take part in the research.
- Two mathematics lessons with the same class will be observed at a time convenient to you as it should not disrupt your timetable and programme. Note that you are not required to do anything beyond what you normally do during the teaching of a mathematics lesson; no extra preparation is needed. The observation will be video recorded. This will allow for a clear and accurate record of your classroom practice.

- Two semi-structured interviews with you are also requested. The first interview will be based on your experience of teaching hearing impaired learners, while the second interview will be based on the observed lessons. The interviews will be conducted outside school hours at a time and place convenient to you. Audio recordings of the interviews will be made.
- Lastly, I would like to have access to your preparation documents.

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

After the successful completion of my Master's degree, I will give feedback of my findings to the school in the form of a written report.

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

Yours sincerely

___________________________	___________________________
Researcher: Mrs. L. le Hanie	Date
___________________________	___________________________
Supervisor: Dr. S. van Putten	Date

I hereby grant consent to Mrs. L. le Hanie to observe two of my mathematics lessons, conduct an interview with me as well as have access to my preparation documents for her

Master's degree research. I also grant consent to Mrs. L. le Hanie to video record the lessons, audio-tape the interviews and analyse my preparation documents.

Teacher's name: ____

Teacher's signature: ____

Date: ____

Email address: ____

Contact number: ____

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Appendix C: Letter of consent to the parents

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Mrs. L. le Hanie
545 Stephan road
Magalieskruin
0182
linda@zikedish.com
Cell: 072 2909 478

5 May 2017

Dear Sir/Madam

Consent to conduct research in your child's classroom

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 oral hearing impaired learners in an inclusive environment.

In order to do the research, I will observe your child's mathematics teacher during two of their lessons. I would like to 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 learners 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. All data collected with public funding may be made available in an open repository for public and scientific use.

If you have any questions or concerns, please do not hesitate to contact me. If you are willing for your child to be present during the video recorded lessons please sign this letter as a declaration of your consent.

Yours sincerely

___________________________ ___________________________

Researcher: Mrs. L. le Hanie Date

____________________________ ___________________________

Supervisor: Dr. S. van Putten Date

I the undersigned, hereby grant consent to Mrs. L. le Hanie to video record the lessons where my child will be present. I am aware that my child will remain anonymous and that the findings of this research will be used to promote teaching and learning in the mathematics classroom.

Parent's/Guardian's name: _______________________

Parent's/Guardian's signature: ____________________

Date: ____

Child's name: ___________________________________

Grade of child: _________________________________

Appendix D: Letter of assent to the learner

Mrs. L. le Hanie
545 Stephan road
Magalieskruin
0182
linda@zikedish.com
Cell: 072 2909 478

20 February 2017

Dear learner

Presence during classroom research

I am enrolled for a Master's degree at the University of Pretoria and want to determine how mathematics teachers teach mathematics to hearing impaired learners in an inclusive environment. This implies that I will not be teaching you. I want to film your teacher with a video camera while he/she is teaching mathematics. This will happen during two of your mathematics lessons. I will be standing at the back of the classroom and the video camera will be focused on your teacher and not you. The video will be used for my studies and no one will see the video recording but my supervisor and me.

That is the only way you will be involved in the research and you do not have to do anything except what your teacher expects you to do. If you have any questions you may contact me at any time.

Yours sincerely

__________________________	__________________________
Researcher: Mrs. L. le Hanie	Date
__________________________	__________________________
Supervisor: Dr. S. van Putten	Date

I hereby grant assent to be present in the mathematics class when my teacher will be video recorded by Mrs. L. le Hanie.

Learner’s name: ______________________

Learner’s signature: ___________________

Date: _______________________________

Grade: _____________________________

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Appendix E: Teacher interview protocol 1

TEACHER INTERVIEW PROTOCOL 1

TEACHING MATHEMATICS TO ORAL HEARING IMPAIRED LEARNERS IN AN INCLUSIVE ENVIRONMENT

Date: ______________________________ Venue: _________________________

Time of interview: ____________________ Duration: _______________________

Interviewer: ________________________

Interviewee: ________________________

Pseudonym:________________________

Male / female: ______________________

Semi-structured interview schedule	
Purpose and instruction: In the letter requesting your permission, we indicated to you that I am busy with a research study on how teachers teach mathematics to oral hearing impaired learners in an inclusive environment. The focus of today's interview will be on your experience with regards to teaching hearing impaired learners. The data collected will only be used for research purposes and no names of participants or any identifying data will be made known in the dissertation. Do you have any questions before we start the interview? May I audio-record the interview? The purpose of recording is to have an accurate record of the data collected.	
Interview questions	
1.	Tell me more about yourself: where you have been teaching and how many years of experience do you have as a mathematics teacher?
2.	How would you describe a good mathematics teacher?
3.	How long have you been teaching hearing impaired learners?
4.	Would you say you need to teach in a different way, now that you have hearing impaired learners in your class? Please expand.
5.	What are the challenges teaching mathematics to hearing impaired learners?
6.	How can the challenges mentioned in question 5 be addressed?

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Appendix F: Teacher interview protocol 2

TEACHER INTERVIEW PROTOCOL 2

TEACHING MATHEMATICS TO ORAL HEARING IMPAIRED LEARNERS IN AN INCLUSIVE ENVIRONMENT

Date: ______________________________ Venue: _________________________

Time of interview: ____________________ Duration: _______________________

Interviewer: ________________________

Interviewee: ________________________

Pseudonym:_________________________

Male / female: _______________________

Semi-structured interview schedule	
Purpose and instruction: Thank you again for your time in order for me to be able to conduct my research. The focus of today's interview will be on the two observed lessons. The data collected will only be used for research purposes and no names of participants or any identifying data will be made known in the dissertation. Do you have any questions before we start the interview? May I audio-record the interview? The purpose of recording is to have an accurate record of the data collected.	
Interview questions	
1.	What were the outcomes of your lessons?
2.	Did the lessons go according to plan?
3.	What in your lessons did you have to adapt due to the hearing impaired learners in your class?
4.	

Take note:

The rest of the interview questions will be based specifically on certain aspects observed during the observations.

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Appendix G: Observational protocol for research diary

POSSIBLE OBSERVATIONAL PROTOCOL FOR RESEARCH DIARY

TEACHING MATHEMATICS TO ORAL HEARING IMPAIRED LEARNERS IN AN INCLUSIVE ENVIRONMENT

Date: ________________________________ Pseudonym: ______________________

Place: ________________________________

Interviewer: ____________________________

Interviewee: ___________________________

Male / Female: _________________________

Descriptive field notes:	
Environment (Positive learning?)	
Personalisation? (Teacher)	
Classroom management (tables/chairs set-up)	
Visual organisers	
Communication	
Notes on methodology	
Thoughts and reflections	