

**LANGUAGE PRACTICES IN THE TEACHING AND LEARNING OF
MATHEMATICS: A CASE OF THREE MATHEMATICS TEACHERS IN
MULTILINGUAL SCHOOLS**

BAFEDILE SAM GAOSHUBELWE

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Supervisor: Dr. S.M Nieuwoudt

Assistant Supervisor: Mrs. J.A Vorster

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I would like to dedicate this work to my wife Matshediso Gaoshubelwe, and my children, who have always been my pillars of strength and who encouraged me to work hard in my studies, even after the horrible accident in which the whole family was involved.

ABOVE ALL, OUR HEAVENLY FATHER FOR GRANTING ME THE KNOWLEDGE, WISDOM AND COURAGE TO PURSUE THIS DAUNTING CHALLENGE.

CHRISTIEN TERBLANCHE LANGUAGE SERVICES

BA (Pol Sc), BA Hons (Eng), MA (Eng), TEFL

Villa Louanne 65

Tel 082 821 3083

Baillie Park

cmeterblanche@hotmail.com

2526

DECLARATION OF LANGUAGE EDITING

I, Christina Maria Etrechia Terblanche, id nr 771105 0031 082, hereby declare that I have edited the dissertation of Mr Sam Goashubelwe without viewing the final product. I declare that all payment for my services have been settled.

Regards,

CME Terblanche

Mrs P. Röscher
Posbus 20151
Noordbrug
2522

Mini-Dissertation: Bafedile Sam Gaoshubelwe

Title: LANGUAGE PRACTICES IN THE TEACHING AND LEARNING OF MATHEMATICS: A CASE OF
THREE MATHEMATICS TEACHERS IN MULTILINGUAL SCHOOLS

It is hereby certified that the bibliography of the above-mentioned document was checked for technical correctness in accordance with the stipulation in "Quoting Sources".

Yours sincerely

P. Röscher

A handwritten signature in black ink that reads "Röscher". The signature is written in a cursive style with a large initial 'R'.

ABSTRACT

The achievement of learners in mathematics is unsatisfactory. There are a number of factors that contribute to this poor performance in the subject. One of these factors is the fact that many learners in South Africa learn mathematics through medium of English while it is not their main language.

This research discusses the relationship between language, thought and social environment against background of the constructivist theory. Special attention is paid to mental connections and socio-cultural theories that are important for the study. The significance of language in algebra learning and geometry reasoning levels provides insight into how mathematical language is used in learning.

The importance of language in mathematics is highlighted, as well as the use of the mathematics register in multilingual classrooms. The language strategies and techniques used in the multilingual mathematics classrooms are discussed.

Case studies were conducted at three schools to investigate the language situation. At these schools Setswana, the learners' main language, and English are both used in the teaching and learning of mathematics. Three lessons from each school were recorded, transcribed and interpreted, using different constructs that emerged from literature.

The study revealed that code-switching is practised as a language strategy in all three schools in the teaching and learning of mathematics. When switching to Setswana teachers often used transliterated words, as well as direct English terminology. Known Setswana terminology was seldomly used. The researcher observed decoding of language to facilitate construction of concepts, but only English mathematical terminology was decoded. Because teachers often code-switched in one sentence, the modelling of both the correct English and Setswana mathematical language was obstructed, and little language teaching took place as teaching styles of the teachers did not allow much learner discourse. Learners were not often required to formulate written explanations or conjectures, and never in Setswana.

Recommendations include that language teaching in mathematics should be part of teacher education programmes, and in-service workshops should be conducted to inform teachers about and sensitise them to different language strategies and techniques. A future study could also focus on the use of bilingual teaching materials in mathematics teaching and learning.

OPSOMMING

Die prestasie van leerders in wiskunde is onvoldoende. Daar is verskeie faktore wat bydra tot die swak prestasie in die vak. Een van hierdie faktore is die feit dat baie leerders in Suid-Afrika wiskunde leer deur medium Engels terwyl dit nie hulle hooftaal is nie.

Die navorsing bespreek die verhouding tussen taal, denke en die sosiale omgewing teen die agtergrond van die konstruktivistiese teorie. Spesiale aandag word geskenk aan geestesverbindings en sosio-kulturele teorieë wat belangrik is vir die studie. Die belangrikheid van taal in die leer van algebra en meetkundige redevoering gee insig in hoe wiskundige taal gebruik word in leer.

Die belangrikheid van taal in wiskunde word uitgelig, asook die gebruik van die wiskunderegister in die meertalige klaskamer. Die taalstrategie en tegnieke wat gebruik word in die meertalige wiskundeklaskamer word bespreek.

Gevallestudies is gedoen by drie skole om die taalsituasie te ondersoek. By hierdie skole word Setswana, die leerders se hooftaal, en Engels gebruik in die onderrig en leer van wiskunde. Drie lesse is by elke skool opgeneem, getranskribeer en geïnterpreteer met die gebruik van die verskillende konstruksie wat uit letterkunde duidelik geword het.

Die studie het getoon dat kode-oorskakeling gebruik word as 'n taalstrategie in al drie skole vir die onderrig en leer van wiskunde. Wanneer hulle na Setswana oorskakel het die onderwysers dikwels getransliterende woorde gebruik, sowel as Engelse terminologie. Bekende Setswana terminologie is selde gebruik. Die navorser het die dekodering van taal om die konstruksie van konsepte te fasiliteer opgemerk, maar slegs Engelse terme is gebruik. Omdat onderwysers soms in een sin oorskakel, is die modellering van beide die korrekte Engelse en Setswana wiskundige taal belemmer, en vind daar min taalonderrig plaas aangesien die onderrigstyle van die onderwysers nie veel leerderdiskoers toelaat nie. Leerders is nie gereeld gevra om geskrewe verduidelikings te verskaf nie, en veral nooit in Setswana nie.

Aanbevelings sluit in dat taalonderrig in wiskunde deel moet wees van onderrigopleidingsprogramme en dat in-diens werkswinkels aangebied moet word om onderwysers in te lig en te sensitiseer vir die verskillende taalstrategieë en tegnieke. 'n Toekomstige studie kan ook fokus op die gebruik van tweetalige studiemateriale in wiskunde onderrig en leer.

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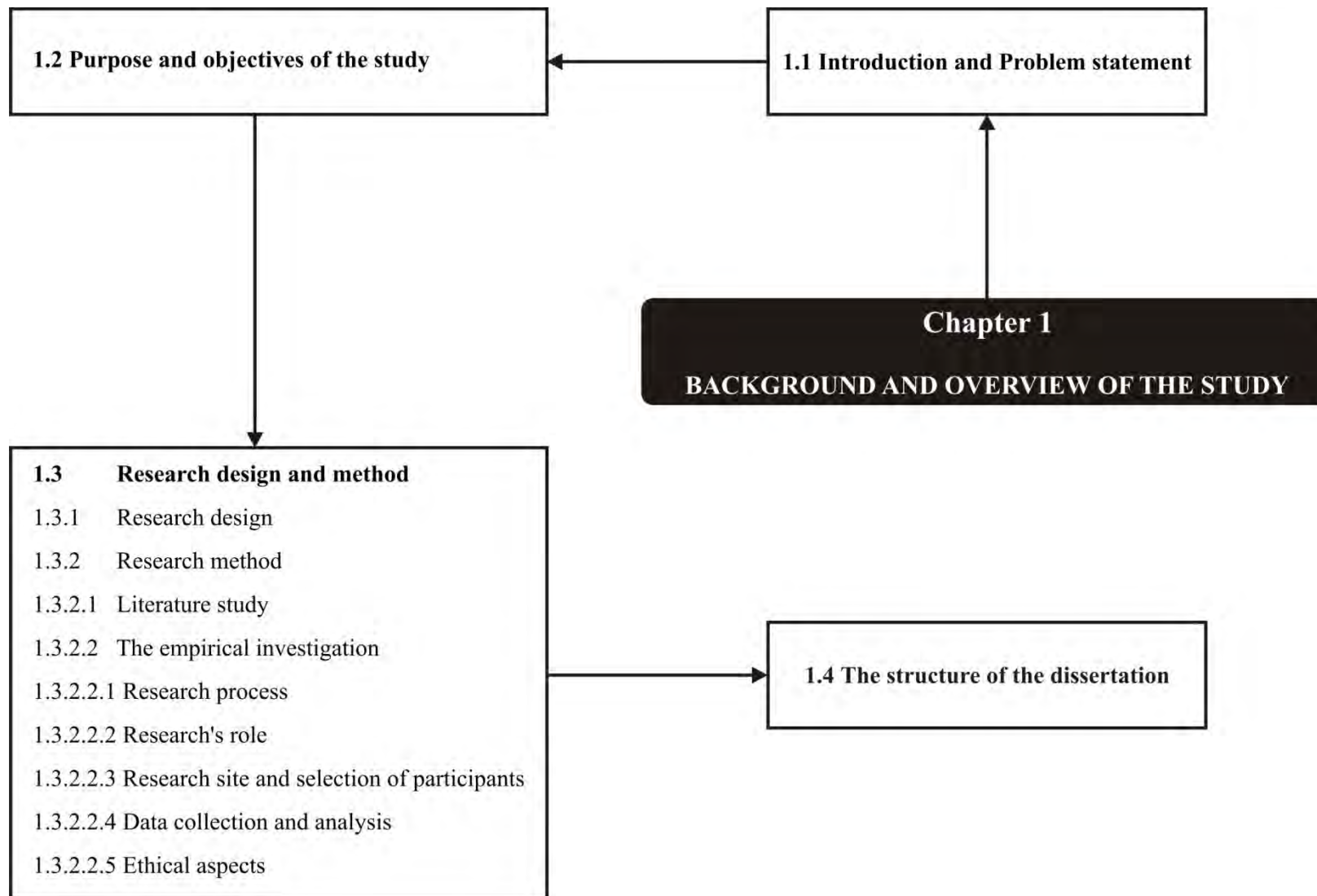
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CHAPTER 1: BACKGROUND AND OVERVIEW OF THE STUDY

1.1 Introduction and problem statement

South African Mathematics Education is facing serious challenges. The North West Province pass rate for Grade 12 Mathematics in 2009 supports this. Only 52, 02% of the mathematics learners passed at 30% and above. The figure is even worse at 40% and above, for only 33.73% acquired 40%, and this is after adjustments and conversions have been made (Department of Education, NWP, 2009). According to the Trends in International Mathematics and Science Study (TIMSS) (2003:55), the language proficiency of learners plays a significant role in the achievement in mathematics, though it is not the only factor.

Conceptual development provides the basis for the meaningful learning of mathematics. Concepts are the building blocks of mathematical knowledge, but it is not the only type of mathematical content. Discovery of relationships, conventions, algorithms, application and problem solving are also critical for meaningful mathematics learning (Cangelosi, 2003:177,178). According to Kilpatrick, Swafford and Findell (2001:116) conceptual understanding is a critical component of mathematical proficiency that is necessary for anyone to learn mathematics successfully. They argue that learners with conceptual understanding know more than isolated facts and methods, they understand why a mathematical idea is important and in which contexts it will be useful. Such learners have organised their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know.

Meaningful learning of mathematics is a process of developing and negotiating meaning, and it is achieved through the medium of language. Mathematics learning is achieved through negotiation of meaning between the teacher and the learner, and among learners themselves, to build meaning together (Khisty, 1995:277; Carlson, 2000:45). Language therefore, is the primary means of teaching and learning. Learners also need language to express their thinking and communicate what they know. Learners' ability to participate in mathematics depends on their ability to talk, listen, read and write. Setati (2005:445) describes the learning of mathematics as a process of acquiring fluency in the language of mathematics, which includes words, phrases, symbols, abbreviations, and ways of speaking, reading, writing and arguing that are specific to mathematics. Mathematics learning therefore requires the ability to understand specialised vocabulary, as well as specialised meanings of common words. This can be referred to as the mathematics register.

Learners' language proficiency is important for the conceptual development and discovery of relationships. According to Gorgorio and Planas (2002:30) mathematical language is universal and

is shared by all who are doing mathematics. However, they caution that the language of doing mathematics in the classroom is far from universal. This is illustrated by the unique language situation in the mathematics classrooms in South African schools. Classrooms have become linguistically diverse. Mathematics learners have to make use of a second or third language in the classroom. This situation introduces complications into the teaching, understanding and communication of mathematics. Both teachers and learners have to work in multicultural and multilingual classrooms. In the multilingual classroom a number of learners may be competent in a variety of indigenous languages (main languages), but the language of learning and teaching (LoLT), namely English, is not their main language. South African learners' poor performances in 1995, 1999 and 2003 TIMSS have partly been ascribed to problems many learners and teachers experience because English as the LoLT is their second language. However, it is difficult to determine the extent to which language contributes to poor achievement (Howie, 2001:3-6; Reddy, 2006: 144).

Setati and Adler (2002:243) point out that the multilingual mathematics classroom is an established practice in South Africa. They further indicate that one of the strategies carried out in the multilingual classes is code-switching. Code-switching entails that the teachers and/or learners switch between the LoLT and the learners' main language. The beliefs and linguistic competencies of the teacher and the number of different main languages in the classroom bring different features that influence the nature of the code-switching (Adler, 2002:85, 93). Code-switching is especially valuable to facilitate conceptual development (Adler, 2001:75). When the teacher wants to probe the thinking processes of the learners, the gateway is the learners' main language (Vorster, 2005:97). Setati (2005) expresses it as follows:

“Many learners in English second language schools are not fluent in English and therefore code-switching practices are not only inevitable but necessary in schools where proficiency in English is being developed at the same time as it is being used as the LoLT”.

The way mathematics language is used to speak or write gives meaning, precision and context to the concept usage. According to Cangelosi (2003:233) mathematical language provides the power to communicate precisely. However, precise communication is only possible if the learners have become apt in using the register. Gutierrez (2002:1049) points out that mathematics teachers should make sure that learners are aware of differences between everyday language and the mathematical register by teaching them what a word means in everyday language and its precise meaning in mathematics. The teacher must teach the learner to use language to interpret mathematical expressions in different contexts. The mathematics teacher and the learners should be able to comprehend and communicate mathematical messages (Cangelosi, 2003:239).

Apart from using language to communicate mathematical ideas, decoding of mathematical terminology can be used to further conceptualisation, for example, *molapalo* is a Setswana term for number line. This is illustrated as follows: *mola* – line, *palo* – number. Hence, the term *molapalo* or number line. In English the term co-interior angles can be used as example, where “co” means “together”, and “interior” means inside.

In a multilingual setting the mathematics register and language teaching is more complex. The mathematics teacher has to teach both the English and Setswana mathematics registers. The teacher in the multilingual mathematics classroom should therefore take care of how to use the different mathematical registers. This leads to a complex situation that needs to be investigated to better understand the current situation in South African mathematics classrooms.

1.2 Purpose and objectives of the research

The study investigated the role of mathematical language as a teaching tool in a multilingual mathematics classroom.

The following were objectives of the research:

- To determine if and how the teacher uses code-switching as a strategy to teach mathematics in the classroom.
- To investigate the extent to which teachers do teaching of mathematical language in the classroom.
- To investigate the extent to which teachers use the teaching of mathematical language as a technique to teach concepts.

1.3 Research design and method

1.3.1 Research design

It is important for the researcher to carefully select the appropriate design for the research in order to carry out the research project successfully. Yin (2009:7) defines the design as the logical sequence that connects the empirical data to the study’s initial research questions and ultimately to its conclusions. Mouton (2002:49) said that the research design addresses the question of what type of study would be undertaken in order to provide acceptable responses to the research problem or research question. The conditions that contribute to the choice of a research design include the type of research question posed by the researcher. The researcher should ask himself whether the questions are “who”, “what”, “where”, “how” or “why” questions. Another condition is the extent

of control an investigator could have over the actual behavioural events (Yin, 2009:8). In this research the researcher responds to the research questions “if” and “how”. No intervention took place and the researcher wants to investigate, but not control, the language situation in multilingual mathematics classes. Therefore, a qualitative approach was selected to do an in-depth investigation in order to understand how the language is used in the multilingual classrooms.

1.3.2 Research method

The conditions set above assisted the researcher in selecting the best research method for this research. The use of language in the multilingual mathematics classroom was investigated within its real life context. Due to the complexity and nature of the language used in multilingual mathematics classrooms, a case study was carried out (Leedy and Ormrod, 2005:135).

Yin (2009: 8) defines the case study research method as an empirical inquiry that investigates a contemporary object with its real-life context when the boundaries between the object and context are not clearly evident, and in which multiple sources of evidence are used. The research object in the case study is often a program, an entity, a person, or group of people. The researcher investigates the object of the case study in depth using a variety of data gathering methods to produce evidence that leads to understanding of the case and answer the research questions or objectives. A case study generally answers one or more questions that begin with “how” or “why”. The questions are targeted at a limited number of events or conditions and their inter-relationships.

1.3.2.1 Literature study

The theoretical study highlights the importance of the main language for mathematics learning and teaching. The study gives valuable information on how code-switching as well as the decoding of mathematical language in the teaching is used in the mathematics classroom. To be able to do the empirical investigation, a thorough literature survey was conducted by means of Nexus and Dialog searches. EBSCOHOST and internet search engines were used. The following keywords and phrases were of importance: (math* and language*) and (learn* or teach* or educat* or instruct*), math* and language, multilingual classroom and math language, code switching and math language, (math* and language*) and concept*.

1.3.2.2 The empirical investigation

1.3.2.2.1 The research process

The researcher wrote a letter to the Head of Department of North West Province Education department to request permission to be allowed to use certain schools for the research. The permission was granted, and then another letter was written to the principals of selected schools to ask permission to utilize their schools in the research.

An appointment was organized with each school principal of the three schools at which the research was conducted. The researcher explained the goals of the research. After obtaining permission from the school principals, the researcher got permission from the mathematics teachers as participants. The purpose of the study was explained, as well as the teacher's role in the research. Participation was voluntary. Participants were free to express their views and ideas regarding the research, and even to withdraw.

After the clarifications, the mathematics teachers willingly acceded to the request. The researcher also asked permission to use an audio-visual recorder when observing the lessons. The names of participating teachers remained anonymous. Interviews were conducted by the researcher only, and deliberations from the interviews were not disclosed to anyone, but were solely used for the purpose of the study.

1.3.2.2.2 Researcher's role

The researcher's role was to conduct the case studies. He therefore had to select the sites and the participants. Furthermore, the researcher visited the teachers, observed their lessons, recorded and transcribed the lessons, conducted the interviews, and analysed and interpreted the data.

1.3.2.2.3 Research site and selection of participants

The case study was conducted in three secondary schools in the Mafikeng district of the North West Province. A purposeful selection of three schools was made, including a poor rural village, a semi-rural school and a school in a township. One mathematics teacher from each school with a Grade 8 class took part.

The learners participated in their natural classroom environments to contribute towards the generation of data. The three cases comprised linguistically diverse mathematics classes, with teachers and learners from various backgrounds, and provided rich data to research the objectives.

1.3.2.2.4 Data collection and analysis

Three lessons from each teacher were observed for the purpose of this study. These lessons were recorded with an audio-tape recorder. The researcher also used an observation schedule while observing lessons. Semi-structured interviews were conducted with these three teachers after the three lessons to allow them the opportunity to talk about their experiences and code-switching. The lessons recorded and observed from each mathematics teacher were transcribed.

To be able to interpret the data, the method of open coding, where constructs are identified from data, was adjusted. This adjustment involved identifying constructs from literature and then studying these constructs as it emerged from the data. The identification of the constructs was then followed by axial coding, where relationships between constructs were identified and the constructs were grouped under the emerging themes (Pandit, 1996). An independent person was used to verify the transcription and interpretation from the audio-tape recordings. Triangulation was reached by using these multiple sources that informed each other.

1.3.2.2.5 Ethical aspects

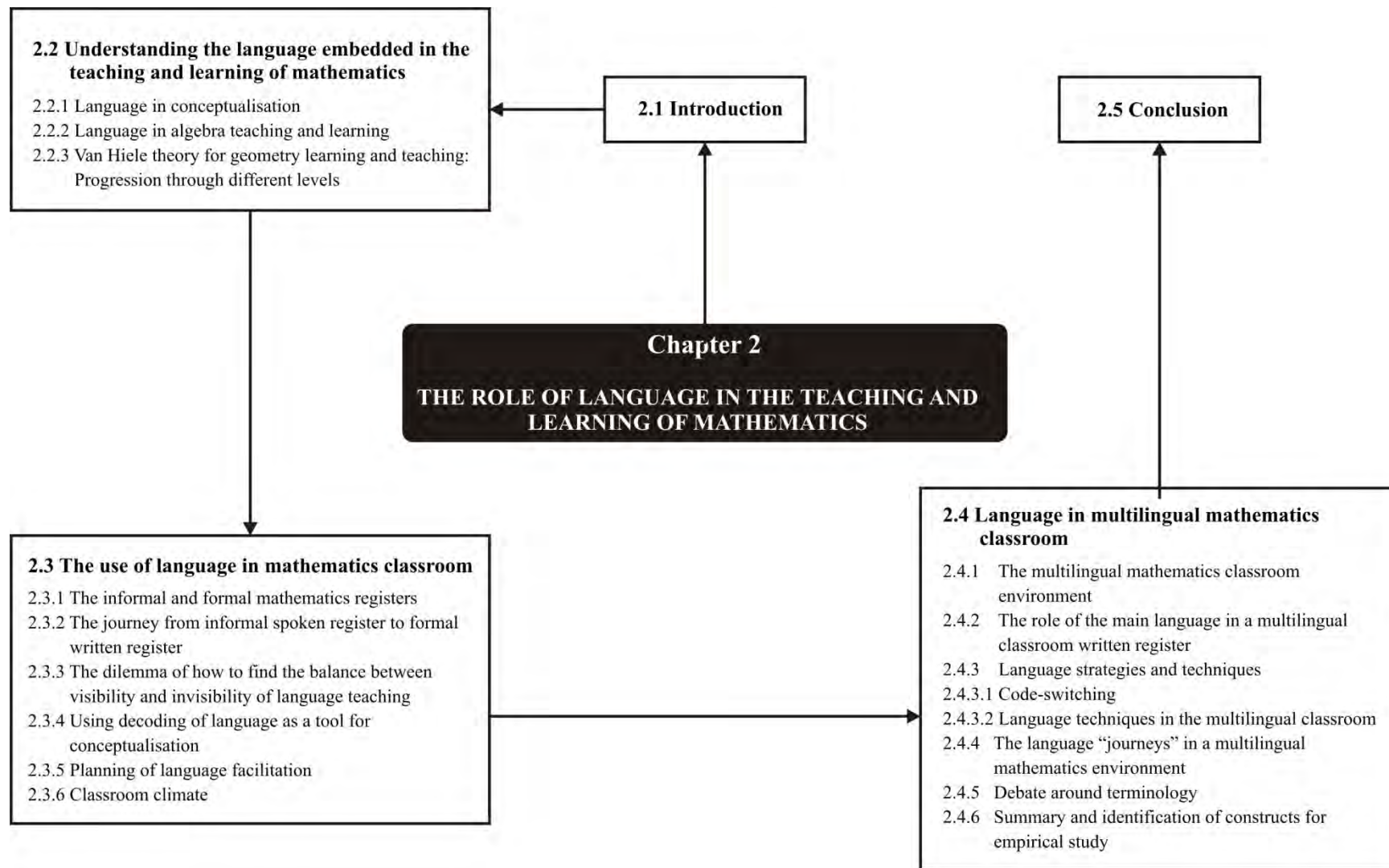
When conducting research, many stakeholders are involved and it becomes important to consider the ethical issues relating to each of the stakeholders. May (2001: 59) says that ethics is concerned with what is right in the interests of not only the project, its sponsors or workers, but also others who are participants in the research project. The researcher also adhered to the North West university's ethics of conduct when conducting the research.

1.4 The structure of the dissertation

Evidence that language contributes to the problems in the teaching and learning of mathematics of especially learners whose first language is not the LoLT, gave rise to this study. A short literature study is given in chapter 1 to clarify the purpose of the study. Furthermore, an overview of the research report is given by means of an outline of the research design and procedures.

Chapter 2 discusses the use of language in the learning and teaching of mathematics. This includes the interrelationship between language and thought against the background of the language features of the different learning theories. Attention is also given to the teaching and learning of mathematics in a multilingual environment and the different strategies and techniques in the teaching and learning of mathematics in multilingual classes.

Chapter 3 reports on the empirical investigation and results and chapter 4 describes the conclusions reached in the study, and identifies themes for future research.



CHAPTER 2: THE ROLE OF LANGUAGE IN THE TEACHING AND LEARNING OF MATHEMATICS

2.1 Introduction

Language development in mathematics is a crucial issue in the learning and teaching of mathematics. Researchers in recent years have revealed that there is a close link between language proficiency and learners' understanding of mathematics (Barwell, 2005; Vorster, 2008; Naudè *et.al.*, 2003 and Setati, 2002). This chapter gives a framework that will form the basis for the empirical study with respect to the language practices of mathematics teachers.

In the first section of the chapter, attention will be paid to the role of language in the teaching and learning of mathematics in general. These principles and phenomena apply to both monolingual and multilingual classes. In the second section of the chapter, the situation in the bilingual or multilingual mathematics environment will get special attention. In this section acknowledgement is given to the fact that learning mathematics in a second or third language may be the source of difficulties.

2.2 Understanding the language embedded in the teaching and learning of mathematics

The research firstly discusses language in concept formation. Attention will be paid to how Vygotsky sees the role of language in concept formation, as well as to the Network Theory. Furthermore, MacGregor and Price's (1999) findings about metalinguistic awareness will be discussed and linked to Kieran's model for the teaching and learning of algebra. Language features of Van Hiele's theory of reasoning levels in the development of a learner's thinking will also be considered. The main focus of this study is not to discuss or explain models and theories, but to look at the role of language within them.

2.2.1 Language in conceptualisation

When teaching mathematics the teacher's role is to create an environment that allows learners to construct and understand mathematical concepts. To be able to manage this, a teacher should apply appropriate learning theories, such as social constructivism. Constructivist theory has two strands, namely the cognitive theory and the socio-cultural theory (Van de Walle *et al.* 2010: 20). These theories are important for the purpose of this study and provide the basis for conceptual development in teaching mathematics. Van de Walle *et al.* (2010: 20) said that although cognitive constructivist theory came from psychology, it helps teachers to be aware that learners are not

empty vessels, and that learners learn through mental networks or connections. This theory also emphasises that mental networks or cognitive schemas are the product of constructing an additional tool by means of which knowledge can be constructed. Hiebert and Grouws (2007:282) maintain that mathematical facts, procedures and ideas are understood if they form part of the mental networks or connections. When the mental connections become stronger the concept developed becomes clear and understandable.

In learning mathematics the networks are arranged, added to or modified (Van De Walle *et al.* 2010:20). Information that exists in the learner's memory is connected through various relationships. Concepts are linked to several others in relationships, so that it forms networks of knowledge. These networks of knowledge are connected to other networks to form schemata (Schunk, 2004:162, 164). This is exactly what happens in the teaching and learning of mathematical concepts, which require strong links for learners to understand them. Hence, language is very important in the formations of networks.

Knowledge about the mental network assists mathematics teachers to understand how to build the new connections that encourage concept networks. A mathematical concept that belongs to different networks can activate different knowledge networks. For example, when mathematics learners are taught the properties of a square, if correctly linked will activate knowledge of a square in algebraic expressions and the Pythagoras theorem. A verbal thought or concept that is used more frequently presents itself more often than others, and it enters completely into the learner's habits.

Vygotsky's socio-cultural theory indicates that the social environment influences understanding through cultural objects, language and social institutions (Schunk, 2004; Van de Walle *et al.*, 2010). Socio-cultural theory has unique foundational features such as the mental processes that exist between people in a social learning environment, and the way information is learned (Van de Walle *at al.* 2010:21). The social cultural view means participating in a community of people who are doing and making sense of mathematics, as well as coming to value such activity (Hiebert & Grouws, 2007:382)

According to Vygotsky (1967:57, 59) the relationship between thought and language is important for effective learning to take place. Word meaning is where thought and speech unite into verbal thought. Verbal thought is a generalised reflection of reality that is also the essence of word meaning. The development of understanding and real communication requires that the meaning of the words are known. The individual's experience is in his mind, but he cannot always

communicate it to others. It becomes communicable when it has meaning and therefore can be expressed in words.

Vygotsky's view is important for the teaching and learning of mathematics. A mathematics learner might know a word or a term, but until the term is generalised a learner will attach no meaning to that term or word. The learner's concept development will be limited unless the word is generalised. This implies that meaning must be given to mathematical terminology using teaching methods to ensure concept forming. A mathematics term is clearly understood when a learner can give relevant specifics and common attributes related to that term.

When new concepts are developed word sense also plays an important role. Word sense is when a word can be used or understood in different ways when it is used in different contexts and all the different nuances of how to use and understand the word is mastered (Vygotsky, 1967: 43). For word sense to be developed the speaker has to be proficient in the language.

Also, mathematics is fundamentally about "meaning". The use of correct language in expressing mathematical concepts, describing content and the interaction and relationships between these concepts are critical in the negotiation of meaning and promoting understanding. Lee (2006:19) summarises the importance of language in mathematics when she said that:

"Each natural language expresses mathematics using words from that language but also uses ways of expression that are recognisable as mathematics throughout the world. One is aware that to be fluent in any language either main language or foreign language is achieved through the ability to think in that language. Hence, for the learners to understand and master mathematical concepts, they must be able to think in the mathematical language".

The teacher should emphasise the internal mental connections of individuals and socio-cultural factors in order to understand conceptual development in mathematics (Hiebert & Grouws, 2007:383). They further said that attending to concept means treating mathematical connections in an explicit and public way that is teaching as infused with coherent, structured, and connected discussions of the key ideas of mathematics. This may include discussing the mathematical meaning underlying procedures and asking questions about different solution strategies and attending to the relationships among mathematical ideas.

For the teacher to reach the learning goals in mathematics the teacher needs language in order to transmit the message to the learners. Not all the conceptual learning theories are under discussion here, even though they are important in the teaching and learning of mathematics, since some do not fall within the focus of this study.

From the above discussion it is clear that language plays an important role in teaching and learning. The following paragraphs will discuss how language features in some theories on teaching and learning of mathematics.

2.2.2 Language in algebra teaching and learning

As noted before the teaching and learning of algebra is a challenge in South African schools. One of the elements of language knowledge, namely metalinguistic awareness, may correspond with a component of algebraic knowledge. Metalinguistic awareness is when attention is given to the form or function of a word or phrase, and not only to its meaning (MacGregor & Price, 1999:451). Kieran (2007: 717) summarises the definition well when saying that

“metalinguistic awareness refers to the ability to reflect on and analyse spoken or written language, for example, being able to pay attention to sounds and spelling of linguistic signs instead of to their meanings. Both symbol awareness and syntax awareness are considered to be components of metalinguistic awareness necessary for success in learning to use algebraic notation”.

Metalinguistic awareness consists of symbol awareness, syntax awareness and the understanding of ambiguity. In language a symbol can be used to express ideas and emotions. Symbol awareness in mathematics includes understanding that numbers, letters and mathematical signs can be used to indicate a number or other entities. Symbols can be manipulated to simplify algebraic expressions. For example, $3(2a + b + c) + 1$ can be simplified into $6a + 3b + 3c + 1$.

Syntax is a part of linguistics that deals with the arrangement of words into phrases and phrases into sentences. In language, syntax describes the patterns of arrangement of words in phrases and sentences, and agreement among words. Syntax awareness reflects sensitivity for grammatical relationships amongst words, phrases and sentences. The correct word order of a sentence is important, for example in a question: “Is he a grade 8 learner?” and in a statement: “He is a grade 8 learner”. When the learners are aware of the syntax it helps them to translate word problems into symbolic form. For example “**a** is 7 less than **b**”.

The symbolic translation of this word problem is:

$$a = b - 7 \text{ or}$$
$$b - a = 7 \text{ or}$$
$$a + 7 = b.$$

A learner who does not have a strong syntax awareness may translate it as $a - 7 = b$.

Another example of syntax awareness in mathematics is when determining the value of x in $2x = 16$. We do not write it as $2x = 16 = 8$. The correct syntax is $2x = 16 \quad \cdot \quad x = 8$.

The learners who are conversant with syntax will experience fewer problems with word problems than those who have no feeling for syntax (Groenewald, Minshall, Otto, Roos, & Van der Westhuizen, 2006:102).

It is important to pay attention to syntax when expecting learners to learn abstract mathematical concepts, otherwise a communication gap may be created that affects the ability of learners to conceptualise as the lesson is in progress. This impedes their general assimilation of the whole exercise as step by step understanding of the explanation of mathematical theorems or algorithms is important in mathematics. It is therefore important that both in mathematics and language the teachers need to ensure that learners understand the syntax.

Pimm identified some similarities in the syntax of language and algebra as early as 1990. He said that the algebraic algorithms are verbally coded in terms of specific precepts dealing with the form of operating at the synthetic level of symbols only, for example:

“collect all the x’ s on one side; take it over to the other side and change the sign; do the same thing to both sides” (Pimm, 1990:20)

Teaching mathematics invariably involves explaining concepts using language. Language is governed by grammatical rules. Therefore the structure of sentences has a far-reaching impact. It is important that the order of symbols of variables, relationships and operations in algebraic expressions and equations corresponds with the structure of the sentences. Sentence construction in mathematical definitions can be very rigid, for example, a description of a ratio in mathematics: “A ratio is a comparison between two numbers or quantities of the same units by division” (Fitton, Long, Blake & De Jager, 2006:289). This word order of the definition of a ratio is very rigid and it is important for the learners to be able to express and put across what the definition say in symbol language, and vice versa.

One of the difficulties in the learning and teaching of algebra is the problem of ambiguity. It is the state of an expression having more than one possible meaning because what is explained is not clearly stated or defined. Something is ambiguous when it can be understood in more than one way. The learner can attach a meaning that is different from the one which the teacher wanted to communicate to the class. In some cases the meaning can be constructed from knowledge of the context and not from the word order. If the context is unknown, different meanings can be attached. An example of ambiguity in an everyday sentence is “The shooting of the hunters was terrible”. The statement can be interpreted in more than one way. This might mean that “when the hunters were shot it was terrible” or “the way in which the hunters were shooting animals were terrible” (MacGregor & Price, 1999:452).

Contextual clues cannot be used to interpret algebraic expressions. However, it plays a role in interpreting word problems and in questions that are not precisely formulated. An example of ambiguity in word problems is: Peter and Paul ate two apples. The meaning will be subjective and dependent on individual construction of meaning. One reader may think that Peter and Paul ate two apples each. Another reader may think that each might have eaten one apple. Another person may interpret it as an open sentence with many possible answers. Mathematics teachers should make sure that ambiguity is avoided at all times during examinations and that it is clear when it is required that a problem be treated as an open problem with different possible answers. The mathematics learners must be able to spot the ambiguity.

The research carried out by MacGregor and Price (1999) indicated that there may be a correlation between the metalinguistic awareness in language and algebra score. Their results showed that when learners obtain high scores in metalinguistic awareness, the learners' score in algebra is also high. The findings also indicated that no learners with low metalinguistic awareness had high algebra scores.

Kieran's model of algebra teaching

Kieran (2007: 713) developed a model that can be used in the teaching and learning of algebra. The model synthesises the algebra into three types, generational, transformational and global / meta-level.

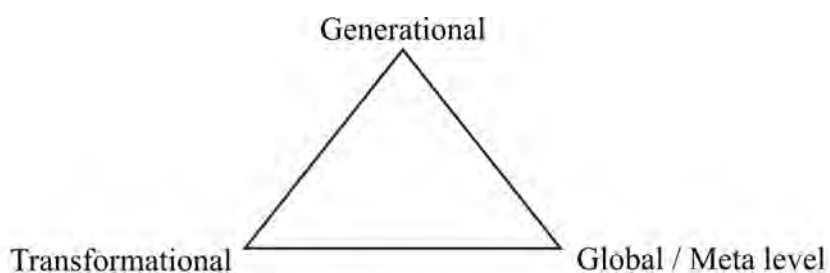


Figure 1: The model of conceptualising algebra learning (Kieran, 2007:713)

Generational activities of algebra involve the formation of expressions and equations in algebra, for example the equations containing an unknown, which represents problem situations, and the expression of the rules used in the establishment of relationships in algebra (Kieran, 2007:713). Generational activities mainly focus on the letter symbolic form, multiple representations and the context of word problems. The letter-symbolic form emphasises the meaning that the learners give

to algebra content in areas such as expressions and equations, the minus and negative numbers, and the structure sense (Kieran, 2007:716). This letter-symbolic form linked well with the symbol awareness of metalinguistic awareness. The learners need to explain and justify their methods while doing mathematics by using a language that would help them in solving the problems.

One of the important aspects of mathematics that help with the understanding of generational activity is modelling. Watson, Redlin and Stewart (2002:206) define mathematical modelling “as finding a function that describes the dependence of one quantity on another”. In mathematical modelling the interaction between languages, graphs, and algebraic representation of situations should be managed (Sproule, 2010:30). In modelling with functions, the mathematics learner should be able to express the model in words (Watson. *et.al*, 2002:209). In this case, the syntax awareness plays an important role in the solving of word problems. Syntax awareness will help the learners to translate the word problems into equations. The learners who have awareness of the syntax will be more able to translate word problems or equations into symbol language than other learners with little or no syntax awareness.

Example: “Two consecutive natural numbers are such that five times the larger exceeds three times the smaller by 31. Find the numbers” (Fitton, Long, Blake & De Jager, 2006:156).

The learner who has syntax awareness will be able to read, understand and solve the word problem. The learner also translates the verbal statement into the algebraic statements that is the symbolic mathematical language. The learner would be able to identify the given information and what is to be calculated. Furthermore, the learner will be able to determine the relationship between known and unknown quantities and use variables to define unknown quantities. The meaning of the term “consecutive natural numbers”, “five times larger”, “three times the smaller” and “larger number exceeds the smaller number” will be understood and used to solve the word problem.

Solution:

Let the numbers be x and $x + 1$

Five times the larger: $5(x+1)$

Three times the smaller: $3x$

$5(x+1)$ exceeds $3x$ by 31 or $5(x+1)$ is 31 more than $3x$.

For these two quantities to equal, you have to add 31 to the smaller of the two.

$$5(x+1) = 31 + 3x$$

$$5x + 5 = 31 + 3x \quad \text{(Remove brackets)}$$

$$5x - 3x = 26$$

$$2x = 26$$

$$x = 13$$

The numbers are 13 and 14.

The rule based **transformational** activities are important in mathematics learning. This includes “factoring, collecting like terms, and substituting one expression from another, multiplying and adding polynomial expressions, inequalities, simplifying expressions, so on” (Kieran, 2007:222). A transformational activity consists of equivalence and theoretical control, the manipulation of expressions and equations, and the use of concrete manipulation in transformational activity. The main emphasis in this activity is on changing the symbolic form of expressions in order to maintain equivalence. $x^6 - 1$ is the difference of squares and also a difference of cubes.

The learner should be able to write $(x^3 - 1)(x^3 + 1)$ as

$$\begin{aligned}
 &= (x^2-1)(x^4+x^2+1) \text{ and when simplified this will be} \\
 &= x^6 + x^4 - x^4 + x^2 - x^2 - 1 \\
 &= x^6 - 1
 \end{aligned}$$

Global or meta level mathematical activity includes problem solving, modelling, working with patterns, justifying and proving, making predictions and conjectures (Kieran, 2007:725). The global or meta-level activity has three types, namely, generalising, proof and proving. The mathematics learners should be able to articulate the relationship using everyday language and mathematical language. In generalisation the learners use algebra to justify and formulate a general statement about numbers. For the algebraic model to be effective, the mathematics teachers and learners should use mathematical language correctly. Hence, the learner will need to have enough vocabulary to be able to move from generational activity to transformational activity, and ultimately to global or meta-level activity.

2.2.3 Van Hiele theory for geometry learning and teaching: The progression of language through different reasoning levels

The Van Hiele theory describes the different levels of thinking that learners pass through as they move from a global perception of geometric figures to understanding of formal geometric proof. According to this model, effective learning occurs as learners actively experience the objects of study in appropriate contexts of geometric thinking and as they engage in discussion and reflection using the language of the reasoning level. Van Hiele identified five levels of reasoning that a learner has to attain in mathematics learning, and labels them visualisation, analysis, informal deduction, formal deduction and rigour, which describe the characteristics of the thinking process. According to Van Hiele (1986), the reasoning levels are sequential and hierarchical in that a learner cannot operate with understanding on one level without having been passed through the previous

levels. This theory, unlike Piaget's theory, does not depend on the age of the child's development, but on the child's experiences with geometry shapes and activities.

Van Hiele reduced the original five levels to three reasoning levels, and labelled it the visual level, descriptive level and theoretical level (Fuys, Geddes & Tischer, 1988). This classification proved to be especially useful in planning school geometry (Van Hiele, 1986). The levels are achieved through different instructional experiences. During each instructional experience learners should investigate appropriate outcomes and develop specific language related to the activity. The mathematics learner engages in interactive learning activities designed to enable them to progress to the next level of reasoning. To reach a specific level a learner has to master the specific language related to the outcomes of that level. Each of the levels in the Van Hiele theory is characterised by a vocabulary that represent the concepts, structures and networks within that level of geometric understanding (Teppo, 1991:210, 213).

Hoffer (1981) made an important contribution when he identified five skills that are necessary for problem solving and linked it to the van Hiele levels. The skills Hoffer identified were visual, verbal, drawing, logical and application skills. The verbal or communication skill is critical in this instance, because in geometry the learners need to describe figures and relationships and thinking processes in words. The mathematics learners need to understand and use the specific terminology used in geometry.

The learners' verbal skills should develop through the three levels. Learners that have reached the visual level will be able to recognise and name shapes. For example, learners can recognise similar triangles. They can recognise the fact that the triangles have the same shape, but are not able to explain the properties of the shapes. No relationships and interrelationships between figures can be observed. The language that the learners use at this level often is informal or even everyday language. Often learners will use their own language to name shapes. The learners' own language may include words or phrases such as corner (angle) and "point" (vertex).

At the descriptive level the learners should be able to describe shapes on the basis of their properties. The learners should be able to describe the relationship between figures. For example, in similar triangles, the learners should be able to describe it as corresponding sides that are a reduction or enlargement of the other sides. The learners at the descriptive level should be able to reason using the formal mathematical language, such as congruent triangles, similar triangles, conjectures, generalisation etc. Descriptions of theorems and relationships may still be less rigid than on the theoretical level.

The language of the theoretical level has a much more abstract and rigid character than that of the descriptive level because it is engaged with causal, logical and other relations of a structure, which at the second level is not necessary. Reasoning about logical relationships between theorems in geometry takes place with the language of the third level, which is rigid, and word order often plays an important role. Van Hiele assigns an important role to instruction in the development of learners' geometric understanding. The movement from one level to another is not a natural process; it takes place under the influence of a teaching and learning programme (Van Hiele, 1986:50). From the previous discussion on the progression of the language through the levels it follows that the planning of a teachers' language use and mathematical language teaching should form an integral part of the programme.

Van Hiele (1986) also identified five learning phases for facilitating the progression from one level to the next in geometry.

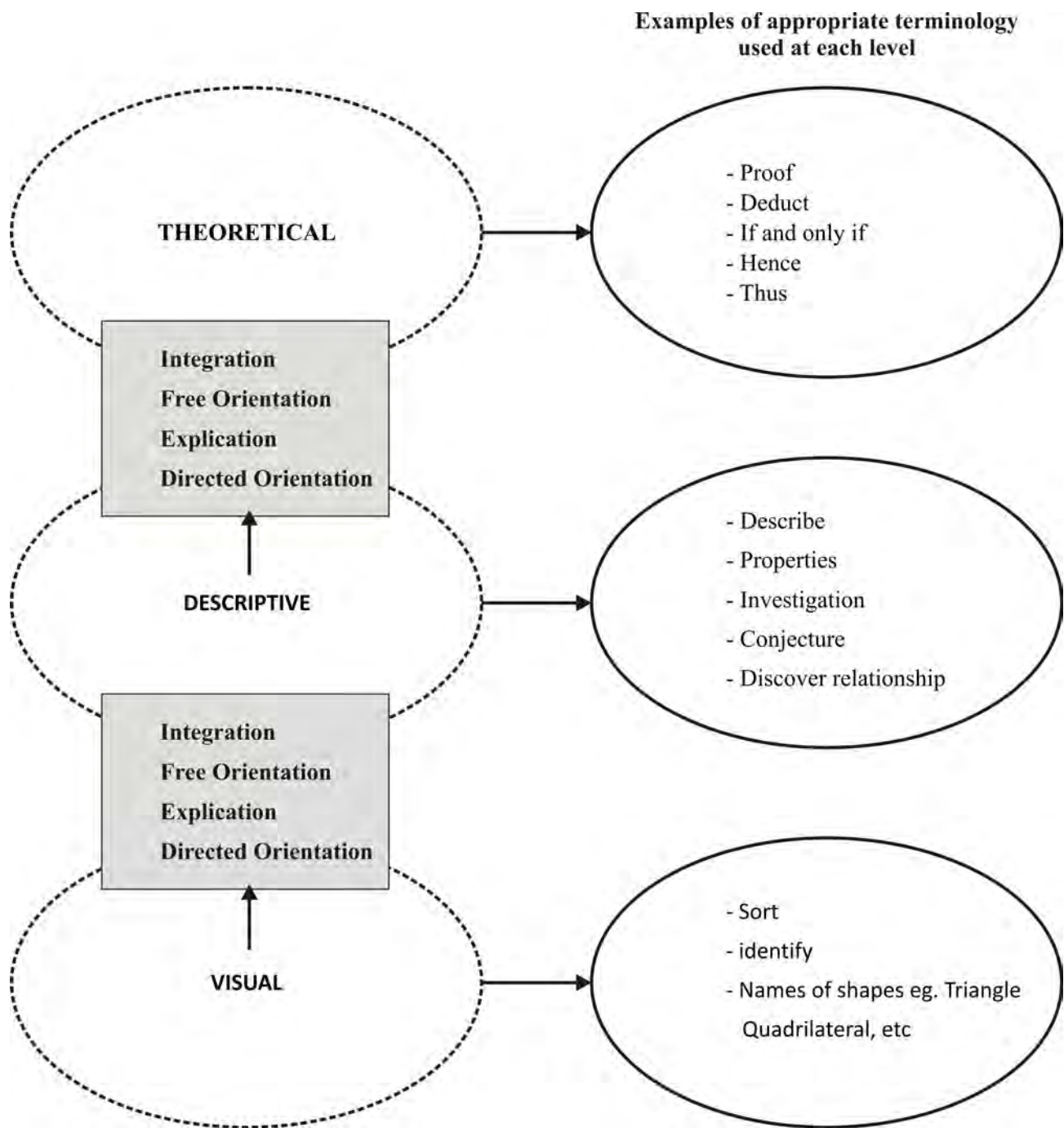


Figure 2: Diagram of the Van Hiele reasoning levels (as applied to secondary school mathematics)

Teachers should provide their learners with appropriate experiences and the opportunities to facilitate these phases.

In the *information phase* the teacher identifies what the learner already knows about the topic through class discussions and reflection. The teacher guides the learners to the new concept or topic. The teacher should use language that the learners are conversant with, including everyday language, in order to help the learner. The learners for example can be given the topic trapeziums.

The following activity is an example of an activity that can be given in this phase:

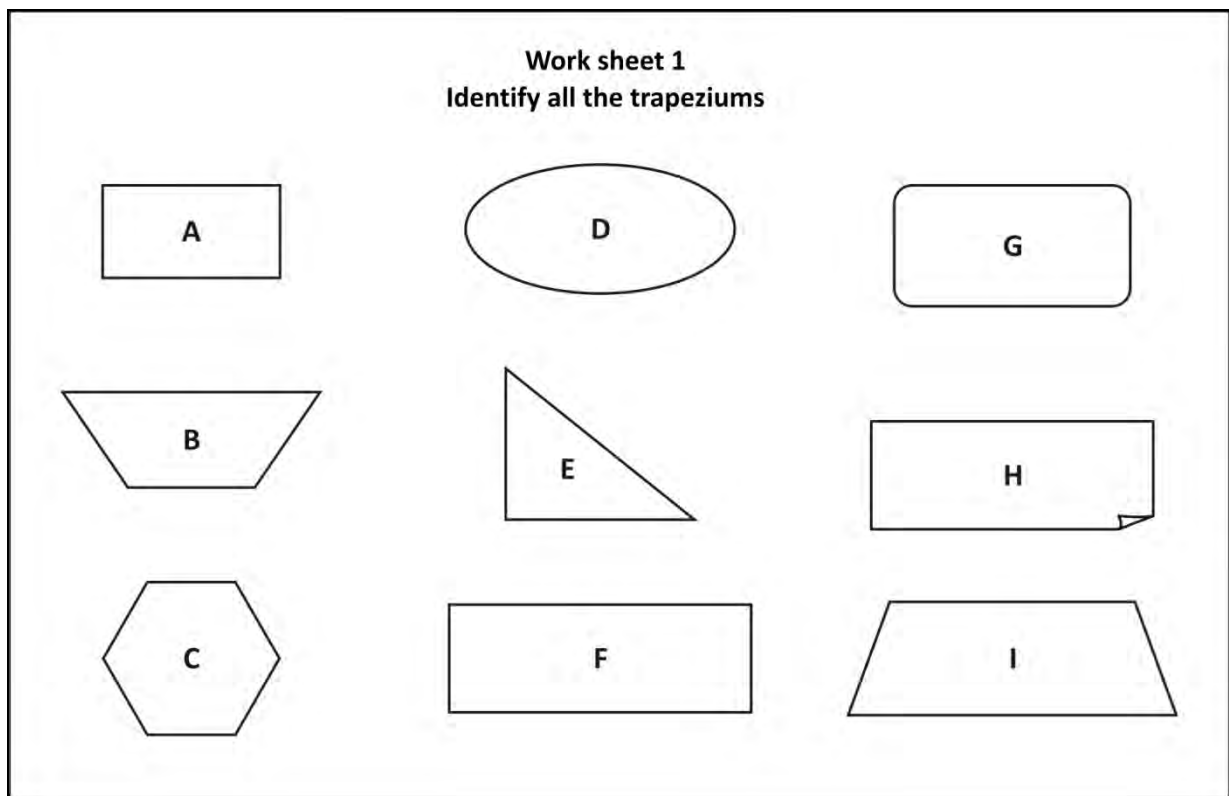


Figure 3: Activity 1

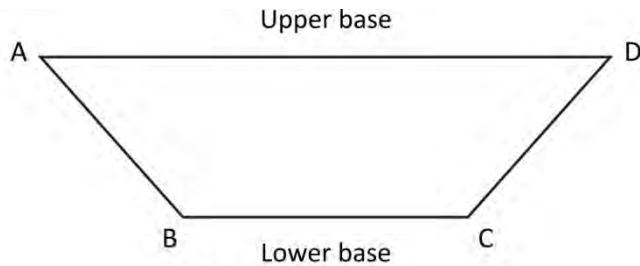
At the *guided orientation phase*, the teacher provides suitable information or instruction to assist the learner to discover properties of and relationship between trapeziums. The teacher gives the learner clear and unambiguous instructions using a vocabulary that would ensure that the learners understand the instructions. The teacher should also orientate the learners to the task enabling them to reach conclusions. Worksheet 2 is an example of a possible worksheet that can be given in this phase.

WORK SHEET 2
Properties of a trapezium

ABCD is a trapezium: Study the following diagram

1. Fill in the blanks:

- A trapezium is a quadrilateral with exactly one pair ofsides.



- The parallel sides are called

2. Study the diagram below and answer questions that follows:

Measure of the size of angle A. _____

3. Measure of the size of angle B. _____

4. The side BC is called _____

5. Measure the size of angle C. _____

6. Measure of the size of angle D. _____

7. Measure each pair of consecutive angles, namely A and B, and C and D. The sum of each pair of consecutive angles is equal to _____

8. The trapezium consecutive angles conjecture state that the consecutive angles between the bases of a trapezium are

9. Think about triangles with two equal sides and decide on a name for this trapezium _____ Trapezium.

The sides that are the same length must be the sides that are NOT parallel.

10. Using the _____ trapezium below:

- Mark the equal sides with the correct marks.
- Label the upper base angles A and B.
- Label the lower base angles X and Y.
- Measure all the angles and write in the degrees on the figure.



11. Write a conjecture about the base angles of an isosceles trapezium

12. Draw diagonals in the trapezium to the right. When you measure the length of the two diagonals you should be able to complete the following.

13. Write a conjecture about the diagonals of an isosceles trapezium

Figure 4: Activity 2

During this phase the teacher should also design a worksheet that will help the learners to understand the mathematical language used in work sheet 2 above. The following worksheet might be used as a language development worksheet.

Work sheet 3: Definition of terminology	
Explain the following words/ concepts.	
1. Quadrilateral	<hr/>
2. Consecutive	<hr/>
3. Isosceles trapezium	<hr/>
4. Congruent sides	<hr/>
5. A diagonal	<hr/>
6. Upper base	<hr/>
7. Lower base	<hr/>

Figure 5: Language worksheet

In the *explication phase* the learners and the teacher interact to summarise what they have learned about a topic in the learners' own words. The teacher introduces technical mathematical language or terminology appropriate to the target level. The learners should now have the necessary knowledge and should be able to use the correct mathematical language for the topic and the level involved. This will give them the language tools to describe their findings in the *free orientation phase* when they have to find their own way of applying and discussing the relevant knowledge. The teacher for example can ask the learners to make a poster with different types of trapeziums.

Through class/small group discussions the *integration phase* gives the learners the opportunity to review and reflect on the process from the start. Language plays a pivotal role in these phases of geometry teaching and learning. Each phase has its own interpretation and usage of the terminology, and through the phases the learners' language should develop so that they can communicate on the target level of reasoning. The phases of learning can best be described by the instruction that enables the learner in each learning period to develop a higher level of geometric reasoning.

2.3 The use of language in the mathematics classroom

In mathematics teaching the interaction between “teacher and learner”, and “learner and learner” to negotiate meaning is very important. Firstly, the teacher should be able to facilitate learning of mathematics through language, and learners should also be able to talk about mathematics to explain their understanding or lack of understanding of concepts and processes to peers and to the teacher.

To facilitate learners' proficiency in mathematical language, the mathematics teacher should model mathematical language, and provide learners with guidance and lead the way in the use of correct mathematical terminology. This implies that teachers need to include teaching of the mathematics register in the planning of their lessons. Pimm (1987: 75) says that

“a register is technical linguistic terms which describe a set of meanings that is appropriate to a particular function of language, together with the words and a particular function of language, together with the words and structures which express these meanings”.

Linguists use the term language register to refer to the meanings that serve a particular function in the language, as well as the words and structures that convey those meanings. Mathematics register, therefore, can be defined as the meanings belonging to the language specifically used in mathematics. A mathematics register is more precise than the language register because the meanings of the terms are much narrower in scope (Lager, 2006: 170). Therefore, it is important to discuss the characteristics of the mathematics register to be able to understand the nature of, and the problems related to the teaching and learning of the mathematics register.

Different discourses are present in the mathematics classroom, the educational or informal mathematical language, educated or formal mathematical language and the symbol language of mathematics. We now take a closer look at the mathematics register.

2.3.1 The informal and formal mathematics registers

An informal mathematics register is the register that is used in explaining mathematical concepts that is not the formal mathematical terminology (Lee, 2006:12, 15). The terminology used in the informal register help the learners to understand the concept better, because it is linked to everyday language and therefore to the pre-knowledge of the learners. Examples of this are the words “slide or glide” used instead of the more formal term “translation”. The words “equal shares” are also an informal term used instead of the “denominators” in fractions.

Mathematics, just like other subjects, has its own register in every language. According to Lee (2006:12, 15) the mathematics register is a way of using symbols, specialist vocabulary, and precision in expression, grammatical structures and formality that are recognisably mathematical.

The mathematics register consists of:

Words that have the same meaning as in the everyday use of the language, for example add, define and group.

Words that have a meaning in mathematical language only, for example, hypotenuse, isosceles, coefficient and graph.

Words that have different meanings in mathematics language than in everyday language. For example, difference, odd, mean value and integrate.

Furthermore, mathematics learners need to be able to read and write the mathematics register to use textbooks and to be able to complete various assessment activities during conceptualisation (Gerber, 2004:5). To be able to do this learners have to be proficient in the language used in the mathematics classroom.

The difficulty learners have to negotiate meaning becomes evident where learners struggle with word problems, language rich problems in sequences and series, linear programming, application of differential calculus and compound interest problems. When doing word problems learners experience problems with expressions such as “increase”, “more than”, “decrease”, “less than”, “as much as”, “the product of”, “twice the number”, “at least”, “at most” and so on. Negotiating the precise meaning of these expressions are difficult for learners. Although these words are used in everyday language, the learners struggle because the meanings of these words now need to be applied very precisely and accurately.

The mathematics curriculum of South Africa emphasises the need for using language to interpret mathematical problems. According to the Department of Education (2002:7) the learners are expected to describe and analyse the subject matter critically, reflect on what they have learned and to think creatively. It is clear that learners need a good command of the written language. However,

the spoken language of mathematics is also important in the teaching and learning of mathematics. The principal function of mathematical language is to transmit meaning accurately.

The mathematics register also includes everyday words that would have a meaning in mathematics different from the everyday language in some contexts, but may have the same meaning in others (Gutierrez, 2002:105). For example, the word “difference” sometimes means the same in both everyday English and in mathematics: Describe the difference between these two examples (meaning you have to describe where the examples differ from each other), but in another context it may have a pure mathematical meaning, e.g. find the difference between 25 and 14. Mathematics teachers should facilitate the shift between these often more figurative interpretations of everyday language and “literal interpretations” of mathematical language. The learner has to master the vocabulary and structure of this register to be able to express, speak, write and think in the language of mathematics. The teacher should help learners to continue to develop mathematical language at the same time that they develop proficiency in everyday language. However, teachers should make sure that learners are aware of the difference between everyday language and the mathematical register by talking about what a term means in general and its precise meaning in mathematics.

Furthermore, the learners might find it difficult to re-define and transform relatively complex verbal information (as presented in word problems) into mathematical expressions or equations, and vice versa. The mathematical terms such as “plus” or “sum of”, “minus” or “the difference between”, “more than”, “less than”, “multiply” and “equal to” must be associated with the relevant non-verbal symbols (graphics) such as +, -, >, <, \times and = in order to execute the given instructions (Naudè, Pretorius & Vandeyar, 2003:299). There is a need for teachers to admit that mathematics is a new language in itself for the learner. Mathematical language includes new words, phrases, symbols, abbreviations, and way of speaking, reading, writing, and arguing, and teachers should plan to include the teaching of the necessary language in their instruction.

The teacher must teach the learners to interpret mathematical expressions within a specific context. For example: The symbol $C(a, b)$ could be the coordinates of C where $x = a$ and $y = b$. This describes the position of a point on a Cartesian plane, but it could also indicate an open interval depending on the context. “ a / b ” could be read as “ b is a *divisor* of a ”, while “ $\{(x, y) / x < y + 6\}$ ” read the “all ordered pairs of x, y such that $x < y + 6$ ”. In this case the meaning of the symbol “/” differs from context to context.

2.3.2 The journey from informal spoken register to formal written register

Experience has shown that informal mathematical language is often used in the mathematics classroom when new concepts are formed, for example, equal shares for denominator in fractions. Adler (2001:131, 133) calls the informal mathematical language in the classroom the educational language, therefore indicating that this language is used in the learning process. When a concept is mastered and the formal mathematical terminology is introduced, she calls it educated language, which then refers to the formal mathematics register. Proficiency in the mathematics register usually develops within formal settings like schools. In most mathematics classrooms, both forms of language are used and they can either be in written or spoken form.

One of the difficulties mathematics teachers face is how to facilitate the journey of progress from predominantly informal spoken language to proficiency in formal written mathematics register.

Pimm (1993:21) uses the following model:

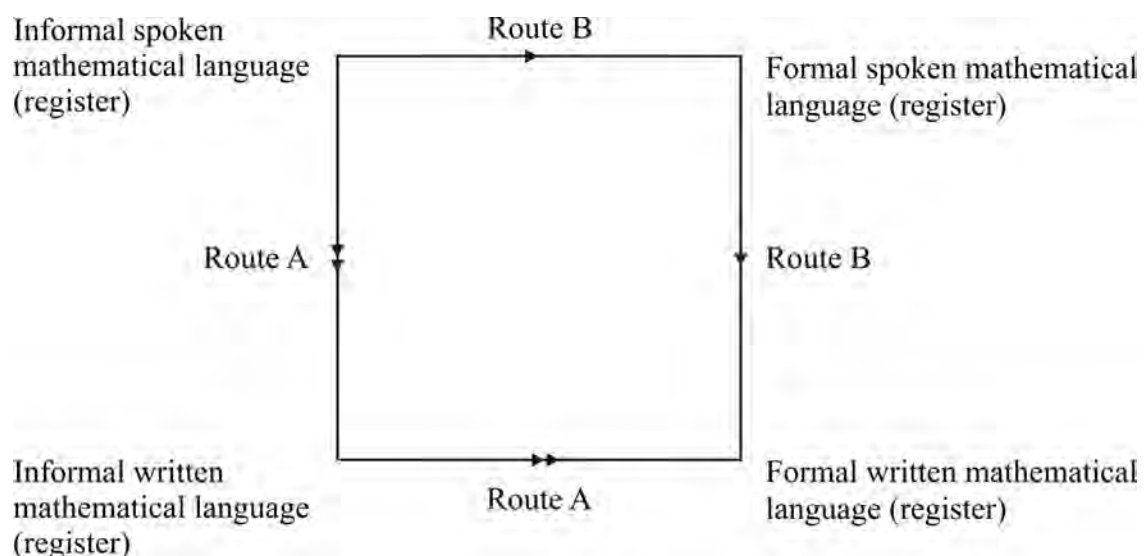


Figure 6: Adapted from Pimm's model (1993: 21)

This model indicates that the mathematics teacher could encourage learners to write down the informal utterance and then work on enabling learners to use the more formal written language (route A in fig.6). Alternatively, the learners could follow the route to the formal spoken mathematical language along route B (in fig.6) working on the formality and self-sufficiency of the spoken language prior to its being written down.

Practical experiences present two scenarios of looking at the language journeys. The learners informally discuss the mathematics among each other. They will often use educational language and even their written utterances will be educational. When the learners interact with or talk to the teacher they may use educated mathematical language. There are ways of talking within mathematics and about mathematics. Talking within mathematics is a way of negotiating meaning while learners engage in tasks in groups; however, talking about mathematics is when learners either talk to the teacher or fellow learners about mathematical ideas (Adler, 2001:101, 102).

The teacher needs to discuss mistakes in mathematical tasks with non-proficient learners to determine whether errors of reasoning or calculation may be caused by a lack in learners' understanding of the mathematical language involved in the task at hand. Sometimes it is necessary to go back to informal language to link the concept to the formal terminology.

2.3.3 The dilemma of how to find the balance between visibility and invisibility of language teaching

The mathematics teacher has to be aware of the visibility and invisibility of language teaching in the mathematics classroom. Adler (2001:116,117) argues that when the language is used to clarify mathematics it is invisible, but when attention is also paid to the use of the correct terminology and phrases, the meaning of words and the correct syntax, it becomes visible. Being explicit about the language benefits most learners, however, the explicit language teaching presents a dilemma. When language is too visible the learner can lose track of the mathematical argument while concentrating on language features, which may impede understanding. One of the challenges mathematics teachers face is how to use both visibility and invisibility of language teaching so that learners benefit from explicit language teaching without obscuring mathematics itself.

The features of language teaching in the mathematics class that can assist the teacher are; attention to pronunciation and clarity of instruction, verbalisation by learners as a tool for thinking, clear verbalisation of mathematical thinking as a display of mathematical knowledge, and verbalisation by learners as a tool for teaching, it helps the teacher to understand the reasoning of the learners (Adler, 2001:118).

One way of teaching mathematical language invisibly is to model the correct terminology and syntax. Mathematics teachers themselves should be able to formulate problems correctly in mathematics, to communicate mathematics ideas using informal, but also more formal and precise terminology. Mathematics teachers have to bridge the gap between everyday English that learners' may use and mathematics (NCTM, 2004:198). The teacher can reformulate learners' words, for

example “corner to corner line” by the correct mathematical term: diagonal, which is a line segment from one vertex of for example, a rectangle to the opposite vertex. The mathematics teacher should ensure that the learners understand the mathematical term, and how to explain concepts and relationships in the correct mathematical language.

2.3.4 Using decoding of language as a tool for conceptualisation

The mathematics teacher should also be a teacher of the terminology and the language needed to learn concepts and skills in mathematics. Decoding the terminology by exploring the origin and the historical background of words may help learners gain a firm grasp on the concept itself. When learners understand the historical roots of certain words or if the word structure is analysed, it often helps them to understand the concepts.

Moschkovich (2000:87) stresses that asking learners for their associations with technical words and expressions will enable teachers to uncover connections that can enhance or may get in the way of understanding. However, such connections can be constructed if terminology is decoded, where relevant. Decoding of language can be used to form a close relationship between language development and conceptual understanding.

The teacher should explain the origin of words to the mathematics learners. For example: When the teacher introduces learners to the term isosceles triangle. The origin of the word isosceles will enable learners to understand the word. Isosceles originate from the Greek word “isosceles” meaning “with equal sides”. The Greek word is made up of “iso” and “skelos”, which means ‘equal’ and ‘legs’ respectively. Thus isosceles triangle has two equal sides.

A diagonal is also one of the words which should be taught by giving the learners the origin of the word. A diagonal comes from a Greek word “diagonus” meaning “slanting line”. A *diagonios* originate from ‘dia’ – ‘across’ and ‘gonia’- ‘angle’ (“angle to angle”). Angle is related to ‘gony’ which is a ‘knee’ (WTNID, 1961:622). Another term which is a combination of two words is the word “bisect”, which comes from ‘bi’, two, and ‘secare’, ‘to cut’. Hence, to bisect means “to cut into two”.

Another example where the history of a symbol helps to give meaning is that of Σ (sigma). Sigma (Σ) is the 18th letter of the Greek alphabet and stands for the letter S. In mathematics it is used for sum. Distributive property comes from distribute, for example, $a(b + c)$ means **a** distributed over **b** and **c**. Another example is translation from transfer, which is to take something from one place to another, like train. Furthermore, transformations originate from the word transform, which is to change something. Mathematics teachers need to inform learners about the origin of words and use

the origin of mathematical terminology to develop the concept. These origins of words and word structure can help the learner to understand concepts in mathematics better.

Analysis of the word structure (morphology) of words often are helpful in bringing mathematical language to life, making terms more meaningful and revealing connections with relevant ideas. For example, the word **co** means together, and therefore the word complementary means “to make full”. The complementary angles are angles adding up to 90° . Cosine comes from together with sine. There are terms that share a root, a prefix, or suffix. Listing words with related parts helps build connections and reduced the number of things those learners should learn.

2.3.5 The planning of language facilitation

Van de Walle, Karp and Bay-Williams (2010:68) maintain that in planning a mathematics lesson the teacher should ensure that the mathematics goals and outcomes are clearly outlined, and this includes language planning. The teacher needs to establish reading language objectives where learners are given mathematical text to read and interpret. The learners should also be able to report what they understood from the text. Furthermore, learners should be able to discuss their solutions with the teacher and amongst themselves. The teacher should ensure that the task to be introduced in the lesson is well thought through.

The teacher should review and list all vocabulary needed for the topic of the lesson. The teacher should also ensure that learners present written and oral tasks. Learners should be encouraged to use the new vocabulary frequently in order to support language development. However, learners should be encouraged to choose the language they feel comfortable with in executing their tasks. The teacher should reflect on how learners will respond to the task and what misconceptions may occur (Van de Walle, Karp & Bay-Williams, 2010:68).

Learners need to be able to determine the meaning of terms and deduce what syntactic and other contextual clues indicate, what is relevant to the correct sequence of operations. The teacher should be able to help the learners recognize the symbols or terms that are used. Pronounce terms, identify and be able to write symbols linked to terms and understand clear definitions of different terminology (Dale & Cues, 1992: 346).

2.3.6 Classroom climate

The classroom climate is created by the interrelationships between the learners, teacher(s), physical resources, learning goals and the learning content (Drinkwater, 2002:9). There are different types of classrooms like the traditional classrooms where the teacher has a direct teaching approach and open classrooms, where learners participate freely in classroom activities. The learners in an open classroom are free to communicate among themselves and ask the teacher for assistance, and the

teacher engages through discussion. The classroom climate affects not only how much is learned, but how long learning lasts and how much future learning there is likely to be. A teacher's leadership style has a strong impact on shaping the personality of a classroom. The teaching skills or lack of teaching skills of the teacher influence the classroom climate. Frequent interactions among learners allow for possibilities of cohesiveness to emerge and in doing this language is needed. The classroom climate impacts on the development of the learners' mathematical language.

The ability of learners to express themselves in the language of mathematics is a key aspect of learning for conceptual development. Learners need to comprehend the technical expressions embedded in the language of mathematics so that they can receive and send messages about mathematics (Cangelosi, 2003:242-243). Mathematics classrooms that are highly interactive, with frequent discussion and collaborative problem solving and inquiring activities, are more likely to encourage mathematical language development of learners. Interactive discussions enable teachers to model and support the use of precise language and technical terms, but also provide opportunities to draw on everyday language. Learners learn and practice communication strategies that they can use to make themselves understood, and they can use pictures to clarify ideas (Gutierrez, 2002:113). Learners should be able to select relevant ideas, discard the irrelevant, and clarify categories of information. Therefore, learners have to read mathematical text frequently and translate it into mathematical symbols.

2.4 Language practices in multilingual mathematics classrooms

The importance of language in the teaching and learning of mathematics have been discussed in the previous section and all these factors are also important in the multilingual classroom. The main points in the discussion that follows are the multilingual mathematics environment, the role of the main language in a multilingual classroom, the context related concerns in a mathematics register in a multilingual classroom, and language strategies in a multilingual classroom.

2.4.1 The multilingual mathematics classroom environment

The South African education system has to cater for learners' diverse languages in the teaching and learning of mathematics. The South African constitution (S.A. 1996: section 6(1)) recognises and promotes respect for and use of all eleven official languages in our multilingual society in general, and in mathematics in particular. The language of teaching and learning (LoLT) in the majority of public schools is English. The mathematics teachers bring their own language background and history to the already diverse language environment of the multilingual mathematics classroom.

The effect of the LoLT on learners' understanding of mathematics has been investigated by many researchers (Moschkovich, 2000; Howie, 2001; Setati & Adler, 2002; Barwell, 2005; Vorster, 2008). The Systemic Evaluation conducted by Department of Education (DoE, 2006:85) concluded that learners whose main language is the same as the LoLT at school obtained scores that were about 25 percentage points (provincial average) higher than the score of learners for whom the LoLT is different from their main language in mathematics. This finding is consistent with what Reddy (2006) found in an analysis of the achievement of South African learners in the Trends in Mathematics and Science Study (TIMSS).

The language background that learners bring to the mathematics classroom affect how and what they learn (Gorgorió & Planas, 2002:9, 11). The mathematics teacher uses language to relate, respond, and analyse the word problems and also helps the learner to understand mathematics (Clauss-Ehlers, 2006:188).

Gorgorió and Planas (2002:5, 13) argue that

“when the learners begin learning a second language, they do not start all over again, but interpret meaning in terms of what they already know- not just about language, but about the context in which it is being used, and about strategies for social interaction”.

This suggests that the process of second language learning (LoLT) is heavily dependent on previous experience, and also on the nature and level of main language development. In a multilingual mathematics environment there should be a way to foster positive contributions from different language learners. The opportunity exists to enhance social skills, promote a rich language environment, which in turn could encourage responsible participation and harmony in the mathematics classroom (Goldstein, 2003:29, 33).

Different learning scenarios exist in multilingual environments in South Africa. According to Adler (2001:19) there are rural, township or urban schools and sub-urban schools. In rural schools, teachers and learners share the same main language and while English is the LoLT, it is rarely used beyond the formal school environment. The learners usually speak, read and write English only in the formal school environment (Adler, 2001). In many township schools the situation is different. Learners with different cultural groupings are brought together and there are many different main languages. Adler (2001:19) says that many teachers in African township schools are Africans. English is not the main language of the teacher or the learners, although it is the LoLT. Teachers in township schools are often multilingual, and many learners are able to speak more than one African language and their English proficiency varies. In townships most of the learners usually understand

the regional African language. For the purpose of this study the suburban schools will not be discussed, as it is not relevant in the context of the study.

2.4.2 The role of the main language in a multilingual classroom

A distinction between a monolingual and bilingual or multilingual classroom should be made in order to understand the role of the main language in a multilingual classroom. In a monolingual classroom, all classroom interactions, debates and discussions take place through the medium of instruction. The language of the learners is also the LoLT. In a bilingual or multilingual classroom the interaction in the classroom is different because learners study in an additional language. Bilingualism refers to the person's fluency in two languages. Such a person can use both languages at the same level, which signifies the person's competencies in both languages are well developed.

Cummins and Swain (1986) make a distinction between balanced and non-balanced bilinguals. A balanced bilingual is when a learner's competencies in both languages are well developed, while a non-balanced bilingual is one who is more competent in one language than the other. They said that a balanced bilingual is superior to a non-balanced bilingual on fluency and flexibility scales of verbal divergence, and marginally on originality. The common underlying proficiency (CUP) model stresses that bilingual proficiency in the main language and English is interdependent across languages (see figure 7).

The proficiency in one language can promote the development of the proficiency in both languages. For many bilingual learners, the size of their total vocabulary across both languages is likely to be greater than that of a monolingual learner in a single language. The bilingual learner needs to reach a threshold level of linguistic competence in both languages if they are to avoid cognitive deficits. If the learner has reached this threshold level in both languages, the learner will be able to promote cognitive growth.

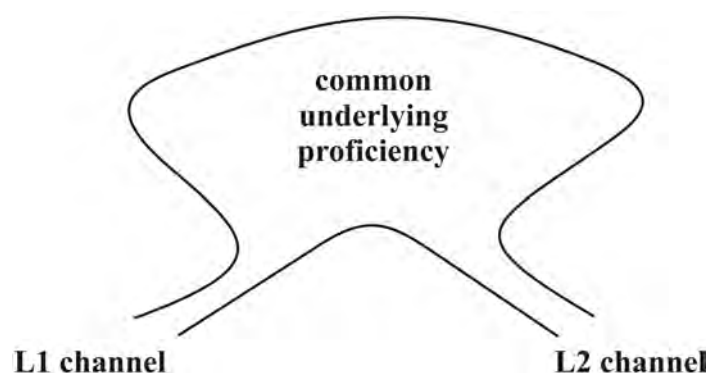


Figure 7: The Cummins' cup model

Competence in a second language below a certain threshold level may fail to give any cognitive benefits. Cognitive benefits may accrue when a learner's second language competence is fairly similar to first language skills. The second language competency is partly dependent on the level of competence already achieved in the first language. The more developed the first language, the easier it will be to develop the second language. When the first language is under-developed it becomes difficult for the bilingual learner to achieve competence in the second language.

In a multilingual mathematics classroom the learner's main language should be fully acknowledged and utilised throughout the teaching and learning of mathematics. The learner who is not proficient in LoLT should be given a chance to use his main language as scaffold.

Proficiency in a language means the ability to use these languages for different purposes and in different domains (Bell, 2006:4). In the context of this study it is necessary for learners to be proficient in the mathematics register and also in the everyday English used in social interaction. The mathematics learner's cognitive academic proficiency starts to develop through the learners' main language during the early years of schooling. The development of academic proficiency can be transferred to English when it becomes the LoLT. It is not only proficiency in the LoLT that is important, Bell stresses that if the learner's main language remains under-developed, then so does the learner's cognitive academic ability. This argument is consistent with Barwell's (2005:206) opinion that the learner's competence in English is necessary, but not sufficient for the learner's successful participation in mathematics even if the learner has good study skills and motivation, and is well supported by their mathematics teachers.

Adler (2001:74) says that when a teacher uses mainly English for explanation, the learners' writing becomes limited, the teacher dominates the mathematics classroom talk and rote learning of procedures takes place. The result is that a teacher's relationship with their classes is often rather one-sided. Teachers maintain close control on what is said or done in the lesson, they try to find out or guess what would help their learners learn more, but the learners do not contribute opinions or insights. The discourse in a mathematics classroom is important. The discourse enables learners to be involved in the learning process. When learners are involved in the learning process they will be more responsible, more self-efficacious, and ultimately more successful. However, to be involved in the learning process in mathematics they must be able to express their ideas and discuss and negotiate with one another. Therefore, there is a need to use the learner's main language in the classroom.

One of the teacher's roles in a mathematics classroom is to enable the learners to take ownership of the language that is used to express mathematical concepts. In order that the learners should be able to use and control mathematical ideas they have to be able to articulate and discuss those ideas. The learners are often not able to argue, explain and formulate their reasoning processes freely in English. Therefore, the mathematics teacher as a facilitator of learning needs to allow the learners an opportunity to use their main language to enable them to take part in the discourse in the mathematics classroom.

Mastery of word sense is important for the understanding of concepts (§ 2.2.1). Word sense can only be mastered when the learner has developed proficiency in a specific language and has reached a certain reasoning level. Therefore word sense usually most extensively developed in the learner's main language. In mathematics, learners need the language that will assist them to reason with confidence in their discussion, and therefore learners' main language is needed to facilitate this feature.

Kasule and Mapolelo (2005:2) draw attention to a dichotomy regarding the LoLT, which is not the main language of learners in a multilingual mathematics classroom. The dichotomy is that the LoLT is an aid through which mathematics is learnt, but at the same time is a source of learning difficulties for second language learners in mathematics. They further said that teaching of the LoLT must receive attention in the mathematics class because learners are assessed through the medium of the LoLT, and mathematical concepts must be developed through means of the LoLT.

2.4.3 Language strategies and techniques

A language strategy is the manner in which the teacher uses the language in the mathematics classroom. There are two main strategies that can be used. The first strategy is that of using the LoLT only, in this case English. In this strategy the mathematics classroom is totally monolingual. The teacher keeps to the LoLT in the classroom, and all discussions and debates in the classroom are done through one language. This strategy is applicable in schools where there are learners with different main languages in a mathematics classroom.

The second strategy is the use of code-switching, as is used in many schools (Vorster, 2005; Setati, 2002 & Adler, 2001). Code-switching refers to the practice of switching between the LoLT and the main language of the learners. This strategy is of great importance to this study, and it will be discussed separately in more detail.

2.4.3.1 Code-switching

Code-switching has now become recognised in multilingual mathematics classrooms in South Africa (Adler, 2001:73). It has become an established phenomenon in many mathematics classrooms (Adler, 2001; Setati, 2002; & Vorster, 2005). Setati (2002:17) further argues that code-switching is an additional teaching resource, a support that allows mediated learning via exploratory talk to occur while learners continue to develop proficiency in English. However, this is only feasible when nearly all learners understand the indigenous language switched to.

Adler (2001:73, 74) draws a distinction between code-switching, code-mixing and code borrowing. She said code-switching occurs in a multilingual environment where the learners are learning through medium of an additional language; that is, the main language is not the language of learning and teaching (LoLT). At most, code-switching entails switching by the teacher and / or learners between the LoLT and the learners' main language(s). The term code-mixing refers to the insertion of single words or short phrases within a sentence in another language. Code-borrowing occurs as learners engage in mathematical talk in their main language, and mathematical English is mixed into their speech. For example, words like 'equal', 'fraction', 'less than' become part of a conversation in Setswana.

In code-switching where the teacher uses a language for a certain purpose and the main language for other purposes, the main language of the learner is often said to be "back staged" (Heller and Martin-Jones, 2001:9-11). The learners' home language is often used for discipline and instruction of learners, but the LoLT, in this instance English, is used for teaching and learning of mathematics. An example of this is "Go ithuta dipalo go bothlofo fela fa lo ka tlhaloganyana melawa e e dirisiwang". (To learn mathematics is easy as long as you understand the rules). Fa o sa tlhaloganye o botse ngwanaka. A o a nkutlwa? (If you don't understand you must ask my child. Do you follow me?). The teacher encourages learners to take an active part in the class. However, all the mathematics is discussed in English.

When the learners' main language is used in teaching and facilitates understanding of concept development, the learners' main language is said to be "front staged". The use of the learners' main language in exploratory talk is stressed. According to Setati (2002:77) many mathematics learners are not fluent in English, and therefore code-switching practices are necessary in mathematics teaching where English is learned at the same time as the LoLT.

Arthur (2001:63) describes that when the teacher translates the content into Setswana, and as soon as the learners understand in their main language (Setswana), the teacher then translates back into LoLT (English), the learners' main language is "front staged".

2.4.3.2 Language techniques in the multilingual classroom

The methods employed by the mathematics teacher in teaching new terminology and new words is referred to as “technique” (Vorster, 2008: 34) and are used in the English-only and code-switching strategies. One of the main techniques to teach mathematical English as well as correct everyday English is for teachers to model the appropriate terminology, grammar and sentence construction. This is also true for the indigenous languages when teachers code-switch. Another technique used to help learners to formulate mathematical language correctly is re-voicing (Adler, 2001:9). Re-voicing is the technique where the teacher listens to the learners’ mathematical talk and repeat what the learner has said in a well constructed sentence in order to lead to them towards the correct and formal mathematical discourse (Adler & Setati, 2000).

“Safe talk” is a dominant although more negative feature in some mathematics classrooms. “Safe talk” is mainly the use of chorused, one-word learner answers to the teachers’ talk and questions. In this technique the teacher hides the fact that little or no learning is taking place (Adler, 2001:82). An example would be when the teacher says: “In equilateral triangle, the three sides are . . .” and the learners would answer in a chorus- ‘equal’. Hornberger & Chick (2001) refer to this choral response from the learners as “ritualization”. Teachers often use this technique to disguise their incompetence, as well as learners’ lack of understanding. This usually happens in the multilingual classroom where the teacher dominates the classroom discussion and access to English is limited.

2.4.4 The language ‘journeys’ in a multilingual mathematics environment

In (§ 2.3.2) reference was made to the informal and formal registers in the teaching and learning of mathematics. The diagram of the route of these registers in the mathematics classroom was discussed as outlined by Pimm (1993:21). This section looks at the informal and formal registers in the mathematics classroom where both Setswana and English are used. This seems to be a really complex journey, as illustrated by Setati (2002:80).

In a multilingual classroom the movement from informal spoken language to formal written language is complicated by the fact that learners’ informal spoken language is typically in their mother tongue. The final aim is for the learners to be proficient in the formal mathematical English so that they can write, read and speak it.

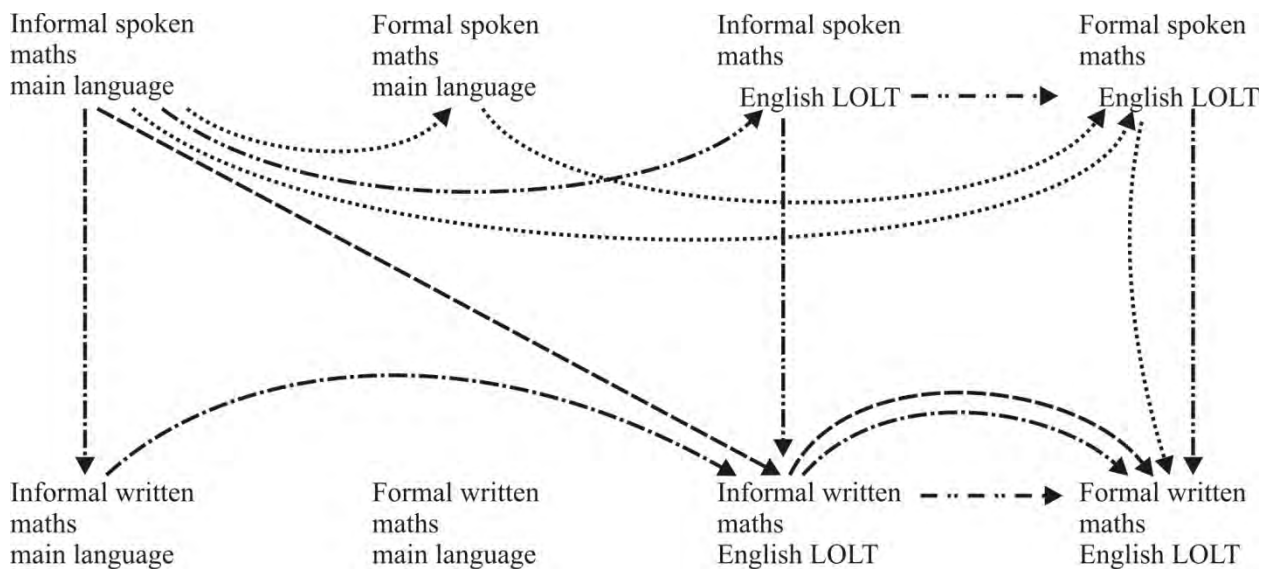


Figure 8: The journey from informal main language to formal mathematical language (Setati, 2000:80)

Figure 8 shows that the movement from informal spoken to formal written mathematics in multilingual classroom takes place at three levels: from spoken to written language, from main language to English and from informal to formal mathematical language.

Different routes are possible. The teacher may firstly work on the learners’ writing of their informal mathematical thinking in both languages, and thereafter on formalising and translating the written mathematics in the LoLT.

The other possibility is to work first on translating the informal spoken mathematical language into informal spoken English and then work on formalising and writing mathematics in English. There are of course many different possible routes that can be followed. The different routes possible received attention in this empirical study when teachers were observed in their classrooms (§ 3.3.2.2).

2.4.5 Debate around terminology

There is an ongoing debate about the mother tongue or English as medium of instruction in teaching and learning mathematics in some African countries (Kazima, 2008: 61). Nigeria, Tanzania and Malawi are used as examples. In these three countries the mother tongue policies have been adopted, and this requires that learners be taught in their mother tongue for their early years of primary schooling. The use of vernacular as medium of instruction had been successfully implemented in Nigeria and new mathematics registers have been developed in six indigenous languages used in the country. The “nationalisation of education” in Tanzania, which means using

Swahili as the medium language of instruction, has been completed. The Tanzanians translated mathematical terminology to Swahili.

The use of terminology in mathematics is important in the classroom. Kazima (2008:60) said that though the mother tongue policy has been adopted in Malawi, translation of mathematical terminology from English to Chichewa was a challenge. She said the strategy of transliterated words was used by the Malawi education system. Transliterated words are defined as the use of words from another language used by the speaker when communicating, but prefixes or/and suffixes from the indigenous language are added and the pronunciation of the word is changed to fit in with the indigenous language. For the purpose of the discussion, these transliterated words will be referred to as “tswanaised” words, as the study takes place in a Setswana environment.

Kazima (2008) argues that borrowing from English is a good strategy because it does not create confusion with the meaning of everyday Chichewa words, which is the indigenous language used in the country. Her argument is that as the borrowed words have no meaning in Chichewa, though they are spelled in that language, the original everyday meaning of the word is lost and therefore misunderstanding is avoided. The learners only learn the correct mathematical concept associated with the word and it rules out confusion with Chichewa words that may have a different meaning in the everyday language. Some examples are: ‘thirayago’ (triangle) and ‘seti’ (set).

2.5 Summary and identification of constructs for the empirical study

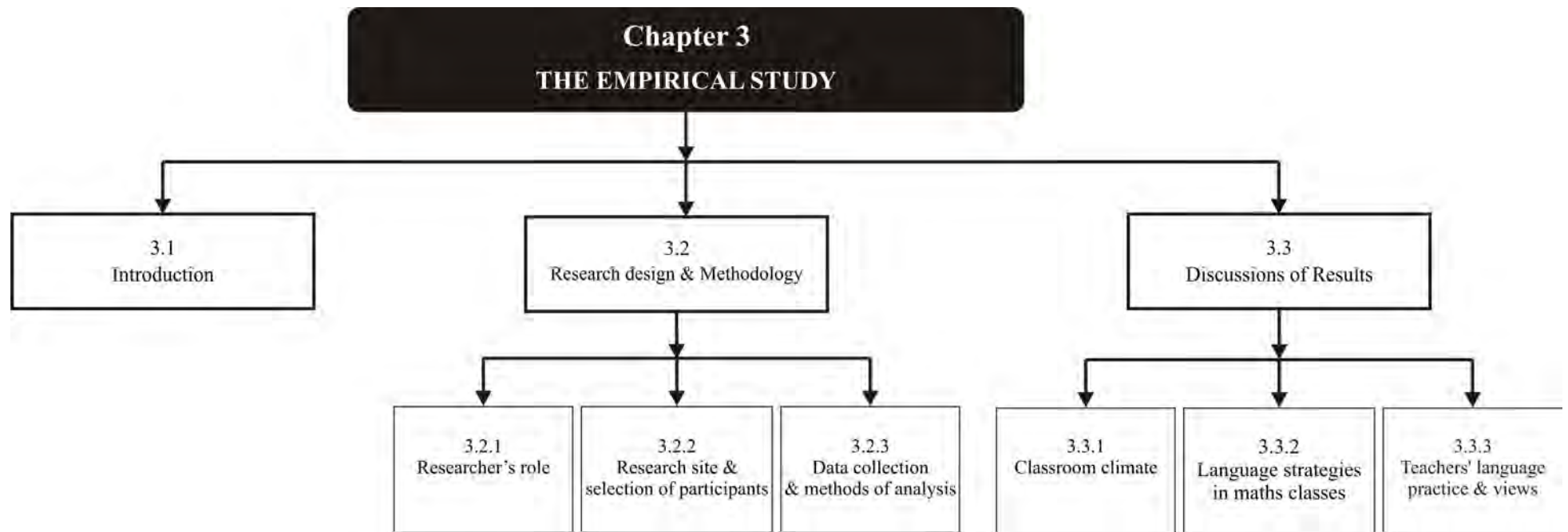
When learners are learning mathematics they have to cope with the LoLT, the educational mathematical language, the educated mathematics register and the symbolic language of mathematics. Problem areas in the mathematics register include the use of rigid expressions (e.g. “if and only if”), prepositions and words with different meanings in the everyday language and in the mathematics register.

Learners have to listen, speak and write the mathematics register to master educational as well as educated mathematical language. They have to learn that the educated mathematics register requires precise formulation and application and that each word in a definition is necessary and contribute to describe the relevant concept unambiguously. The language teaching has to take place in the mathematics classroom, but the fine line between the visibility and invisibility of language must be managed so that the language does not obscure the mathematics.

In the multilingual mathematics classrooms the situation becomes complicated and the learner’s main language comes into play, which is different from English as LoLT. Code-switching has been

introduced as the main teaching strategy. Furthermore, front stage or back stage use of the main language indicates the importance the teacher ascribed to the main language to facilitate mathematical understanding. The language journeys become complicated because two mathematics registers are used in the classroom, the Setswana mathematics register and the English mathematics register. The Setswana mathematics register will help the teacher to use Setswana to formulate concepts and communicate mathematics to fellow learners. In multilingual classroom the teacher who is not proficient in the learners' main language should encourage learners to use their main language with their peers in the mathematics class. A Setswana or English glossary and notes in both languages can be used to help learners to understand the concept developed in mathematics.

From the literature study constructs were identified that will form the basis for the discussion in the empirical investigation (Figure 9, see chapter 3): The use of terminology (transliterated terms, the English and Setswana terminology) (§ 2.4.5); use of mathematics registers (front stage, back stage and language journeys) (§ 2.4.3.1; § 2.4.4); modelling of languages (English and Setswana terms) (§ 2.4.2); and language techniques (decoding of terminology and safe talk) (§ 2.3.4; § 2.4.3.2).



CHAPTER 3: THE EMPIRICAL INVESTIGATION

3.1 Introduction

The previous chapter's (chapter 2) literature study provided the theoretical framework on which this empirical investigation will be based. The themes and constructs were also identified in the literature (§ 2.5) and will be discussed in this chapter.

The aim of the empirical investigation was to gain insight into the role of mathematical language as a teaching tool. The focus of the investigation was to try and understand how language is used in a multilingual mathematics classroom and therefore the language practices of mathematics teachers were investigated. The researcher's main objectives were to:

- 3.1.1 To determine if and how the teacher uses code-switching as a strategy to teach mathematics the classroom.
- 3.1.2 investigate the extent to which teachers do teaching of mathematical language in the classroom.
- 3.1.3 investigate the extent to which teachers use the teaching of mathematical language as a technique to teach concepts.

3.2 Research design and method

A qualitative investigation by means of a case study has been conducted. The objectives of the research necessitate an in-depth study to explain the situation in the classroom (§ 1.3.2.1).

3.2.1 Research site and participants

The research was conducted in three secondary schools in the Mafikeng education district of the North West Province. At each school one grade 8 teacher was selected with his/her mathematics class. The Grade 8 mathematics learners participated in their natural classroom environments without any special intervention. The three cases consisting of 'linguistically diverse' mathematics classes, with teachers and learners from various backgrounds (see table 1), provided rich data to research the objectives.

Table 1: Profiles of the three schools

	School A	School B	School C
Type	Rural	Semi-rural	Township
Main language of majority of learners	Setswana	Setswana	Setswana
Medium of instruction	English	English	English
Language policy	Allowed to switch to the main language of learners when necessary.	Allowed to switch to the main language of learners when necessary.	Allowed to switch to the main language of learners when necessary.
Teacher's main language	Xhosa, proficient in Setswana	Zulu, proficient in Setswana	Setswana
Teacher's qualification and experience	3 year primary teachers diploma, (maths major) Teaching experience: 19yrs (math) same school	4 year primary teachers diploma (not maths major) Teaching experience: 22yrs – 16yrs math (various schools)	BSc Hons (BScEd – math major) Teaching experience: 8yrs (math) same school
Class size	35	41	26
Resources	poorly resourced	inadequately resourced	well resourced

3.2.2 Data collection strategies and methods of analysis

An in-depth analysis of the transcriptions of the audio-tape recordings and interviews is important for the study to understand and interpret the data. Therefore, the transcribed lessons' lines were numbered and the transcriptions of lessons, as well as the interviews with the teachers were coded to see whether the constructs generated from literature, emerged from the data. The field notes and classroom observations helped to interpret the data. The constructs were then clustered by means of axial coding to form themes described and discussed in the following paragraphs (§ 2.5 and § 3.3.2.1 – 3.3.2.4).

3.3 Discussions of the results

3.3.1 Classroom climate

The following table reflects the classroom climate of the three Grade 8 mathematics classrooms (§ 2.3.6).

Table 2: The classroom setup

	School A	School B	School C
Class arrangement	Traditional - learners sitting in rows	Learners sitting in groups	Traditional – learners sitting in rows
Teaching approach	Teacher-centred	Organised as an open classroom	Teacher-centred
Teaching style	Direct teaching style with question and answer method	Not really the approach that one expected in an open classroom. Teacher dominated the classroom discussions.	Direct teaching style with question and answer method
Learners' participation	Learners communicated with the teacher only by answering questions. No learner-learner interaction (minimal learner participation)	Learner–learner interaction was observed. Learners talked to each other using Setswana.	Teacher dominated the classroom discussions. No learner to learner interaction was noticed (minimal learner participation)

3.3.2 Language strategies and techniques used in the mathematics classrooms

The main phenomenon studied in this research was code-switching. In the observed classes, English was used as the LoLT and the main language of all the learners was Setswana. Therefore, the mathematics teachers switched from English to Setswana and vice versa. The view of Mary, one of the participating teachers, was that language is important as a communication tool, even for learning and understanding of mathematics concepts (IB, L4)¹. All the teachers taking part in the research shared this view. In the observed lessons, it became clear that the teachers used code-switching as the main strategy to help the learners in understanding mathematics.

¹ IB – means interview with teacher B

L4 – line 4 on transcribed interview.

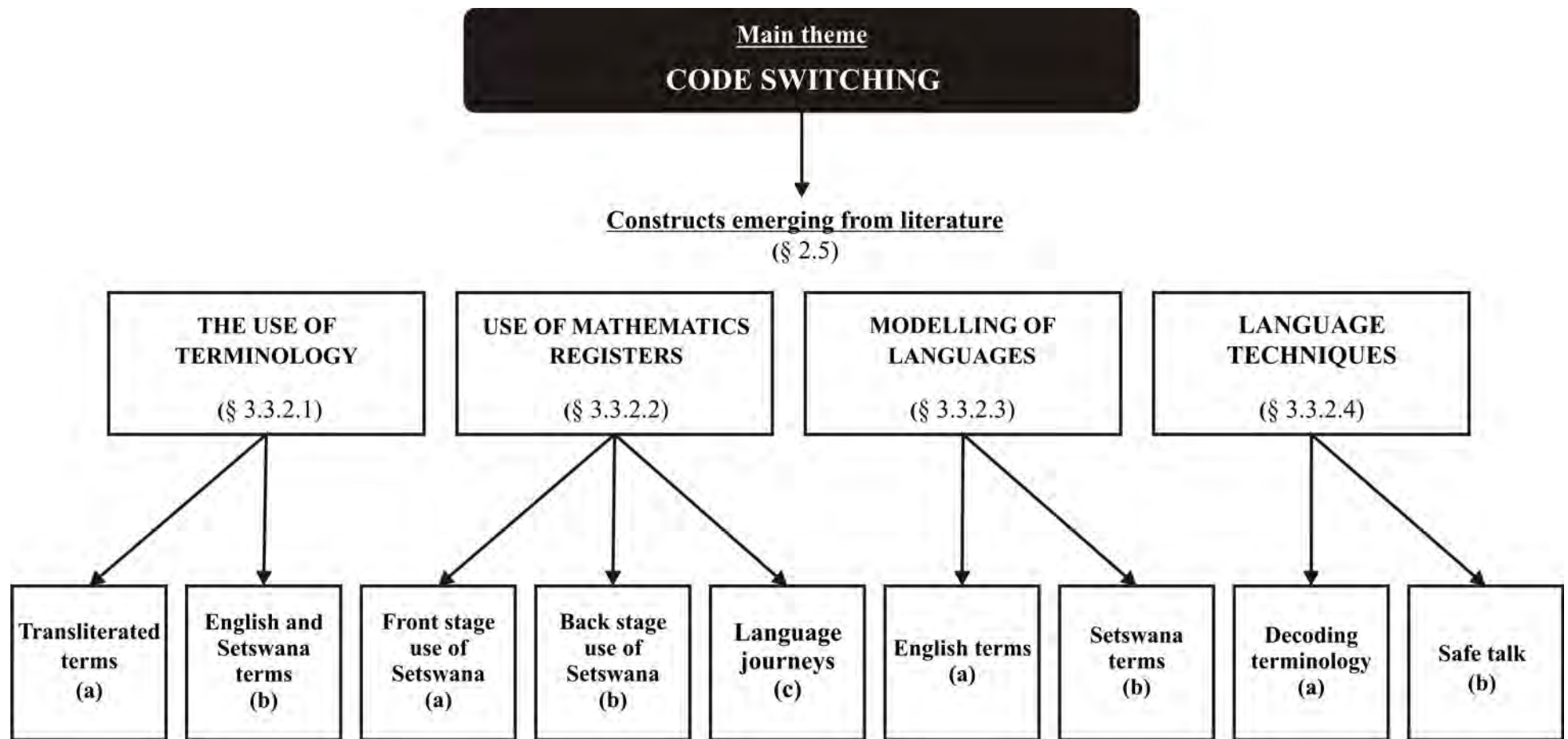


Figure 9: Language strategies and techniques used in the three Grade 8 mathematics classrooms

The researcher identified the following constructs from literature: The use of terminology (transliterated terminology, the English and Setswana terminology); use of mathematics registers (front stage, back stage and language journeys); modelling of languages (English and Setswana terms); and language techniques (decoding and safe talk) (see Figure 9).

3.3.2.1 The use of terminology

Under this topic, the constructs transliterated words (Setati, 2008), English terminology in Setswana sentences and the use of the correct Setswana terminology will be discussed.

a. Transliterated or tswanalized words

All the teachers who participated in this research used borrowed words that were transliterated. For the purpose of this discussion, it will be called tswanalization, because the teachers pronounce English words as Setswana words by adding prefixes and suffixes so that the word fit in better with the Setswana sentence. For example, teacher B said:

“Hee, maar re rata go di-tshêntshă² a itse rona mo mmetsheng tsona tse re ntse re di dira tse, re rata go tshameka ka tsona, ga re rate go dira selo straight fela jalo?” (B1, L167-169).

The teacher used the word di-tshêntshă and mmetsheng when referring to change and mathematics as opposed to the Setswana words “fetola” and “dipalo” respectively. Other tswanalized words that teachers used were “diengeleng (angles) vs dikhutlo”, “dilaene (lines) vs mela”, “disheipi (shapes) vs dipopego” and so forth. When using the main language in their lesson presentation, the teachers often did not use the correct Setswana terminology, although there is existing Setswana terminology, as indicated above.

Teacher C often used tswanalized words and the correct Setswana terminology consecutively, for example:

“Ke di co-interior angles, the angles which are on the same side of the transversal line, err... Parallel lines, di mo saeting letlhakore le lengwe but mo gare ga di parallel lines” (C₁, L81-83)³.

² The underlined words are tswanalized terminology.

³ In quotes C₁:L81 – 83 means, teacher C, lesson 1 and lines 81 – 83

This may create a problem for the learners because a learner may not be aware that the teacher has translated the word. The word “saeting” is a tswanalised version of “side”, which is “letlhakore” in Setswana”. The researcher whose indigenous language is Setswana was confused by the teacher’s use of the terminology. Some learners might not follow the teacher’s explanation or think that saeting letlhakore was the correct term for “side”.

Teacher A also translated the terminology to English, but in a more effective way. He said “*AB is a straight line, ke mola o o tlhamaletseng*” (A₃; L11). In this instance the teacher used the correct mathematics term in English and followed it up by using a translation of the whole sentence using the correct terminology in Setswana. Teacher B used the same pattern as Teacher A in following the English by its translation in Setswana when he said “*But first let us write, re kwale mona 1, 2, 3, 4, 5, 6, 7, 8*” (B₃, L 28). He also said “... AB e na le dikarolwana di le tharo, three segments of a line...” (B₁:L80-81).

Teacher B was of opinion that code-switching is useful because it helps the teacher to simplify the content if one used the indigenous language (IB⁴, L19). When asked whether the use of tswanalized words in teaching mathematics does not create a problem, the teacher responded by saying:

“It does create a problem because the learners now translate that particular term in their own language, and relate it to something they know”. She furthermore commented: “Our mother tongue is not well known or understood scientifically by the learners. We don’t get some of the concepts in Setswana and some of words have double meaning in Setswana, for example “tsebe” (page), the same word tsebe is “ear” in English”.

One could argue that there are also English words that have different meanings, where a learner has to determine the meaning from the context. Examples of tswanalized words used by the teachers in these lessons, with the original English term and the correct Setswana terminology can be found in appendix B.

b. English terminology in Setswana sentences and the use of the correct Setswana terminology

As the two constructs are interrelated, they will be discussed together.

All the participating teachers used both English and Setswana terminology. The teachers used Setswana when they explain the concept to the learners, but they often kept on using the English terminology without translating it to the correct Setswana term or tswanalizing it. Examples of where the teachers used the English terminology, omitting the use of the correct Setswana

⁴ IB means interview with teacher B

terminology, were quadrilateral vs sekhutlonne (“angles four”), pentagon vs sekhutlotlhano (“angles five”), proper fraction vs palo- phatlotota, prime number vs paloikarodi, etc.


The use of the correct Setswana mathematics terminology would often help the learners to understand the concept, for example, selekanyadikhutlo vs protractor. This is self-explanatory. Selekanyo means measure, and dikhutlo means angles, therefore the Setswana term explains the function of the protractor that measures angles. Another important Setswana term that is self-explanatory is palo-phatlo (a fraction). Sharing in Setswana is “phatlola”, and “palo” is number. If palo-phatlo was used continuously, the original meaning of the term fraction would always be used and the meaning would be clear for the Setswana learner, as the meaning of the word fraction may be clear to an English learner.

The following are examples where the use of the English words created problems in understanding: The teacher used the words “ray” and “line segment”, and the learner later referred to it as “relay” and “settlement line” (B₂, L11-12). From this it is clear that the learner has no idea what these terms mean. It may have been that the learner knew the word “relay” from athletics and settlement from “informal settlement”, but it is clear that he did not understand the mathematical terms. This indicates that while Setswana terminology may create confusion because there are sometimes different meanings in the everyday Setswana, as teacher B argued, this might also happen in English, and therefore this argument is not a good motivation not to use the correct Setswana terminology.

3.3.2.2 The use of the English and Setswana mathematical language registers


a. Code-switching front stage and back stage

The practice observed in all the lessons was that the teachers switch from English to Setswana deliberately. The teachers confirmed this during the interviews (IA, IB & IC). Code-switching is a widespread phenomenon in South African schools (Adler, 2001; Setati, 2002 & Vorster, 2005). The mathematics teachers used Setswana front stage regularly, which means that they used Setswana to explain mathematics and not only for disciplinary purposes. For example, teacher A said:

“ABCD, fa o lebelela saete e, saete e, e lekana le e. $AD = DC = BC = AB$. Re be rere this quadrilateral⁵ ke a square, and all the angles of a square are equal, le tsona diengele tsa teng is equal to 90° . Saene e  e raya 90° . E bontsha gore this angle is equal to 90° . If fa o tsaya protractor ya gago, protractor o be o mejara fa (pointing the diagram) e ya go go fa 90° . Re

⁵ In the quotes where code-switching is used the Setswana is in italic and the English in the usual format.

be re re this shape *ke ya* quadrilateral, because *e na le* four sided figure, it's a four sided figure. Now another quadrilateral, *gobane oa itse gore* rectangle is a quadrilateral because opposite sides are equal and also a square is err..is a quadrilateral because all the sides of a square are equal. Now *re be re nna le* another figure *e e bidiwang* a parallelogram. Parallelogram, *fa re bua ka* a parallelogram. *Ba ya go go botsa ba re, re bolele* the properties of a rectangle, *gore o bona jang gore sheipi e, ke* a rectangle? *Fa o e lebeletse fela jaana, gore o e bona jang gore ke* a rectangle? *Ka gore* opposite sides are equal and also the angles of a rectangle are equal to 90^0 , then *re be re re* that shape *ke yone* a rectangle” (A₁, L62 – 75).

Translation⁶: When you look at ABCD, this side is equal to this side. $AD = DC = BC = AB$. We say this quadrilateral is a square, and all the angles of a square are equal, and angles are also equal to 90^0 . This sign  denotes 90^0 . It indicates that this angle is equal to 90^0 . If you take your protractor, a protractor and measure this angle (pointing to the diagram), is going to give you 90^0 . Now another quadrilateral, because opposite sides are equal and also a square is err... is a quadrilateral because all the sides of a square are equal. Now we have another figure called a parallelogram. Parallelogram, when we speak of a parallelogram. They are going to ask you, to give us the properties of a rectangle, how do you notice that this shape is a rectangle? Because opposite sides are equal and also the angles are equal to 90^0 , then we say that shape is a rectangle.

Teacher B also use Setswana front stage when he said:

“*Dira* a dot or point *e kgolo gore motho yo o kwa morago a bone gore fa re bua ka* a dot or a point *re bua ka selo se se ntseng jang? Nna ga ke itse gore a dot ke eng? Jaanong ke ba tla gore mo pheiging ya gago* or a piece of paper, *kgotsa mo bukeng ya gago kwa morago*, make some points *le fa di ka nna ten fela, dira ka pele re se ka ra senya nako. Tse ten fela* they will be enough. *Dira* straight laene *sa di dot* dot. Are you through? *E nne* straight laene *sa di dot ne'?*” (B₁, L12 – 18).

(Translation⁷: Draw a large dot or point so that a people sitting at the back can see what a dot or a point looks like? I don't know what a dot is. Now in your page or a piece of paper or at the back of your book, make some points even if it is ten only. Make it quick, we don't want to waste time. Ten only, they will be enough. Draw a straight line of dots. Are you through? It must be a straight line of dot, ok.)

Teacher C used Setswana front stage in the following phrase:

⁶ In the translation the English words that were originally in the teachers' sentences are underlined.

⁷ In the translation the English words that were originally in the teachers' sentences are underlined.

“Go raya gore dilaene tseo di a lekana ka distance mara ga gona fa di kopanang teng. Di tsamaya fela jaana like le dutse jaana le dutse parallel. A ke re ga gona fa le kopanang teng?” (C₁, L7 – 9).

(Translation: It means those lines are equal in distance, and they do not meet anywhere. They are arranged in the same way like you are sitting, you are sitting parallel to one another. You are not going to meet anywhere ok?)

The teachers quoted above used Setswana to explain the mathematics concepts. In other words Setswana was used as a vehicle for learners to understand the concepts under discussion. Another observation is that the mathematics teachers did not use Setswana mathematical terminology; instead they used tswanalized words or the English word. Both languages, English and Setswana, were also used back stage in the teaching and learning of mathematics. For example, teacher A said *“Good learners. You are really studying well. If you keep doing that you will pass your mathematics”* (A₃, L17- 18). In this instance, the teacher did not use English to assist the learners to develop the mathematics concept. The teacher used it for the purpose of encouraging and ensuring the learners that they are doing well in their work. The same teacher (A) said in Setswana:

“Ke a leboga ngwanaka. Fa o ka tshwara fela jalo you will do well in mathematics” (A₃, L116).

(Translation: Thank you my child. If you can keep doing that you will do well in mathematics).

The Setswana was used for other reasons than facilitation of conceptual understanding.

b. Language journeys

In a situation where English is not the learners’ main language, the teacher’s language practices in the classroom becomes important. The medium of instruction in all the participating schools was English, the learners’ main language was Setswana as indicated in § 3.2.2. The teachers’ language journey can be described as moving from English mathematical language to Setswana mathematical language with tswanalized terminology. Teacher C illustrated this, when he said:

“Parallel lines so are lines that are equidistance from each other. Equidistance from each other but never meets. They are never going to meet. Equidistance: from the words equi- it comes from the word equal, go raya gore dilaene tseo di a lekana ka distance maar ga gona fa dikopanang teng. Di tsamaya fela jaana like le dutse jaana le dutse parallel a kere ga gona fa le kopanang teng?”(C₁:L4-9).

Translation: Parallel lines so are lines that are equidistance from each other. Equidistance from each other but never meets. They are never going to meet. Equidistance: from the words equi- it comes from the word equal, it means those lines are equal in distance but they do not meet anywhere. They are just like you are sitting, you are parallel, and there is no where you will meet.

The teacher first used English mathematical language, and switched to Setswana mathematical language with the tswanalized word “dilaene” (line) instead of the correct Setswana word “mola” (line).

The same language journey is used by teacher B, when he said:

“There are many different kinds of lines, *re ka se ka ra tlola fela ra re selo se le ke laene se le because motho mongwe a ka nna a dira e nngwe gape laene but e na le a different name. Re tshwanetse ra e fa leina laene e ya rona. Re tshwanetse ra itse go e differentiate from another lines. This is a line. Then I said to you increase a line increase by a dot fa re se na go dira jalo re be re bitsa laene e ya rona a line segment. Re na le line segment AB. Re inkerisitse ka fa, re inkerisitse ka fa. Re eksthendile ka didot tsele, jaanong like line segment ya rona, ga e tlhole e le yona re e tsetse dierō. Teng mo go na line e ya rona re kgona go ntsha another line” (B₁:L68 -77).*

(Translation : There are many different kinds of lines, we cannot just jump and say this thing is a line because a one person can make another line but with a different name. We should give our line a name. We should know to differentiate it from another line. This is a line. Then I said to you increase a line increase by a dot after doing that we call our line a line segment. We have line segment AB. We have increased it from this side; we have increased it from this side. We have now extended that dots like our line segment, we no longer have it we have inserted arrows. In this line of us we can extract another line)

The same can be said about teacher A,

“It is a four sided figure, *gore re re this shape ke quadrilateral re e bona jang? Re na le disheipi tse di tshwanang le boteraengele, e na le three sided figure” (A₁:L5 -7).*

(Translation: It is a four sided figure, for us to call this shape a quadrilateral how do we see it? We have shapes like triangles, it is a three sided figured”

Teachers in some instances moved from formal spoken tswanalised words to the mathematics in English. The following quotations illustrated this language journey:

“*Disaete tsothle ga di lekane. $AB \neq BC \neq AC$. This type of a triangle is called scalene. Ke triangle e e maswe, ga ena popego. All sides are not equal*” (C₃:L40 – 41).

“*Saete e, e lekana le e (referring to $AB = CD$), e e lekana le e (referring to $AC = BD$). Which is $AB = CD$, $AC = BD$. This shape e bidiwa a rectangle. E bidiwa quadrilateral. Why? E na le four sides. Now a triangle, a triangle e na le only three sides. Triangle e na le three sides. A re lebelele mo di traengeleng*”(A₂:L14 – 18).

“*Distance mo gare ga tsoone ga e fokotsege le e seng go oketsega e constant. AB and CD ke parallel lines. Any line that cut through the parallel lines, we will call it a transversal. So EF is a transversal. Re na le **Transvaal** le **Transkei**. The word **trans** means cross (*kgabaganya*). Fa o kgabaganya Vaal river re na le Transvaal. Fa o kgabaganya Kei river re na le Transkei. Jaanong fa o kgabaganya parallel lines re na le ...*” (A₃: L67 -70).

(Translation: Distance between does not decrease or increase it is constant. AB and CD are parallel lines. Any line that cut through the parallel lines, we will call it a transversal. So EF is a transversal. We have **Transvaal** and **Transkei**. The word **trans** means cross (*kgabaganya*). When you cross the Vaal river we have Transvaal. When you cross the Kei river we have Transkei. Now if you cross the parallel lines we have ...).

There was no clear evidence of a journey from informal to formal mathematical language used either by the teachers or by the learners. The journey was mostly from English mathematical terminology to the Setswana mathematics with tswanalized words. Although the journey from Setswana mathematics with tswanalized words to English mathematical terminology also occurred sometimes.

3.3.2.3 Modelling of languages

(a). Modelling incorrect English:

The teachers in this study modelled incorrect English during lessons. This may adversely affect the English language development of the learners. An example of modelling incorrect English is:

“*between those spaces mark another dots, increase those dots until there is no space*” (B₁, L 20- 21).

At grade eight, learners are already conversant with “points”. The teacher was trying to introduce a topic about “points and lines”. The word “dot” used by the teacher is not mathematical language and there was no need for her to use it at all, because the learners understand the correct mathematical term “point”. The word “another” is also used incorrectly, and the sentence construction is clumsy and obscures what the teacher is trying to say. A better way to put it for

example would have been “Mark the two points, and between these points insert points until there is no space left”.

Teacher C also modelled the incorrect English when she said that “Parallel lines so are lines that are *equidistance* from each other”... (C₁:L4-9). The teacher could have said, “Parallel lines are lines that are equidistant from each other”.

Teacher B also modelled the incorrect English when she said, “*Re tshwanetse ra itse go e differentiate from another lines*” (B₁:L68 -77). When the teacher switched from Setswana to English, she used incorrect English completely. The teacher could have said “differentiate between two lines or amongst lines” instead of “*differentiate from another lines*”.

Teacher A modelled the incorrect English when he said, “*Re be re re this shape ke a quadrilateral, because e na le four sided figure, it’s a four sided figure*” (A₁:L66 -76). The teacher could have said “a quadrilateral is a four sided figure”, instead of “This shape is a quadrilateral because it has four sided figure”. The teacher did not construct a correct English sentence.

Though it cannot be expected that every sentence a teacher uses must be perfect, one of the aims of using English as LoLT is to better the proficiency of the learners in English. Modelling incorrect English defeats this purpose. In teaching the mathematics, the teachers should try to use the correct English in order to assist the learners to develop their language proficiency.

(b) Modelling incorrect Setswana:

The teachers mixed English with Setswana, which is the learners’ main language. The teachers are all proficient in Setswana, though teacher A is a Xhosa and teacher B is a Zulu, as confirmed during the interviews (IA, IB & IC). The teachers used some incorrect Setswana terms when teaching. Examples of incorrect words used were “menona”, which should be “menwana (finger)” (A₂, L 116); “zameng” which should be “lekeng (trying)” (B₂, L115). Teacher B said “Ra re re na le bokhutlo le tshimologo” (B₁, L 152). In this case the sentence construction was incorrect. The correct sentence would be “Ra re re na le tshimologo le bokhutlo”, “We have the beginning and the end”. As it is important to develop the proficiency of the learners’ main language, and teachers should also try to use correct Setswana. With all three teachers it was very difficult for the researcher to determine whether the teachers modelled the correct language (either in Setswana or English) because the teachers used short English or Setswana sentences, in fact, it was very difficult to determine whether they had completed a sentence in either language.

3.3.2.4 Language techniques

(a) Decoding of terminology

All the teachers in the case study sometimes did decoding of terminology in their lesson presentations. Teacher B said: “*Equidistance comes from the word ‘equi’ meaning equal and ‘distance’ which is the length*” (B₃, L6 – 7). Teacher B did language teaching in mathematics deliberately. This is supported by his response to the interview question, when he said:

“I would explain the word corresponding. The word correspond relates to company or correlate which means that the angles are corresponding then they are together on the same side of the transversal” (IB, L44- 46).

Decoding of terminology was also found in teacher C’s explanation about equilateral triangles: “*Equi–equal, and lateral – sides*” (C₃: L 23- 24). Therefore, the learners were clearly shown that in equilateral triangles, all sides were equal.

Teacher A also used language teaching for example:

“Re na le Transvaal le Transkei. The word trans means to cross (kgabaganya). Fa o kgabaganya Vaal river re na le Transvaal. Fa kgabaganya Kei river le Transkei. Jaanong fa o kgabaganya parallel lines re na le ...” (A₃, L65- 67).

This was evident during the explanation of the term “transversal”. Teacher A, however, only explained one part of the word “trans”. The explanation of the other part **versal**’s origin was omitted.

The use of decoding terminology language in mathematics helps because if the learner understands the meaning of the word it makes the concept clearer and it eliminates possible ambiguity.

(b) Safe talk

The term safe talk was introduced by Heller and Martin Jones (2001:13) where the discourse in class is used in such a way that neither the learner nor the teacher is made to feel uncomfortable. A safe talk technique that was observed during the class visits is the chorus-like answers with which the teachers participating in the research allowed the learners to respond to the questions. This is a safe talk technique referred to as “ritualization”. Teacher B used more chorus-like answers than the other two teachers. In one observed lesson, she used it 37 times (B₁:L1 – 260). The teacher did not direct the questions to individual learners and it seemed as if the teacher did not want the researcher to notice when the learners did not understand well. Teacher A and teacher C, unlike teacher B, asked questions like “*Re na le isosceles triangle, two sides are . . .*” (A₂, L60) and “*Revolution, how many degrees?*” (C₁, L133). The teachers in these cases did not allow the learners the chance to respond to the questions. The teachers together with the learners’ answered the questions, and the teachers speaking louder than the learners do. In these classrooms where the safe talk was employed as a technique there seemed to be the minimum participation without loss of face for either the

learners or the teachers. The re-voicing technique was not observed in all the lessons, the interactions in all the classes were initiated by the teacher, and learners did not initiate any discussion in the classroom. The teaching method used by the teachers restricted participation during their teaching, and therefore learners' mathematical talk was non-existent.

3.3.3 Discussion of the teachers' language practices and views

The teachers who participated in the research were situated in different types of schools, namely a rural, semi-rural and township school. Furthermore, the teachers' main languages differed although they were all proficient in Setswana. The researcher investigated whether these factors influenced the language use.

Teacher A is a Xhosa, and proficient in Setswana, and the following observations can be made about his language use in the classroom: The teacher mostly modelled correct English, but sometimes he modelled incorrect Setswana (A₂:L116). Teacher A used many tswanalized words in his Setswana sentences (A₁, L6). Although the normal practice in his classroom was for learners to respond to questions in English (Lesson A₁:A₂), the teacher allowed learners to respond to questions in their main language when they wanted to. Learners did not often make use of this concession. Only one learner responded in Setswana when explaining the difference between two pairs of parallel lines in a diagram on the chalkboard (A₃:L116).

Teacher B is a Zulu and proficient in Setswana. As was the case with teacher A, teacher B switched between English and Setswana regularly and used many tswanalized words. The teacher sometimes modelled incorrect English (B₁:L68 -77).

Teacher C is a Motswana, and switched to Setswana. The teacher used proper and well-constructed Setswana sentences whenever she switched to Setswana. Teacher C switched to Setswana less in the third lesson than she did in the previous two lessons. This was a revision lesson, and the teacher used only English. The teacher did not translate difficult English words to Setswana like she used to do in the previous lessons (C₁, C₂). The learners completed worksheets, which limited the communication between the learners and the teacher, and amongst the learners themselves. The learners responded to the questions on the worksheets only in English. The response were mainly written on the worksheets, but sometimes also on the chalkboard.

The researcher investigated the learners' use of language in the classroom, though it was difficult to find out how learners used the language because learners were not given a chance to talk during the lessons presentations. This might be due the teaching methods the teachers used, both teacher A and C used the chalk and talk method. The learners were only allowed to talk when they responded to

the questions asked by the teachers. Learners from school B could be heard speaking Setswana while they were discussing activities given to them in their groups. Only two learners in nine observed lessons were heard speaking Setswana to the teachers in response to questions.

“Ke figure e e nang le disaete tse tharo” (B₂:S₁ L7)⁸, and “Pharologanyo ke gore fela parallel lines tse di eme tsele di robetse” (A₃:S₂₃ L116).

(Translation: It is a three-sided figure (B₂:S₁ L7). The difference is that some parallel lines are horizontal and others vertical).

One feature that was observed in nine lessons was the absence of written Setswana language. No Setswana word was written on the chalkboard or any Setswana used in the worksheets completed. It was used neither by the learners nor by the teacher.

The geographical location of the school, either rural, semi-rural or township school did not have any influence in the language practices in these classrooms. All three teachers used the language in the same way; they switched from English to Setswana, and used borrowed Setswana words in a similar way. The researcher expected the township school to use more English in the mathematics classroom than the rural schools. However, this was not the case.

Apart from the constructs, the following discussion emerged from the interviews with the teachers:

The three mathematics teachers interviewed indicated that teaching mathematics in a language different to the learners’ main language is a disadvantage. The learners are taught in their mother tongue in early years of study and this disadvantages them when they are in higher grades (classes), because they have grasped many concepts in their mother tongue. Teacher A said that the department of education should be blamed for learners’ not understanding mathematics in English (IA, L18- 22).

The teachers were of the opinion that learners cannot use English beyond the classroom, which clearly shows that the language use in mathematics is a “school based language” (IA: L25). Access to the language is limited to the mathematics teacher and the school. The mathematics learners are unable to communicate fluently in English. The use of English in the classroom limited learner participation in the classroom. One may say at grade 8 learners in the observed schools were not yet ready to learn mathematics in English. The reasons advanced by the teachers were:

⁸ B₂:S₁L7, means teacher B, lesson 2, student (learner) 1 and line 7

The socio-economic status of the community, and the fact that in most of the families there are no televisions and telephones. Learners do not interact with learners who are in higher institutions. Low level of education of the parents and there is no media centre (library) in the community.

According to the teachers some of the strategies that they employed in their mathematics classrooms were to:

- Allow the maximum learner participation in the classroom by using both English and Setswana in teaching mathematics (IA, L35 – 37).
- Use real and concrete examples in explaining mathematics concepts (IB, L32- 36).
- Teaching the language in the mathematics concepts (IB, L52 – 57).

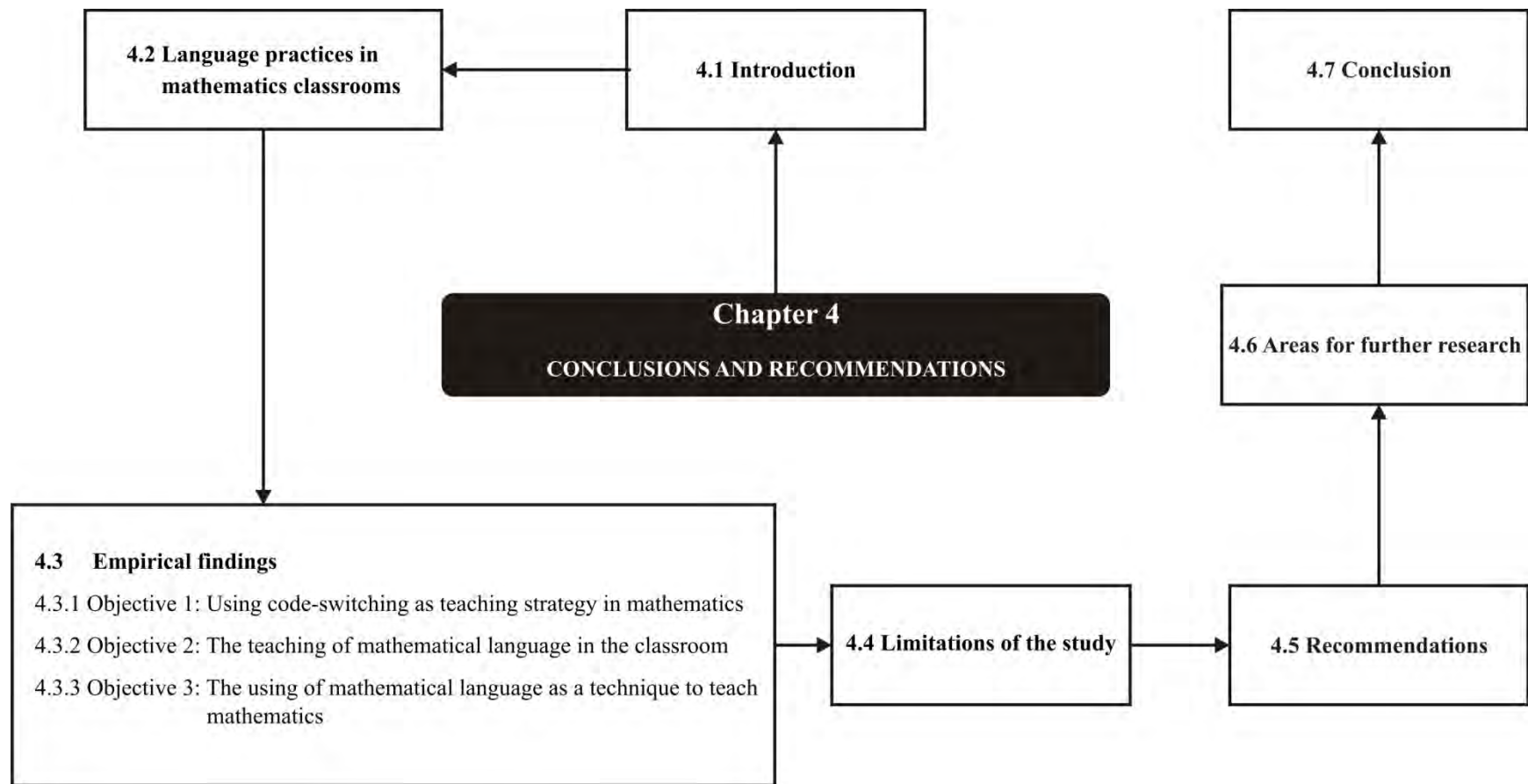
In response to how they teach corresponding and alternate angles to grade 8 learners the teachers said the best way to teach these angles is by use of the diagram (IA, IB,IC). All the teachers agree that the best way is to show learners the position of the angles. Teacher B (IB, 52- 54) also stressed that explaining of the word may assist the learners in grasping the terminology, for example “alter” meaning “change” in alternate angles. Lack of terminology in Setswana was also given as a factor disadvantaging the learners in understanding mathematical terminology like corresponding and alternating angles (IB, L7 – 9).

3.4 Conclusion

The mathematics terminology used by the teachers was mostly in English or transliterated (tswanalized). Though English is regarded as the medium of instruction in the participating schools, the teachers switched to Setswana often. The teachers used mainly tswanalized words instead of the correct Setswana mathematical terminology. The teachers knew mathematics terminology in both English and the tswanalized version. The language journey observed was either from English mathematical language to Setswana mathematical language with tswanalized words or vice versa, but with short sentences.

While observing the language practices in the mathematics classrooms it was observed that the teachers modelled some incorrect English and some incorrect Setswana sentences in their classrooms. The teachers paid attention to the decoding of the English terminology when new terminology was introduced to the learners. In teacher B’s lessons learners were able to communicate with each other in their groups. The learners used Setswana to communicate with one another in their groups. While the worksheet, which was in English, was completed there was no communication between the learners. This might be, because learners were using only English.

Hence, the use of English in mathematics teaching minimized learner participation. The teachers also used safe-talk in their mathematics classrooms, which gave little opportunity to learners to develop their own mathematical utterances.



CHAPTER 4: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Introduction

This chapter provides a synopsis of the research. The synoptic discussion contains two sections, namely important insights gained from the literature review regarding the language practices in the mathematics classrooms, and the discussion of the empirical findings. The chapter will close with the limitations of the study, recommendations for future research, and general concluding remarks.

4.2 Language practices in mathematics classrooms

Literature shows that language plays an important role in the teaching and learning of mathematics in general, as well as in the multilingual classroom in particular. The study of the work of the following researchers who mainly contributed to the insight gained about specific features that is of importance for this study:

In Vygotsky's in-depth study of language and thought, two of the constructs "*word meaning*" and "*word sense*" were of special importance for this study. Mathematical terminology cannot be understood until the concept has been formed that gives meaning to the word and it can be generalized (see § 2.2.1). Though Vygotsky's theory does not only apply to mathematics, it is very important for a study about language in mathematics, and even more so in the multilingual mathematics classroom. For the learners who have not formed the concept, the terminology has no meaning and then they will forget it easily or apply it wrongly, for example, the observation of the learner that used the terms "*relay*" and "*settlement line*" instead of "*ray*" and "*line segment*" respectively in the class of teacher B (lesson 2) (see § 3.3.2.1). This clearly showed the importance of word meaning and word sense, which is needed for the learners to understand when a term or word has a meaning that depends on the context and the different nuances in which the word is used.

In understanding algebra, Kieran's model of algebra learning that describes generational, transformational and global levels of conceptualisation (see § 2.2.2) is important. This linked with MacGregor and Princes' metalinguistic awareness. Symbol awareness, syntax awareness and the ambiguity are especially important in word problems and modelling with functions. The teacher should make sure that ambiguity is avoided at all times in question papers or anything described in words that have to be modelled in symbol language in mathematics. Here word sense also plays an important part (see § 2.2.1). The progression of language through different reasoning levels of Van Hiele in geometry highlighted how the learners' language has to develop from the visual level to the

theoretical level. Teachers should be aware of the language development in each phase and should help the learners to grasp the concept. Though the Van Hiele theory is intended for geometry learning, it can also be applied in other strands of mathematics, such as algebra and trigonometry (see § 2.2.3).

The communication between the teacher-and-learner, as well as amongst learners is very important. In the mathematics classroom the discourse of the language plays a major role. The informal as well as the formal mathematics register is used in the learning process. When the teacher introduces a new topic to the learners, the informal mathematics register is often used and the aim is to progress to the formal mathematics register.

The introduction of a LoLT different from learners' main languages made the learning situation in multilingual classrooms more complex than in monolingual classrooms. The researchers (Adler, Barwell, Setati and Vorster) agree that the learners' main language is important for learners' understanding of mathematics. In this regard Cummins' theory of bilingualism that highlighted the importance of the learners' main languages in teaching and learning was of importance to this study. The threshold theory gave us the barometer according to which two languages complement each other. When both learners' main language and English, as LoLT, have reached the threshold level, the learners benefit the most. It is therefore important that it should be seen to that the learners maintain a high proficiency in both languages.

Furthermore, different important constructs (the use of terminology, use of mathematics registers, modelling of languages and language techniques) were identified from the literature study that were used in the classroom observations in the empirical investigation in order to satisfy the research objectives as will be discussed in the next section (§ 3.3.2.1- 3.3.2.4).

4.3 Empirical findings

From the observations made by the researcher during class visits and interviews held between the researcher and the participants, it became evident that code-switching is practiced in all participating schools.

4.3.1 Objective 1: Using code-switching as a teaching strategy in mathematics

All mathematics teachers who participated in the research used code-switching strategy in their teaching. The language journey was observed and this was not as complex as described in the literature study (§ 2.4.4). The route of language journeys was rather simple, as the teachers switched

from the English to Setswana and vice versa with no clear development from informal to formal mathematical language. One teacher used formal mathematics language in lesson 3 (teacher C), this could be because the teacher was preparing the learners for assessment, which is in English only (§ 3.3.3). Little evidence could be found of the development of learners' use of written mathematical language in English, and none in Setswana. The teachers used either English front stage or Setswana front stage depending on the topic they were teaching, with no clear preference for one language, although the teacher whose own main language was Setswana (Teacher C) conducted most of the first two lessons through medium Setswana.

The teachers used mainly transliterated terminology, and in this study tswanalized words, when they switched to Setswana (§ 3.3.2.1). Existing Setswana terminology was seldom used. It seemed that when more advanced terminology was involved, code-mixing took place and the English terminology was mostly used unchanged. The transliteration used by the teachers was not planned. Maybe this is because in South Africa the use of terminology in code-switching to the main languages of the learners in mathematics is intuitive. There is no policy about how terminology should be used, unlike in other countries (§ 2.4.5), therefore transliteration is done haphazardly and code-mixing takes place with English terminology in Setswana sentences.

4.3.2 Objective 2: The teaching of mathematical language in the classroom

Except for decoding of terminology for teaching concepts (objective 3), little planned language teaching took place (§ 3.3.2.4). In lesson 3 teacher C modelled the English mathematical register excellently. However, because the other two teachers often code-switched in one sentence it obstructed language modelling, because neither the sentence construction, nor the grammar of the English, nor the Setswana emerged clearly. The teachers also sometimes modelled incorrect English and Setswana while they were teaching (§ 3.3.2.3).

All the teachers dominated the classroom discussions because of the direct teaching method they were using in their lesson presentations. Therefore, the learners' language use was not visible enough to be commented on, and language teaching techniques such as revoicing could not be implemented. Safe talk was often observed where learners answered in a chorus and only one or two words were added to the teacher's sentence. The learners were seldom given tasks where they had to discuss the mathematics amongst themselves.

4.3.3 Objective 3: The use of mathematical language as a technique to teach mathematics concepts

Contrary to what was expected, two of the teachers employed decoding of terminology purposefully to advance concept development (§ 3.3.2.4), one of the teachers more often than the other. However, only English terminology was decoded as existing Setswana terminology did not feature in the observed classes.

4.4 Limitations of the study

The teachers who participated in the research were all from the same district of Education in the North-West Province; therefore, the results cannot be generalized to all the mathematics teachers in the province or the republic.

The study was limited to the teachers' language practices in grade 8 mathematics only. The study focused on a specific grade in the Mafikeng district of Education, and therefore it cannot be generalized to all multilingual mathematics classrooms.

4.5 Recommendations

Teachers should be given training on the language usage in mathematics. In-service workshops should be conducted on how to facilitate learner's mathematical language development in multilingual mathematics classes, as well as how to plan code-switching to benefit the language development of learners' proficiency in the mathematics registers of both languages.

The teacher educators should incorporate the development of student teachers' own language proficiency in their mathematics course curriculum. This will assist the students to develop the academic language required for teaching mathematics through the medium of Setswana and English.

4.6 Areas for further research

Future projects in this area could include a study on the use of transliterated words in mathematics. The study could focus on reasons for teachers using the transliterated words and whether it added value to understanding of mathematics through medium of the main language.

The use of bilingual dictionaries (materials) in the mathematics classrooms could form a topic for future research, researching the impact of bilingual study materials on mathematics learning.

4.7 Conclusion

Although different case studies have been conducted on language practices in mathematics classrooms, it is an ever changing landscape, and valuable observations have been made in this study. There were no major differences observed between rural, semi-rural and township schools. Code-switching, and especially the use of terminology, was conducted in an intuitive manner. As both languages were often used in one sentence, constructive language modelling was not possible. Except for decoding of terminology for the purpose of promoting conceptualisation, no purposeful language planning was observed and neither the learners' English, nor Setswana mathematics registers were developed in a constructive way. The lack of learners' discourse, due to the teaching style of the teachers, robbed the teachers of opportunities to use language teaching techniques.

From this study it became clear that mathematics teachers need to be trained to make the transition from informal to formal registers in both languages, as well as being properly trained to use code-switching effectively.

BIBLIOGRAPHY

- ADLER, J. 2001. Teaching mathematics in multilingual classrooms. Dordrecht : Kluwer Academic.
- BARWELL, R. 2005. Integrating language and content: Issues from mathematics classroom. *Linguistics and Education journal*, 16(2005):205 – 218.
- CANGELOSI, J.S. 2003. Teaching Mathematics in secondary and middle school: An interactive approach. 3rd ed. Upper Saddle River, NJ : Merrill Prentice Hall. 436p.
- CARLSON, C. 2000. Scientific literacy for all: Helping English language learners make sense of academic language. *Science Teacher*, 62(2):48 -52.
- CLAUSS-EHLERS, C.S. 2006. Diversity training for classroom teaching. New York : Springer Business Media, Inc. 237p.
- CLEMENTS, D.H. & BATTISTA, M.T. 1992. Geometry and spatial reasoning. (In Grouws, D.A., ed. Handbook of research on mathematics teaching and learning. New York : Macmillan/NCTM. 420-436p).
- CONSTITUTION **see** SOUTH AFRICA
- CUMMINS, J. & SWAIN, M. 1986. Bilingualism in education: aspects of theory research and practice. London: Longman. 402p.
- DALE, T.C. & CUEVAS, G.J. 1992. Integrating mathematics and language learning. (Richard-Amato, P.A & Snow, M.A. Multicultural classroom. Readings for content-area teachers. London: Longman. 413p).
- DEPARTMENT of Education **see** SOUTH AFRICA
- DOERR, H. M & TINTO, P.P. 2000. Paradigms for teacher-centred, classroom- based research. (In Kelly, A.E. & Lesh, R.A. Handbook of research design in mathematics and science education. Mahwah : NJ, Lawrence Erlbaum. p. 403 – 428.)
- DOYLE, A., CHAMPAGNE, M. & SEGALOWITZ, N. 1978. Some issues on the assessment of linguistic consequences of early bilingualism. (In PARADIS (ed.), M. Aspects of Bilingualism. Columbia : Hornbeam Press).
- DRINKWATER, M. 2002. Didactic guidelines for creating a favourable classroom climate in outcomes-based Physical Science classes. Potchefstroom : North-West University (Dissertation-M.Ed.) 267p.

- FITTON, S., LONG, C., BLAKE, P. & DE JAGER, T. 2006. On track with maths. Learner's book, grade 8. Cape Town. Pumelelo Publishers (Pty) Ltd. 311p.
- FUYS, D., GEDDES, D. & TISCHLER, R. 1988. The Van Hiele model of thinking in geometry among adolescents. *Journal for Research in Mathematics Education*. Monograph Number 3. Reston, VA. NCTM.
- GERBER, A.N.S. 2004. The influence of second language teaching on undergraduate mathematics performance. South Africa. University Pretoria, 54p.
- GOLDSTEIN, T. 2003. Teaching and learning in a multilingual school: choices, risks and dilemmas. Mahwah, NJ : Lawrence Erlbaum Ass., Inc. 219p.
- GORGORIÓ, N. & PLANAS, N. 2002. Teaching mathematics in Multilingual Classrooms. *Educational Studies in Mathematics*, 47:7-33.
- GROENEWALD, M., MINSHALL, G., OTTO, H., ROOS, H. & VAN DER WESTHUIZEN, H. 2006. Maths today. Learner's book, grade 9. Cape Town : Maskew Miller Longman (Pty) Ltd. 298p.
- GUTIERREZ, R. 2002. Beyond essentialism: The complexity of language in teaching mathematics to Larina/o students. *American Educational Journal*, 39(4):1047-1088.
- HELLER, M. & MARTIN-JONES, M., eds. 2001. Voices of authority: Education and linguistic difference. Westport, Conn. : Ablex Publishing. 442p.
- HIEBERT, J. 2007. The effects of classroom mathematics teaching on students' learning. (In Grouws, D.A., ed. Handbook of research on mathematics teaching and learning. New York: Macmillan/NCTM. 371 - 403p).
- HOFFER, A. 1981. Geometry is more than proof. *Mathematics teacher*, 74:11 – 18 [In Hoz, R. 1981. The effects of rigidity on school geometry learning].
- HORNBERGER, H.N. & CHICK, J.K. 2001. Co-constructing school safe time: safe talk practices in Peruvian and South African classrooms. (In Heller, M. & Martin- Jones, M. Voices of authority: education and linguistic difference. Westport, Conn. : Alex Publishing. 31-35p).
- HOWIE, S. 2001. Products and findings. Distribution of mathematics achievement. Third International Mathematics and Science – Repeat (TIMSS–R). Pretoria : Human Sciences Research Council. [Web:] <http://www.hrsc.ac.za/corporate/media/2000/timss200/appendix.g>. [Date of access: 24 May 2006].

- KASULE, D. & MAPOLELO, D. 2005. Teachers' strategies of teaching primary school mathematics in second language: A case of Botswana. *International journal of education development*. 25(6):1 -12, Nov.
- KAZIMA, M. 2008. Mother tongue policies and mathematical terminology in the teaching of mathematics. *Pythagoras*, 67:56-63, June.
- KHISTY, L.L. 1995. Making inequalities: Issues of language and meanings in mathematics teaching with Hispanic students. (In Secada, G., Fennema, E. & Adajian, L.B., eds. New Cambridge : University Press. p 279 – 285.)
- KIERAN, C. 2007. Learning and teaching algebra at the middle school through college levels (In Lester, Jr, F.K. In Second Handbook of research on mathematics teaching and learning. USA. Information age Publishing Inc. 1324p).
- KILPATRICK, J., SWAFFORD, J. & FINDELL, B. 2001. Adding it up: Helping Children learn Mathematics. Washington, DC : National Academy Press.
- KYLE, G. & WHITTLE, T. 2010. Spot on mathematics grade 8. Sandton : Heinemann Press.201p.
- LEE, C. 2006. Language for learning Mathematics. Assessment for learning in practice. New York. Open University Press. 118p.
- LAGER, C.A. 2006. Types of mathematics language reading interactions that unnecessarily hinder Algebra learning and assessment. California. Taylor and Francis Group, LLC. 165-190p.
- LEEDY, P.D. & ORMROD, J.E. 2005. Practical research: planning and design. 8th ed. Hillside: N.J. Prentice Hall. 135p.
- MACGREGOR, M. & PRICE, E. 1999. An exploration of aspects of language proficiency and algebra learning. *Journal for research in mathematics education*, 30(4), 449-467.
- MOSCHKOVICH, J.N. 2000. Learning mathematics in two languages: moving obstacles to resources. (In Secada W.G (Ed.), Changing the faces of mathematics: Perspectives on multicultural and gender equity. Reston, Va: National Council of Teachers of Mathematics. 85-93p).
- NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM). 2004. Principles for standards for school Mathematics. Reston, Va: National Council of Mathematics Teachers.
- NAUDÈ, A., PRETORIUS, E & VANDEYAR, S. 2003. Improving teachers' in-service professional development in mathematics and science. *Early child development and care*. Vol 173. Numbers 2-3/ June 2003. p 293-315(23).
- NCTM see NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM).

- PIMM, D. 1990. Speaking mathematically. Communication in mathematics classrooms. New York. Chapman and Hall, Inc. 217p.
- PIMM, D. 1993. Communicating mathematically. (In Durkin, K & Shire, B. eds. Language in mathematical education: research and practice. Philadelphia, Pa: Open University Press, 18-24p).
- REDDY, V. 2006. Mathematics and science achievement at South African schools in TIMSS 2003. HRSC Press.
- SCHUNK, D.H. 2004. Learning theories. An educational perspectives. 4th ed. Englewood Cliffs, NJ : Prentice Hall. 522p
- SETATI, M. & ADLER, J. 2002. Between languages and discourses : Language practices in primary multilingual mathematics classrooms in South Africa. *Educational Studies in Mathematics*, 43:243 – 629.
- SETATI, M. 2005. Teaching mathematics in a primary multilingual classroom. *Journal for Research in Mathematics Education*, 36(5):447 – 466.
- SETATI, M. 2002. Language practices in intermediate multilingual mathematics classrooms. Johannesburg: University of Witwatersrand (Thesis- D.Phil).
- SHUNK, D. H. 1996. Learning theories. 2nd ed. Englewood Cliffs, N.J.: Prentice Hall. 512p.
- TIMSS 2003 see TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY.
- TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY. 2003 (TIMSS2003). [Web:] <http://timssbc.educ/timms2003.html>. [Date of access: 07 October 2006]
- SOUTH AFRICA. Department of Education. North West Province. 2009. Provincial assessment, certification & accreditation report Grade 12 Examination results. Mafikeng.
- SOUTH AFRICA. Department of Education. 2006. Systemic Evaluation provincial report grade 6 intermediate phase. North West Province. Mafikeng: Department of Education.
- SOUTH AFRICA. Department of Education. 2002. National Curriculum Statement. Grade 10-12 (General). Pretoria: Department of Education.
- SOUTH AFRICA. 1996. Constitution of the Republic of South Africa 1996 as adopted by Constitutional Assembly on 8 May 1996 and as amended on 11 October 1996. Constitutional Assembly, Republic of South Africa. (B34B-96). 141 p. (ISBN 0-260 -20716 – 7).
- SPROULE, S. 2010. Patterns and modelling: the answer series. Claremont : The Answer Pub. 49p.

- STEWART, J., REDLIN, L & WATSON, S. 2002. Pre calculus mathematics for calculus. (4th ed.). Duxbury: Brooks/ Cole. 959p.
- SWAIN, M. 1986. Communicative competence. Some roles of comprehensible input and comprehensible output in its development. (In J. CUMMINS & M. SWAIN, 1986, *Bilingualism in education: aspects of theory research and practice*. London: Longman. 402p).
- TEPPO, A. 1991. Van Hiele Levels of Geometric thought revisited. *Mathematics teacher*, 84(3):210-221, March
- VAN DE WALLE, J.A., KARP, K.S. & BAY-WILLIAMS, J.M. 2010. Elementary and middle school mathematics: teaching developmentally. (7th ed.) Boston : Allyn & Bacon.
- VAN HIELE, P.M. 1986. Structure and insight: a theory of mathematics education. New York: Academic Press. 246p.
- VORSTER, J.A. 2005. The influence of terminology and support materials in the main language on the conceptualisation of geometry learners with limited English proficiency. Potchefstroom : North-West University (Dissertation- M.Ed.) 277p.
- VORSTER, J.A. 2008. Investigating scaffold to code-switching as strategy in multilingual classrooms. *Pythagoras*, 67:33-41, June.
- VYGOTSKY, L.S. 1967. Language and thought: the problem and approach. (In De Cecco, J.P., ed. *The psychology of language, thought, and instruction*. London: Holt, Rinehart and Winston. 56-60p).
- WEBSTER'S THIRD NEW INTERNATIONAL DICTIONARY. 1961. USA: G & C. Merriam Co. 2662p.

APPENDIX A

PERMISSION TO CONDUCT RESEARCH



education

Lefapha la Thuto
Onderwys Departement
Department of Education
NORTH WEST PROVINCE

First Floor,
Garona Building
Private Bag X2044,
Mmabatho 2735
Tel.: (018) 387-3429
Fax: (018) 387-3430
e-mail: ptyatya@nwpg.gov.za

OFFICE OF THE SUPERINTENDENT-GENERAL

Enquiries: Mphiliso Tyatya
Tel: 018 387 3429
Fax: 018 387 3430
E-mail: sgedu@nwpg.gov.za

16 September 2009

**To: B.S. Gaoshubellwe
Mafikeng
2745**

**From: Mr. H.M. Mveli
Superintendent-General**

PERMISSION TO CONDUCT RESEARCH SURVEY

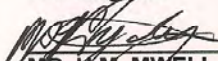
Reference is made to your correspondence dated 04 September 2009 regarding the above matter. The content is noted and accordingly, approval is granted to your kind self to conduct research in Reboneilwe Secondary School.

This permission is, however, subject to the following provisions: -

- That your point of contact with the North West Department of Education will be Ms. Semaswe, who is responsible for all schools in the district.
- That the onus to notify school manager of your target school about your research rests with your good self.
- That participation in your project will be voluntary.
- That as far as possible the general school functionality should not be compromised in the course of your research.
- That the findings of your research will be made available to the Education Department upon request.

With my best wishes

Thanking you.



MR. H.M. MWELI
SUPERINTENDENT GENERAL

CC: Ms. S. Semaswe – Executive Manager: Ngaka Modiri Molema District

*“STAND UP, TEAM UP AND REACH OUT”
“A PORTRAIT OF EXCELLENCE”*



education
Lefapha la Thuto
Onderwys Departement
Department of Education
NORTH WEST PROVINCE

10 Nelson Mandela Drive, Mafikeng
Private Bag X10, Mmabatho 2735
Tel.: (018) 387-2000
Fax: (018) 381-7322
Fax: (018) 381-7345
e-mail: jhlongwa@nwpg.gov.za

NGAKA MODIRI MOLEMA DISTRICT

Enquiries : E Jacobs
Tel : (018) 397 2018

05 August 2008

TO : MR B S GAOSHUBELWE
FROM : S J HLONGWA
ACTING REGIONAL EXECUCITVE MANAGER
SUBJECT : PERMISSION TO USE SCHOOLS FOR RESEARCH

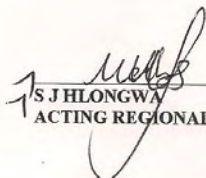
Dear Sir

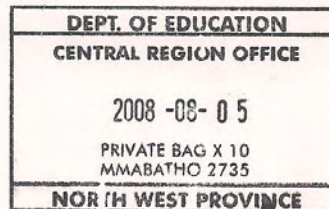
With reference to the above mentioned permission is hereby granted for your research at the following schools:

- Barolong High School
- Utlwanang Barolang High School
- Setumo High School
- Sejankabo High School
- Reikanne High School
- Kebalepile High School
- Mogakolodi Masibi High School
- Mosikare Secondary School
- Tselakgosi Middle School
- Tiego Tawana Middle School
- Boingotlo Middle School
- Ikopanyeng Middle School
- Reboneilwe Secondary School

Kindly furnish this office with a report at the end of your research.

We wish you all the best in your studies and await positive outcomes.


S J HLONGWA
ACTING REGIONAL EXECUCITVE MANAGER



Enq : B. S. GAOSHUBELWE
Cell: 079 526 8841

P. O. BOX 23495
MAFIKENG
2745
01 AUGUST 2008

THE REGIONAL EXECUTIVE MANAGER
CENTRAL REGION
MAFIKENG

DEAR SIR

RE: PERMISSION TO USE SCHOOLS FOR RESEARCH

I hereby wish to apply to be granted a permission to use the following schools for my M.Ed (Mathematics Education) Research project:

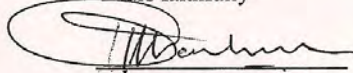
- Barolong High School
- Utlwanang Barolong High School
- Setumo High School
- Sejankabo High School
- Reikanne High School
- Kebalepile High School
- Mogakolodi Masibi High School
- Mosikare Secondary School
- Tselakgosi Middle School
- Tiego Tawana Middle School
- Boingotlo Middle School
- Ikopanyeng Middle School

The research project is based on the "Language practices in the teaching and learning of mathematics in multilingual schools". One mathematics teacher will be used in this project between August and September 2008. The mathematics teacher's lessons will be recorded using a video machine so as to transcribe and analyse language teaching in the mathematics classrooms.

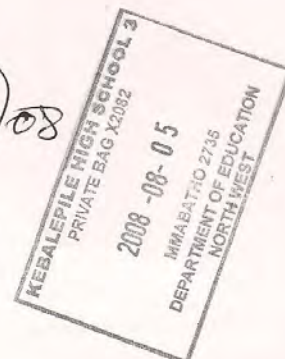
I further wish to inform you that these recorded lessons will only be used for the studies purpose, and not for anything else.

Hoping that my application shall be esteemed by you Sir.

Yours faithfully


B. S. GAOSHUBELWE

Received 05/08/08
A. P. H.
Deputy Principal
Permission granted.



Enq : B. S. GAOSHUBELWE
Cell : 079 526 8841

P. O. BOX 23495
MAFIKENG
2745
01 AUGUST 2008

THE PRINCIPAL
TSELAKGOSI MIDDLE SCHOOL
MAFIKENG

DEAR SIR/MADAM


RE: REQUEST TO UTILIZE MATHEMATICS TEACHER IN THE RESEARCH

I hereby wish to use your mathematics teacher in my M.Ed (Mathematics Education) research project.

The research is based on the "Language practices on the teaching and learning of mathematics in multilingual schools". I will only use one mathematics teacher in my project in August 2008. Three mathematics lessons will be recorded using a video machine. These lessons will only be used for study purpose.

Hoping for your positive response

Yours faithfully



B. S. GAOSHUBELWE

Enq: B.S GAOSHUBELWE
Cell: 079 526 8841

P.O.Box 23495
MAFIKENG
2745
07 SEPTEMBER 2009

**THE PRINCIPAL
REBONEILWE SECONDARY SCHOOL
COLIGNY**

Dear Madam

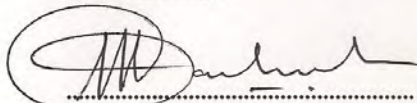
RE: REQUEST TO UTILIZE MATHEMATICS TEACHER IN THE RESEARCH

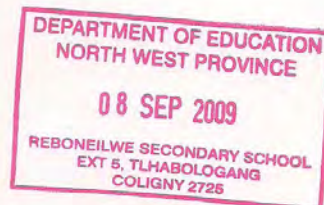
I hereby wish to requests the Principal and the School Management team (SMT) to use your grade 8 Mathematics teacher in my M. Ed (Mathematics Education) research project.

The research is based on the **“Language practices on the teaching and learning of mathematics in multilingual schools”**. The permission for the project has been granted by the Superintendent General, see the attached letter. I will only use one mathematics teacher in my project in September and October 2009. Three mathematics lessons will be recorded using an audio-visual machine. These lessons will only be used for the study purpose.

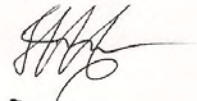
Hoping for a positive response.

Yours faithfully


.....
B.S GAOSHUBELWE



Received 07th Sept. 2009



Permission granted.

APPENDIX B

GLOSSARY

Transliterated Words	English	Setswana
mejara	measure	Lekanyetsa
eró	arrow	Letshwao
teroisa	draw	Go thala
eksethenda	extend	Go atolosa
inkrisitse	increase	Oketsega
juenile	join	Kopanya
botraengele	Triangles	dikhutlo-tharo
Disaete	Sides	Matlhakore
tshêntshă	change	Fetola
prekretara	protractor	selekanyadikhutlo
inthasekshene	intersection	Makopanelo
mmetsheng	mathematics	Dipalo
sheipi	shape	Popego
dilaene	lines	Mela
engele	angle	Khutlo
pheiging	page	Tsebe
traya	try	Go leka
tichere	teacher	Morutabana
rombase	rhombus	
sekwere	square	Sekwere
vouta	Vote	Tlhopa
rekthengele	Rectangle	

APPENDIX C

INTERVIEW SCHEDULE GUIDE

Please feel free to speak your mind. This information will remain confidential, and your name will not be mentioned.

1. Is your mother tongue and your learners' the same? Is this an advantage or a disadvantage in teaching mathematics using English, why?
2. Mention all learners' home languages in your mathematics class.
3. What is the language medium of your school (LoLT)?
4. What is the language strategy of the school where you are working?
5. Can your learners use English beyond the classroom?
6. In your judgment, are your learners ready to learn mathematics in English? **Please explain.**
7. Would you say English is a barrier to your learners' understanding of mathematics?
8. Name some of the different strategies you use to facilitate your learners' understanding of mathematics taught using English.
9. What role does informal spoken language play in the teaching of mathematics?
10. How would you explain the following terms to a grade 8 mathematics learner:
 - 10.1. Corresponding angles
 - 10.2. Alternating angles

APPENDIX D

OBSERVATION SCHEDULE

A. CODE-SWITCHING

ENGLISH	Formal mathematics	
	Informal mathematics	
	Everyday	

SETSWANA	Formal mathematics	
	Informal mathematics	
	Everyday	

B. CODE MIXING

ENGLISH MIXED WITH SETSWANA WORDS	Formal English	
	Informal Setswana	
	Tswanalization	

SETSWANA MIXED WITH ENGLISH WORDS	Formal English	
	Informal Setswana	
	Tswanalization	

C. LANGUAGE TEACHING

Teaching Origins	
Word structure (morphology)	

D. CODE SWITCHING

BACK STAGE	
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APPENDIX E

Field notes

Name of the observer: B.S GAOSHUBELWE

Place of observation:

Topic:

Date:

Time observation began:.....

Time observation ended:.....

1. Classroom layout (sketch).

2. Description of the classroom content and arrangement.

3. Focus on the classroom activities.
