SEARCHING FOR COMMON GROUND: DEVELOPING MATHEMATICAL REASONING THROUGH DIALOGUE

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DECLARATION:

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

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ABSTRACT

In the majority of the schools in the Eastern Cape, South Africa, teaching and learning takes place in the second language, English, of both teachers and learners. The purpose of this research was to elicit the perceptions of teachers in multilingual mathematics classes about language issues that they encounter and to ascertain whether they could experientially learn the theory of dialogic teaching through an intervention in order to introduce dialogue in practice in their classes. The effect of the intervention on teacher practices was qualitatively observed and the effect of the teacher practices on learner reasoning competence, numeracy competence and English language competence was quantitatively tested by using validated pre- and post-tests.

The study follows a mixed method concurrent triangulation design with both quantitative and qualitative results. Two cohorts of students/teachers studying for qualifications at Nelson Mandela Metropolitan University centres throughout the Eastern Cape expressed their opinions about language challenges and solutions through questionnaires, reflective writing and poetry. A cohort of BEd Honours (Mathematics and Science) students experienced a semester long intervention on the theory and practice of dialogic teaching, particularly exploratory talk, and were tasked to introduce the practice into their multilingual mathematics classes in the form of reported action research. The next phase of the study focussed on the practices of three teachers and their grade seven multilingual mathematics learners who were observed and tested over a period of nine months. The following year the observations and testing were repeated with one teacher and his grade seven learners to ascertain whether the intervention would result in similar findings.

The results enhance the validity of the Vygotskian claim concerning the relationship between language use, social interaction and reasoning development. In classes where there was evidence of dialogic practices the learners collaborated in groups using code-switching and their main language. Their reasoning, numeracy and English skills test scores improved statistically significantly.

Teachers were able to give voice to their deep-felt emotions through poetry. They felt that the devaluing of isiXhosa had resulted in the loss of learners' main language literacy competencies and consequent loss of cultural capital; however they considered it necessary to develop English competence in the learners, even if it was at the expense of developing mathematical competence. The introduction of exploratory talk in their home languages served the dual purpose of promoting the value of isiXhosa in an academic environment as well as enhancing mathematical reasoning. It appears that when teachers focus on developing language as a tool for reasoning, significant improvements in learners' problem solving competences occur. When the language used is the main language of both teachers and learners both mathematical understanding and cultural identity are enhanced. The study concludes with a suggestion for a model for future interventions to train teachers to introduce dialogic practices in multilingual mathematics classes.

KEYWORDS

Dialogue

Dialogic teaching

Exploratory talk

Multilingual

Mathematics

isiXhosa

TABLE OF CONTENTS

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

CHAPTER SEVEN

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION AND OVERVIEW

1. INTRODUCTION

In many schools in the Eastern Cape educators teach mathematics to learners in a language that is not their main, home or first language (Adler, 2001; Setati & Barwell, 2008; Webb & Treagust, 2006; Webb & Webb, 2008a). Most of the learners in this province are isiXhosa home language speakers while the official Language of Teaching and Learning (LoLT) in their schools is English (Webb & Treagust, 2006). Setati (2005a) notes that in South Africa mathematics is not only taught in English to promote understanding of the subject, but also to enable learners to become competent in the language. The reason for this approach is that English is overridingly seen as the language which provides access to goods and social mobility (Gee, 2004; Setati, 2005a). However, poor learner achievement has often been attributed to second language teaching and learning (Alidou, Boly, Brock-Utne, Diallo, Heugh, & Wolff, 2006; Howie, 2003).

Adler (2001) recognises that poor mathematics achievement cannot only be attributed to language proficiency, and that there are many interrelated factors which affect learning. She maintains that learning is "constituted in and through social and discursive practices" (Adler, 2001:8), and that teacher-centred teaching methods provide little opportunity for learners to engage in social interactions, or for meaningful construction of knowledge (Alidou, et al., 2006; Heugh, 2002). In order to counteract the obstacles resulting from teacher-centred methods Moschkovich (1999, 2007), Adler (2001), and Setati (2001, 2005a), amongst others, have researched teacher support strategies to promote mathematical discussions. These strategies include modelling patterns of discussion and vocabulary usage, revoicing learner contributions, building on learners' verbal offerings, code-switching, and acting as a language guide (Adler, 2001; Moschkovich, 1999, 2007; Setati, Adler, Reed & Bapoo 2002; and Setati, 2005a).

This study investigates teacher perceptions and practices in multilingual mathematics classes in the Eastern Cape and maps a journey travelled by teachers who were introduced to mathematico-linguistic strategies which aimed at helping them to better understand the problems inherent when teaching and learning in a second language. The research also attempts to measure the impact of these strategies on teacher practice and learner achievement, specifically in terms of learner problem solving, numeracy and language skills.

2. RESEARCH PROBLEM AND QUESTIONS

During the past ten years of teaching in-service mathematics educators at the Nelson Mandela Metropolitan University (NMMU) I have become concerned that many teachers in the Eastern Cape have limited mathematical knowledge and teaching skills and struggle to implement effective strategies to facilitate mathematics teaching to learners whose main language is not English. The problem that I have identified is the apparently low level of dialogue and mathematical discourse that occurs in many Eastern Cape multilingual mathematics classrooms. The aim of this study is therefore to ascertain educators' perceptions about the challenges and strategies they use to teach mathematics in bi/multilingual classes and to design and implement an intervention that could foreground exemplars and uncover possible dialogic strategies to facilitate meaningful mathematics comprehension, as well as to assess the efficacy of the intervention. During the process, the teacher and learner responses to these exemplars and dialogic strategies were used to inform further intervention and implementation in the classroom.

The objectives of this study are:

1. To identify Eastern Cape educators' perceptions about language strategies and language usage in multilingual mathematics classes;
2. To research the design and implementation of an intervention for educators to promote the introduction of dialogic practices;
3. To track educators' practice in multilingual mathematics classrooms before, during and after an intervention;
4. To ascertain whether the introduction of dialogic practices, particularly exploratory talk, increase reasoning, numeracy and English skills in grade seven multilingual mathematics classrooms.

Reformulation of the above objectives as a central research question resulted in the following:

> Can dialogic strategies be experienced and implemented by Eastern Cape educators of multilingual learners in order to enhance reasoning skills, numeracy skills and English skills?

The subordinate questions which needed to be answered to inform the above central question are:

- What are Eastern Cape teachers' perceptions about language strategies and language usage in multilingual mathematics classes?
- Can dialogic strategies be promoted by means of an intervention for educators?
- Can teachers in the Eastern Cape identify and create opportunities for exploratory talk in multilingual mathematics settings?

- Can the introduction of dialogic practices, particularly exploratory talk, increase mathematical reasoning, numeracy and English skills in multilingual mathematics classrooms?

3. BACKGROUND

Multilingual mathematics teaching and learning has become a worldwide issue and noted researchers have conducted studies on the strategies that might aid teachers to enhance their learners' mathematical understanding (Adler, 2001, Barwell & Kaiser, 2005; Moschkovich, 2007; Setati & Adler, 2001; Vorster, 2008). Worldwide there is a tension between what language experts believe should be policy and the articulation and implementation of the particular policy (Heugh, 2008). Following this line of argument she, and others, suggest that in South Africa after 1994 too much emphasis was placed on policy and too little on policy interpretation, implementation and teacher training (Heugh, 2008; Probyn, Murray, Botha, Botya, Brooks & Westphal, 2002).

Classroom studies in several sub-Saharan states reveal that using a language that is not the learners' home language coerces educators to use teacher-centered methods of instruction which include chorus teaching, repetition, memorization, and recall. These ineffective practices are considered, by some researchers, to promote low academic achievement and school ineffectiveness, impeding access to quality education (Alidou, et al., 2006). Despite these research findings, which highlight the importance and effectiveness of mother-tongue education (Heugh, 2008), English is the language of choice of the majority of parents and teachers in South Africa for teaching and learning because, as noted earlier, it is seen as a means to access social goods (Gee, 2004; Setati, 2005b) and satisfies a number of political imperatives (Hartshorne, 1992).

In the province of the Eastern Cape Province in South Africa, which stretches from the Western Province in the south west to the border with KwaZuluNatal (KZN) in the north east, and borders the Free State and Lesotho in the north, isiXhosa is the main language of the majority of teachers and learners. Notably, in rural areas of the province (where this study was conducted in part) access to English is often severely limited and there is little chance of hearing the language outside the school premises. English under these circumstances can be considered a foreign language (EFL), as opposed to an additional language (EAL), which would best describe the English in some urban communities where learners encounter the language more often, as English is spoken by some members of their communities and there is more English language stimulation in the form of billboards, newspapers and signage. Nevertheless, throughout the province, the hegemony of English dictates that most schools choose English as the language of learning and teaching (LoLT). A further complicating factor in the Eastern Cape context is that, although isiXhosa is the dominant language and is widespread in the province, there are a number of different dialects spoken - isiBaca, isiHlubi, isiCele, isiBomvana, isiThembu, isiMpondo, isiNtlangwini and isiXesibe (Nomlomo, 1999). Also, the non-isiXhosa language demographics reveal that Afrikaans is spoken in the south west in some urban and rural areas, Sesotho is spoken in the areas to the north, and isiZulu speakers are found in the north eastern areas. The map in figure 1.1 has been drafted by the researcher to illustrate the language demographics of the Eastern Cape.

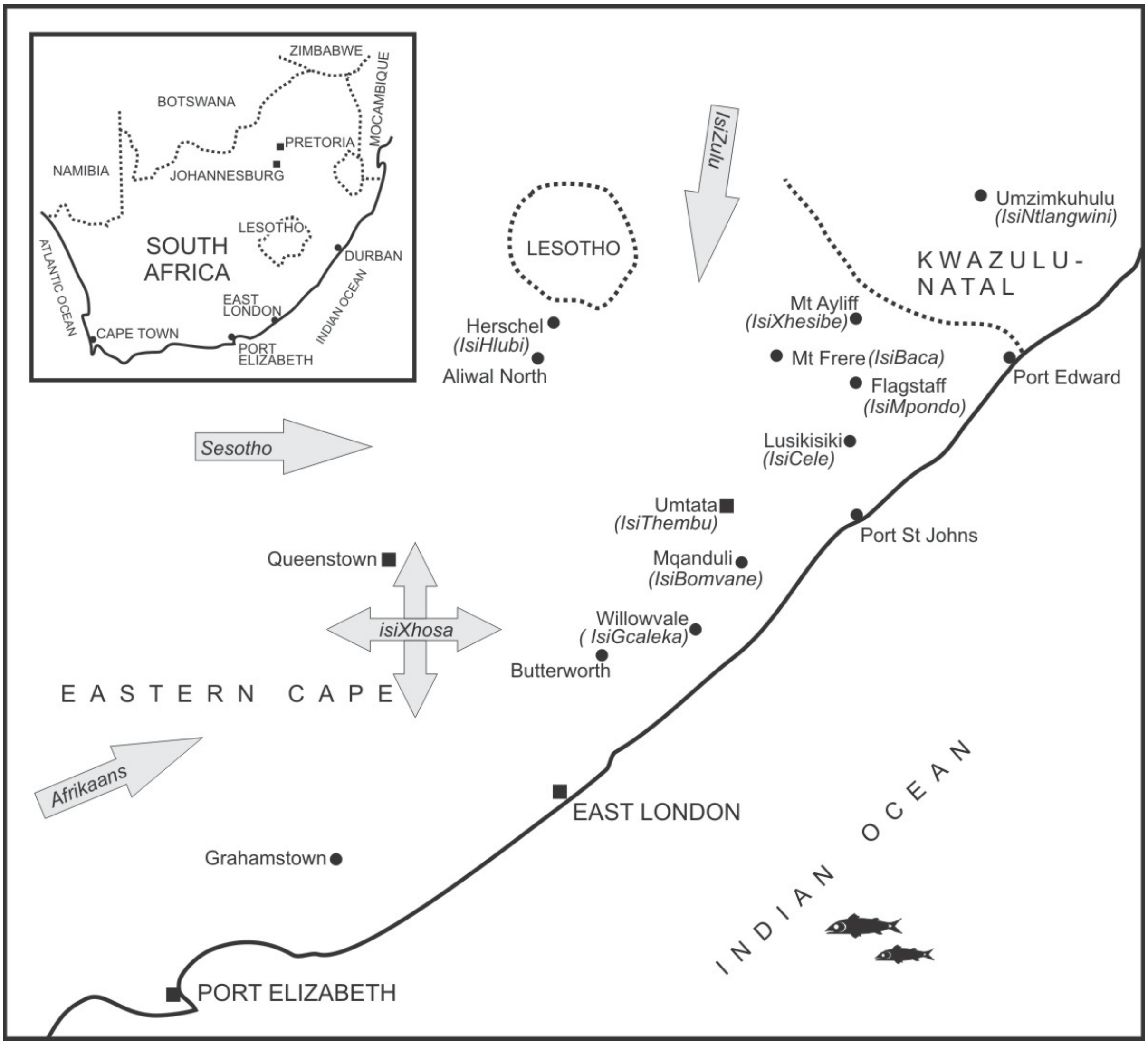


Figure 1.1 Map of Eastern Cape, South Africa showing language demographics

The difference between the multilingual settings in South Africa in general, and the Eastern Cape in particular, compared to those in schools in the United States of America, the United Kingdom, Australia or parts of Canada, is that second language learners of the latter contexts are immersed in English communities. Conversely, personal observation in many classrooms suggests that Eastern Cape learners have little or no opportunity to develop their basic interpersonal communication skills (BICS) in English (Webb & Webb, 2004). The lack of developed BICS means that these learners have little or no framework available to them within which to develop their cognitive academic language proficiency (CALP), not only orally, but also in terms of reading and writing (Cummins, 1984).

In contrast to their learners, most of the in-service teacher education students (who formed the sample in this study) at the NMMU are able to converse quite effectively on a social level in English, but personal observation suggests that generally they still have insufficient academic language ability to cope with the written academic assignments and the language of tuition of the programmes. This issue of poor linguistic ability is problematic as, in order to be inducted into the literacy of mathematical discourse, teachers are required to learn a new lexicon and be immersed in the calculational mathematical and conceptual mathematical discourses, as suggested by Sfard, Nesher, Streefland, Cobb and Mason (1998). As such, this study aims to provide an opportunity for teachers to engage in meaningful dialogue about mathematics with colleagues through experiencing the advantages of engaging in dialogic practices, especially exploratory talk; and to create opportunities to encourage dialogue through exploratory talk in a preferred language in their mathematics classrooms. The study's relevance is based in the fact that, although Adler (2001) and Setati (2005a) have pioneered research into mathematics teaching in multilingual classrooms in South Africa, mainly with Setswana-speaking teachers and learners, little research has been undertaken in the Eastern Cape where there is an isiXhosa/English tension in the classrooms.

4. TEACHING AND LEARNING THROUGH DIALOGUE

Discourse is multifaceted as it encompasses learners being receptive (listening, reading, interpreting) as well as being expressive through speaking, writing, gesturing and imagining (Mercer, Wegerif & Dawes, 1999). Lerman (2001) includes all forms of language under the banner of discourse, incorporating gesture, signs, artefacts and mimicking. Mathematical meaning is dependent on constructions through discursive activity (Gee, 2004; Pirie, 1991). As noted earlier, studies have shown that discourse plays a profound role in knowledge construction and that dialogue can be promoted as a tool to facilitate reasoning (Cooke, 1998; Truxaw & DeFranco, 2008). 'Dialogue', in general, is used to mean the interchange of ideas between two sources; however, in this study it is focussed on the development of classroom talk. Various researchers have analyzed different types of dialogue that are foregrounded when learners reason together to solve problems (Mercer, 1995; Wegerif & Mercer, 1996; Wegerif & Scrimshaw, 1997). For this study I have focussed on exploratory talk as a dialogic teaching strategy which could be introduced into Eastern Cape mathematics classrooms. The emphasis is on exploratory talk, rather than other dialogic practices, as it has been introduced successfully to learners of different ages in the United Kingdom and has been successfully implemented in multilingual Mexican schools (Rojas-Drummond & Fernandez, 2000; Rojas-Drummond & Mercer, 2004) as well as in science education research in the Eastern Cape (Webb & Treagust, 2006). As the method of introducing exploratory talk is well documented for all stages of schooling it appears that it could be adapted to a South African multilingual mathematics situation (Dawes, Mercer & Wegerif, 2003; Dawes & Sams, 2004). Mercer and Littleton (2007:59) define exploratory talk as follows:

> Exploratory talk is talk in which partners engage critically but constructively with each others' ideas. Statements and suggestions are offered for joint consideration. These may be challenged and counter challenged, but challenges are justified and alternative hypotheses are offered. Partners all actively participate and opinions are sought and considered before decisions are jointly made. In exploratory talk, knowledge is made publicly accountable and reasoning is visible in the talk.

Mercer (2004) maintains that language is a social mode of thinking. It can be used as a tool for teaching and learning as well as for constructing knowledge, creating shared understanding and solving problems collaboratively. He states that the strategy of being involved in a social activity through exploratory talk between peers in the classroom increases reasoning skills. His findings support a sociocultural view of intellectual development, as proposed by Vygotsky (1978), and show positively the value of teaching learners explicit use of language to enhance reasoning.

Sfard (2008) has coined the term *commognition* to define the close relationship between communication and cognition. She defines *commognition as* "a combination of communication and cognition" and emphasises that interpersonal communication and individual thinking are "two facets of the same phenomenon" (Sfard 2008: xvii). In this thesis I investigate social practices that could develop mathematical reasoning that draw together, rather than exclude, learners in mathematics classrooms.

5. RESEARCH DESIGN AND METHODOLOGY

The research design falls into a combination of a post-positivist and an interpretivist paradigm (see chapter three). The methods used are both quantitative and qualitative and the study as a whole can be seen as a mixed method design with quantitative results informing the qualitative results (Babbie & Mouton, 2008). The study was conducted in three phases as illustrated in figure 1.2.

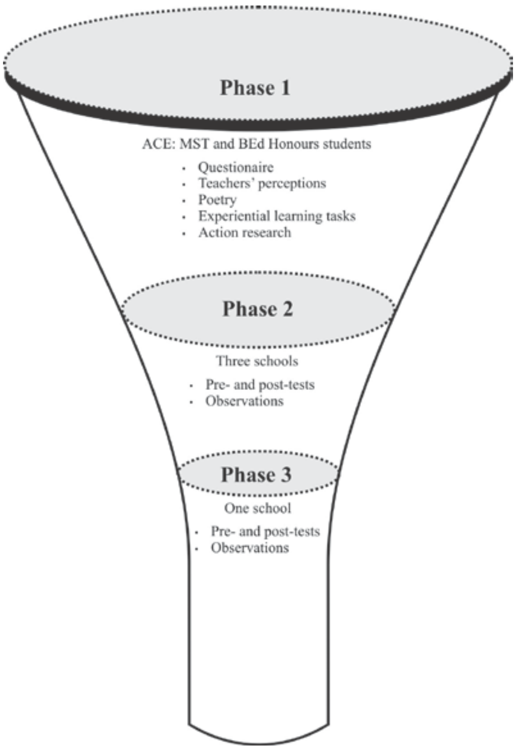


Figure 1.2 Focus funnel through the three phases of the study

5.1 Phase One

Because I wanted to establish the status quo concerning methods of mathematics teaching in multilingual mathematics classes in the Eastern Cape, I used questionnaires to elicit both the challenges teachers face in terms of teaching in a second language and the practices they employ to minimise those challenges. They were also asked to comment on their own choice of language use in their classrooms. I asked the teachers to describe their teaching contexts in order to freeze a snapshot of their perceptions about their knowledge of teaching strategies and their practices in multilingual classrooms as I wanted to understand the world in which they were operating. Phase one data focussed on a sample of students who were studying for qualifications at the NMMU off-campus sites (see table 1.1) throughout the Eastern Cape, viz. those studying towards an Advanced Certificate in Education: Mathematics, Science and Technology (ACE: MST) and students enrolled for a BEd Honours (Mathematics and Science) qualification.

Table 1.1

Participants in phase one: Demographics and number of students

Centre	**Number of students ACE:MST**	**Number of students B Ed Honours**
Port Elizabeth	28	32
King William's Town	33	33
Kokstad	27	29
East London		30
Ngcobo		29
Mthatha	54	26
Queenstown	34	
Total number of students	176	179

Because of awareness of the pressures that teachers are under to answer what they think their lecturer requires, the language module in the ACE: MST was designed to open a space for the students to express their emotions about their language issues in poetry and to write about their own teaching milieus. This was done to provide a window of opportunity for them to reflect on their identity and worldviews without the constraints of assessment. The aim was to extend the common ground between the students and their lecturers where each others' positions were valued and respected. Both quantitative and qualitative data from the questionnaires and the qualitative data from poetry and reflective writing were used in an attempt to gather data for the first objective and to answer the question, "What are Eastern Cape teachers' perceptions about language strategies and language usage in multilingual mathematics classes?"

The same cohort of BEd Honours (Mathematics and Science) students, from centres scattered around the Eastern Cape (see table 1.1) was exposed to an intervention that was designed to raise awareness of dialogic teaching practices, particularly exploratory talk. They learned the strategies experientially through various tasks and exercises, then wrote action research assignments on their own attempts to introduce exploratory talk into their classrooms. This section of the study was aimed at fulfilling the second objective, to research the design and implementation of an intervention for educators to promote the introduction of dialogic practices. Through experiential learning I hoped to create the common ground between teacher and learner of a shared understanding of the frustration and anxiety that occurs in multilingual mathematics classes.

5.2 Phase two

The second phase of the study was 'funnelled' down to three schools in Port Elizabeth. In this study the schools are called North Primary School, South Primary School and West Primary School, which are not their real names. Three teachers, of grade seven mathematics classes in the three different schools were identified as a convenience sample to teach target groups of learners; however, one teacher taught two grade seven classes, so both his classes were included as target classes in the study. Two classes, taught by other teachers in the same school, and one class from each of the other schools were identified as control groups of learners. All four target groups and four control groups were tested using pre- and post-tests of Raven's Standard Progressive Matrices (RSPM), Admissions and Placement Assessment Programme (APAP) Numeracy tests and APAP English skills tests (Raven, Court & Raven, 1995; Watson, 2004a). These tests were chosen as the RSPM test is purported to be language- and culture-free and tests reasoning and logical thinking. The numeracy test presented mathematical language and tested basic numeracy skills and the English skills were unrelated to mathematical language but related to English language as a subject of study. The target educators were observed teaching in their classrooms on a regular basis (four times per target teacher) throughout the intervention to monitor the implementation of dialogue. The target group educators attended workshops on the theory and practice of dialogic teaching throughout the study, while the control group of teachers did not. The observations were used to attain the third objective of this study, namely to track educators' practice in multilingual mathematics classrooms before, during and after an intervention to document if they could implement dialogic practices.

5.3 Phase three

The third phase of the study focussed on one school, North Primary School. A teacher, Mr Hlam, who had successfully introduced exploratory talk to two classes the previous year, was asked to introduce the strategy to a new cohort of two grade seven classes in 2008. He had not taught these learners previously and they had not been exposed to dialogic teaching practices beforehand. The remaining two grade seven classes at the school, who were taught by teachers who had not been exposed to the intervention, were used as control groups. The target teacher's practices were observed on a regular basis (ten times over the period of the intervention) in order to track his practice before, during and after the intervention to shed further light on the third objective. Again the target learners were observed and both target and control classes were tested pre- and post- the intervention using

RSPM, numeracy and English skills tests. The quantitative studies of both phases two and three were designed to shed light on the final objective of the study, which was to find out whether the introduction of dialogic practices, particularly exploratory talk, could significantly increase mathematical reasoning, numeracy and English skills in multilingual mathematics classrooms.

The results of phases one, two and three were analysed as a comprehensive whole in an attempt to answer the focal question of this study, namely, “Can the introduction of dialogic practices, particularly exploratory talk, increase reasoning skills, numeracy skills and English skills in multilingual mathematics classrooms?”

6. SAMPLE AND SETTING

As noted earlier, the teachers who participated in this study were convenience samples as they were drawn from students who were studying for formal qualifications through NMMU (phase 1), or were teachers who had previously studied at the NMMU or who were known to the researcher (phases 2 and 3).

6.1 Phase one

The first phase of this study included students who were studying for two different qualifications. A cohort of 176 ACE: MST students were studying a language module called ‘Language, Thought and Context’. They attended block session lectures with NMMU trained tutors in Port Elizabeth, King William’s Town, Kokstad, Mthatha and Queenstown. The students (teachers) taught mathematics and science in rural, peri-urban and urban schools in Port Elizabeth, Grahamstown, Graaff Reinet, Uitenhage, King William’s Town, East London, Butterworth, Fort Beaufort, Mthatha, Maluti, Mbizana, Matatiele, Mount Frere, Mount Ayliff, Idutywa, Cofimvaba, Lusikisiki, Ngcobo, Libode, Qumbu, Queenstown, Lady Frere, Cradock, Whittlesea, Sterkspuit and Molteno, a fairly representative sample of teachers throughout the Eastern Cape. The teachers had at least three years' teaching experience (a requirement to be registered for the ACE programme), and many had many more experience than this minimum requirement.

Phase 1 of this study also included 179 BEd Honours (Mathematics and Science) students enrolled at NMMU teaching centres in Port Elizabeth, East London, Kokstad, Ngcobo, King William's Town and Mthatha who were engaged in a semester module called 'Teaching Mathematics in Multilingual Classrooms'. This module was designed to introduce teachers to the theory and practice of dialogic practices, especially exploratory talk, and to make them participant observers in their own classrooms where they reflected on their own language practices and were required to comment on the use of exploratory talk in their classes. This convenience sample included teachers of more than five years' teaching experience from schools in rural, peri-urban and urban schools. I chose this cohort because I personally taught the module in all the centres in the Eastern Cape and, as such, had easy access to the students and was able to build up a rapport with them over the course of the contact sessions.

6.2 Phase two

The three schools (North Primary School, South Primary School and West Primary School) selected for phases two and three of the study were drawn from township areas in Port Elizabeth. These schools constituted a convenience sample as the teachers had either recently graduated from NMMU with mathematics and science qualifications or had attended workshops at the university and, as such, were known to the researcher. Mr Hlam taught at North Primary School; Mr Mzondo taught at South Primary School and Ms Zondani taught at West Primary School. The names of teachers and schools have been changed for anonymity. The teachers' schools were easily accessible for observation visits by the researcher; and the teachers were within a short distance from the university. They were willing and able to attend workshops on the research strategy after school hours if asked to do so. The three schools selected were all previously disadvantaged and similarly sized and resourced schools in Port Elizabeth. Four classes (two from one school) were selected as target classes and four (also two from the same school) became control classes. The selection of target classes was random except that where one teacher taught two grade seven classes, both were considered as target classes. The same number of control classes was selected from that school so the entire grade seven year was included in the study.

6.3 Phase three

One of the schools that participated in the 2007 study was selected to be studied in-depth during 2008 as the teacher had demonstrated that he had considerable expertise in introducing dialogue in his classroom. This school was also chosen as the school principal had acknowledged the efficacy of the programme and requested that the intervention be repeated. The progress of the introduction of exploratory talk to the target classes was observed and documented, classroom observations and interviews were undertaken, and the same pre- and post-tests used in phase two were administered to the learners. Two control classes were pre- and post-tested in the same school. As in the previous year, all the grade seven learners in the school participated in the study.

7. DATA COLLECTION

As stated earlier, both quantitative as well as qualitative data were generated in various ways.

7.1 Quantitative data

The quantitative data were generated from two sources: the questionnaire the BEd Honours students completed in phase one and the results of the pre- and post-test scores of the target and control groups of learners in phases two and three, that is the results of the

RSPM tests which assessed reasoning skills, the standardised APAP Numeracy Skills criterion-referenced tests which tested basic numeracy and mathematical language, and the APAP English Skills criterion-referenced tests that tested general English competence (see chapter three for more details on these tests). The data were analysed statistically in order to reveal any statistically significant trends between and within schools and years.

7.2 Qualitative data

Qualitative data were generated from written reflections sparked by the open-ended questions of the questionnaire, as well as reflective writing and poetry submitted by the teachers. Various tasks and exercises were introduced in the BEd Honours module and the data generated by inspection of these instruments were qualitatively analysed. The research methodology also used teacher reflections and descriptions of their lessons, observations of the introduction of exploratory talk into their classrooms during phase one, and analysis of videos clips of interaction among learners as they practised the tenets of exploratory talk in classroom situations during phases two and three.

During the ACE: MST and BEd (Honours) contact sessions discussions were held during workshops and during feedback on assessment of assignments and questionnaires. Videotapes were made of the discussions during the contact sessions in each centre. The intervention and observation in the schools in both years was conducted by a team of NMMU researchers who triangulated their observations and conclusions through regular planning meetings and reflection sessions. The lesson observations were documented using observation checklists (see Appendix H) and video recordings. Digital recorders were used to document discussions in meetings for further reference.

8. ETHICAL ISSUES

The students were assured of anonymity and confidentiality. Written permission from the participants was obtained for data to be used for research purposes only. The students were aware that they were fully entitled to refuse permission and could withdraw from the study at any time. For the final two phases in the classrooms, permission was obtained from the principal and teachers to use the observations for research purposes only. Again anonymity and confidentiality have been ensured. All video, paper and electronic data has been stored securely at the NMMU Bird Street Campus.

9. CLARIFICATION OF TERMS

In this study I have used the terms ‘bilingual’ and ‘multilingual’ seemingly interchangeably to represent classes in which two or more distinct languages are used for learning and teaching. In the same vein I have used the terms ‘primary language’, ‘main language’ or ‘mother tongue’ to describe the language a person feels most comfortable using. Usually a child learns the basis of their first language from their family, as opposed to a second language, which they could learn at school. Learners of English language could be referred to as English Second Language (ESL) learners or Second Language Acquisition (SLA) learners or English Additional Language (EAL) learners, but I have preferred the term ‘multilingual’ learners. I have also varied the term ‘teacher’ with ‘educator’; and the term ‘target’ with ‘experimental’ to describe the groups that experienced an intervention.

I have used Alrø & Skovsmose’s (2004:3) definition of ‘dialogue’ as “an inquiry process which refers to a presentation (and confrontation) of two or more different (and contradictory) points of view, with the aim of identifying a conclusion that can be agreed upon”. The inquiry process includes an exploration of participant perspectives as well as a willingness to suspend one’s pre-understandings.

The definition I have used for discourse is from Tsui (2004, in Airey, 2009:29): "A discourse is a process in which meanings are negotiated and disambiguated, as well as a process in which common grounds are established and widened". Gee (1994:143) uses 'Discourse' with a capital 'D' to represent "a socially accepted association among ways of using language, of thinking, feeling, believing, valuing and acting that can be used to identify oneself as a member of a socially meaningful group". He considers discourse to be subset of Discourse. Mathematical discourse includes the representations, tools and activities of mathematics.

Finally, I have used the term 'common ground' in the title of this study to represent the shared space of learning between teacher and student with respect to the intended object of learning (Airey, 2009). I have also used 'common ground' as the intersection between circles in Venn diagrams of different contexts that I have constructed for visual clarity. Other definitions of terms that may need explanation appear in Appendix A.

10. A NOTE OF TRANSCRIPTION

A simple transcription format has been used in which speech is written in grammatical words and phrases to represent the sense of what was being said. To distinguish English from isiXhosa utterances, for clarity, I have italicised the isiXhosa words. Non-verbal aspects of communication are placed in brackets.

11. SUMMARY AND OUTLINE OF CHAPTERS

In this chapter I have described the research problem and stated the main research question together with the objectives that I aim to achieve in this study. I have given a background to the situation in South Africa, and particularly in the Eastern Cape, where expertise in both mathematics and English language is limited among learners. I have looked briefly at recent research that has been done in this field, have placed the study in a sociocultural framework based on Vygotsky's (1978) recognition of the importance of language and social interaction in learning, and have outlined Mercer and Littleton's (2007) recommendations on the introduction of exploratory talk. An overview of the study has been mapped, the sample has been described, and an overview of the research design and data collection methods has been given. Finally, I have touched on ethical issues and the clarification of some of the terms used.

Chapter two includes an expanded review of pertinent literature while the research design and methodology is dealt with in more depth in chapter three. The results generated via quantitative data techniques are presented in chapter four, while the qualitative results are recorded in chapters five (phase one) and six (phases two and three). These results are discussed in chapter seven with reference to the objectives of this study, while the relevance and implications of the findings of the study are considered in chapter eight.

CHAPTER TWO

LITERATURE AND RELEVANT READING

1. INTRODUCTION

In the previous chapter an overview of the research study was described. This chapter provides a general background necessary to situate the study through an overview of relevant research. The philosophical stance which underpins this study is described within the sociocultural framework provided by Vygotsky (1978). In order to link second language learning and the learning of mathematics, this study promotes the use of dialogue in the learner and teacher's main language, together with code-switching, to promote easy communication in order to improve their mathematical reasoning skills through social interaction. Mercer and Littleton's (2007) research into dialogue and the development of learners' thinking are scrutinized. Gee's (1994, 2004) concepts of discourse, Fairclough's (2001) concepts of power and social practice and Setati's (2005a) emphasis that language is always political, are also highlighted in a sociolinguistic educational context. The field of research into multilingual and multicultural mathematics teaching and learning is mapped by looking at research conducted in Africa by, among others, Heugh (2002, 2008), and in South Africa by Adler (2001) and Setati (2001, 2005a).

Concept cartoons have been used extensively in science education research and mathematical concept cartoons have been generated in the United Kingdom since 2007. A set of mathematics concept cartoons published by Dabell and Mitchell (2007) were used in this study in order to trigger exploratory talk in mathematics classrooms and, as such, the theory and practice of using triggers to generate classroom discussion is reported. The choice of the particular quantitative and qualitative tools used in the study is explained. The Language in Education Policy (LiEP) and statements in the National Curriculum Statement (NCS) promulgated in post-apartheid South Africa are noted. Thereafter, attention is drawn to various studies and statistics that illustrate the state of mathematics teaching and learning in South Africa, and which lay bare the urgent need for interventions in order to raise the mathematics competences of our learners to the standard required for an industrialized country.

2. PHILOSOPHICAL FRAMEWORK

This research is socioculturally situated and is located within a Vygotskian framework. The cognitive development perspective of this study was based on the writings of Piaget and Vygotsky. From Piaget, a developmental psychologist, arises the premise that when participants co-operate, socio-cognitive conflict occurs which it is possible to resolve, and move forward, through discussion. Any unsound reasoning would be exposed in the discussions and modified (Piaget, 1952). Vygotsky, who envisioned knowledge as a conversation of mankind, propounded the inherently social nature of all human processes and saw conflict as dialectic (Vygotsky, 1978). His work is based on the premise that knowledge is social and is constructed via co-operative efforts to learn, understand and solve problems (Johnson, Johnson & Holubec, 1993). Fundamental to a sociocultural explanation of learning and development is Vygotsky's proposal that children's' intellectual development is shaped by the acquisition of language, as this makes dialogue possible between and among children and other members of the community (Mercer & Littleton, 2007). Vygotsky believed that interaction between a child and others (discussion, dialogue, argument) at an intermental level became internalized as a basis for intramental reflection and logical reasoning – and that there is a dialectic relationship between the intermental and intramental, so that understanding occurs through interaction with others.

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category.
>
> (Vygotsky, 1978: 11)

Vygotsky viewed the construction of knowledge as a social activity where more able adults and peers mediate the child's encounters with the world that she or he is learning about. The knowledge gained is internalized through participating in the cultural life of the community and using cultural tools. Rogoff (1990:vii) concurs that children's development "occurs through guided participation in social activity with companions who support and stretch children's understanding of, and skill in, using cultural tools" .

However, in language the paths are often overgrown with trips and traps, which hamper the journey as Wittgenstein (1931, as cited in Sfard, 2008:68) clearly perceived:

> Language sets everyone the same traps; it is an immense network of easily accessible wrong turnings. And so we watch one man after another walking down the same paths and we know in advance where he will branch off, and where to walk straight on without noticing the side turning, and so forth. What I have to do then is erect signposts at all the junctions where there are wrong turnings so as to help people past the danger points.

Mathematics is itself a specialized discourse and when one is a learner of mathematics, however clear and well written the signposts at junctions are, one sometimes cannot read nor comprehend them. If mathematics is being taught and learned in a foreign or additional language, the 'signposts at all the junctions' need to be clear and explicit.

3. CULTURAL REPRESENTATIONS

Gee (1994) echoes Rogoff's (1990) claims regarding cultural tools and maintains that cultural models exclude English second language learners from participating comfortably in educational discourse as they do not know the 'rites of passage' for entry to the 'club' (Gee, 1994: 143). In the case of South Africa the dominant mainstream cultural model in schools is expressed through the medium of English, which marginalizes the non-mainstream students (Webb & Webb, 2008a). Exacerbating the problem is the fact that teachers themselves grapple with competency in English (Childs, 2008). Gee (1994) warns that mainstream dominant discourses, and particularly school based discourses, privilege those who have mastered them (mainstream/insiders) and do significant harm to those who have not (non-mainstream/ outsiders) (Gee, 1994:158).

Lerman (2001), using Bernstein (1970, as cited in Lerman, 2001) and Gee's (1994) arguments, posits that there is evidence to support the premise that disadvantaged groups do not perform as well as advantaged groups. The disadvantage stems from the different linguistic codes embedded in each language group by families, communities and schooling. Lerman (2001) reinforces Gee's (1994) standpoint that people are positioned in practices as powerful or powerless according to the structure of the discourse and the personal histories of the participants. Lerman and Zevenbergen (2004) maintain that classroom practices are cultural representations that are accessible to students according to their own individual cultural backgrounds. They add that learners bring varied backgrounds and discourses with them to school and encounter different classroom experiences based on the teacher's own perceptions and identity. Lerman (2001) also claims that questioning is an integral part of classroom practice and notes that different types of questioning influence the acquisition of knowledge and social interaction in the classroom. Bernstein (2000, as cited in Lerman & Zevenbergen, 2004) argues that it is not possible to convey knowledge without values; and knowledge and cultural values are relayed to learners through pedagogic discourse. As noted in chapter one, Tsui (2004, cited in Airey, 2009:29) defines 'discourse' as "a process in which meanings are negotiated and disambiguated, as well as a process in which common grounds are established and widened".

In this study, which is situated in a convoluted and entangled context where the medium of instruction is not the main language of either teacher or learner, I endeavour to show that common grounds between teacher and learner can be widened through using dialogic practices.

4. DISCOURSES AND DIALOGUE

Gee (1994:xix) describes discourses as “ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing that are accepted as instantiations of particular roles by specific groups of people.”. He maintains that discourses are always social and that each of us is a member of many different discourses.

4.1 Discourses

Gee (1994) views language as being divided into one primary and many secondary discourses. The primary discourse is the oral language learned as a child, whereas secondary discourses are specialized discourses which are used in specific social sites and situations other than the home. These secondary discourses are mastered by building on and extending the primary discourse. Gee (1994) calls the control of these secondary discourses ‘literacy’. Therefore mathematical literacy, in Gee’s sense, becomes the ability to use the specialized language of mathematics in a particular site in society (Airey, 2009).

Pirie (1991) noted that there is a very real danger of learners not understanding the mathematical register, or of using different interpretations of the informal language used with peers, and opened the doors to studying peer discussion. She illustrated the effect of group problem solving on the language learners used and the affect the use of language had on the problem solving process. Pirie (1991) emphasizes that there must be ground rules on how learners work in groups in order for the group interaction to be effective and Mercer and Littleton (2007) spell out explicit guidelines on ground rules that are necessary for the development of dialogue in groups. For example, learners should share relevant ideas and help each other to understand the problems set. They must listen to each others’ contributions and respect their ideas, even if they disagree. Learners can challenge and counter-challenge arguments, but they must give reasons and substantiate their challenges. If possible they should work towards an equitable consensus (Mercer & Littleton, 2007:58).

In this study I look at the discourse of mathematics and suggest a strategy with explicit guidelines that could aid second language users of English (both teachers and students) to more effectively participate in mathematical discourse. The strategy focuses on the development of primary discourse dialogue to scaffold the development of secondary discourse (in this instance, mathematical discourse).

4.2 Dialogic perspective of teaching and learning

A dialogic perspective of learning, based on the Vygotskian viewpoint, that cognition is aided by cultural processes, claims that dialogism is ‘practice-oriented’ and communication is seen as an ongoing process of negotiation between people and contexts (Barwell & Kaiser, 2005). A dialogic view of learning presumes that mathematics knowledge is created in the classroom through reasoning and argumentation between teacher-and-learner and learner-and-learner (Barwell & Kaiser, 2005). In some instances the reasoning need not necessarily be verbal as a gesture, phrase, equation or diagram can evoke a whole dimension of shared meaning (Lerman, 2001).

Alexander (2004) draws on the work of Bakhtin (1981) in describing dialogic teaching as that which takes place when learners’ thinking and reasoning on a particular topic is moved forward by both the teacher and the learner making significant (and substantial) contributions, as opposed to monologic teaching that is characterized by ‘teacher talk'. Dialogic teaching includes questions that are structured so as to provoke thoughtful answers and answers that provoke further questions that are seen as the building blocks of dialogue.

Another feature is that exchanges between an individual educator and a learner, or between learners, are chained into coherent and continuing lines of enquiry. These features are endorsed by other researchers (Mortimer & Scott, 2003; Rojas-Drummond & Mercer, 2004). Mercer and Littleton (2007: 42) summarize the attributes of dialogic teaching by describing situations such as when students are given opportunities, and encouragement, to question, state points of view and comment on ideas and issues that arise in the lessons; when the educator engages in discussions with students which explore and support the development of their understanding of content; when the educator takes students' contributions into account in developing the subject theme of the lesson; in devising activities that enable students to pursue their understanding themselves, through talk and other activities; and when the educator uses talk to provide a cumulative, continuing, contextual frame to enable students' involvement with the new knowledge they are encountering.

Mortimer and Scott (2003) developed a grid to explain four classes of communicative approach (table 2.1). The interactive – non-interactive axis indicates how actively the teacher and learners are involved in the dialogue whereas the authoritative – dialogic axis represents the extent to which the teacher, or the learners', ideas dominate in the classroom as regards content and direction.

Table 2.1

Mortimer and Scott's four classes of communicative approach (2003)

	Interactive	**Non-interactive**
Authoritative	interactive/ authoritative	non-interactive/ authoritative
Dialogic	interactive/ dialogic	non-interactive/ dialogic

Interactive/dialogic means the learners could be asked by the teacher for their individual views, which are written on the board, the teacher then asks if others agree and whether they wish to add or elaborate; however no evaluation of answers is given or definite direction that could close down learners' reasoning. Non-interactive/dialogic indicates that the learners talk among themselves, while interactive/authoritative dialogue suggests that the teacher acts explicitly as an expert and directs the conversation along predefined routes. Non-interactive/authoritative communication means that the teacher lectures with no input from the learners (Mortimer & Scott, 2003).

Mortimer and Scott (2003) make two claims. Firstly that the different types of 'teacher talk' varies according to the extent to which the teacher is being positioned as an 'expert' and the extent to which learners are offered possibilities for substantial contributions. Secondly, the different types of talk are not represented on a continuum from good to bad. There may be occasions when teachers are not concerned about exploring learners' views, as when introducing new concepts.

The key is that the educator knows he or she has a repertoire at his/her disposal for using language as a tool for teaching and learning. In multilingual classrooms the further complication of learners not understanding the teachers' language results in adding strategies (such as re-voicing, code-switching and translating) to the repertoire. The crucial issue is that the teacher makes the correct choice so that dialogue supports the understanding of both the language and the mathematical concepts for as many learners in the class as possible. In Eastern Cape classrooms, personal observation has shown that there is a paucity of explicit verbal argumentation between learner-and-learner and that there is little opportunity that learners can be guided towards greater understanding by a more capable peer through social interaction and dialogue (Taylor & Vinjevold, 1999; Webb & Webb, 2004). The approach used in this study emulates the strategy used by Mercer (1995, 2004) towards dialogic learning, i.e. understanding and encouraging learner talk and discussion so that their reasoning becomes visible.

5. ZONE OF PROXIMAL DEVELOPMENT

Vygotsky's theorizing centres on the Zone of Proximal Development (ZPD). Most assessments test what a learner can achieve on his or her own; however, Vygotsky maintains that what a child can achieve when given a measure of support and guidance lies within the child's ZPD. These are attainments that the child would be able to achieve to the same level unaided at some time in the future. Vygotsky (1978:86) defines the ZPD as:

> The distance between the actual developmental level as determined by independent problem solving and the level and potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

Vygotsky thus expects peer interaction to be most effective when a more adept child or adult is able to assist, or scaffold, a less adept child with the kind of help that suits his/her ZPD. Piaget also maintained that peer interaction has a potentially important role to play in development, but his emphasis was on learners who were more or less at the same stages of development.

5.1 Scaffolding

The metaphor of 'scaffolding' has been used widely to encapsulate the sense of guidance that helps learners to move through the ZPD. Bruner maintains that scaffolding helps learners accomplish tasks that they would not have been able to do on their own. Bruner (1978, as cited in Mercer & Littleton, 2007:15) states:

> [Scaffolding] refers to the steps taken to reduce the degrees of freedom in carrying out some task so that the child can concentrate on the difficult skill she or he is in the process of acquiring.

Tharp and Gallimore (1998) built on the concept of the ZPD and the metaphor of scaffolding, extending the notion by characterizing the ZPD not as one point of growth for each child but as a multitude of 'growing edges' relating to all areas of competence.

> There is no single zone for each individual. For any domain of skill, a ZPD can be created. There are cultural zones as well as individual zones because there are cultural variations in the competencies that a child must acquire through interaction in a particular society… Whatever the activity in the ZPD we find assistance is provided by the teacher, the adult, the expert, the more capable peer.
>
> (Tharp and Gallimore, 1998:96)

Figure 2.1 illustrates the four stages of progression through the ZPD as adapted by Mercer and Littleton (2007:17).

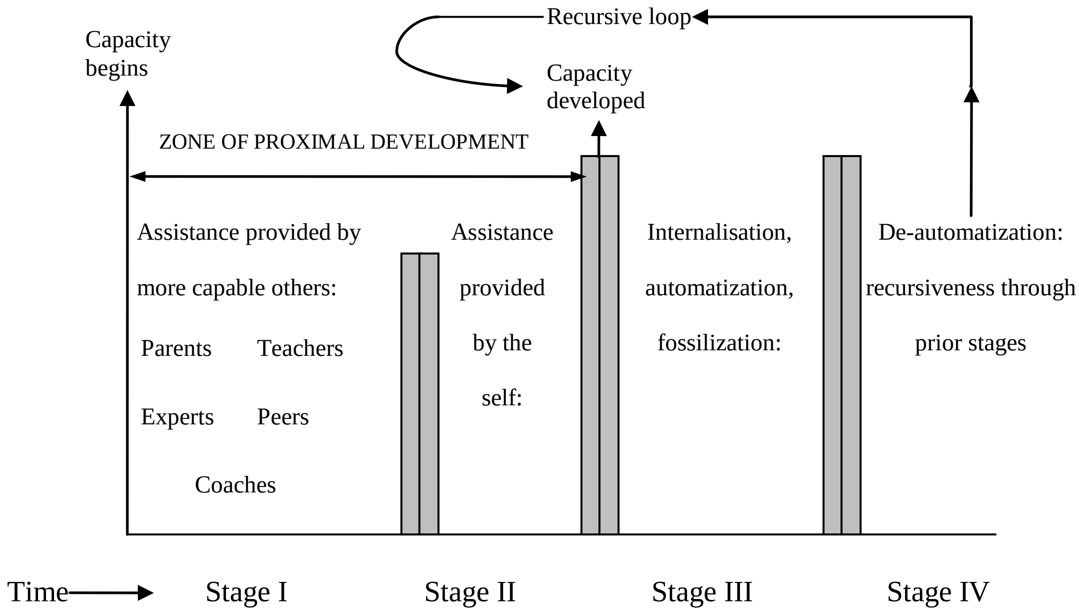


Figure 2.1 Genesis of performance capacity: progression through the ZPD and beyond (Source: Faulkner (1998) Learning relationships in the classroom, London: Routledge)

In the first stage more competent others assist the learner through scaffolding. In the second stage the learner assumes his own role as scaffolder, often by internalizing the reasoning process. In the third stage performance becomes automatic. In the fourth stage the learner regresses because of changes in the task or changes in the learning situation, and the cycle is repeated (Mercer & Littleton, 2007).

A criticism of the scaffolding metaphor is that teaching and learning interactions in schools are complex and multifaceted, and even more so in classrooms where learners cannot vocalize their needs in a language familiar to them. Teacher-learner relationships are far more fragmented than the parent-child relationship Vygotsky envisaged or the expert weaver–apprentice relationship that Tharp and Gallimore (1998) describe. Mercer and Littleton (2007) propose that a theory of teaching and learning should be separated from one-to-one relationships (ZPD) or images of concrete physical tasks (scaffolding).

> A problem with applying the concept of the Zone of Proximal Development to the school setting is that it seems to be predicated on the assessment of an individual's capabilities at one point in time, rather than with a continuing process of guided development in a collective environment. Faced with the responsibility for the advancement of large numbers of learners, teachers are expected to help their students develop ways of thinking that will enable them to travel on intellectual journeys, so that they understand and are understood in wider communities of discourse.
>
> (Mercer & Littleton, 2007:19)

An added complication for the teacher of mathematics in a multilingual classroom is that the teaching of mathematics is conducted in English, and not the learner or teacher's first language and the intellectual journeys are truncated, because learners do not understand nor are their needs understood, thus they are denied access to mathematical discourse .

5.2 Intermental development zone (IDZ)

Mercer and Littleton expand Vygotsky's concept of ZPD to an Intermental Development Zone (IDZ) that, they maintain, is a more fluid and dynamic concept and includes the dynamics of development through dialogue. (Mercer & Littleton, 2007:21)

> For a teacher to teach and a learner to learn, they must use talk and joint activity to create and negotiate a shared communicative space, the IDZ, which is built from the contextual foundation of their common knowledge and aims. If the quality of the IDZ

is successfully maintained, the adult can enable the learner to operate just above their capabilities and to consolidate this experience as new ability and understanding.

Dialogic teaching can be linked to the concept of the Intermental Development Zone (IDZ), which is a knowledge framework that is cumulative, goal-oriented, dynamic and contextual. Alexander (2004) argues that to be an effective dialogic teacher, one has to develop the understanding and reasoning of a whole class and thus will use a range of discursive strategies in order to establish and maintain a collective IDZ.

This study endeavours to train teachers to encourage talk and joint activity in mathematics classrooms in order to create a shared communicative space, in the words of this study a common ground, where new ability and understanding can be experienced.

6. TEACHING THROUGH DIALOGUE

As mentioned, in the Eastern Cape observation has shown that very little learner talk takes place (Taylor & Vinjevold, 1999, Webb & Webb, 2004). A possible reason could be that talk between learners in a classroom has traditionally been discouraged because it is seen to be disruptive or subversive (Webb & Webb, 2004).

6.1 Initiation-response-evaluation cycle

Classroom talk in general has been studied extensively over the past few decades and it appears that the most common kind of classroom interaction that takes place is the Initiation-Response-Evaluation (I-R-E) questioning cycle (Sinclair & Coulthard, 1975). This type of classroom talk, where the teacher asks a question, the learner makes a simple statement as an answer, and the teacher responds – usually merely to agree with the answer or reject it - has been criticised as a means of keeping control of the class by the teacher rather than being used as a pedagogic tool (Webb & Treagust, 2006). Furthermore, this type of communication leads learners to believe that mathematical knowledge is fixed, discovered and cannot be questioned (Barwell & Kaiser, 2005).

Most researchers in the field of classroom discussion reject this form of interaction and feel that it does not even qualify to be described as discussion. Unfortunately in multilingual South African classrooms, where learners are unable to express their reasoning in English, the I-R-E cycle abounds (Taylor & Vinjevold, 1999), particularly in the Eastern Cape (Webb & Treagust, 2006). An alternative to the IRE cycle as advocated by the National Curriculum Statement (Department of Education, 2003) is collaborative learning. It is stated that Mathematics enables learners to work collaboratively in teams and groups to enhance mathematical understanding (Department of Education, 2003).

6.2 Collaborative Learning

In everyday contexts the terms ‘collaborative’ or ‘cooperative’ bring to mind the concept of people working together in order to achieve an aim. In the classroom the term ‘collaborative learning’ has come to mean that “participants are engaged in a coordinated continuing attempt to solve a problem or in some other way construct common knowledge” (Mercer & Littleton, 2007:25). Other researchers, such as Barron (2000), share the idea that there should be a joint commitment to a shared goal among learners, which includes reciprocity and the continual negotiation of meaning. Learners need to develop a shared knowledge of the task or problem termed “intersubjectivity” by Rogoff (1990) and Wertsch (1991).

Even when learners in the Eastern Cape are seated in groups, this does not mean that they are collaborating – they could be working individually or in parallel. In fact research has shown that even when learners are set tasks specifically for group interaction, their results are rarely productive (Alexander, 2004; Blatchford & Kutnick, 2003).

Experimental studies support the opinion that discussion among learners that is sustained and focussed helps learners to solve problems as well as increasing the learning of the individual (Dawes & Sams, 2004; Wegerif, Littleton, Dawes, Mercer & Rowe, 2004).

Why then do we find so little dialogue in formal education? Barnes and Todd (1977:127) suggest that learners will engage in meaningful discussion when they are not overseen by the teacher.

> Our point is that to place the responsibility in the learners' hands changes the nature of that learning by requiring them to negotiate their own criteria of relevance and truth. If schooling is to prepare young people for responsible adult life, such learning has an important place in the repertoire of social relationships which teachers have at their disposal.

Barnes and Todd (1977), in their seminal book *Communication and Learning in Small Groups,* maintain that the interactions in a classroom require a degree of explicitness that is not necessary in everyday conversations. They claim that knowledge should be made publicly accountable - relevant information should be shared effectively, opinions should be clearly explained and explanations examined critically. They also argue that successful group work relies on learners sharing views about what is relevant to the discussion and having a joint conception about what they are trying to achieved.

Other researchers, such as Mercer and Littleton (2007), concur with this view. Their research claims that not only are the quality of talk as well as the social interaction significant, but also that collaborative talk could be viewed as a social form of thinking.

> …talk and social interaction are not just the means by which people learn to think, but also how they engage in thinking… [D]iscourse is cognition is discourse … One is unimaginable without the other.
>
> (Resnick, Pontecorvo & Säljö, 1997, as cited in Mercer & Littleton, 2007:29)

Sfard (2008: xvii) endorses this view and takes it one step further from the intersocial to the interpersonal in her book, *Thinking as Communicating*, as she coins the term 'commognition' as a combination of communication and cognition and stresses that individual thinking, the individualized version of interpersonal communication, and interpersonal communication are two facets of the same phenomenon. Both Piaget and Vygotsky interpreted the role of thought as ‘inner speech’. Piaget felt that speech was initially a means of social interaction which later became a means of thought through inner speech, whereas Vygotsky felt that individual development was inextricably linked to the social milieu. He envisaged social speech as a means of interacting with others and inner speech as a means of to talking to oneself – to reflect, think and self-regulate (Tudge & Rogoff, 1999).

Cooke (1998) developed learning materials for multilingual learners. He claimed that talk provides the chance for students to reflect, hypothesize and verbalize new learning and test out their understanding of a situation , which he called ‘thinking aloud’. The process of thinking aloud enabled learners to explore new information and concepts and build their understanding of them by responding to other students’ ideas and by getting a response to their own ideas. He believes that not only do learners need to interact verbally with each other and the teacher, but also that in learning about mathematics, a vital part of that learning is being able to handle the language conventions and genres in which mathematical discourses are framed. Cooke (1998:7) states:

> This approach embodies the notion that students need to use language to learn in all subject areas and at the same time develop their language skills. In other words all lessons should offer students activities which effectively integrate language and subject content.

Cooke (1998) maintains that collaborative learning activities provide learners, using an additional language for learning, the opportunity to acquire English language skills in a cognitively demanding yet linguistically and socially supportive situation. The activities aim to provide opportunities for learners to engage with the knowledge, concepts and skills detailed in the curriculum in a way which allows them to bring their own experience, ideas and abilities to the situation and make connections between these and the ‘new learning’ they are engaging in. In order to do this the activities often present the learning as a problem to be solved in a context which supports learners understanding and encourages reflective and problem-solving talk. The aim of the activities is to maximize the participation of both teachers and learners by providing a focus for intensive learner-learner and teacher-learner interaction. Cooke (1998) believed that collaborative learning activities are designed so that a focussed task is presented which requires purposeful discussion for its successful completion.

In order to stimulate this kind of exploratory talk according to Cooke (1998), it is necessary for the task to pose a problem to the learners. The solving of this problem will inevitably involve decisions being made. It is this need to reach decisions and justify them that potentially provides the necessity for learners to use exploratory talk productively. In the same way it presents the teacher with the chance to gain some insights into learners' thinking through listening to the group dialogue and also through asking open ended questions which encourage the learners to paraphrase, summarise and explain and thereby make their thinking explicit.

Cooke presents four activity types that can be used to stimulate "thinking aloud" by posing problems for the learners: matching activities; sorting activities; sequencing activities and ranking activities (see table 2.2). He gives examples of these activities for all learning areas.

Table 2.2

Types of Thinking Activities (adapted from Cooke. 1998: 33)

	Types of thinking	**Key Visuals**	**Content examples**
Matching	Identifying, labelling, naming, describing, measuring, estimating.	Maps, labelled diagrams, tables, matrices, series of maps/diagrams with captions.	Matching names of parts to diagram of the circle. Matching names to pictures of angles.
Sorting	Classifying, defining, generalizing, applying taxonomy criteria, comparing, contrasting.	Branching diagrams, tables, tick charts, Venn diagrams, headed columns.	Classifying quadrilaterals. Sorting examples into expressions and equations. Sorting numbers into rational and irrational categories.
Sequencing	Sequence, describing processes, instructing, narrating, chronological order	Time lines, flow charts, cycle diagrams, picture/diagram sequence	Working out the logical order of solving a geometry rider.
Ranking	Evaluating, judging, applying criteria, selecting, comparing, judging relative size, importance, value or other measures.	Rating table, continuum, quadrant, scoring chart, table, bull’s eye chart.	Comparing trigonometric ratios in quadrants. Comparing the sizes of angles.

The sample of ACE:MST students in this study were studying for a module called Language, Thought and Context which is offered as part of the qualification. Stephen Cooke’s (1998) ideas are translated into mathematical activities which teachers could incorporate into their teaching plans (see Appendix C).

7. TEACHER CHARACTERISTICS AND STRATEGIES

If social and interpersonal communication is an important facet of learning, what strategies can teachers employ to facilitate learning under these circumstances? Rojas-Drummond and Mercer (2004), who studied interactions in Mexican classrooms, found that teachers whose learners achieved highest results in their study demonstrated the following characteristics:

- They used question-and-answer sequences not just to test knowledge but also to guide the development of understanding. These teachers often used questions to discover the initial levels of learners' understanding and adjusted their teaching accordingly, and used 'why' questions to get learners to reason and reflect about what they were doing;
- They taught not just 'subject content', but also procedures for solving problems and making sense of experience. This included teachers demonstrating the use of problem-solving strategies for children, explaining to children the meaning and purpose of classroom activities and using their interactions with children as opportunities for encouraging children to make explicit their own thought processes;
- They treated learning as a social, communicative process. These teachers used questions more for encouraging learners to give reasons for their views, organizing interchanges of ideas and mutual support amongst learners and generally encouraging learners to take a more active, vocal role in classroom events.

(Mercer & Littleton, 2007:40)

The above characteristics were incorporated into the classroom observation checklist that was devised to document teaching and learning in phases two and three (see Appendix H). In this Eastern Cape study the teacher, whose learners achieved the most significant increases in their learners' Raven's Progressive Matrices scores of mathematical reasoning, consistently exhibited the above traits.

7.1 Questioning

According to Mercer and Littleton (2007) questions can serve many different communicative roles, for example to test learners' knowledge; to manage classroom activities or to assess learners' understanding – or a combination of functions. They maintain that teacher questioning can be used as functions in the development learners' learning and their own use of language as a tool for reasoning. They can encourage learners to make explicit their thoughts, reasons and knowledge and share them with the class; they can model useful ways of using language that children can appropriate for themselves in peer group discussions; and they can provide opportunities for children to make longer contributions in which they express their current state of understanding, articulate ideas and reveal problems they are encountering (Mercer and Littleton, 2007: 36).

In an environment where learners are not competent in the LoLT it is difficult for a teacher to create a classroom climate where the above functions take place; however, in this study research has shown that under certain circumstances and using specific strategies, learners can make appreciable strides in mathematical reasoning. In this case the teacher used questioning to draw the learners along a particular line of reasoning; used words such as “we” and “us” to emphasise solidarity; used dialogue to scaffold the learners’ reasoning and actively solicited learners’ views without giving evaluative feedback which could have closed down the, at first, halting responses. The teacher encouraged the learners to use their main language for discussion, but modelled the mathematical language required for the task at hand.

Boaler (1997) concentrated on questioning as a means of moving towards conceptual discourse. She encouraged both teacher and learners to ask, “Why?”, “How do you know?” or “What if…?” in order to lead learners to reflect and discuss their reasoning. This type of questioning is divergent as the questions open up the possibility of different responses. Convergent questions, on the other hand, are closed and often lead to limited responses or one-word answers.

According to the Natal College of Education guide (1997) questioning is an important skill in the classroom; however, many learners are not asked to think aloud; to put their thoughts in order; to form reasoned conclusions; to analyse problems; to focus on main points; or to make up questions of their own. In other words, learners are often not encouraged to think for themselves or to learn to enquire. Learners often give poor answers in examinations, partly because they have never been encouraged to give extended answers orally in class. In order to be a good questioner, the teacher must also be able to listen to the learners' responses. This helps to encourage interactive learning. Table 2.3 lists possible reasons for a teacher to use questioning in the different stages in a lesson and it is included in the observation checklist that I compiled to record classroom observations.

Table 2.3

Purposes of questioning (Source: Natal College of Education, 1997)

Stage in lesson	**Purpose for questioning**
Introduction	establish human contact; assist in introducing a topic; discover what the class knows; revise previous work; pose problems which lead to the subject of the lesson.
Explanation	maintain interest and alertness; encourage reasoning and logical thinking; discover if learners understand what is going on.
Whole class	focus and clarify; lead the children to make observations and draw inferences for themselves; clear up difficulties and misunderstanding and assist individual learners.
Conclusion	revise the main points of the lesson; test the results of the lesson, and the extent of the learners' understanding and assimilation of the material taught; suggest further problems and related issues.

Socratic questioning is a type of questioning that can be used to cross examine another person's claims and premises (Paul & Elder, 2008). It involves asking a series of questions around a central issue. A question is answered with a question in order to tease out the reasoning behind it. The teacher forces the learner to defend his/her position by offering arguments against it. Very often there is no correct answer but the reasoning behind the stance is probed and critical thinking is engendered. It is not only the teacher who is responsible for judicious questioning in the classroom, but the role can be played by learners among themselves in group interactions.

7.2 Group interaction

As noted previously, from personal observation in the Eastern Cape and in other areas, learners work *in* groups but seldom *as* groups (Webb & Webb, 2008a). Although they sit in close proximity their interaction is limited to disagreements and disputes; group interaction is seldom focussed on talk neither is it educationally productive. They may interact, but they seldom ‘interthink’ – and often work totally independently of each other (Alexander, 2004; Dawes & Sams, 2004; Mercer & Littleton, 2007). In many cases one learner dominates the discussion to the extent that others withdraw, or assume passive roles (for example, scribe) in the group; sometimes learners ignore each other’s ideas and stick to their own agendas. In some cases the emphasis is on a power struggle concerning a disagreement and the task is marginalized. This creates the possibility of learners engaging in personal attacks on each other that are irrelevant to the lesson (Barnes & Todd, 1995; Kutnick & Rogers, 1994). In Eastern Cape classrooms group discussions invariably take place in the participants’ home language although in mathematics classes mathematical terms are expressed in English.

8. TYPES OF TALK

Terms originally defined by Barnes and Todd in 1995 are used by Mercer (1995) to characterize talk between learners into a three-part typology in order to reflect different ways in which learners talk together. As reported in Mercer and Littleton (2007:59):

Firstly, disputational talk is characterized by disagreements and individualized decision-making and where short assertions and counter-assertions are made. There are few attempts to pool resources, to offer constructive criticism or to make suggestions. Disputational talk has some characteristic features – short exchanges, consisting of assertions and challenges or counter-assertions.

Secondly, cumulative talk takes place when learners build positively but uncritically on statements and assertions made by other learners. Partners use cumulative talk to construct 'common knowledge' by accumulation. Cumulative talk is exemplified by repetitions, confirmations and elaborations.

Finally, exploratory talk is actualised when learners engage critically, but constructively, with others' ideas, and justifications and alternate hypotheses are offered with joint consensus eventually being reached. Statements and suggestions are offered for joint consideration. These may be challenged or counter-challenged but challenges are justified and alternative hypotheses are offered. Partners all actively participate, and opinions are sought and considered before decisions are jointly made. Compared with the other two types of talk, in exploratory talk knowledge is made more publicly accountable and reasoning is more visible in the talk.

8.1 Exploratory talk

Central to exploratory talk is the belief that collaborative thinking skills can be taught explicitly in order to enable both teachers and learners to understand talk as 'thinking aloud with others' (Monaghan, 2004). This resonates with the aims of the new South African curriculum, that collaborative and constructivist measures are important for meaningful learning to take place (Department of Education, 2003). Unfortunately exploratory talk, the type of discussion that is generally believed to best support constructivist learning, is the form of discussion least often heard in classrooms (Lemke, 1990).

Mercer and Littleton (2007) expand on their descriptions of the different types of talk: Disputational talk rarely results in joint reasoning and knowledge construction as it often degenerates into defensive stances and personal diatribes associated with bickering (Alexander, 2004; Dawes & Sams, 2004; Mercer & Littleton, 2007). Information is either flaunted or withheld. Despite the fact that there is interaction, it often involves individualized reasoning. With cumulative talk ideas are shared and consensus reached; however, there is seldom any challenge, or the constructive conflict of ideas whilst constructing knowledge. Cumulative talk operates hand-in-hand with empathy, trust and solidarity and results in repetition and confirmation of other learners' proposals and suggestions. Exploratory talk foregrounds reasoning and as such is most applicable in mathematics classrooms. Learners present their ideas clearly and explicitly so that they can be analysed and evaluated by others in the group. Learners compare possible explanations and reach decisions jointly. Exploratory talk combines constructive conflict and the open sharing of ideas. It thus uses conversation to reach visible, rational consensus. Mercer and Littleton (2007) maintain that exploratory talk typifies language that includes the principles of accountability, clarity, constructive criticism and receptiveness to well argued counter-proposals. These are principles highly regarded in adult educated discourse and thus learners should be exposed as early as possible to the means of using language as a collective reasoning tool. Alexander (2004:9) warns that classrooms should not be places where teachers do most of the talking; where questions are closed and where, instead of creative problem solving, learners use their energy to spot the correct answer; and where discussion is subverted by one-way communication from the teacher. Unfortunately in the Eastern Cape many factors, such as teachers' lack of content knowledge and lack of fluency in English, conspire to make the majority of the mathematics classrooms resemble Alexander's caveat scenario (Taylor & Vinjevold, 1999; Webb & Webb, 2004). The practice of using exploratory talk in the classroom does not occur spontaneously, or there would be many more evident examples of meaningful discussion in classrooms which could result in enhanced reasoning and understanding.

Exploratory talk has to be taught explicitly and practised continually for results to be evident (Mercer & Littleton, 2007). To this end, learners should be taught that their understanding requires a high level of speaking and listening (in any language that they understand). In order for this to occur ground rules for speaking and listening should be formulated collectively by the teacher and learners so that the ownership of the rules helps the groups to implement them. Discussion should include all participants and mutual respect should be afforded for all persons, opinions and ideas; all relevant knowledge and information should be shared and not withheld; reasons should be requested and given for all claims; and the groups should strive to reach agreement. (Mercer, 2004)

If learners can recognize the advantages of using group work, it will encourage them to engage with each other more. Listening to a range of ideas can help them to reach a more informed decision by learning how to think aloud and expressing their ideas without fear of ridicule. By engaging in group work learners are able to think more clearly when alone. By helping others to learn learners clarify their own understanding. Talking allows learners to reflect on how and what they have learned. Often learners come to the conclusion that they can learn better together than alone. This development can only take place through the conscious guidance of the teacher, who is far more than a facilitator of learning, but "someone who can use dialogue to orchestrate and foster the development of a community of enquiry in a classroom in which individual students can take a shared, active and reflective role in building their own understanding" (Mercer & Littleton, 2007:74). Thus teachers can use classroom activities and discussion to develop Intermental Development Zones (IDZs) with learners, and among learners. The teacher becomes a key discourse guide and models ways of developing exploratory talk by asking for reasons at appropriate times and reviewing with the whole class what has been achieved and what they may have learned. The plenary session at the end of a lesson is an organized continuity of the particular IDZ experience and helps learners to consolidate their learning. In these sessions teachers not only reflect on the learning taking place, but also model the mathematical terms and concepts that the learners have encountered – and the new mathematical words, sentences and discourses that may have been introduced in English.

This study proposes to introduce the practice of exploratory talk in mathematics classes where learners are traditionally silent (for the dual reason that it is a cultural norm, as well as that the learners are reticent to speak unfamiliar mathematical language in a language that is itself unfamiliar). The hypothesis is that, if by using their home language while interacting in groups, learners can be taught to develop a dialogue closely resembling exploratory talk, their mathematical reasoning could be made explicit.

8.2 Accountable talk

Other researchers have independently formalized similar characterizations of collaborative talk. Chinn and Anderson (1998) identified a type of talk they called Collaborative Reasoning (CR) which was studied in teacher-led discussions with learners. They claimed that during CR discussions learners expressed their ideas and suggested new ones as well as challenged others' positions. They maintain that the quality of the reasoning and the levels of thinking displayed were higher than in conventional discussions and that learners actively participated in the construction of knowledge giving supporting evidence for their stances (Chinn and Anderson, 1998). Michaels and O'Connor (2002), together with Resnick (1999:5) use the term accountable talk, which resembles the concept of exploratory talk:

> Accountable talk seriously responds to and further develops what others in the group have said. It puts forth and demands knowledge that is accurate and relevant to the

> issue under discussion. Accountable talk uses evidence in ways appropriate to the discipline. Finally it follows established norms of good reasoning. Teachers can intentionally create the norms and skills of accountable talk in their classrooms.

Keefer, Zeitz and Resnick (2000) defined a set of types of informal dialogue which included critical discussion (achieving shared understanding through accommodating divergent viewpoints and reconciling differences of opinion), explanatory enquiry (overcoming a lack of knowledge by identifying correct knowledge by using cumulative discursive steps), eristic discussion (initial conflict and antagonism is acted out through rhetorical attacks and defences of participants' own positions, and could achieve a position of provisional accommodation), and consensus dialogue (discussion among speakers who agree with each other's opinion). There are some obvious connections between 'eristic discussion' and disputational talk, and between 'consensus dialogue' and cumulative talk. Exploratory talk seems to embody some tenets of both 'explanatory enquiry' and 'critical discussion'. Keefer et al. (2000:79) comment on the challenge of helping teachers "to lead discussions that are appropriate to the content and goals of the dialogue, scaffolding children to reason within the constraints of the dialogue rules and to initiate shifts in context when the content or the course of argumentation might warrant it".

8.3 Argumentation

Webb (2007) describes the argumentation, that Keefer et al. (2000) mention, which has properties similar to exploratory talk. Toulmin (1958) proposed a model of argumentation which led to the development of the 'Toulmin Model' (1958, as cited in Webb, 2007:140), which has the following main components, data (these are facts that those involved in the argument appeal to in support of their claim), claims (these are tentative explanations whose merits are still to be established), warrants (these are the reasons, rules or principles used to justify the connections between the data and the knowledge claim), backings (these are the assumptions that are given to justify the warrants) (Webb, 2007). An argument would typically move from data to the claim, to the warrant, to the backing and finally to the conclusion (Driver, Newton & Osborne, 1998; Yackel, 2002). Toulmin then added rebuttals, which resonate with the counter arguments and alternative hypotheses of exploratory talk. Some researchers, however, have found difficulty in identifying the difference between data and warrants (Simon, Erduran & Osborne, 2002) as they claim that Toulmin was not assessing how learners develop understanding, but how best to present an argument. Osborne, Erduran, Simon & Monk (2001) simplified the model to include only three components - data, claims and warrants. This resonates with the positions, claims and justifications required for talk to be considered exploratory.

9. AN OVERVIEW OF RECENT RESEARCH STUDIES

In this section some of the studies that have been conducted that relate to this research will be described.

9.1 'Thinking together'

In a 2006 study, Mercer and Sams aimed to raise learners' awareness of using language as a means of thinking together; to develop learners' abilities to use language as a tool for reasoning; and to apply language effectively in studying mathematics (Mercer & Sams, 2006). The teachers in the target classes were trained in the introduction of exploratory talk in mathematics classrooms and were given lesson plans to conduct. The learners in both their target and control classes were tested pre- and post-intervention using SATs mathematics items. As research, for example Kutnick (2005), has uncovered that many peer-based interactions are marred by dominance by one or more learners and reticence in others, Mercer and Sams (2006) realized that learners should be taught specifically how to relate to each other in positive ways. In the target classes exploratory talk ground rules were negotiated with the learners: all relevant information must be shared; all members of the group should contribute to the discussion; all opinions and ideas must be respected and considered; everyone should be asked to make his/her reasons clear; challenges and alternatives must be made explicit and negotiated; and the team must seek to reach consensus (Mercer & Sams, 2006). They analysed transcripts of the learner discussions focusing on effective use of exploratory talk and the data generated revealed that the learners in the target classes achieved significantly better in the post-test than the learners in the control classes (Mercer & Sams, 2006).

9.2 Exploratory talk in South Africa

Webb and Treagust (2006) spearheaded research on exploratory talk in South Africa in science classrooms. They investigated two cohorts of grade seven learners in the Eastern Cape. They introduced exploratory talk through means of triggers in order to ascertain whether learners' problem solving and reasoning scores would improve after an intervention. Statistical analysis of the difference between pre- and post-tests of the target and control groups indicated that the scores of the learners, who had experienced the intervention, increased statistically significantly over the comparison group's scores. This result was consistent in both studies.

9.3 Visible and invisible language

Setati, Molefe and Langa (2008) researched a pedagogic strategy that ensured that language in the multilingual classroom was both visible, so that it is clearly understood by all, and invisible, that it did not detract attention from the mathematical task at hand. The object of the study was to show that both language and mathematics are in constant and complex interplay. In order to do this they encouraged the use of the learners' main languages deliberately in order to solve real-world, challenging mathematical tasks. They found that when learners discussed the problem in their primary language, the language was neither a resource nor a stumbling block as it was transparent (invisible). The researchers argue for the increased use of learners' main language in dialogue and discussion as it is an aid to mathematical reasoning. They claim that the main language should work together with, and not in opposition to, the use of English to make mathematics more accessible (Setati et al., 2008).

9.4 Dilemmas of teachers

In their pioneering work into mathematics teaching in multilingual classrooms in South Africa, both Adler and Setati have uncovered many dilemmas and contradictions that teachers have to face in their dual role when teaching proficiency in English in the mathematics classroom (Adler, 2001; Setati, 2005a). Adler (2001), in her seminal book, *Teaching Mathematics in Multilingual Classrooms*, highlighted three dilemmas of teachers of mathematics in multilingual classrooms – the dilemma of code-switching, the dilemma of mediation and the dilemma of transparency. Adler (2001:135) saw the notion of a dilemma as the key to exposing teachers to both the complexity of teaching in multilingual classrooms and as a source of praxis where teachers could reflect on and adapt their teaching practices to meet the needs of multilingual learners.

9.5 The practice of code-switching

The practice of code-switching purportedly ensures that the percentage of main language usage increases in the classroom and that an additive model is employed, with the resultant transfer of mathematical concepts from the one language to another. However this presupposes that code-switching is a technique that comes naturally to multilingual teachers; however, educators feel guilty if they code-switch as they feel they are depriving their learners of an opportunity to acquire English (Setati, 2005b). Extensive research has been conducted on code-switching (Adler, 2001; Setati, 1998, 2001; Moschkovich, 1999, 2007; Vorster, 2008).

Code-switching in socio-linguistics refers to the practice of using two or more linguistic varieties in a single communicative sequence (Moschkovich, 2007) and is considered to be a tool which can provide spontaneous and reactive discussion of concepts by learners and teachers in their home language (Setati et al., 2008). In this study the term code-switching is used to include code mixing and code borrowing. Extensive research has been done on code-switching around the world (Adler 1998, 2001; Khisty, 1995; Moschkovich, 1996, 1999, 2007). According to Moshkovich (2007), a misconception about code-switching is that it stems from a deficit model and is used when the speaker is unable to recall suitable words or phrases in the language being spoken. She disagrees and promotes the view that code-switching should rather be seen as a complex language practice which allows for the greater use of the main language while still using the official language of learning and teaching. Instead of being considered to be a deficiency or a sign of semilingualism, code-switching should be seen as a hybrid language practice that is the mark of fluency in two languages (Moschkovich, 2007). In fact Clarkson (2007) suggests that switching between languages is a distinct advantage as it gives students access to alternate meanings and relationships.

Although code-switching appears to be a technique that comes naturally to multilingual teachers, the teachers interviewed in this study were not confident that they were dealing with code-switching correctly and were concerned that they have experienced no formal preparation for this strategy from either the Department of Education or from the tertiary institutions at which they were trained as educators.

Learning mathematics not only includes learning the words and phrases that are specifically mathematical, but also understanding of these written and spoken words and phrases. Pimm (1987) researched the spoken and written language of mathematics. He explored relationships between terminology and comprehension and the relationship between everyday and specialist usage of language. Pimm (1987:76) used ‘register’ to clarify his notions:

> The mathematics register is a set of meanings that belong to the language of mathematics (the mathematical use of natural language) and that a language must express if it is used for mathematical purposes.

Halliday (1978:195) emphasizes the point that mathematics is not a language per se as there is no one for whom mathematics is a native language; however:

> A register is a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings.

The learning of both ordinary English as well as mathematical English, using a particular register, is problematic for multilingual learners.

9.6 Ordinary English and mathematical English

Setati (2005a:78) describes communicating mathematically as managing the interaction between ordinary English (OE) and mathematical English (ME), formal and informal mathematics language and procedural and conceptual discourses.

Monaghan (1999) believes that teachers are responsible for the development of both OE and ME. He maintains that there are three types of vocabulary in mathematics – general (e.g. chair, water); technical (e.g. trigonometry, rhombus) and specialist (e.g. point, similar) and warns of the pitfalls inherent in thinking that learners understand the meanings of specialist words in ME whereas they often bring their OE meanings into the mathematics context. For example, if a learner is asked, “What is the difference between 12 and 7?”, in an ME context the answer is 5; however, in an OE context the learner could legitimately answer that one number has two digits and the other one digit; or that one is an even number and the other odd (Monaghan, 1999:8). Pimm (1991) uses the terms logical language (for OE) and meta-language (for ME) and notes that the distinction between the two is often murky. ME uses symbols extensively in order to compress information. Multilingual learners, often have to learn both ME and OE simultaneously. Although there is considerable work being done on the mathematical registers of the nine official African languages (Young, van der Vlugt & Qanya, 2005), research is necessary to identify whether teachers and learners embrace the terminology, or whether they maintain the English terms and vocabulary, as was found in this study.

9.7 Informal to formal language

Pimm (1991) visually portrayed a difficulty which confronts teachers, which is "how to encourage movement in their learners from the predominantly informal spoken language in which they are fluent, to the formal language that is frequently perceived to be the landmark of mathematical activity" (Pimm, 1991:21).

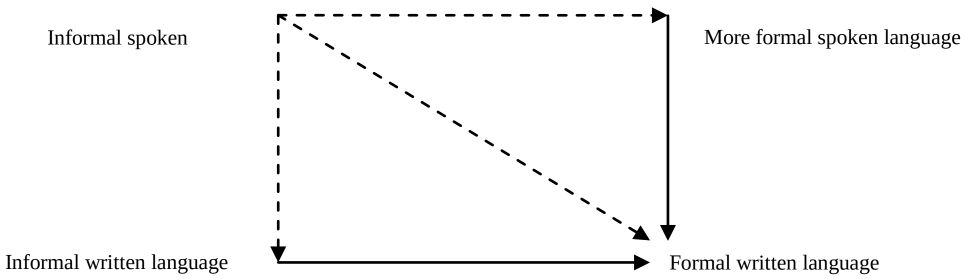


Figure 2.2 Alternate routes from informal spoken to formal written mathematics language (Pimm 1991:21)

This study focuses on the top horizontal line of figure 2.2, the movement from informal spoken to more formal spoken language, as it investigates the development of dialogue in primary school multilingual mathematics classrooms, but the learners need to traverse, over time, to the bottom right hand corner of figure 2.2 in order to be sufficiently conversant with mathematics for tertiary education. Setati (2005b:84) maps various routes from informal spoken mathematics in the learners' main language to formal spoken mathematics in English.

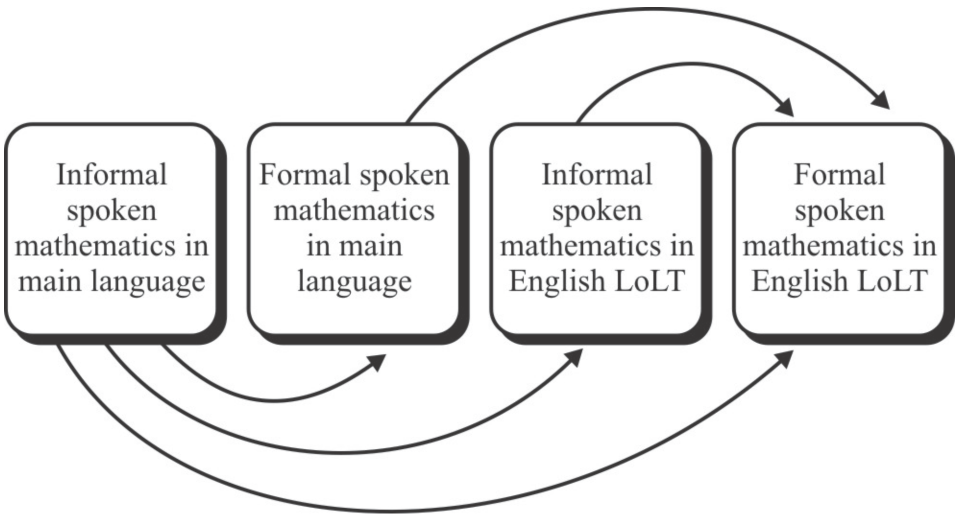


Figure 2.3 Routes from informal spoken language in main language to formal spoken mathematics in English LoLT (adapted from Setati, 2005b:84)

The routes are varied and convoluted but this study shows that under certain circumstances the journey can begin.

It has been noted that mathematics teachers can play an important role in the development of learners' awareness and use of language as a tool for reasoning, as well as for producing a collaborative and inclusive classroom ethos (Mercer & Sams, 2006). In addition, Barwell and Kaiser (2005) argue that policymakers and mathematics educators have stressed the difference between the precise subject language of mathematics and the more informal talk that learners use in the mathematics classrooms, and they feel that this has had a detrimental effect on inducting learners into mathematical practices. Furthermore, Barwell and Kaiser (2005) argue that if learners can be encouraged to talk informally about their mathematical reasoning, there is more chance that they will be able to develop formal mathematical discourse.

In order to talk either formally or informally about mathematics, learners have to acquire the mathematical words to use in order to put them into sentences and develop a dialogue. There needs to be a common ground of language that all interlocuters use and understand in order for the dialogue to create meaning. The following diagram from Webb (2007) describes a linguistic taxonomy which roots the theoretical position for discussion. This taxonomy is especially important in multilingual classrooms where the learners have to learn the individual words for the objects, before being able to make sentences encapsulating a concept, before being able to participate in any meaningful dialogue or mathematical discourse.

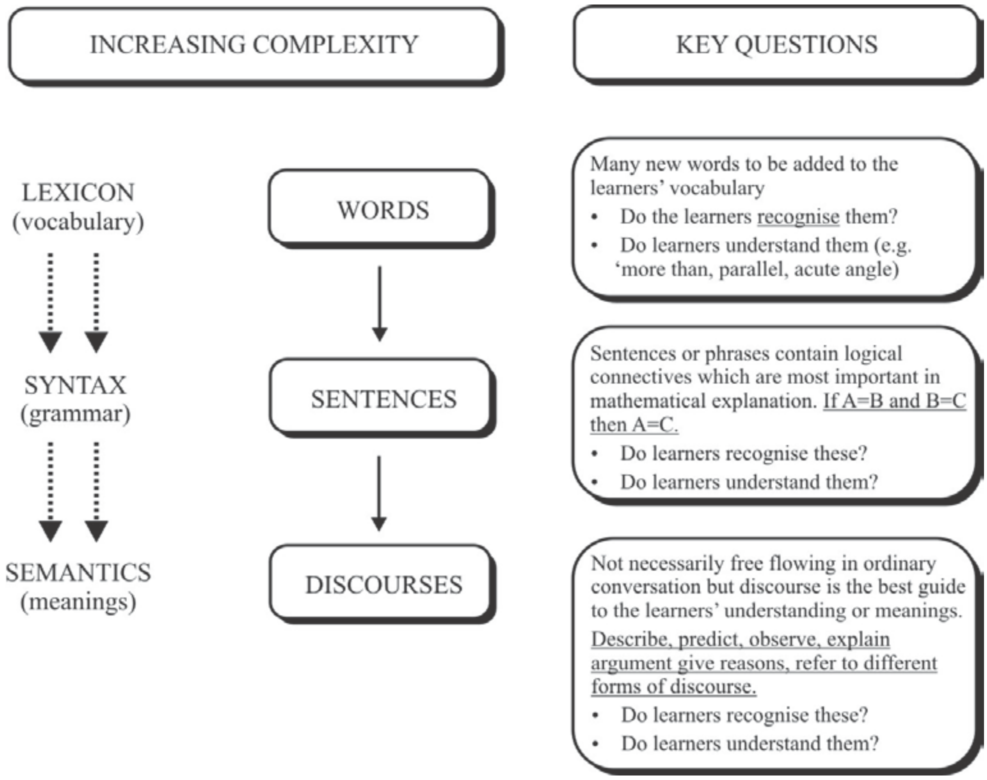


Figure 2.4 Linguistic taxonomy (Webb, 2007:32)

Heugh (in Alidou, et al., 2006), believes that the language policy models that are dominant in South Africa are examples of subtractive bilingualism (straight for English) or transitional bilingualism (early exit from mother tongue). Setati (2005a) and Gee (1994) ascribe this to learners', teachers' and parents' desire for access to social goods. Alexander, in the film Sink or Swim (Westcott, 2004), maintains:

> Because of the hegemonic position of English in the world today, because it is the key to social mobility, to upward social mobility, people understandably and justifiably want their children to learn English in South Africa. What most people don't understand is that it doesn't follow, therefore, that they will acquire the best command of English if they are taught from day one through the medium of English. That does happen, of course, but it happens only under very specific conditions, conditions which don't exist in most South African schools. Certainly not in most black schools.

This means that children who were disadvantaged before the fall of apartheid are disadvantaged after the fall of apartheid. This view is echoed by Alidou, et al. (2006) who maintain that the challenge is how to meet the aspirations of the people of South Africa. In Alexander's words from the film, Sink or Swim (Westcott, 2004):

> The language question is not simply about language, it is very much about the depth in which a child understands these concepts ... The way forward is what I call 'bilingual mother-tongue based education', in other words giving priority to the home language but also accepting that English-medium is desired and desirable, but not to the exclusion of the child's first language.

It is this sentiment that drives this research. For learners to successfully reason mathematically they need to communicate in their main languages; however, to meet their aspirations in the workplace they need to learn the discourse of mathematics - the ways of talking about mathematics, listening to mathematics, acting in a mathematics class or community, interacting mathematically, believing, valuing and using mathematics and the mathematics register (Setati, 2005a). Mathematical discourses develop from both formal and informal communication of mathematical ideas and it is the premise of this study that the majority of informal discourse should be in the most familiar language for the learner, whereas formal mathematical discourse should be re-voiced in English.

9.8 Procedural and conceptual discourse

Setati (2005a) researched the occurrences of procedural (calculational steps in solving a problem) and conceptual (reasons for calculating in particular way) discourse in a multilingual class. Mercer (1995) sees the teacher as a guide who facilitates situations where learners use dialogue to articulate their mathematical reasoning. The teacher is also seen as a role model of a competent mathematics speaker (Pimm, 1987). The teacher is thus an exemplar of the accepted ways of interacting with and speaking about mathematics. As has been shown in figure 2.3 above, there is a route from informal mathematics speaking to formal spoken mathematics; however, the timing of the transitions is crucial so as not to discourage learners from tentatively expressing their reasoning in words. Exploratory talk in the learners' main language helps learners to develop their ideas and concepts in a 'safe' environment. It is through informal exploratory talk, with code-switching of mathematical terms, that learners begin to develop conceptual discourse. It is the teacher's challenge to keep the balance between informal and formal talk so the learners can explore their ideas sufficiently to be able to become fluent in conceptual discourse, either spoken or written. Adler (2001:3) concurs, as she describes the 'dilemma of mediation'.

> The dilemma of mediation involves the tension between validating diverse learner meanings and at the same time intervening so as to work with the learners to develop their mathematical communicative competence.

The tensions between learners' diverse meanings and communicative competence are not the only dilemmas vying for attention in teachers' consciousness. There is an internal balance between the educators' own knowledge, practice and identity that needs to be addressed.

10. INTERSECTION BETWEEN KNOWLEDGE, PRACTICE AND IDENTITY

Da Ponte (2009), maintains that mathematics teacher education concerns developing teacher knowledge, teacher practice and teacher identity. In his presentation at the 33rd Conference of the International Group for the Psychology of Mathematics Education (PME) in Thessaloniki he included a Venn diagram, adapted in figure 2.5, depicting his theoretical perspectives about teachers. I have used this diagram to visually represent that the intersection between the three circles is the common ground where knowledge and practice and identity overlap.

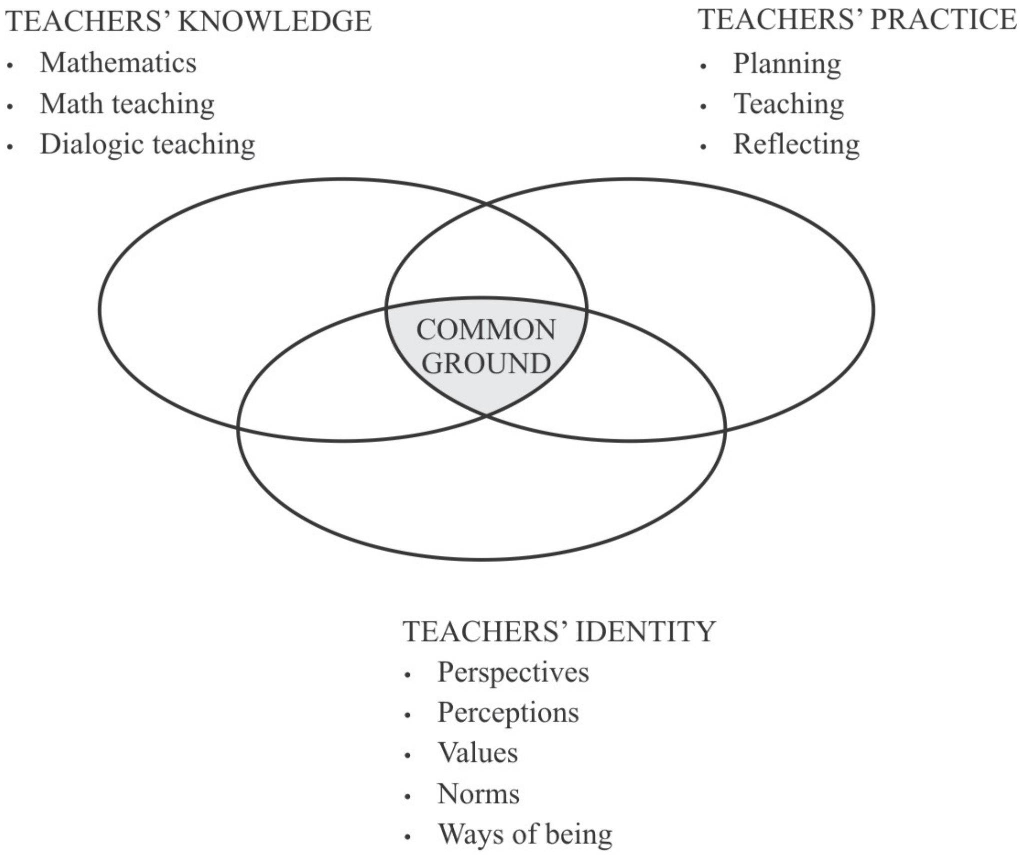


Figure 2.5 Common ground between teacher knowledge, practice and identity (Adapted from da Ponte, 2009)

Da Ponte maintains that the emerging 'inquiry tradition' where teachers use theory to question practice and use practice to identify and understand empowering theory currently has widespread support among mathematics teacher educators (da Ponte, 2009). Groves (2009) adds to this view by describing inquiry communities, where participants engage in dialogue and argumentation in order to solve problems. Inquiry communities link with communities of practice (Lave & Wenger, 1991; Wenger,1998) and are typified by the development of thinking skills; mathematical reasoning; progressive discourse and a classroom climate that encourages the learners to become mathematical thinkers and the teacher to become a facilitator rather than a figure of authority (Groves, 2009). Alrø and Skovsmose (2004) are interested in learners who become involved with processes of inquiry as this opens up a new space for communication. Their hypothesis is that “the qualities of communication in the classroom influence the qualities of learning mathematics” (Alrø and Skovsmose, 2004). They define ‘dialogue’ as “an inquiry process which refers to a presentation (and confrontation) of two or more different (and contradictory) points of view, with the aim of identifying a conclusion that can be agreed upon” (Alrø & Skovsmose, 2004). They note that Paulo Freire (1972, as cited in Alrø and Skovsmose, 2004) considered dialogue to be fundamental for the freedom to learn and is integral to the concepts of empowerment and emancipation.

11. POLITICAL ROLE OF LANGUAGE – POWER AND IDENTITY

Research shows that language, like multilingualism, is always political (Hartshorne, 1992; Heugh, 1997; Gee, 1994, 2004; Setati, 2005b). Language is used by society to determine power (Fairclough, 2001), and in South Africa language has been used in the past as a means of domination and separation (Setati, 2005b, Webb, 2002). Thus in post-apartheid South Africa the trend has been to reject the use of African languages as the language of learning and teaching (LoLT) as it was seen in the past to be a means of oppression by keeping the education standard inferior to that of English speakers (Hartshorne, 1992).

11.1 Power in discourse

According to Bamgbose (2008) the main South African languages are deeply embedded in the political history of the country. Colonialism and apartheid have meant that all of the languages have acquired socio-political meanings, with English currently highly prestigious, Afrikaans generally stigmatized, and the African languages with little economic or educational value. Although the African languages, as well as Afrikaans, are numerically "major" languages, they are "minority languages" in language-political terms. In terms of power and prestige, English is the major language of the country, with Afrikaans lower on the power hierarchy, and the African languages effectively marginalized (Webb, 2002). This means that the South African languages are engaged in asymmetric power relations, with English and African languages at opposite sides of the continuum. This also means that English can be used for discrimination and manipulation, and may already have become a vehicle in the struggle for power between the different socio-economic and political groups, regardless of colour (Webb, 2002).

Fairclough (2001:39) states that power in discourse concerns "powerful participants controlling and constraining the contributions of non-powerful participants". He defines three types of constraints – contents (what is said and done), relations (the social relations people enter into the discourse) and subjects (their subject positions they occupy). Fairclough (2001:47) maintains that "the whole social order of discourse is put together and held together as a hidden effect of power" and that one dimension of this power is the elevation of one social dialect to the position of a standard or 'national' language. The establishment of the dominance of standard English and the subordination of other social dialects was part and parcel of the establishment of the dominance of the capitalist class and the subordination of the working class in the United Kingdom (Fairclough, 2001). Power, 'in' discourse or 'behind' discourse, is not a permanent and undisputed attribute of any one person or social grouping. In fact, those who hold power at a particular moment have to constantly reassert their power, and those who do not hold power are always liable to make a bid for power (Fairclough, 2001). He maintains that this is true whether one is talking at the level of the particular situation, or in terms of a social institution, or in terms of a whole society. Power at all these levels is won, exercised, sustained, and lost in the course of social struggle (Fairclough, 2001). In broad terms, Fairclough claims that 'inculcation' is the mechanism of power-holders who wish to preserve their power, while 'communication' is the mechanism of emancipation and the struggle against domination. Correspondingly, a long-term focus of the struggle over discourse is the issue whether constraints on contents, relations and subjects are to be imposed through inculcation or coordinated through communication (Fairclough, 2001).

The hegemonic position of English in South Africa has resulted in English being the preferred language for schools and business as it is a passport to tertiary education, good jobs and positions of influence and power (Adler, 2001). The results of research on mathematics and literacy have been shown to have a distinctly bimodal distribution with a peak for English speakers far higher up the scale than the peak for English second language learners (Fleisch, 2008). As mentioned, those that were disadvantaged before the fall of apartheid are still marginalized – not because of their colour, but because of their fluency in English.

Because of the unbalanced relations of power that have been mentioned it has been very difficult to build up sufficient trust for teachers to acknowledge many of these issues and they have most frequently given the answer which they think the enquirer or researcher would like to hear (Lerman, 2001; Naidoo, 1992). In order to enable teachers to own the reality of the language environments of their classrooms and the language strategies they use to overcome the language barriers experienced by both themselves and the learners in their classrooms, and to allow them to explore their own attitudes and emotional involvement in language issues, it has been essential to break through this resistance/denial (Benton & Fox, 1990). In this study it appears that using poetry and asking teachers to write their own poems proved to be a most effective way of creating awareness and penetrating to the deepest levels the feelings attached to issues of language. This activity filled the ‘identity’ circle in da Ponte’s diagram and the balance between teacher knowledge (of dialogic teaching and multilingual practices); teacher practice (of introducing exploratory talk and dialogue) and teacher identity (perspectives and ways of being) intersected to create a common ground where teachers felt valued, respected and empowered. Only once this breakthrough was achieved could one engage teachers in an honest assessment of what was happening in their classrooms. The lack of effective teaching and the failure of learners to learn are identified as a language issue that empowered educators and experts can work on together.

11.2 Empowerment

Traditional views of power have negative connotations including oppression, control and authority, whereas the post-modern view is far more positive. Power is envisaged as being productive, creative, effective, active and part of everyday life (Albertyn, Kapp, & Groenewald, 2001). Empowerment embodies the sense that power comes from within; if a person is feeling strong and energised, she or he will be effective. The locus of control will be moved from a powerful others to within the empowered people. They will thus be intrinsically motivated and in control of their own lives. Self-regulatory and disciplined behaviour will be the result of empowerment (Albertyn et al., 2001). At a micro-level empowerment refers to the way that an individual feels about herself or himself; including, among others, issues of self-esteem, dignity, feelings of self-efficacy, self-confidence, positive self-concept, leadership, coping skills, sense of agency and personal responsibility (Albertyn et al., 2001).

Albertyn (2005) has tabled the characteristics of facilitators who work towards empowerment, and the principles of empowerment. In short, facilitator characteristics include role modelling, uncritical group support, solidarity and trust, providing a secure environment, allowing freedom of expression, humility (subordinate ego), not fostering dependency, the ability to identify strengths, genuine respect, identification with learners and the ability to listen and reflect. The principles of empowerment include the centrality of the individual, bolstering of self esteem, success with small immediate goals, the use of a natural support network, skills development, creating clear goals and tasks, increasing access to information and resources, providing opportunities for freedom and autonomy, creating a clear line of responsibility and identifying with learners (Albertyn, 2005). The characteristics and principles mentioned above were used as a guide to compare and contrast the practices of the educators observed in phases two and three of this study.

11.3 Experiential learning

Because I wanted the teachers to experience the alienation of writing an assessment task in an unfamiliar language, as well as to experience the principles of exploratory talk, before they endeavoured to introduce the strategy to their learners in the classroom, I used a model of experiential learning as depicted in figure 2.6 from Rooth (2000).

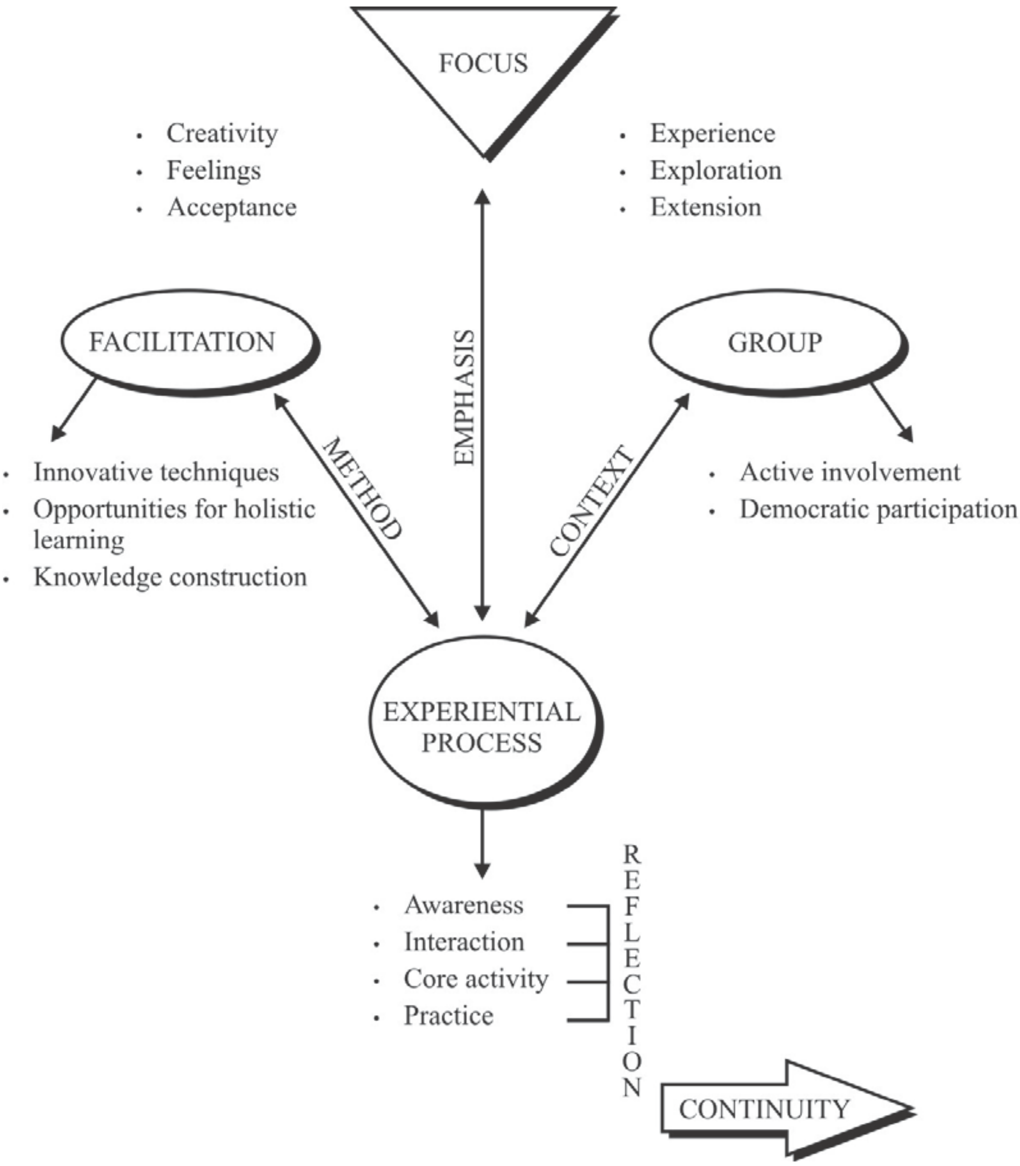


Figure 2.6 Model of experiential learning (Rooth, 2000)

The aim of the experiential exercises used with the students was to make them aware of strategies that are effective when teaching mathematics to multilingual learners, with the emphasis on exploratory talk. I facilitated the process by using innovative exercises – they wrote poetry, they were assessed in a language that was not their main language, they were given triggers to precipitate group discussion, and they discussed action research projects. These were all opportunities for holistic learning and knowledge construction. I was able to facilitate, but not control, the interactions in the groups. They participated actively in their groups through discussion. In the reflections and evaluations after the intervention, the students expressed their appreciation of the opportunity to experience feelings of alienation and frustration (with the assessment task); feelings of creativity and acceptance (with the poetry task); feelings of exploration and extension (with the action research assignment) and awareness of the power of dialogue (in their group interactions).

12. CONCEPT CARTOONS

Transformative learning is a process of examining, questioning, validating and revising perceptions by using a triggering event to stimulate critical reflection (Albertyn, 2009). I used triggers in the form of Raven’s Standard Progressive Matrices (RSPM) items and concept cartoons to guide the students towards critical thinking and reflection. Because the students taught mathematics in different phases, there could have been a power relationship in their groups that could have limited their interaction. If one person had known more mathematics than the others, cumulative talk could have prevailed. I thus used triggers that none of the students had been exposed to in order to raise their consciousness about the forms of dialogue in which they were engaging. Transformative learning takes the students to a deeper level where they can see the reasons why they are doing the activities and discover the story behind the story (van der Merwe & Albertyn, 2009).

In this study triggers, in the form of concept cartoons were used to enable learners to develop a language taxonomy in both mathematics and English. The triggers also served to enable the learners to practice the ground rules of exploratory talk before they implemented the strategy with their curriculum exercises. Concept cartoons were first conceptualized by Naylor and Keogh in 2000 in a Science context in order to develop skills of argumentation and discussion in learners. Argumentation is this context encompasses a process where learners make a claim, provide suitable evidence to justify it, and defend the claim logically until a meaningful decision has been reached (Webb, Williams & Meiring, 2008). Yackel

(2002) maintains that an emphasis on argumentation can provide a conduit through which new mathematical concepts and tools could emerge, as well as requiring that teachers need a deep understanding of learners' conceptual development. The use of discussion as a tool to increase reasoning has gained emphasis in classrooms worldwide (Webb et al., 2008; Yore, Bisanz & Hand, 2003; Yackel, 2002). Discussion, however, requires scaffolding and structure in order to support learning (Norris & Phillips, 2003).

The cartoons, which consist of simple drawings and minimal text, are not meant to be humorous but are designed to promote thinking. An aspect of the cartoons that has an empowering effect on the students is that the sense of 'unknowing' can be transferred onto the children depicted in the cartoons. The participants in the group discussion do not have to 'own' the lack of knowledge displayed. The cartoons represent visual situations in familiar contexts and use everyday language so that learner participation is maximized, particularly for those who are English language learners. Various viewpoints are expressed about the topic, some indicating typical misconceptions, and other views expressing alternative answers. In 2007 Dabell and Mitchell published a set of Mathematics Concept Cartoons which were used in this study.

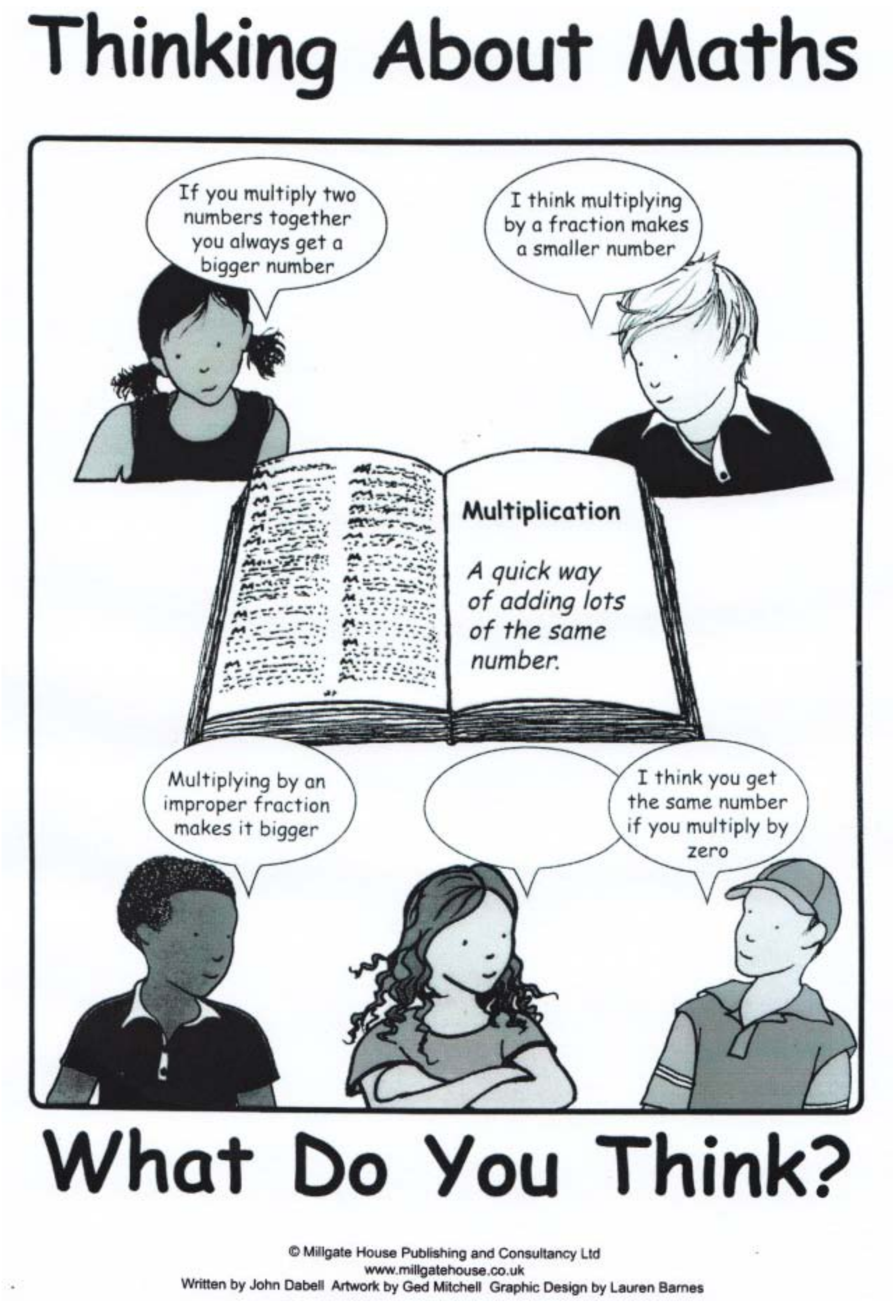


Figure 2.7 Example of a Concept Cartoon (Dabell, Mitchell, & Barnes, 2007)

In a study conducted in East London, South Africa, Webb, Williams and Meiring (2008) reported that when initially using concept cartoons most learners made assumptions without supporting their claims in any way. They also rarely disagreed with each other and cumulative talk abounded (Webb et al., 2008). Their claims were also mainly intuition-based; however, by the end of the intervention the learners were able to show instances of exploratory talk as they used “I think” followed by “because” in the course of their dialogue.

Webb et al. (2008) concluded that, although their study was limited, the results showed positive improvement in the learners' use of exploratory talk when concept cartoons were used as a trigger. They warn that the process takes time and that teachers must have a sound knowledge of what constitutes authentic discussion, argumentation and exploratory talk before they can implement strategies in the classroom. In this study mathematical concept cartoons were used to initiate exploratory talk in the classrooms and then the principles of exploratory talk were used in dialogue concerning curriculum mathematics problems and issues.

13. QUANTITATIVE AND QUALITATIVE MEASURES

The RSPM test was chosen to test reasoning skills as the learners were second language English learners and, for the reasons discussed previously, it was imperative to use a test of reasoning that was not language specific. The RSPM test was selected because research has indicated that it is a valid test of general intelligence, or Spearman's *g* factor (Jensen, 1998, Kaplan & Sacuzzo, 1997; Lynn, Allik, Pullman & Laidra, 2004).

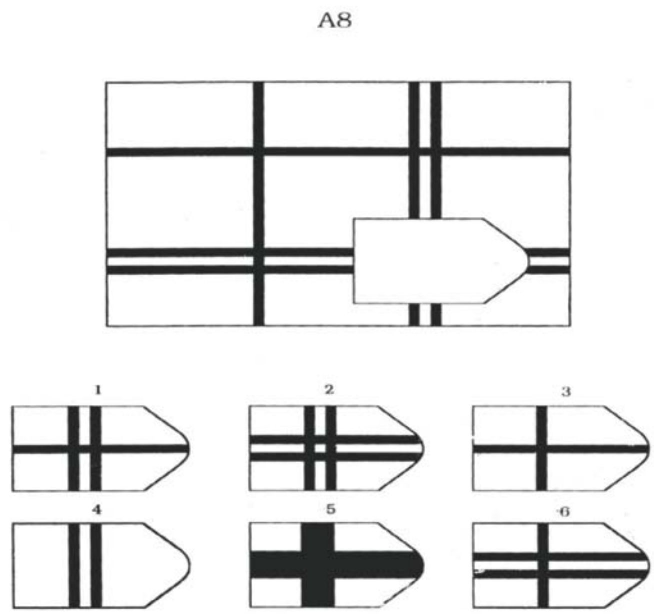


Figure 2.8 Example of Raven's Standard Progressive Matrices Item (Raven, Court & Raven, 1995)

These views are challenged by other researchers and Raven, Raven and Court (1998, 2000) refer to several studies which voice criticisms; however, some research attests to the validity of the test (Abdel-Khalek & Raven, 2006; Gregory, 1992). Lynn and Vanhanen (2002) cite many studies in 61 countries which have collected normative data for the RSPM test. It is thus regarded as the most extensively used test in cross-cultural studies of intelligence (Abdel-Khalek & Raven, 2006). Table 2.4 shows the published means for twelve year old children for the United Kingdom (UK), Kuwait, United States of America (USA) and India (Abdel-Khalek & Raven, 2006). These scores are compared with the percentile scores of the post-test of the overall target group of this Eastern Cape study spanning 2007 and 2008.

Abdel-Khalek and Raven (2006) conducted research in Kuwait on 6 594 students and plotted the percentiles of the Kuwaiti norms against the 1979 norms of the United Kingdom. They also presented data for selected age groups from other international countries. They commented that missing data was from black children from the USA and from South Africa as “most of the samples leave much to be desired” as they reveal “huge differences between these groups and the data cited” (Abdel-Khalek & Raven, 2006:175). This study provides quantitative data for black learners in the Eastern Cape at grade seven level.

Table 2.4

Comparison of RSPM percentiles for 12 year old learners from different countries

Percentile	**UK**	**Kuwait**	**USA**	**India**	**Eastern Cape post-test scores of overall target Group**
95	53	50	51	52	47
50	42	40	40	40	37
5	27	19	22	22	18

I chose the Admission and Placement Assessment Programme (APAP) developed at NMMU to test possible differences in numeracy and English skills before and after the intervention as these tests are standardized, criterion-referenced measures with proven reliability and validity (Foxcroft, Watson, Seymour, Davies & McSorley, 2002; Watson, 2004a; Watson, 2004b; Watson, 2004c). The results were scrutinized using a developmental perspective so that levels of progression of the learners could be identified. Progress maps for the tests appear in Appendix B and the quantitative data generated is reported in chapter four.

Lerman (2000, 2001) uses the metaphor of a camera lens to encapsulate an object of research from a sociocultural perspective and maintains the researcher's focus on a particular part of the complex process whilst taking cognisance of the view that would be obtained if the camera either zoomed out or in. He maintains that when 'zooming out' researchers address practices and meanings, whereas when 'zooming in' results in a "study of mediation and of individual trajectories" (Lerman, 2001:87). His stance is that in mathematics education language and discursive practices are fundamental as "we are constituted within language and the associated practices" (Lerman, 2001:87). To focus my gaze on the qualitative data being generated in this research, I have kept in mind Lerman's (2001) suggestions for researching discursive teaching and learning which include: Vygotsky's zone of proximal development, intersubjectivity and internalisation; the functioning of discursive practices, including positioning and 'voice'; the social relationships in the context; mathematical artefacts; and development as a process of thinking/speaking mathematics (Lerman 2001:101-107).

Qualitative and quantitative measures were used in this study to attempt to ascertain whether Eastern Cape educators could introduce dialogic strategies in order to improve reasoning, numeracy and English skills. The background history of policy and results point to an urgent need for effective intervention.

14. LANGUAGE POLICY AND CURRICULUM DEVELOPMENT IN POST-APARTHEID SOUTH AFRICA

The Language-in-Education Policy (LiEP) should be understood within the context of post-1994 South Africa, with a new democracy in place emphasising pluralism, reconciliation and the extension of powers of decision making being devolved to the local level (Republic of South Africa Department of Education, 1997). The LiEP promotes the principle of no discrimination on the basis of language set out in the South African Constitution (Constitution of the Republic of South Africa 1996 – Government Gazette No 17678) by recognizing all 11 official languages: Sesotho, Sepedi, Setswana, Tshivenda, Xitsonga, isiNdebele, isiXhosa, siSwati and isiZulu as well as English and Afrikaans. The LiEP advocates additive bilingualism. This policy also gives School Governing Bodies the responsibility of selecting school language policies that are appropriate for their circumstances. There is policy support for languages other than the LoLT and support of practices including code-switching (Department of Education, 2003a); however, although the LiEP has been linked ostensibly to the change of the distribution of political power the practice of overvaluing English and undervaluing African languages persists (Setati,2005a). Heugh (2008) maintains that policies are promulgated but that implementation has not yet taken place.

Research has shown that learning mathematics is inextricably connected with communicating mathematically (Adler, 2001; Moschkovich, 1999, 2007; Pimm, 1987, 1991) In the National Curriculum Statement (NCS) Grades 10-12 (General) Mathematics (Department of Education, 2003a:2) one of the critical outcomes is to "communicate effectively using visual, symbolic and/or language skills in various modes" whereas another is to "work effectively with others as members of a team, group, organization and committee". The importance of language in the learning of mathematics and the social context of learning are thus emphasized. In the NCS Grades 10-12 (General) Overview (Department of Education, 2003b:13) it is noted that “Teachers should understand… that… learning in a language which is not one’s home language needs to be addressed through the way in which they teach, plan activities and assess learner performance”. The strategy of developing exploratory talk among learners through dialogue in the language they understand best, speaks directly to this perceived barrier to learning.

There is little doubt about the importance of language in the mathematics curriculum as expressed in the LiEP and the NCS; however policy interpretation, implementation and teacher training may need serious consideration if the issues of mathematics performance, as reported in the next session, are to be addressed (Heugh, 2008; Probyn, Murray, Botha, Botya, Brooks & Westphal, 2002).

15. ISSUES OF MATHEMATICS PERFORMANCE

Fleisch (2008:1) describes a metaphor of two education ‘systems’ in South Africa. The first ‘system’ consists of mainly former white and Indian schools as well as the independent schools. The schools are well resourced and produce the majority of the students who study further in tertiary institutions. The learners are from the middle and high classes and their mathematics and literacy competences are comparable to those in first-world countries. The second school ‘system’ enrols working class and poor learners. The learners’ literacy is limited and their mathematical skills are rudimentary. The majority of the learners are taught in a language that is not their main language. The schools are under-resourced and the teachers are often under-qualified (Fleisch, 2008). It is within this sector of education that this study on promoting mathematical reasoning is placed.

15.1 South African and international studies

Various studies have been made by the South African government and by international organisations after 1994 in South Africa (table 2.5). The Grade Three Systemic Evaluation during 2001 tested approximately one third of the current Grade Three enrolment in the country. The results showed that an average of 30% on the numeracy task was obtained by the sample. There was a high concentration of learners who scored below 20%, but also a significant percentage of learners who scored over 60%.

The Grade Six Systemic evaluation in 2004 revealed that learners obtained a mean score of 27% for mathematics. The results were divided into four bands of achievement levels – outstanding, achieved, partly achieved, not achieved. 12% of learners in the sample attained the ‘achieved’ or ‘outstanding’, level, whereas 81% of the learners were categorised in the ‘not achieved’ band.

Table 2.5

Large scale assessment of learner achievement in South Africa (Fleisch, 2008:5)

	Assessment	Agency	Year	Grade	Schools	Learners	Objective of test
Government	Systemic Evaluation in Grade 3	DoE	2001	3	14 000	51 307	Numeracy, Literacy and Life Skills
	Western Cape Education Department Grade Six Learner Assessment Study	WCED	2003	6	1 079	34 596	Literacy and Numeracy
	Grade 6 Intermediate Phase Systemic Evaluation	DoE	2004	6	1 000	34 015	Mathematics, language and natural science
	Western Cape Education Department Grade Three Learner Assessment Study	WCED	2004	3	1 093	34 877	Literacy and Numeracy
	Western Cape Education Department Grade Six Learner Assessment Study	WCED	2005	6	1 040	31 726	Literacy and Numeracy
	Western Cape Education Department Grade Three Learner Assessment Study	WCED	2006	3	1 086	82 879	Literacy and Numeracy
Cross-National	TIMSS 1999	HSRC	1999	8			Mathematics and Science
	SACMEQ II	HSRC	2001	6	168	3 163	Reading and Mathematics
	TIMSS 2003	HSRC	2003	8	254	9 000	Mathematics and Science
School Improvement Baseline Studies and Evaluation	District Development Support Program (DDSP)	Khulisa	2001	3	453	14 700	Literacy and Mathematics
	Quality Learning Project (QLP)	Joint Education Trust	2001	9, 11	102	8 453	Literacy and Mathematics

The Western Cape Education Department Grade Six Learner Assessment Study conducted in 2005 disaggregated the results according to former Departments of Education – Cape Education Department (CED, white); Department of Education and Training (DET, black); House of Representatives (HOR, coloured). The research reported the grade level of mathematics at which the learners were performing.

Table 2.6

Numeracy pass rates by grade and ex-department 2003/2005 (Fleisch, 2008:10)

Ex - Department	**Percentage of learners performing at Grade Six level - 2003**	**Percentage of learners performing at Grade Six level - 2005**
CED	62,4%	64,5%
DET	0,1%	0,2%
HOR	3,8%	5,3%
Total Province	15,6%	17,2%

The results of the study showed that in 2003 fifteen percent of the learners in the Western Province were performing numeracy tasks at grade six level. As table 2.6 illustrates, in 2003 one tenth of a percent of the learners in the under resourced schools could perform at Grade Six level as compared with sixty two percent of learners in better resourced schools. When the study was repeated in 2005 the picture was not very different.

15.2 Trends in Mathematics and Science Study (TIMSS) Studies

The international TIMSS (Third International Mathematics and Science Study, later called Trends in Mathematics and Science Study) studies conducted in 1999 and 2003 painted a bleak picture, as South Africa scored the lowest of all participants in both studies. South Africa also had the largest variation in scores, ranging from mostly very low to a few very high scores, a distribution skewed to the left. The learners wrote the TIMSS tests in either English or Afrikaans with those who took the test in Afrikaans writing in what is both their home language and LoLT, while most of the learners who wrote in English did so in a language that was not their mother tongue (Reddy, 2006). Reddy (2006) notes that in the 2003 TIMSS test a large achievement gap existed between those learners who spoke English as a home language (average score of 349) as opposed to those who did not speak English at home (average score of 192). The South African mean score was 264 compared with an international mean of 467, although there was the largest spread of scores of all participating countries. The mean of learners from former black schools was 227 compared with a mean of 456 (close to the international average) of learners from former white schools. In a word problem posed in English, but that required simple division, seven out of every one hundred South African grade eight learners achieved full marks as compared with seventy eight out of every one hundred in Singapore; fifty out of every one hundred in England; and eleven out of every one hundred in Botswana (Howie, 2003). Reddy (2006) notes that it is difficult to determine the effect that language had on the mathematics results as there were other inequalities that also could influence performance, for example socio-economic variables, the nature of teaching and the appropriate level of cognitive demands in classroom interactions that are made on the learners (Reddy, 2006). Nevertheless, it seems fair to attribute the lower average scores of the learners who wrote in English, at least in part, to issues of language.

Fleisch (2008) in his book *Primary Education in Crisis* attributes language as one of the causes for South African learners' underachievement in reading and mathematics. He mentions health, poverty, expenditure, language and the knowledge of teachers. He also suggests that inappropriate teaching could be "caused by a combination of a misinterpretation of the new curriculum, a lack of and under-utilisation of textbooks and readers, poor subject and pedagogical knowledge and ineffective methods" (Fleisch, 2008:138). This study attempts to contribute to this necessary body of research by making teachers reflect on the language difficulties both they and their learners face and to formulate their own possible strategies to ameliorate their local situations; it attempts to teach a cohort of teachers about researched and reliable strategies using dialogue and exploratory talk in the classrooms and follows two cohorts of teachers as they implement the strategies during the school year, testing learners before and after an intervention.

15.3 Southern and East Africa Consortium for Monitoring Educational Quality (SACMEQ); District Development Support Programme (DDSP) and Quality Learning Project (QLP) studies

The Southern and East Africa Consortium for Monitoring Educational Quality (SACMEQ) conducted a study of a sample of grade sixes in 2001 which linked scores to academic mastery. Half the learners tested were deemed to be performing below the basic numeracy level (Moloi & Strauss, 2005). The District Development Support Programme (DDSP) in 2001 revealed that the majority of the grade three learners were using concrete methods to calculate instead of abstract mathematical methods. For example they would do repeated addition rather than multiplication. The Quality Learning Project (QLP) recorded baseline data on grade nine and grade eleven learners. Ninety percent of the learners identified themselves as being black and the rest described themselves as ‘coloured’. Eighty percent of the grade nines identified less than fifteen percent of the questions as correct. The grade eleven students were particularly weak in reproducing knowledge, theorems and defining concepts. This could indicate that they had not been taught the content, or that they did not understand the basic theory underlying mathematics procedures.

15.4 Senior certificate results

Pass rates in mathematics in the Senior Certificate examinations are also very low. Table 2.7 presents the Mathematics Senior Certificate summarized results for 2008.

Table 2.7

2008 Number of Senior Certificate passes per percent range

(Source: The Herald, April 2009)

Percent Range	**Number in Range**
0-29	162 168
30-39	46 715
40-49	26 754
50-59	20 715
60-69	16 781
70-79	12 902
80-100	12 673

2008 was the first examination of the National Curriculum, in which every candidate wrote either Mathematics or Mathematical Literacy. In these figures there is no distinction between English first language learners and multilingual learners. According to the table above, the majority of learners achieved less than 30% in the mathematics examination, which is a cause for concern.

15.5 Western Cape Department of Education

Table 2.8, sourced from the Western Cape Department of Education in 2006, shows a comparison of ten years' of mathematics enrolments - national, Western Cape and Khayalitsha, a township near Cape Town (van Jaarsveld, 2007).

Table 2.8

Comparison of National, Western Cape and Khayelitsha mathematics enrolments against national senior certificate enrolments over the past ten years.

(Source: National Department of Education and Western Cape Education Department)

Enrolments	**Total Senior Certificate Enrolment (National)**	**National (Mathematics)**		**Western Cape (Mathematics)**		**Khayelitsha (Mathematics)**	
		SG	**HG**	**SG**	**HG**	**SG**	**HG**
1996	518225	194983	68541	14746	3294		
1997	559233	150046	65015	16335	3703		
1998	552862	89613	79019	18477	3758		
1999	511474	231199	50105	18040	3770	1167	72
2000	489941	245497	38520	18290	3963	1233	27
2001	449371	229075	34870	11020	3464	1289	28
2002	443821	225524	35465	17516	4119	1294	50
2003	440267	222367	35956	17504	4446	1218	51
2004	467985	236155	39939	16933	5093	1343	97
2005	508363	259099	44053	17474	4992	1342	82

Table 2.9 compares the number of the passes recorded in the same areas for the same ten years as table 2.8.

Table 2.9

Comparison of National, Western Cape and Khayelitsha mathematics passes for the past ten years against national senior certificate enrolments

(Source: National Department of Education and Western Cape Education Department)

Passes	**Total Senior Certificate Enrolment (National)**	**National (Mathematics)**		**Western Cape (Mathematics)**		**Khayelitsha (Mathematics)**	
		SG	**HG**	**SG**	**HG**	**SG**	**HG**
1996	518225		25912	9234	2830		
1997	559233	63342	22467	8320	3042		
1998	552862	45826	28094	9748	3094		
1999	511474	72179	19854	9288	3091	206	7
2000	489941	79631	19237	9201	3162	271	5
2001	449371	72301	19504	9555	4321	318	16
2002	443821	96302	20528	11021	3679	483	25
2003	440267	99426	23412	11070	3938	550	26
2004	467985	103721	24143	10751	4268	626	47
2005	508363	106550	26383	10556	4321	522	39

A disturbing insight from the tables presented is that, on average, only 20% of the senior certificate population achieved a pass in mathematics while only 53% of the population was enrolled for mathematics at either Higher or Standard grade levels during the period.

16. CHAPTER SUMMARY

In this chapter I have described the research literature that has provided the framework for this research. I have used the philosophical framework provided by Vygotsky (1978) on which to structure my research as Vygotsky believed that learning takes place in a sociocultural environment and that language is central to the teaching and learning process. The research by Gee (1994), Adler (2001), Setati (2001) and Mercer (2004), among others, steered this research in the direction of looking at exploratory talk as a strategy to encourage teacher-learner and learner-learner dialogue in Eastern Cape classrooms and to break the prevalent practice of I-R-E focussed teaching. The premise is that if learners can be supported to define, however haltingly, their mathematical reasoning in words in a language most familiar to them, they can be aided in the ZPD by a more competent fellow learner, or the teacher. In the Eastern Cape, where the norm is for the learners to sit silently in class, this is a major change in teaching and learning practices.

In order to gauge the teachers' beliefs and practices about the language policy and language usage I used Fairclough (2001), Gee (1994, 2004) and Setati's (2005a) conceptions of power and identity and sifted through curriculum documents to ascertain documented support for dialogue, code-switching and main language interaction. The basis for my research on interactions in the classroom is Mercer's (1995, 2004) study concerning sociocultural discursive practices and the development of exploratory talk. I believe that this study is built on an accepted and tested framework of previous research and adds a new gaze on interactions in multilingual mathematics classrooms in the Eastern Cape. In this section the theoretical underpinnings of the study have been presented. The research methodology follows in chapter three.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

1. INTRODUCTION

In the previous chapter the theoretical aspects of this study were presented and the related literature was discussed. In this chapter the construct identification, the paradigms underpinning this study, the relevant research methodologies and analysis of data used to achieve the aims and objectives of the study, are reported. The aim of the study is to ascertain educators' perceptions about the challenges and strategies they use to teach mathematics in bi/multilingual classes and to design and implement an intervention that could foreground possible dialogic strategies that would facilitate meaningful mathematics comprehension among learners.

To reiterate, the objectives of this study are to:

1. Identify Eastern Cape educators' perceptions about language strategies and language usage in multilingual mathematics classes;
2. Research the design and implementation of an intervention for educators to promote the introduction of dialogic practices;
3. Track educators' practice in multilingual mathematics classrooms before, during and after an intervention;
4. Ascertain whether the introduction of dialogic practices, particularly exploratory talk, increase reasoning, numeracy and English skills in grade seven multilingual mathematics classrooms?

2. PARADIGMS

Philosophical ideas are, in the main, concealed in research and need to be identified as they influence the mode of inquiry (Cresswell, 2009). In terms of research the underpinning philosophical ideas which determine the type of problems that should be investigated and the way in which they should be investigated are termed paradigms (Babbie & Mouton, 2008). The term paradigm means a theoretical model that is universally accepted at a particular moment and which provides the framework in which one situates one's research (Mouton, 2001).

2.1 Overview of paradigms

A review of the literature suggests that three main paradigms exist, namely positivism (empiricism); interpretivism (or hermeneutics) and critical theory. Denzin and Lincoln (2005) refer to positivism, post-positivism, constructivism, critical theory and participatory paradigms. Creswell (2009) and Creswell and Plano Clark (2007) also consider the traditional three paradigms; namely post-positivism, constructivism and 'advocacy and participatory paradigms', but they exclude positivism and define a fourth notion, namely that of pragmatism.

According to Burrel and Morgan (1979) sociological paradigms can be divided into quadrants that define mutually exclusive views of the social world, based on different views on the nature of science and society. These views of the world can be placed on a Cartesian plane ranging vertically on a continuum from order to change, and horizontally from the subjective to objective realms.

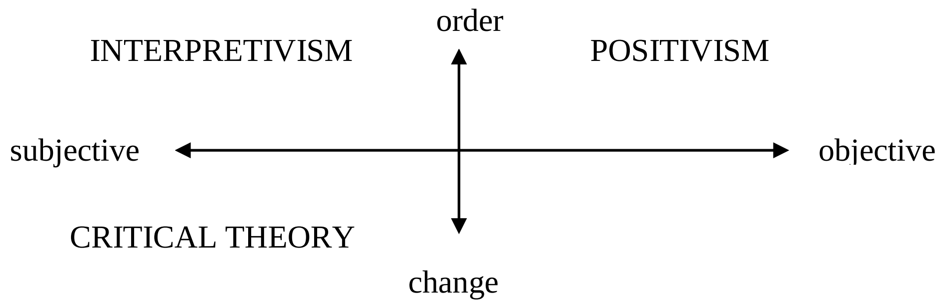


Figure 3.1 Burrel and Morgan's quadrants (1979)

In this schemata positivism is objective and deals with order; interpretivism is subjective, but also deals with order; while critical theory, which is subjective and advocates change, appears diametrically opposed to positivism. Habermas (1971, as cited in Babbie & Mouton, 2008) highlights the scientific, interpretive and critical theory paradigms, while Babbie and Mouton (2008) focus on positivism, phenomenology and critical theory as three important metatheories. However, despite the varying nomenclature, the traits are essentially the same and research paradigms can be compared in terms of interest, focus, worldview, ontology, view of knowledge, methodology, methods and intended outcome (Ernest, 2009).

2.2 Paradigm of this study

The term 'qualitative research' incorporates concepts of field research, naturalistic enquiry as well as ethnographic research (Mouton, 2006). The study has been conducted in the natural setting of the educators and learners. The focus is on process rather than outcome and the insider, or 'emic' view is emphasized (Babbie & Mouton, 2008). The ontological viewpoint is that both educators and learners experience an internal reality of their subjective experience. My epistemological standpoint is that during the study I have been an empathetic observer, whose gaze is coloured by my own subjectivity.

A potential barrier to the insider perspective is that I am an English-speaking, white woman who is attempting to understand the perceptions and practices of isiXhosa-speaking, black educators who have a different worldview and culture from my own. In order to mitigate possible misunderstandings in each phase of the study I used an isiXhosa-speaking research assistant to verify that my understandings were congruent with the sentiments expressed in the questionnaires and observations. The isiXhosa grammar and spelling was checked by an isiXhosa linguist who is experienced at editing. The educators were consulted wherever there were nuances of understandings, particularly in the last section of the study where the focus was on one educator.

The primary goal of qualitative research is to obtain thick descriptions, or “a rich, detailed description of specifics” (Geertz, 1975, as cited in Babbie & Mouton, 2008:272) of opinions of educators and events in the classrooms in order to understand the dynamics in multilingual mathematics classrooms. This study describes as accurately as possible the perspectives and opinions of educators concerning language policy and language usage in Eastern Cape mathematics classrooms through discussions and questionnaires, and evaluates whether an intervention has an effect through observation and experimental method. The object, however, is not to generalize the findings to theoretical populations, but to understand the social actions in specific mathematical classrooms in the Eastern Cape in South Africa. The emphasis is on developing new interpretations about the effectiveness of strategies implemented by educators (Babbie & Mouton, 2008). The premise of this study is that in multilingual mathematical classrooms educators and learners experience the external world subjectively, depending on the way they, individually, interact with both the mathematical concepts experienced, the language in which the concepts are explored and the interaction with peers and the educator. I have used a mixed mode methodology by using statistics to triangulate the qualitative results. Essentially the methodology used in the study is interactional and interpretive, using interviews, observations and group discussions to tease out the reality of multilingual classrooms in the Eastern Cape, South Africa (Terre Blanche, Durrheim & Painter, 2006). Qualitative research is associated with a contextualizing, idiographic strategy and in this study a particular sector of the population, a sample of educators of mathematics teaching second-language learners in the Eastern Cape, were studied in order to understand the particular constraints and opportunities that the setting affords.

Cresswell (2009) interconnects worldviews (paradigms), strategies of inquiry and research methods around the core of research design as is illustrated in figure 3.2.

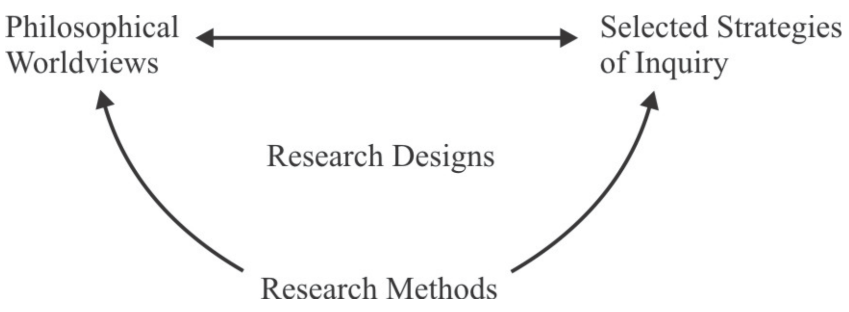


Figure 3.2 A framework for design – the interconnection of worldviews, strategies of inquiry, and research methods (Cresswell, 2009:5)

It is within Cresswell's (2009) framework that this study was structured and designed, and within which the philosophical underpinnings, research methods and research design are viewed. I have endeavoured to relate my worldview, strategy of enquiry and research methods.

2.2.1 Objective one

In order to identify educators' perceptions about language strategies and language usage, I used a quantitative method of data collection by implementing a questionnaire that could be statistically analysed. Quantitative methods and a postpositivistic paradigm would not allow me into the students' worlds, though, so I decided to supplement the quantitative data with qualitative data that was informed by the interpretivist paradigm. I wished to understand the contexts and the worldviews of the NMMU students who were teachers who taught in a second language to learners who learned in a second language. I used various instruments (reflective writing, open-ended questionnaire responses, observations and poetry) to gain an insight into the constructs identified from the student submissions that could help achieve objective.

2.2.2 Objective two

In order to attain the second objective of this study, to research the design and implementation of an intervention for educators to promote dialogic practices, I again used an interpretive paradigm as I wished to understand how the students felt and reacted when they experienced dialogic learning themselves. I therefore used qualitative methods to gather data to inform me about the transformative learning that the students experienced while engaging with the exercises and tasks. I used instruments which included: experiencing writing a numeracy test in an unfamiliar language, using triggers to experience and practice exploratory talk, choosing to use different languages in different phases of a lesson and reflective action research assignments that the teachers wrote after introducing exploratory talk into their own mathematics classrooms. The data could also help me to reflect on each of the exercises, and the intervention as a whole, in order to improve the delivery the next time the intervention was delivered.

2.2.3 Objective three

The third objective was to track educators' progress before and after an intervention. In order to achieve this objective I required to know what the eduators' practices were before, during and after the intervention. I thus used an interpretivist paradigm again and felt that the best instrument to use to gather qualitative data to achieve this aim would be classroom observations.

2.2.4 Objective four

A quantitative method of data collection was chosen to test the effect of dialogic practices on the reasoning skills, numeracy skills and English skills of the learners. I felt that an experimental design, with pre- and post-tests on target and control groups, would objectively test whether the intervention had made a measureable difference to the target groups and would give me an insight into the learners' reasoning competence, numeracy competence and English competence, which were the constructs that I wanted to analyse in the light of this objective. This section of this study fits Cresswell's (2009) typical scenario of quantitative research as it has a postpositivist worldview. I needed to identify whether any improvement in reasoning, numeracy and English had occurred before and after the intervention through statistical testing.

2.2.5 Characteristics of paradigms (Ernest, 2009)

The two main philosophical underpinnings that apply to this study, namely the scientific and interpretive paradigms, were summarized by Ernest (2009) in table 3.1.

Table 3.1

Summary of scientific and interpretive paradigm characteristics (Ernest, 2009: 1-35)

	Scientific	**Interpretive**
Interest	Prediction and control of the material world	To understand and make sense of the human world.
Focus	Validation of laws and theories	Exploration of meanings and actors understandings.
Worldview	Scientific worldview	World of human meanings.
Ontology	Objects in physical space	Subjective or intersubjective reality.
View of Knowledge	Objective knowledge	Personal or socially constructed knowledge.
Methodology	Experimental, seeking general laws.	Case studies of particular contexts.
Methods	Mainly quantitative using predetermined instruments and categories.	Mainly qualitative focusing on textual and spoken responses from individuals.
Intended outcome	Objective knowledge and truth in the form of laws	Illuminative and illustrative case studies.

Using Ernest's (2009) categories of interest, focus, worldview, ontology, view of knowledge, methodology, methods and intended outcome, the quantitative section of this study falls within a scientific, or positivistic, paradigm because I endeavoured to use scientific method to be as objective as possible and to keep as many variables the same with only one, the introduction of exploratory talk in target classes, different. I predicted that the use of dialogue in the learners' main language would increase their mathematical reasoning, and my focus was to prove this premise through pre- and post-tests that could be statistically evaluated.

However, an interpretive research paradigm provides another framework of this study as my interest is to understand the difficulties and frustrations of educators who teach mathematics in a language, which is not their mother tongue, to learners who do not understand either the mathematics or the language they are using. I am also interested in understanding what strategies educators use in their classrooms in order to alleviate this situation, and in introducing the educators to a possible strategy that could help them teach mathematics more effectively. The focus of this study is to explore the realities in multilingual mathematics classes and the educators' understandings of possible strategies that can be implemented. My worldview focuses on human interactions and my ontology is the intersubjective reality of the classroom. My view of knowledge is that it is socially constructed as my premise is that mathematical reasoning is improved through dialogue with other participants. The methodology employed in this study is a series of observations – firstly with cohorts of students studying for qualifications at the Nelson Mandela Metropolitan University, then with three practising educators, then focusing on one particular educator's practices in the classroom.

As such, this study concurs with Lather's (2006) view that it is possible to work across paradigms, as there are multiple ways of conducting educational research "in the hope that more interesting and useful ways of knowing will emerge" (p. 53).

3. RESEARCH DESIGN

I found Babbie and Mouton's (2008) metaphor of research design, compared with building a house, to be useful. They compare the idea of the research project with the idea of building a house; the research design equates to the architectural design of the house, whereas the research process (or methodology) is likened to the construction process (method and tools) as illustrated in table 3.2.

Table 3.2

Differences between research design and research methodology

(Babbie & Mouton, 2008:75)

Research Design	**Research Methodology**
Focuses on the end-product. What kind of study is being planned and what kind of results are aimed at.	Focuses on the research process and the kind of tools and procedures to be used.
Point of departure = Research problem or question.	Point of departure = Specific tasks (data-collection or sampling) at hand.
Focuses on the logic of research: What kind of evidence is required to address the research question adequately?	Focuses on the individual (not linear) steps in the research process and the most "objective" (unbiased) procedures to be employed.

I have reflected on the philosophies and paradigms that informed my study and then have looked at the design that could best help me to attain the objectives stated.

3.1 Qualitative and quantitative design

The usual choice when embarking on research is between using qualitative or quantitative data collection processes. As described above, sections of this study fit into the quantitative approach, whereas other sections are best described as qualitative methodology. Table 3.3 demonstrates the differences between quantitative and qualitative methodologies.

Table 3.3

Qualitative and Quantitative Methodologies (Babbie & Mouton, 2008: 273)

	Quantitative studies	**Qualitative Studies**
Approach to setting	Controlled settings Selected samples	Natural settings Whole context
Aims of Research	Quantitative descriptions Explanation and Prediction	Thick descriptions Interpretive understanding (verstehen)
Research Strategy	Hypothetico-deductive Generalizing (nomothetic)	Inductive Contextualising (ideographic)
Notion of Objectivity	Natural Science definition; maximum control over extraneous factors Validity and reliability	Intersubjectivity: gaining trust and rapport in order to get as close as possible to subjects Trustworthiness and credibility

I have provided quantitative statistical results of the survey on beliefs about language policy and practice followed by quotes that support the results. I then presented the statistical results of the pre- and post- tests for the second two phases of the study. Figure 3.3 diagrammatically represents the flow of the quantitative process.

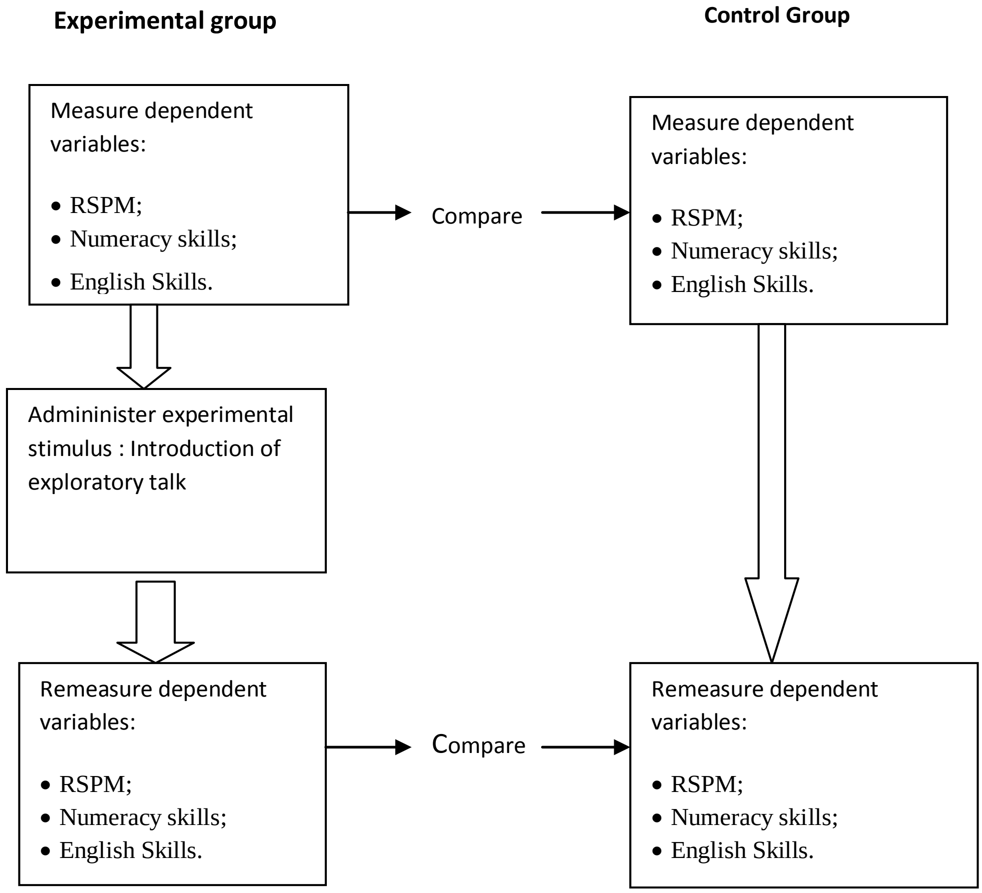


Figure 3.3 Representation of experimental method with target and control groups (adapted from Babbie & Mouton, 2008:210)

The qualitative design of this study has the following features which are regarded by Babbie and Mouton (2008) as being typical of qualitative research design:

- A detailed engagement with the object of study
- Selecting a small number of cases to be studied
- An openness to multiple sources of data (multi-method approach)
- Flexible design features that allow the researcher to adapt and make changes to the study where and when necessary

I had detailed engagement with the object of the study as I used different cohorts of teachers in different milieus for a minimum of six months (the duration of a semester module) for each cohort. Although the ACE:MST and BEd Honours cohorts were relatively large, I ‘funnelled in’ to three teachers in phase two and only one teacher in phase three, so in some phases I did study a small number of cases. I used multiple methods as I designed instruments then identified constructs from the student submissions, that I felt would help achieve the objectives of the study. I used flexible design features, particularly with the questionnaire and the classroom observations, as the constructs emerged after analyzing the data into themes. In some cases the themes that emerged were different from those that I had envisaged.

3.2 Mixed method design

Cresswell (2009) perceives that using both qualitative and quantitative methods in a mixed method study is legitimate as it utilizes the strengths of both approaches, particularly for research in the social sciences. Tashakkori and Teddlie (2003) provided the first handbook to describe mixed method research and the fact that there is currently widespread support for the approach is attested to by the publication of several journals devoted to the approach, for example the *Journal of Mixed Method Research* and *Quality and Quantity.*

Cresswell (2009) describes six types of mixed method studies that he and his colleagues, Plano Clark and Gutmann devised in 2003 – sequential explanatory strategy; sequential exploratory strategy; sequential transformative strategy; concurrent triangulation strategy; concurrent embedded strategy; concurrent transformative strategy. Cresswell (2009) explains that the difference between the strategies depends on the timing of the data collection (whether it was concurrent or sequential); the weight given to each of the quantitative and qualitative approach (whether both approaches were given equal weight or whether one received priority) and the mixing of the data (whether the qualitative and quantitative data were kept separate, connected, integrated or embedded).

This study follows a concurrent triangulation approach (figure 3.3) as both qualitative and quantitative data were collected during the same period and the data were compared to determine whether there was corroboration in analyzing the results. Ideally the weighting between the results should be equal.

Cresswell visually represents this design in figure 3.4 where QUAN and QUAL have the same number of letter to indicate equal weight of the forms of data.

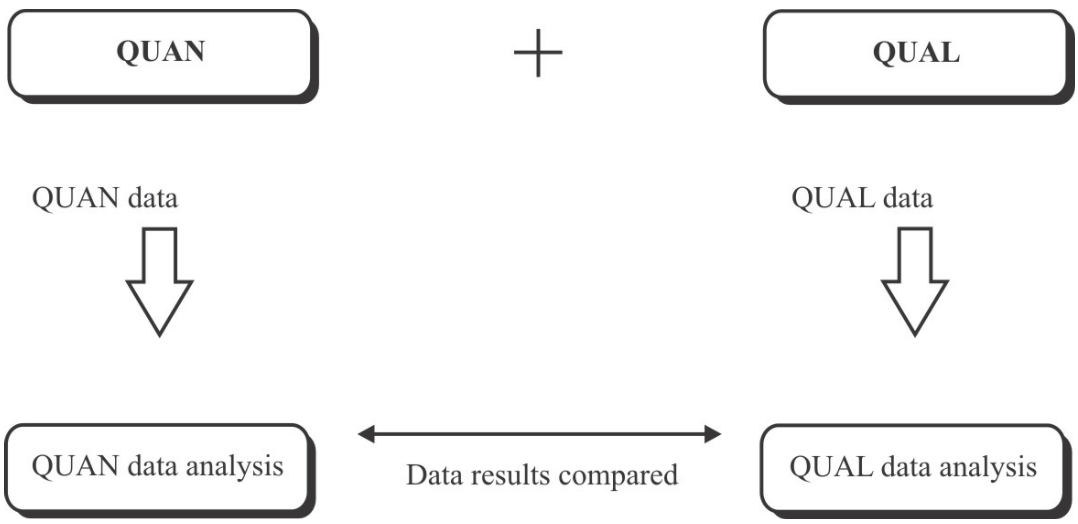


Figure 3.4 Concurrent Triangulation Design (Cresswell, 2009:210)

3.3 Design in phases

The study is divided into three phases. Phase one attempts to address objectives one and two whereas phases two and three attempt to address objectives three and four.

The first phase provides an overview of the perceptions that educators believe about teaching mathematics when teaching in a language that is not the main language of either educator or learners, and provides an overview of the students engaging in dialogic practices during an intervention to sensitise them, particularly, to the use of exploratory talk. As I am a mathematics education lecturer at the Department of Mathematics Education at the Nelson Mandela Metropolitan University I have access to students who are studying for qualifications in which I am involved as a lecturer. The educators who participated in the first phase of the study were engaged in part-time education studies at advanced certificate and

Honours degree levels as registered mathematics education students. This section of the study spanned a geographical range of urban and rural areas in the Eastern Cape (as determined by where the students were located). The focus then shifted in phase two to three individual educators and classrooms in Port Elizabeth in schools linked to the university via community engagement projects such as Family Maths and Scientific Literacy as well as an ICT outreach. The third phase of the study focussed on one school, and particularly on one educator, in Port Elizabeth. The strategies the educator used were documented and the effect of these strategies on the learners was interrogated. The intention was that the findings of this study should inform further interventions that aimed at changing the perceptions and practices of educators of multilingual mathematics learners. The three phases are again illustrated visually as follows in figure 3.5, as noted in chapter one.

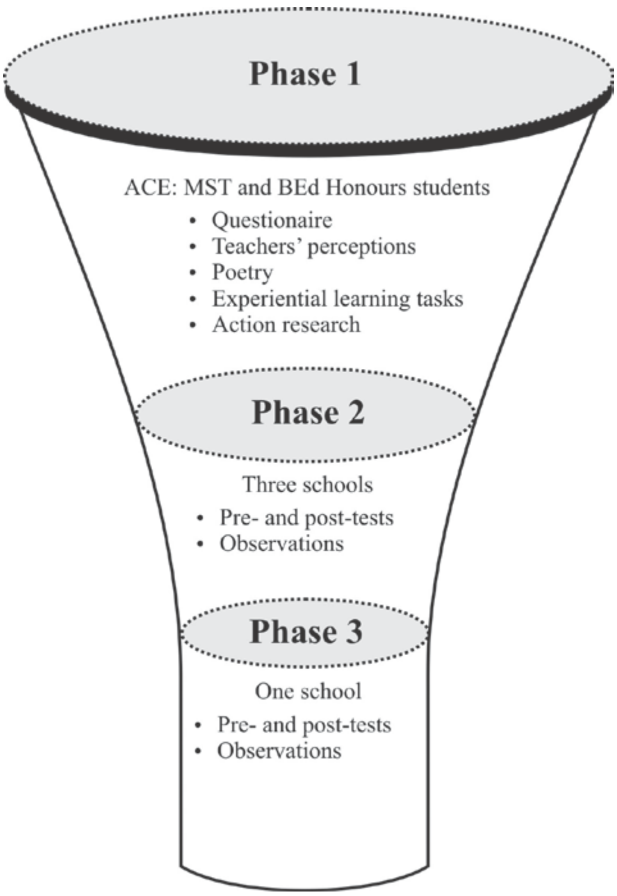


Figure 3.5 Focus funnel through the three phases of the study

The phases can be viewed as a ‘funnelling process’ where a fairly large sample of educators participated to provide insights into their perceptions of second-language teaching and learning, and experienced an intervention to introduce them to dialogic practices; after which three case studies were used for observation and testing; and finally an individual case was examined in depth to more fully interrogate the strategies used by a educator who had embraced the strategy of using dialogue in his mathematics classes. The phases were designed to obtain a snapshot of educators’ perceptions and practices on a broad base first and then zoom in to specific cases, finally to focus the lens on a particular teacher’s practices and the effect they had on learners’ reasoning, numeracy and English skills (Lerman, 2001).

4. SAMPLE AND SELECTION

As mentioned, this study was designed in three phases to attain the four specified objectives. Two cohorts of students studying at NMMU and three teachers were used as the sample.

4.1 Sample for objective one

In order to identify constructs in order to achieve objective one and to open a window on the identities and background of the students, to encapsulate their concepts of the power of language, to identify the challenges and strategies they used before the intervention and to gauge their views on language usage in the classroom, I focussed on two samples. Firstly, a cohort of 176 Advanced Certificate in Education, Mathematics, Science and Technology (ACE: MST) students in Port Elizabeth (28); Queenstown (34); Mthatha (55); King William’s Town (32) and Kokstad (29) participated in the study. The educators were all from previously disadvantaged schools and travelled from outlying rural areas to attend lectures at the centres during block sessions during school holidays. The details are represented in table 3.4.

Table 3.4

ACE:MST student numbers and home town's from each centre

Centre	Educator's Home Town	Students
Port Elizabeth Centre:		**28**
	Port Elizabeth	8
	Grahamstown	5
	Graaff Reinet	6
	Uitenhage	9
King Williams Town Centre:		**33**
	King William's Town	7
	East London	8
	Butterworth	8
	Fort Beaufort	9
	Mthatha	1
Kokstad Centre:		**27**
	Maluti	6
	Mbizana	8
	Matatiele	2
	Mount Frere	10
	Mount Ayliff	1
Mthatha Centre:		**54**
	Idutywa	7
	Cofimvaba	7
	Lusikisiki	5
	Ngcobo	4
	Mthatha	10
	Libode	8
	Qumbu	8
	Mount Fletcher	5
Queenstown Centre:		**34**
	Queenstown	11
	Lady Frere	7
	Cradock	6
	Whittlesea	1
	Sterkspuit	8
	Molteno	1
Total Student Registration		**176**

The second sample included 179 students who were studying for a BEd Honours qualification. The students were situated in Port Elizabeth (32), East London (30), Kokstad

(29), Ngcobo (29), King William's Town (33) and Mthatha (26). These areas were chosen as NMMU has established study centres run by a centre manager in each town. This facilitated communication with the students and collection of tasks and assignments. The centres represent urban (Port Elizabeth, East London), peri-urban (King William's Town, Mthatha) and rural (Kokstad, Ngcobo) communities; however the distinction is not clear cut as students travel from rural areas to attend lectures at the peri-urban and urban centres.

4.2 Sample for objective two

I personally workshopped the activities designed to promote dialogic practices during contact sessions at all the BEd Honours centres. I thus observed their reactions and heard their reflections. For validity I videotaped all the sessions and a research colleague viewed the DVDs. We checked our results by comparing and discussing each contact session until we had reached consensus.

4.3 Sample for objective three

In order to track educators' practice before, during and after the intervention in phases two and three I used two different samples. For the first cohort, I asked five purposively selected school principals in Port Elizabeth, who were involved with the NMMU Mathematics Education Department in various community engagement projects, to allow their grade seven mathematics educators to take part in the study. In response to my request the principal educators nominated grade seven mathematics educators in their schools. I interviewed these educators to ascertain whether they had any reservations and explained the extent of the commitment required. I decided to include two classes from one school as target classes as the same educator taught both classes. The remaining two grade seven classes at that school became control classes. I chose two other schools where one class in each school became the target class and one class in each school became the control class. The selection criteria for the choice of the schools was that they were similarly situated and resourced in townships on the Eastern side of Port Elizabeth; conveniently near the Missionvale campus of the NMMU where my department is situated. The demographics of the three schools were similar, as both educators and learners were first language isiXhosa-speakers.

For the second cohort of classroom observation I asked one of the three grade seven educators, who had participated in phase two, to allow me to study his teaching methods in more depth, as the researchers' observations the previous year had shown that he had fully embraced the strategy of using dialogue in his mathematics classes and had implemented the strategies that had been introduced in the intervention. I wanted to ascertain whether similar results could be replicated with a new cohort of learners the following year. I thus focussed on four grade seven classes at one school, of which two classes were taught by the identified educator. Those two classes formed the target group and the other two classes, which were taught by different educators, were the control classes.

4.4 Sample for objective four

So that I could test the effect of dialogic practices on the learners' reasoning, numeracy and English language skills in the first year of this study I used the same sample that I had used to interrogate objective three, namely four target classes (two from one school taught by the same teacher) and four control classes (two from one school taught by different teachers). During the second year I identified two grade seven classes that were taught by the same teacher as target classes. The other two grade seven classes in the school, taught by different teachers, became the control classes.

5. DEVELOPMENT OF THEMES AND CONSTRUCTS

The conceptualization of figure 3.6 helped to organise and plan the development of the themes and measurable constructs necessary to address the four objectives of this study and to guide the design of the study. The literature search of previous studies and theories together with the theoretical framework led to the mixed method design of both quantitative and qualitative measures. For measuring quantitative empirical evidence in the real world I pre-identified the constructs of reasoning, numeracy skills and English language skills. There are suitable validated tests, which I located, to measure these constructs so the research in this section was deductive. I tested the learners in target and control groups pre- and post- an intervention to attempt to ascertain whether the intervention had any effect on the learners' reasoning, numeracy and English skills and whether any conclusions could be drawn concerning objective four. These tests lead to the creation of knowledge about the efficacy of dialogic practices using the learners' main language in multilingual mathematics classes in the Eastern Cape.

As regards qualitative measures, at the beginning of the study I did not have clear constructs that would lead to conclusions concerning objectives one, two or three. These constructs would have to be drawn out inductively from the qualitative data gathered. I planned to go into the field and use instruments such as reflective writing, poetry, questionnaires, observations and experiential tasks to identify relevant constructs from real life, from which I could tease out themes which could be measured qualitatively in order to achieve the objectives set. From the quantitative and qualitative measures of the constructs conclusions could be drawn and knowledge concerning teaching strategies in multilingual mathematics classes could be created.

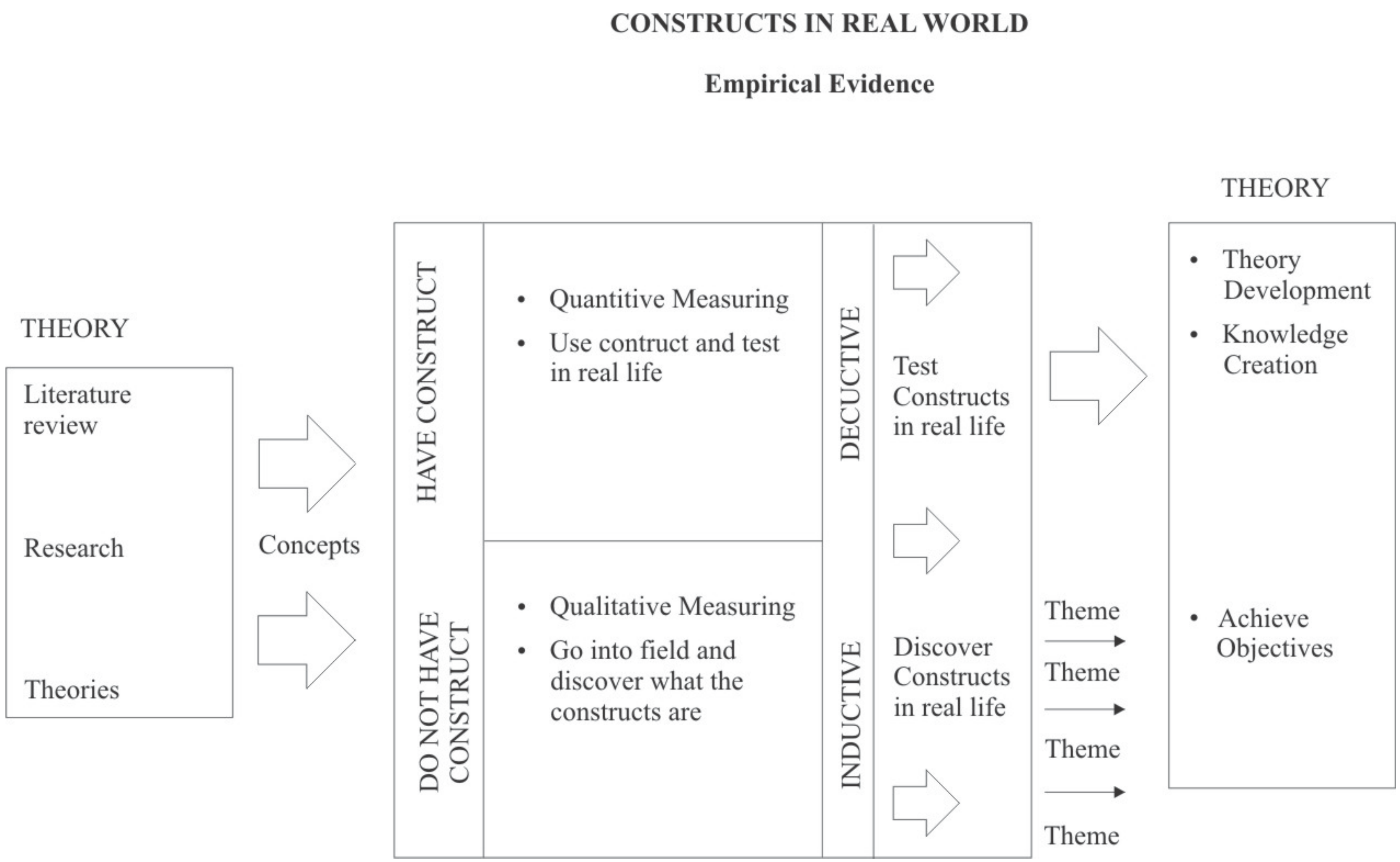


Figure 3.6 Researcher's conceptualization of research design

6. DATA COLLECTION: QUANTITATIVE DATA

The quantitative data were gathered via a number of instruments. During the first phase of this study the responses to the questionnaire on challenges, strategies and solutions were scrutinized for quantitative themes that could address objective one. The number of occasions a participant mentioned a theme was numerically calculated and analysed. The educators' language choice responses were also handled empirically. In the second and third phases of this study the constructs of reasoning competence, numeracy competence and English language competence had been deduced. The results of the pre- and post-tests were statistically analysed in order to give insight to objective four of the study. The quantitative instruments are described in more detail in the following sections.

6.1 Questionnaire Responses

In order to gauge educators' perceptions about language problems and solutions in their schools, the BEd Honours students were given an open-ended questionnaire, reproduced in Appendix D, that was designed to identify possible constructs that could be measured. Before I could implement an intervention I needed to know what the educators' present practice was concerning the use of languages in their multilingual mathematics classes. I also used the questionnaire to gather quantitative data about their prior knowledge and prior experience of challenges they encountered and solutions they implemented in their multilingual mathematics classes. Because I did not yet have measurable qualitative constructs I had to have the questionnaires completed to analyse inductively what the constructs were in real life. The questionnaire questions were as follows:

- List some of the challenges that languages present at your school;
- List some of the solutions to the challenges that languages present at your school;

- List some strategies that you have found help multilingual mathematics learners understand mathematical concepts;
- Which language do you believe should be the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?
- Which language is actually the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?
- Which language would your learners choose to be the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?

The answers to the first three questions were sorted into themes that will be discussed in the qualitative results section of this study. The answers to the last three questions were captured onto spreadsheets and analysed statistically. The reasons that the educators gave for their personal language preferences were analysed qualitatively.

6.2 Pre- and post-testing of learners

During the phase two and phase three observations in the classrooms, pre-tests and post-tests (nine months later) were conducted in both target and control classes in order to gather data to address objective four. The tests were conducted at the same time of the day in the same order in all classes so that there was uniformity in the application of the tests. I worked with two NMMU colleagues to ensure that the tests were conducted in exactly the same way in each class. At all times there was either a researcher or an educator in the class who was fluent in isiXhosa and who could explain the implementation method to the learners and field any queries, should a problem arise. The same researchers conducted all the pre- and post-tests so that there would be uniformity in the testing process and so that unexpected variances in practice could not sully the standardisation of the application of the tests. The researchers implemented the RSPM test, the APAP Numeracy skills test and the APAP English skills test.

The reason for using the RSPM test was that it is a language-free test therefore the results are not coloured by the degree of the participants' English competence. The test is a well established assessment tool of the ability to reason. It has been used for a range of age groups and has been proved to correlate with academic achievement (Carpenter, Just & Schell, 1990). The 60 puzzles (set in five groups of twelve) can be administered in booklet form with separate answer sheets; however, in this study we used a data projector to beam the slides onto a screen sequentially. The objective for using the RSPM test was to deduce whether there had been, over the nine months of the duration of the intervention, any significant improvement in the learners' reasoning skills.

The Admissions and Placement Assessment Programme (APAP) tests are standardized, criterion-referenced measures of language and numeracy skills with proven reliability and validity devised and verified at NMMU (Foxcroft et al., 2002; Watson, 2004a). The total possible score for each test is 100. The learners' test performances were divided into four score ranges/levels. At the lowest level was 'developing', followed by 'expanding', then 'functional' with 'proficient' at the upper level. Participant's test performances are criterion-referenced in that they are compared with a standard of proficiency rather than with the performance of others. This type of scoring is developmentally orientated. In this study the results of individual learners were not scrutinized, but the scores were viewed as being representative of a cohort of learners. One of the unique features of the skills-based, developmental orientation of the APAP tests is the use of progress maps for all the skill areas assessed, as a frame of reference for assessing learning. The progress maps are reproduced in the Appendix B and the results are reported in chapter four.

The APAP English skills test (Watson, 2004b) assessed three skill areas:

- *Language use:* assesses knowledge of language in terms of the use of nouns, pronouns, subject-verb agreement, comparatives, adverbs, adjectives, verbs, and subordination/coordination.
- *Reading Skills*: Measures comprehension of passages that are 90 words or less, primarily on non-academic, everyday subjects. The reading skills tapped include identifying main ideas, making inferences and drawing conclusions, the ability to read critically, and problem-solving ability.
- *Sentence meaning*: assesses vocabulary knowledge within the context of sentences drawn from the content areas of natural science, history/social studies, arts/humanities, psychology/human relations, and practical situations. Areas tested include particle verbs, basic and important idioms, adverb/adjective phrases, basic nouns, verbs, adjectives, adverbs of frequency, sequence of adverbs, prepositions of direction and place, comparatives, connectives, and commands.

The numeracy test assessed basic operations e.g. addition, subtraction, multiplication and division of whole numbers, and reading information off different types of graphs.

The pre- and post-tests were conducted, administered and scored in the same way for the target and control groups for both phases two and three. The results were entered into electronic spreadsheets by an independent administrator and the raw data were emailed to a statistician, an NMMU senior lecturer, for statistical analysis to determine whether there had been any improvement when comparing the target and control groups pre- and post-scores. The results of the quantitative tests are tabled in the following chapter. The data collection methods for the qualitative data are reported next.

7. DATA COLLECTION: QUALITATIVE DATA

Qualitative data were collected to inform the first three of the four objectives of the study. The instruments used to collect data are described in the following sections.

7.1 Perceptions of educators – reflective writing and poetry

The objective of this section of the study was to unpack the beliefs and feelings educators nurture about the teaching of mathematics in multilingual classrooms in the Eastern Cape and to document strategies that they use in the classroom. The students studying for an ACE:MST module on language were given the opportunity to discuss and write reflectively on their personal language experiences and in this way give form to their feelings and frustrations about language usage in their schools. The constructs for this portion of the study were identified from the students' responses. The exercises were designed to give the educators a safe space where they could express themselves without the constraints of assessment towards a class mark. In order to encourage educators to interrogate issues of language, identity and power they were asked to reflect on their own experiences and write a short poem in which they shared their feelings about language and the impact that language has on identity. The educators needed to develop confidence in their own experiences and perceptions in order to be willing to express them in open discussions and exploratory talk within a constructivist learning and teaching environment (Benton and Fox, 1985). It, therefore, became very important to create spaces in which educators, who are not English first language speakers, felt free to share their 'language stories' and reflected on the multilingual realities of their mathematics classrooms - and the teaching and learning implications for mathematics. Educators who believe that mathematics and poetry are two extremes of a continuum were enabled to make the link between logical thinking and feeling (Benton & Fox, 1985). This experience opened a door for the educators to express emotions in a mathematics context which they previously perceived to be 'absolutist', and served to bridge the gap between the perceived rigidity and sterility of mathematics and the educators' opinions and experiences concerning pride, power and identity. The students shared their insights concerning the relationship between language, society and culture and the impact that language has on learners and learning.

7.2 Semi-structured Questionnaire

The next aspect that I felt would help to interrogate the educators' perceptions about their language strategies and usage was knowledge of the challenges and strategies that they used in multilingual mathematics classes before they experienced the intervention. In order to gather data the students were asked to complete a semi-structured questionnaire with three open-ended questions concerning the problems they experience teaching in the multilingual mathematics classrooms of their schools and to describe solutions and strategies which they use in their classes to help their second-language learners understand mathematics (see Appendix D). The BEd Honours students were expected to be inquirers into their own practices as well as to reflect on the use of their main language, English and code-switching in mathematics classrooms. The rationale for this was to ascertain what strategies educators believe work in their contexts in order to circumvent the lack of English fluency in multilingual mathematics classrooms; and to gauge whether any discursive teaching strategies were being implemented. The constructs were identified inductively from the students' responses.

Educators have difficulties in teaching mathematics in classrooms where the LoLT is not a language familiar to the learner, thus I wanted the students to reflect on the nature of the problems they experience, and be challenged to find solutions rather than being overwhelmed and feeling helpless; and to document the strategies that they use to aid teaching and learning. The intention of this exercise was to lead the educators to reflect on their teaching situations and to identify positive strategies that could be implemented.

7.3 Numeracy test in an different languages – English and isiXhosa

The DVD, “Sink or Swim” (Westcott, 2004), produced by the Project for the Study of Alternative Education in South Africa (PRAESA) was shown to all the BEd Honours students in order to expose them to the difficulties faced by learners when the LoLT was not their main language. So that the students could relate to the learners’ difficulties while writing assessments in a language that is not their main language, they were given a numeracy assessment to complete. isiXhosa-speaking students were given copies of the test in English, English-speaking students were given copies in isiXhosa, and some students were given the test in both English and isiXhosa. The researcher observed the students’ body language while completing the test and afterwards a discussion highlighted their emotions and frustrations with their inability of some of them to understand the questions even when they were convinced that they knew the correct answers. The completion of the exercise was videotaped in each centre so that nuances of their gestures, body language and utterances could be recorded and analysed

7.4 Experiencing Exploratory Talk using triggers

The BEd Honours students, who were all practising teachers, were introduced to the tenets of Exploratory Talk, as envisaged by Mercer and Littleton (2007). The RSPM items are purported to be language- and culture-free. I encouraged the students to be mindful of the ground rules of exploratory talk that they had devised together. The students discussed the logic leading to the solution to the items in their groups using English, isiXhosa and code-switching.

The students had previously read Setati’s (2005a) article, Teaching Mathematics in a Multilingual Primary School, and Mercer and Sam’s (2006) article, Teaching Children how to use Language to solve Maths Problems. The students were guided through the main arguments of the articles towards the concepts of mathematical discourse and dialogue in multilingual classrooms in order to ground their reflections on their own practices in an informed manner.

After an intervention in which the students, in groups, developed their own set of ground rules for exploratory talk so that the students would 'buy-in' to the strategy; the students worked first individually then in groups to solve examples from the RSPM test using the theoretical tenets of exploratory talk in practice so as to cement in their own experience the advantages of dialogue in problem solving. RSPM items consist of graphical puzzles and are used to test cognitive (reasoning) skills. These tests are widely used in psychology and education as a test of non-verbal reasoning (Richardson, 1999). Also, Raven's tests appear to be appropriate for exploring links between language practices and the non-culturally biased tradition of research in cognitive development as they correlate well with similar tests of reasoning and with measures of academic achievement (Raven, Court & Raven 1995, Richardson, 1991). The test is divided into 5 parts (A, B, C, D, and E). Each part has 12 puzzles (60 in total) in increasing degrees of reasoning difficulty.

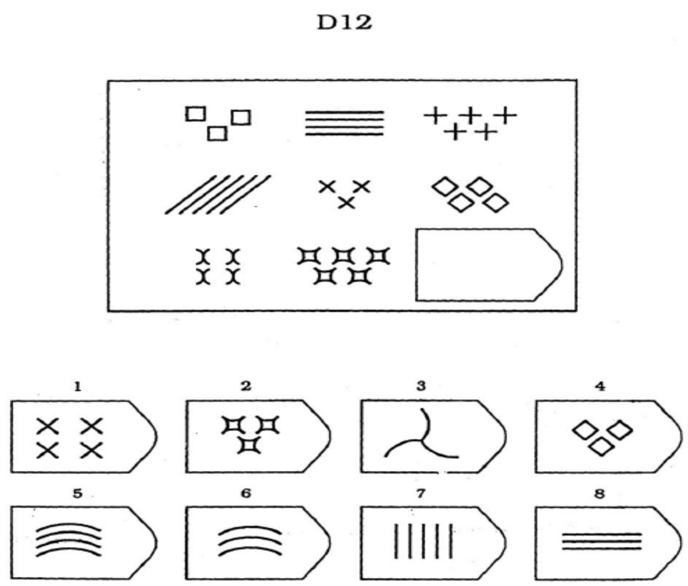


Figure 3.7 Example of Raven's Standard Progressive Matrix
(Raven, Court & Raven, 1995)

The students had to decide in groups which of the eight options would best fit the gap in the pattern. These discussions also enabled them to approach problem solving in groups where the object was not only to solve the problem, but to tease out the verbal mechanics of moving towards consensus. Each group presented its collective reasoning in a plenary session.

In order to provide another trigger for the development of dialogue, the students were given Mathematics Concept Cartoons to discuss in their groups. Each situation shows learners discussing a alternative mathematical conception. For example in one cartoon there the learners are debating the answer to “5 x 0 x 6”. The learners each have different perceptions.

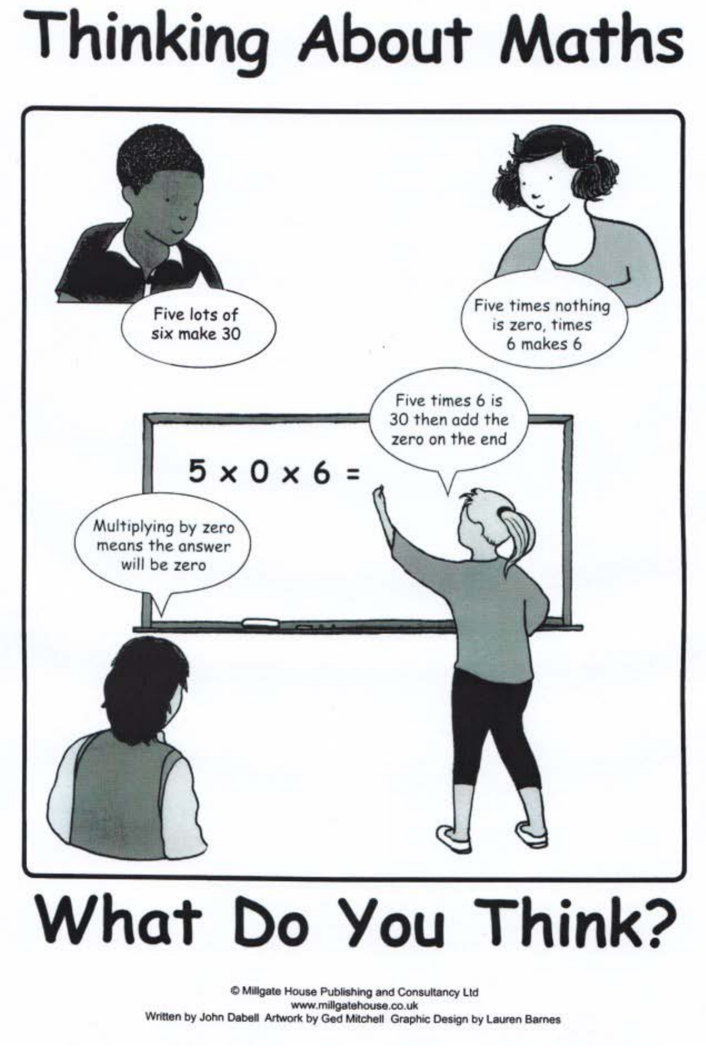


Figure 3.8 Example of concept cartoon (Dabell, Mitchell, & Barnes, 2007)

The objective of concept cartoons is for the learners to discuss their own perceptions in the light of the statements in the concept cartoon and to analyse which, if any, opinions expressed are mathematically correct. The participants are required to examine each thought-bubble in turn to decide whether the view expressed is correct or incorrect and to give a reason for their decision. Ultimately they should devise a mathematical statement of their own which describes the scenario depicted.

The discussion in groups about the concept cartoons helped the educators to ground the practice of exploratory talk in mathematical activities. They were encouraged to focus on their dialogue; to notice when they were using instances of disputational talk ("The right answer is 6"; "No, it's not. It's option 5"); cumulative talk ("The right answer is 6"; " Yes, the answer is 6"); and exploratory talk ("The right answer is 6 because the pattern is 3,4,5 in a different order in each row"; "I disagree, because there must be lines squares and crosses in each row, so I think it must be 3"). They were also made aware of the language they used in dialogue – was it mainly their first language or English? Again the interactions between the teachers were videotaped for later reference.

7.5 Identifying when different languages could be used in a lesson

The students were requested to work in groups on the worksheet in Appendix E, but not to work out the answers. Instead, they were tasked to suggest which languages should be used at which stages of the lesson and why they thought this should be so, and to give reasons for their choices.

Although this section of the workshop was not structured, the educators drew on their own experiences and were able to relate to the issues. The interactions among the students and their whole class discussion thereafter were videotaped for further reference.

7.6 Action Research assignments

The study also investigated whether the BEd Honours students, who were mathematics educators, could promote and implement exploratory talk successfully in their mathematics classes. They were tasked with conducting a mini action-research project on the development of exploratory talk in their schools and to write an assignment on their experiences and insights concerning their own action research; as well as to reflect on the efficacy of the exercise.

8. PHASE TWO: THREE EDUCATORS IN THREE SCHOOLS

The three educators of the target classes, Mr Hlam (North), Mr Mzondo (South) and Ms Zondani (West), attended regular contact sessions at the university. I workshopped with them the theory of the use of dialogic practices and some exercises that had been part of the BEd Honours module, particularly exploratory talk in mathematical classrooms. We devised a series of lessons together where the educators introduced their learners to triggers and the ground rules of exploratory talk. Concept Cartoons were used as triggers to practice the ground rules of exploratory talk. The object was to trigger and practice discussion among the learners on a topic from outside their usual milieu and then to use the same process with curriculum mathematical material, so that exploratory talk becomes part of the fabric of classroom interaction and is not seen as a strategy that is only used with triggers.

8.1 Intervention and planning

I regularly met together with all three educators of the target classes in the three schools to explain the objectives of the research; to train them in the theory and practice of dialogic strategies; to build a community of practice; and to plan a set of lessons so that the educators had a coherent lesson schedule to follow. I believed that it was vitally important that they felt included in the research and were not being judged in any way. We discussed the difficulties and solutions that they experienced individually through teaching mathematics to learners whose main language was not English and workshopped the introduction of discussion and dialogue, particularly exploratory talk. Together we explored many of the activities that I had used with the BEd Honours students. The educators were tasked to develop ground rules for exploratory talk with their learners and to ask the learners to make posters which would be stuck on the walls to remind the learners.

During the intervention we changed from joint meetings at the university to individual planning sessions with each educator after I had observed their class teaching. The educators were overburdened with other after-school meetings and activities and they found it easier to talk one-on-one with me about their individual situations and progress.

8.2 Lesson Observation

I devised an observation checklist (Appendix H) and videotaped each educator teaching a mathematics class at the start of the study before the first meeting with the target educators in order to set a baseline standard and document the initial practices of each educator. Thereafter, a research assistant and I videotaped each educator on average every three to four weeks during the study and the lessons were transcribed using the computer program Transana version 2.3. After the observed lesson the researcher would sit with the educator, who had been allocated free time from the school principal for this purpose, and reflect on what the educator felt had gone according to plan and what could be improved. We planned the strategy for the next few weeks of lessons. I felt that it was imperative that the educators did not introduce the strategy of using dialogue in the learners' main language as an addendum to classroom mathematics, removed from the usual curriculum mathematics that the learners' experienced. We planned to use triggers, in the form of Concept Cartoons, to initiate and practice the skills required for the development of dialogue, but emphasized the progression into curriculum material so that the strategy would become second nature to the learners in their everyday mathematical learning.

9. PHASE THREE: ONE EDUCATOR AT ONE SCHOOL

During the third year of the study one of the educators who had participated in the previous years' investigation, Mr Hlam, was approached to continue the project in greater depth with his two Grade seven mathematics classes at North Primary School. The principal of his school supported the continuation of the study as he had perceived the value of the intervention for his learners. As Mr Hlam had participated in this study for the duration of the previous year he was well versed in the practices of exploratory talk and became a fellow planner and investigator during the nine months that the research took place in his school. Two control classes were selected at the same school; however, the teachers of the control class were not party to the planning sessions between the educators of the target classes and the researchers.

9.1 Planning

I occasionally met with the participating teacher and my research assistant at the university, but more often we discussed future strategies at the school after a reflection on the lesson observed that day. I left the planning of the lessons entirely up to him as I felt he had considerable experience and expertise both in teaching mathematics and in using dialogic strategies.

9.2 Lesson Observation

The observation sessions followed the same pattern and frequency as in the previous phase. Sometimes my research assistant or I would visit the school and sometimes we would go together in order to observe the whole class or to focus on different groups. The same observation checklist was used (Appendix H) as during the previous year. The lessons were videotaped and transcribed and analysed using the transcription programme, Transana 2.3.

10. SUMMARY OF RESEARCH DESIGN

Table 3.5 is a summary of the research design that clarified constructs and instruments that would be used to address each objective. This summary of the phases, objectives, sample, instruments, data type and constructs also appears in Appendix F.

Table 3.5

Summary of research design

Phase	Objective	Sample	Number of participants	Instrument	Data	Construct
One	To identify educators' perceptions	ACE: MST students	176	Reflective writing	Qual	Identify from submissions
				Poetry	Qual	Identify from submissions
	Language strategies	BEd Honours students	179	Questionnaire section: challenges/strategies/solutions	Quan + Qual	Identify themes: present challenges and strategies
	Language usage			Questionnaire section: LoLT	Qual	Language choice
One	To research the design and implementation of an intervention for educators to promote dialogic practices	BEd Honours students	179	Experiential test in unfamiliar language	Qual	Identify from submissions
				Triggers to practice exploratory talk	Qual	Identify from submissions
				Different languages in a lesson	Qual	Identify from submissions
				Action research assignments	Qual	Identify from submissions
Two and Three	To track educators' practice in the Classroom before and after an intervention	Phase two: 3 teachers	3	Personal and video observation	Qual	Identify themes:
		Phase three: 1 teacher	1	Personal and video observation	Qual	Questioning, classroom climate,
						Language usage, group work
						Whole class discussion
Two and Three	To test the effect of dialogic practices on -Reasoning skills -Numeracy skills -English skills	Phase two: 3 teachers	3	Raven's Standard Progressive Matrices	Quan	Reasoning competence
		4 target classes	114	APAP Numeracy Skills	Quan	Numeracy competence
		4 control classes	112	APAP English skills	Quan	English competence
		Phase three: 1 teacher	1			
		2 target classes	89			
		2 control classes	90			

11. PARTICIPANT ACCEPTANCE

At the beginning of each phase of this study the participants were given a letter which spelt out their participation in the research. They could choose to sign the acceptance form or not; however, no educator refused to sign. They were assured that participation was voluntary and that no portion of the data collection would be used for any purpose other than this research. They were given a guarantee that they could withdraw from the study at any time and that no personal details would be disclosed. In all three phases the participants signed willingly.

In phases two and three the signed acceptance of the principal was accepted in loco parentis as the principals were assured that no video footage would be used other than for research purposes. The research approach aimed at providing the participants with a sense of empowerment and support. At all times the participants were reminded that their views and actions were not being investigated to provide information which would lead to criticism, but to provide insights into the contexts in which they function.

12. RELIABILITY AND CREDIBILITY

Quantitative and qualitative methods rely on different degrees of validity. Babbie and Mouton (2008) depict the differences succinctly in table 3.6:

Table 3.6

Quantitative and Qualitative notions of objectivity (Babbie & Mouton, 2008)

Quantitative	**Qualitative**
Internal validity	Credibility
External validity	Transferability
Reliability	Dependability
Objectivity	Confirmability

The reliability of quantitative results can be gauged according to whether a test returns the same results repeatedly. The reliability of the results of this study could be assured because statistical treatment of the numerical survey results provided satisfactory Cronbach α scores and showed similar trends in all centres. The reliability of the RSPM and APAP tests are assured through rigorous validation over many years. The same procedures of delivery were followed with both the target and control groups for the pre- and post-tests for both cohorts.

The validity of quantitative results refers to the extent with which the statistical results reflects the real meaning of constructs that are under observation. As regards the RSPM and APAP tests, I did not formulate my own tests but used tried and tested instruments so that I could compare the RSPM results with validated results from across the world. The APAP tests have been used in many studies in the Eastern Cape (Watson, 2004c) and thus were considered by NMMU to be a valid instrument. The analysis was undertaken by a qualified statistician in order to ensure that statistical analysis was sound. I asked the students to complete the questionnaire about their challenges, strategies and language choices before the commencement of the first lecture so that they would not be influenced in any way by the course content.

With qualitative results the terms are not as prescriptive, and descriptions like ‘credibility’ and ‘dependability’ seem less rigorous than the quantitative counterparts; however the study requires the same degree of reflection. Guba and Lincoln (2005) refer to trustworthiness in the sense of neutrality in the findings or decisions of a study. Babbie and Mouton (2008) maintain that a quantitative study cannot be transferable unless it is credible; and it cannot be credible if it is not found to be dependable. They judge credibility according to the following criteria: prolonged engagement; persistent observation; triangulation; referential adequacy; peer debriefing and member checks. In this study I believe a measure of credibility is achieved because the duration of the study was over four years during which different cohorts of students studying at NMMU were questioned to ascertain whether the results were consistent; and the cohorts were revisited to assess in discussions whether the perceptions reported were correct. The study in the classroom was repeated with another cohort of students to check whether the educator could replicate to a degree the results, after an intervention. All observations were analysed by two researchers independently and the results compared. The visits to the schools were numerous, not only to gather video and observation checklist data, but to acclimatize and sensitize the learners, and the educator, to intrusions of researchers and video cameras into the classrooms. Triangulation was addressed by utilising two researchers in the field, as well as by using different methods to elicit data and check credibility. The questionnaires were analysed until the data were saturated. The quantitative study was repeated in two different years with different cohorts of learners to test for possible transferability. I have endeavoured to give thick descriptions of the perceptions expressed in the reflective writing, questionnaires and poetry and to describe the experiential activities and classroom interactions richly. I used purposive sampling of students, schools and educators so that I could control the range of information about the chosen context. I therefore endeavoured to ensure dependability in the sense that if this study were repeated with similar respondents, the results would be similar. Guba and Lincoln (2005) maintain that there can be no credibility without dependability in qualitative research (as there can be no reliability without validity in quantitative research) but if one can be established then the other follows as the overlap methods ensure triangulation

13. CHAPTER SUMMARY

In this chapter I have explored the Scientific and Interpretive paradigms and I have explained my perception for locating my study in both, which resulted in a mixed method design. The paradigms have informed the research design, which fits Cresswell’s (2009) definition of a concurrent triangulation design.

The sample and setting of the study have been described. The study is situated among educators in the Eastern Cape and cohorts of educators were identified for each objective. The four objectives of this study mentioned in chapter 1 are addressed by both quantitative and qualitative measures. The constructs for the quantitative empirical data are language choice, reasoning competence, numeracy competence and English competence. These constructs have been measured in this study by using pre- and post-tests of RSPM tests and APAP Numeracy and English skills tests. The constructs for the qualitative data had to be identified from participant responses. In order to uncover the constructs various instruments were designed – a questionnaire; reflective writing, poetry, experiential activities and classroom observation. The constructs will be used to interrogate the data in chapter seven. Ethical concerns and issues of reliability and credibility have been explored. In the next chapter I will describe the quantitative results for phase one of the study.

CHAPTER FOUR

QUANTITATIVE RESULTS

1. INTRODUCTION

In the previous chapter I described the paradigms that informed my study. I described the research design and instruments used to measure the constructs that I believed would furnish data to enable me to achieve the study objectives. In this chapter I report on the quantitative data that gathered for objectives one and four.

The first data that I report on are the results of the open-ended questionnaire on educators' perceptions about language strategies and language choice in English second language classrooms. These data were generated from the cohort of 179 BEd Honours students in various areas of the Eastern Cape and will be used in an attempt to answer one of the sub questions of this study, namely, 'What are educators' beliefs and attitudes about language strategies and language usage in multilingual mathematics classes?'

Secondly, I report on the results of the data gathered from the RSPM pre- and post-tests of reasoning and the APAP Numeracy and APAP English skills tests (conducted in phases two and three). These data will be used to assist in answering answer another sub-question of this study, namely, 'Can the introduction of dialogic practices, particularly exploratory talk, increase mathematical reasoning in multilingual mathematics classrooms?'

2. QUESTIONNAIRE OF PERCEPTIONS ABOUT LANGUAGE

The open-ended questionnaires generated data from the responses of the one hundred and seventy nine participants who were BEd (Honours) students who were studying a module on language practices in multilingual classrooms. The educators were asked to list challenges they encountered and strategies they implemented, as well as giving personal language choices for the language they used in their classes. Although this chapter is essentially concerned with quantitative results, qualitative results have been reported simultaneously in order to give a more comprehensive picture of the data.

2.1 Problems faced in multilingual classrooms

The questionnaires were scrutinized and themes concerning both the difficulties that the educators faced in teaching mathematics to multilingual learners and the solutions (that they implemented before the intervention) to the difficulties they faced were identified. The dominant emerging problems were the learners' difficulty in communicating in English; difficulty in understanding mathematical content; non-participation of learners in class and lack of reading and writing competence in the learners' main language, even though they can speak the vernacular fluently.

Table 4.1

Table of student responses for challenges faced in multilingual classrooms (n=179)

n	**Centre**	**Poor English ability**	**Difficulty understanding mathematical content**	**Non participation of students**	**Lack of literacy in main language**
29	PE	28	11	4	2
22	Kokstad	22	3	2	10
13	Ngcobo	13	7	6	0
33	KWT	19	2	2	2
38	Mthatha	23	11	9	0
44	EL	37	19	8	2
179	Total	142	53	31	16
	Percent	79%	30%	17%	9%

Note. PE=Port Elizabeth; KWT=King William's Town; EL=East London

The majority of the educators (79%) felt that the poor English language ability of their learners was a major contributing factor to their learners' lack of understanding and poor results in mathematics. This resonates with Howie's (2003) analysis of the South African

TIMSS results which led her to believe that fluency in English is a significant factor in learning science and mathematics in the South African context.

Some of the comments by the students to the open-ended question are listed below:

> It is a communication barrier as the learners do not understand the question, or the exam questions - Port Elizabeth;
>
> They do not have the correct vocabulary to use when explaining concepts. As a result the educator has to read and assume what the learner is trying to say. They cannot understand instructions – Port Elizabeth;
>
> Learners are demanded to speak in English but most of them cannot express themselves very well and this results in poor performance in maths - King William's Town;
>
> Learners are unable to communicate in a foreign language especially in English. It becomes difficult to understand a lesson taught in a language they do not know and like – East London.

An educator in East London has a unique problem in that she teaches mathematics at a school for the deaf. She said "The learners have an inability to link sounds to the spelling of words, including numbers. Sign language must be recognised as an official language, so that deaf learners may be accommodated in our communities, not be isolated because of their language." As sign language is a recognised language in the South African constitution, this is an example of non-implementation of policy (Heugh, 2008).

Thirty percent of the educators mentioned learners' difficulty in understanding mathematical content as one of the problems they face. Examples included:

> Learners do not understand the subject matter – East London;
>
> Understanding – learners do not own content - Mthatha;
>
> Learners do not use mathematical terms with ease – East London.

Non-participation by learners was expressed in terms of a reluctance to speak English, for example:

> If too much pressure is put on children to speak too early, they may become anxious and this will distract them from listening, understanding and making sense of English – Kokstad;
>
> Lack of learner participation due to the fear – Port Elizabeth.

Two educators in Kokstad drew attention to the fact that some of their learners spoke a main language that was different from the other learners, viz., Sesotho as opposed to isiXhosa. They felt that his made code-switching difficult in the classroom, so they used English only.

Nine percent of the respondents mentioned learners' inability to read and write in their main language as a difficulty that they faced. Lack of competence in language skills in the learners' main language is referred to in the literature (Alidou, et al., 2006; Heugh, 2008). Examples of comments made by the teachers surveyed are:

> Learners must learn isiXhosa from Grade R or they have a problem in writing i.e. building of words and phrasing – Ngcobo;
>
> Spend some time building language proficiency in isiXhosa – Kokstad.

In order not to dwell on negative perceptions I asked them to mention solutions that in their experience solved some of the challenges.

2.2 Solutions the educators feel assist in alleviating the problems

The main themes identified concerning solutions to the problems faced were the use of code-switching, group work, a focus on teaching and learning English language skills, contextual support for learners, facilitation of learning by the educator and/or peers and increased access to both the main language and English (see table 4.2).

Table 4.2:

Table of responses for solutions to problems in multilingual classrooms (n = 179)

n	Centre	Code switching	Group work	Focus on English skills	Contextual support	Facilitation educator / peers	Access to both languages
29	PE	15	9	10	9	9	3
22	Kokstad	18	15	13	8	0	0
13	Ngcobo	13	13	2	7	1	0
33	KWT	23	12	11	10	9	2
38	Mthatha	23	14	12	13	4	5
44	EL	29	19	20	12	5	7
179	Total	121	82	68	59	28	17
	Percent	68%	46%	38%	33%	16%	9%

Note. PE=Port Elizabeth; KWT=King William's Town; EL=East London

The majority (68%) of educators mentioned code-switching as a resource. This indicates that these educators feel free to 'own' code-switching as a strategy. Examples of statements referring to code-switching included:

> Code-switching helps multilingual mathematics learners. Using language to explain abstract mathematics concepts – Kokstad;
>
> They become lost in class discussion and begin to have a clue when code-switching is used – King William's Town;
>
> Code-switching should be used because you have to interpret – Port Elizabeth;
>
> Use of code-switching for clarity and explanations – Mthatha;
>
> I switch to Xhosa or code-switch if I see the learners are not understanding a new concept or word - Kokstad.

Some form of group interaction was mentioned in 46% of the responses.

> Work in groups – discuss in whatever language is easier to use – King William's Town;
>
> Allow group work with the leader or scribe having a good or some command of English – Mthatha;

> Give learners positive reinforcement for their active participation during group work – Kokstad;
>
> Group work enhances understanding because peers sometimes revert to teenage ‘lingo’/’slang’ to explain – East London;
>
> Group work where members assist each other in their main language – Ngcobo.

Thirty eight percent of the educators felt that there should be a greater focus on developing their learners’ English skills.

> Learners must learn to communicate mathematical concepts or methods using English as a language – Port Elizabeth;
>
> There must be a change in attitude and do extra English classes – Mthatha.

Contextual support was mentioned in 33% of the responses.

> Need more contextual support like, hands on activities, visuals, print and non print media – Ngcobo;
>
> Cognitively demanding task with context embedded – Ngcobo;
>
> Use day-to-day life experiences as examples while teaching maths – East London.

Facilitation of learning by the educator or peers was referred to in 16% of the questionnaires. It was often referred to specifically in the context of one learner interpreting questions for another learner who did not understand the LoLT.

> If a learner does not understand a concept let others explain, help him to understand – Port Elizabeth;
>
> Continuously practicing from the side of the educators. Asking questions that can stimulate thinking. Simplify complex questions so that they can be understandable – Port Elizabeth.
>
> Learners should be mixed in groups so that somebody who can understand English in each group to help the rest - East London.

Access to both English and the learners' main language was considered to be an important asset in 9% of the cases.

> Even though it will be time consuming teach using both languages, i.e first (primary) language as well as second language – Port Elizabeth.

Translation was mentioned as a strategy that educators utilized to help multilingual mathematics learners understand mathematical concepts; however the educators could have concatenated code-switching and translation.

> I translate – because I want them to be able to remember what has been said – Port Elizabeth;
>
> I teach a new section in Xhosa then translate it into English – Port Elizabeth;
>
> I am a little bit wary of translation as it is time consuming - King William's Town;
>
> I use the learners in my class to translate what I am saying. It takes longer, but it works - East London;
>
> As far as possible on the question paper I would, for example, use multilingual terms in brackets. – East London;
>
> I encourage learners to use Xhosa if they have problems answering in English – Ngcobo.

Other strategies that certain educators mentioned included helping learners to build a vocabulary of English mathematical terms and their isiXhosa counterparts; using simplified or modified vocabulary; using the chalkboard for diagrams, methodology and vocabulary; modelling answers to problems; using a great deal of repetition; using worksheets and textbooks and relating mathematical concepts to the learners' real life experience.

3. EDUCATORS' PERSONAL CHOICE OF LANGUAGE

Before the intervention I wanted to ascertain what languages they used in their mathematics classrooms, so that I could develop appropriate exercises in the intervention.

The educators were asked to choose which language they personally felt should be used in teaching mathematics, which language was the de facto language used in the classroom, and which language the learners would choose, if they were given the choice. These results are summarized in table 4.3

Table 4.3

Choices of LoLT (n=179)

Educators' choice of LoLT		**de facto LoLT**		**Learners' choice of LoLT**	
English	**Main language**	**English**	**Main language**	**English**	**Main language**
156	23	178	4	97	81
87%	13%	99%	2%	54%	46%

One hundred and fifty six (87%) of the 179 educators chose English as the LoLT as opposed to twenty three (13%) who chose the learners main language. This bears testimony to Setati's (2005a) claim that the hegemony of English, and the doors that it unlocks to social goods, appears to override the need to understand mathematical concepts. Some students succinctly ratified their choices:

> English, because all the question papers are asked in English, and also to assist them so that they can cope in the workplace, real life situation – Mthatha;

> They are supposed to be fluent in English in order to get a job – Ngcobo.

Despite mentioning code-switching as strategies that they use in classrooms ninety nine percent (178 out 179) of educators stated that English was the official LoLT in their classrooms, as opposed to two percent (4 out of 179) of the sample of educators who stated that the learners' main language was actually the de facto LoLT. The discrepancy in numbers could be because some educators said that both English and the main language were used jointly as the LoLT in their classes.

> Both languages because in my school – I have Xhosa as the vernacular. If I use Xhosa as introduction and explanation of instruction and concepts, it leads to better

understanding of the learning content. The formal part (terminology) must be in English – East London.

When the educators were asked to reflect on which language the learners would choose, ninety seven educators (54%) chose English – “Parents take their learners to ex-Model C schools if you teach them in Xhosa,” - as opposed to eighty one educators (46%) who felt their learners would prefer to be taught in their main language – “Xhosa, because it is their primary language and they feel they understand it much better than any other language.” Again the discrepancy in the sum is because some educators felt their learners would prefer a mix of English and their main language. This indicates that the educators feel learners would be divided in their choice – fifty four percent for English as opposed to forty six percent who the educators presume would choose their main language as LoLT.

The next set of quantitative data addressed objective four.

4. MEASUREMENTS OF REASONING SKILLS BEFORE AND AFTER THE INTERVENTION

The purpose of this section is to report the quantitative data generated in the overall pre- and post-tests of the study over the two years combined, as well as the results gathered in 2007 and 2008 separately in the target and control classes. The tests conducted were:

- Raven’s Standard Progressive Matrices (RSPM) including sections A, B, C, D and E;
- Admissions and Placement Assessment Programme (APAP) Numeracy Skills;
- Admissions and Placement Assessment Programme (APAP) English Skills including subsections for language usage, reading skills and sentence meaning.

Both a total score for the RSPM test, out of sixty, and the scores of subsections A-E, out of twelve for each section, were calculated. The numeracy tests were calculated as a percentage and the English overall test score was also out of one hundred. The subsections of English Skills, language usage, reading skills and sentence meaning were calculated as a percent.

The pre- and post-test scores were analysed in an attempt to answer a key question in this research study, namely, 'Can the introduction of dialogic practices, particularly exploratory talk, increase mathematical reasoning in multilingual mathematics classrooms?'

226 learners (114 in four target classes and 112 in four control classes) were tested in three schools 2007 and 179 (89 in two target classes and 92 in two control classes) in one school in 2008; thus 405 learners participated in phases 2 and 3 of this study, the classroom observation phases. In the overall study the scores of the two cohorts were combined in order to gain an overarching picture of whether the intervention on dialogic practices can be presumed to have made any significant difference to the learners' reasoning.

4.1 Combined overall data over two years for reasoning skills tests

The following inferential statistics were obtained using the combined target group data and combined control group data for the reasoning skills tests (RSPM) over the duration of this section of the study that is over the two years combined. The results are summarised in table 4.4.

In table 4.4 MS is defined as the sum of squares (based on, between and within group differences) divided by the degrees of freedom (df). F is the sample statistic that is used to calculate the probability value (p) and is defined as the mean sum of squares (MS) of the independent variable divided by the Error MS, which is the variation due to factors other than the independent variables included in the ANCOVA model.

Table 4.4

Inferential statistics derived from reasoning skills tests (n = 403) (df = 400)

		MS	**F**	**p**	**Partial η^2**
Section	Pre-Test	20225.61	382.57	.000*	.489
	Year	15.76	0.30	.585	.001
	ExpCon	1279.43	24.20	.000*	.057
A	Pre-Test	499.82	162.18	.000*	.288
	Year	2.57	0.83	.362	.002
	ExpCon	6.55	2.13	.146	.005
B	Pre-Test	1537.72	259.96	.000*	.394
	Year	13.21	2.23	.136	.006
	ExpCon	51.46	8.70	.003*	.021
C	Pre-Test	897.38	158.69	.000*	.284
	Year	0.78	0.14	.710	.000
	ExpCon	80.65	14.26	.000*	.034
D	Pre-Test	1040.53	191.05	.000*	.323
	Year	12.23	2.25	.135	.006
	ExpCon	87.83	16.13	.000*	.039
E	Pre-Test	75.18	34.41	.000*	.079
	Year	0.82	0.37	.541	.001
	ExpCon	60.63	27.75	.000*	.065

Note. * denotes $p < 0.05$

The “Pre-test” rows indicate that all the tests were statistically significant with regard to the pre-tests. The critical result for this study is the significance level in the “ExpCon” rows, as this shows that there is a significant difference between the mean scores of the experimental (target) and control groups. There is a significant statistical difference in all tests except RSPM subsection A (the easiest reasoning section). It was necessary to account for the fact that the target and control sample group could not initially be balanced with regard to the dependent variables, i.e. in this study not only the differences in the means between the target and control groups were considered, but also the initial positioning of the learners in terms of the RSPM test scores. For this reason Analysis of Covariance techniques had to be applied. Analysis of covariance is a more sophisticated method of analysis of variance (ANOVA) as it allows for the inclusion of continuous variables (covariates) into the

ANOVA model. In this study the covariates were the initial scores of the participants. In other words the result of the treatment alone could be statistically evaluated between the target and control groups by eliminating the possibility that one class was inherently more able than another. As the result for “Year” in table 4.4was not significant in any of the tests, we can conclude that there was no statistically significant difference in the average post-test scores between Year 1 (2007) and Year 2 (2008) in the reasoning tests.

The variable eta squared (Partial η^2) is the practical significance statistic for the relevant independent variable and is only applicable if $p < 0.05$ i.e. statistically significant. The interpretation with regard to practical significance is as follows:

$eta^2 < 0.01$	not significant
$0.01 < eta^2 < 0.09$	small significance
$0.09 < eta^2 < 0.25$	moderate significance
$eta^2 > 0.25$	large significance

In this data set more than two independent variables have been analysed so p-values were calculated for each variable. Partial eta-squared statistics are relevant for all variables, or interactions, for which $p < 0.05$ is observed. For each significant result, based on both the p-values and partial eta-squared, post-hoc tests were conducted and Cohen’s-d statistics were calculated.

As noted above, the data generated by the RSPM tests were treated statistically using ANCOVA and the results of various views of the data are reported in tables 4.5 and 4.6.

4.2 Overall study: Reasoning skills changes - statistical and practical significance

Table 4.5 maps the significance of the target and control groups’ test results for both years combined. The Raven’s scores are sectioned into 5 categories of 12 reasoning problems in increasing levels of difficulty in each category i.e. total of 60; whereas the subsections are scored up to a maximum of 12.

Table 4.5

Overall study target and control groups' reasoning skills pre-post change in mean score (n=403; target, n = 202; control, n = 201)

		Pre-	**Post-**	$\Delta \bar{x}$	**d**	**p**	**α**
Total	Target	26.11	35.09	8.99	1.31	.000	0.93
	Control	26.27	31.69	5.42	0.57	.000	
Categories							
A	Target	8.31	10.05	1.74	0.72	.000	0.82
	Control	8.14	9.76	1.62	0.62	.000	
B	Target	6.46	8.64	2.18	0.83	.000	0.84
	Control	6.53	8.00	1.46	0.50	.000	
C	Target	4.72	6.81	2.08	0.86	.000	0.74
	Control	5.02	6.04	1.02	0.35	.000	
D	Target	5.06	7.11	2.05	0.81	.000	0.83
	Control	5.14	6.23	1.09	0.35	.000	
E	Target	1.55	2.48	0.94	0.53	.000	
	Control	1.44	1.66	0.23	0.13	.000	0.40

Note. $\Delta \bar{x}$ denotes change in mean scores between pre-and post tests. A positive score implies that the post-test mean was higher than the pre-test mean.
d = Cohen's d.
α = Cronbach's α

Table 4.5 shows that there was a statistical difference between the mean pre-post scores of both the target groups as well as the control groups. This indicates that learning did take place in all groups during the nine-month period of the intervention in both years as the post-test means are all higher than the pre-test means for both target and control groups. Teaching of curriculum materials and learning took place and maturity levels increased for all learners; however statistically significant greater gains were observed in the target groups of both years than in the control groups.

The unit for reliability is Cronbach's coefficient alpha (α) and overall values are given for combined target and control groups. The threshold value for accepted statistical reliability is that $\alpha > 0.70$. The reliability levels for RSPM ($\alpha = 0.93$) may be considered as reliable. Cohen's d statistics were calculated to determine whether statistically significant ($p < 0.05$) pair-wise differences were practically significant. A small practical significance is noted where $0.2 < d < 0.5$; a moderate practical significance is noted if $0.5 < d < 0.8$ and a large practical difference is recorded if $d > 0.8$. Expressed differently, an effect size of less than 0.2 is considered to be insignificant, an effect size between 0.2 and 0.5 is considered to be of small significance; an effect size between 0.5 and 0.8 is considered as being moderately significant, while an effect size of 0.8 and greater is considered to be highly significant. Effect size as expressed by the Cohen's d statistics is defined as the difference in means divided by the pooled standard deviation and is a measure of magnitude (or significance) of the differences between the pre- and post-test scores (Gravetter & Walnau, 2008). As regards the total RSPM tests the practical significance of the target groups is larger than the practical significance of the control groups.

4.3 Overall study: Differences between target and control group reasoning skills changes

Differences in mean score change between pre- and post-tests for target and control groups are reported in table 4.6.

Table 4.6

Overall study reasoning skills - mean difference between target and control mean scores (n = 403)

Section	**$\Delta\bar{x}$ target**	**$\Delta\bar{x}$ control**	**Mean difference**	**p**
Total	8.99	5.42	3.57	.000
A	1.74	1.62	0.12	.000
B	2.18	1.46	0.72	.000
C	2.08	1.02	1.06	.000
D	2.05	1.09	0.96	.000
E	0.94	0.23	0.71	.000

Note. A reported p = .000 implies p < .05

$\Delta\bar{x}$ denotes difference in means. A positive score implies that the post-test mean was higher than the pre-test mean. As noted earlier the differences in the change in mean scores between the target groups was statistically significantly larger than the change in mean scores between the control groups' pre- and post-tests. As p<.05 in all cases Cohen's d was calculated in order to gauge the effect size of the practical significance of the differences, which is reported in table 4.7.

Table 4.7

Overall study comparison of practical significance for reasoning skills changes (n = 403)

	Target		**Control**	
	d	**Effect**	**d**	**Effect**
Total	1.31	large	0.57	moderate
A	0.72	moderate	0.62	moderate
B	0.83	large	0.50	moderate
C	0.86	large	0.35	small
D	0.81	large	0.35	small
E	0.53	moderate	0.13	insignificant

d = Cohen's d.

The mean differences for the RSPM tests in the overall study have been graphed below to visually illustrate the increases in reasoning skill that occurred in the overall study pre-post the intervention.

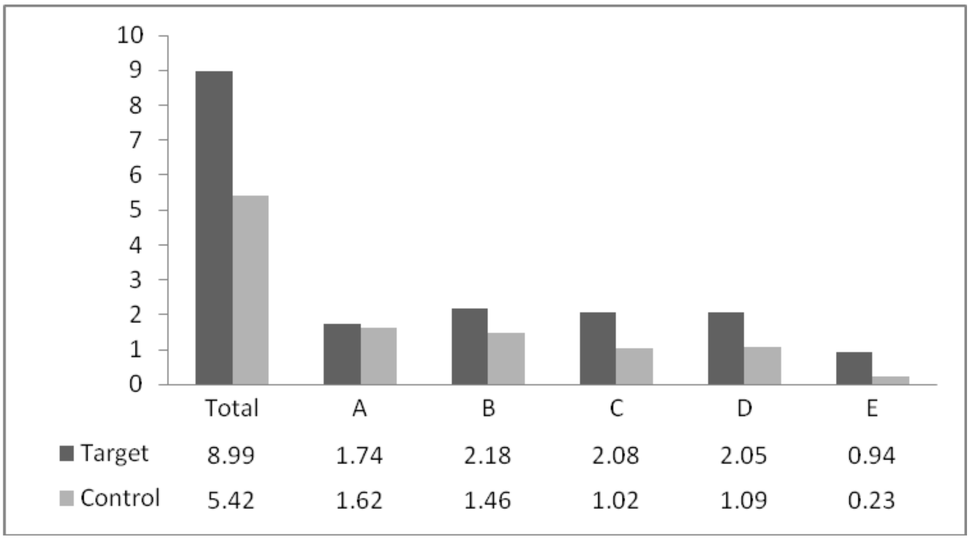


Figure 4.1 Overall study reasoning skills tests: Graph of mean differences between pre- and post-tests

The discrepancy between the mean differences between the target and control groups in RSPM subsection A are not as large as the discrepancies between the mean differences in sections B to E, which test more complicated reasoning. This suggests that in the relatively straight forward problems in section A there was no appreciable difference between the scores of the target and control groups; however in the sections that required more advanced reasoning the classes that had experienced instances of problem solving through discussion in their main language were able to perform better.

The reasoning skills results for each of the two cohorts will now be reported separately.

4.4 2007 Pre-post mean differences in reasoning skills – three schools

The following table repeats the format of the data reporting for the overall study. Table 4.8 represents the mean differences between the target and control groups from the three schools that were tested in 2007.

Table 4.8

2007 mean difference between target and control reasoning skills mean score changes from pre- to post-test in three schools (n = 224; target, n = 113; control, n = 111)

Category	**$\Delta\bar{x}$ Target**	**$\Delta\bar{x}$ Control**	**Mean difference**	**p**
Total	8.22	5.42	2.8	.000
A	1.36	1.73	-0.37	.000
B	2.25	1.75	0.5	.000
C	2.08	0.88	1.2	.000
D	1.63	0.82	0.81	.000
E	0.9	0.23	0.67	.000

Note. A reported $p = .000$ implies $p < .05$

$\Delta\bar{x}$ denotes difference in means. A positive score implies that the post-test mean was higher than the pre-test mean.

It is noticeable in table 4.8 that in RSPM subsection A the control group mean difference score change is higher than the target group mean difference. As has been mentioned, the target group performed better than the control group in the categories that required more complex reasoning skills. The use of RSPM section A items in the target classes as triggers to encourage exploratory talk did not therefore train the learners to achieve better scores. The d-values in the table below describe the practical significance, or effect, of the mean differences.

Table 4.9

2007 comparison of practical significance for RSPM mean score changes from pre- to post-test (n = 224)

	Target		**Control**	
	d	**Effect**	**d**	**Effect**
Total	1.24	large	0.63	moderate
A	0.58	moderate	0.52	moderate
B	0.94	large	0.29	small
C	0.88	large	0.24	small
D	0.65	moderate	0.12	insignificant
E	0.52	moderate	0.51	moderate

d = Cohen's d.

In the reasoning skills test category A the control mean change was higher than the target group mean change in score (see figure 4.2). The practical significance for the target and control groups is similar.

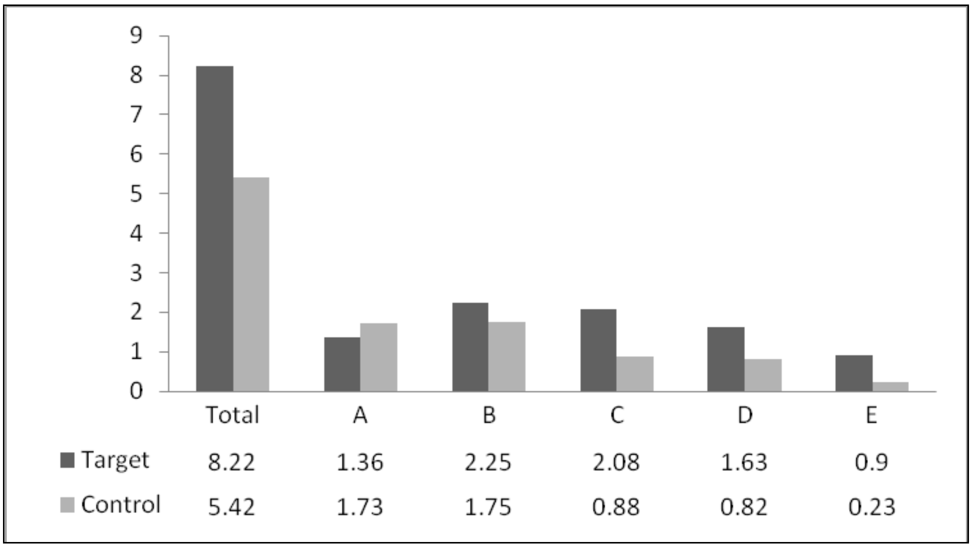


Figure 4.2 2007 Graph of mean differences for the reasoning skills tests – three schools

From the graphs it can be seen that the differences in the two bars representing Target and Control groups for RSPM-A is less than the differences in the bars representing target and control groups for the other subsections. This again indicates that using RSPM items from category A in the target class as triggers did not skew the test results.

A comparison was made between the three target groups' 2007 RSPM results. To this end Scheffé tests were conducted on the items that were statistically significant. In order to test whether the difference between three or more groups is significant in terms of one to each of the other two, partial eta-squared statistics are used where $p < .05$ is observed, as the formula that is used for partial eta-squared eliminates the effect of the other independent variables. For each significant result post-hoc tests are conducted to determine which comparisons of mean differences are significant and which are not (Gravetter & Wallnau, 2008). The results of the Scheffé tests on the 2007 data (three schools) are represented in table 4.10.

Table 4.10

Scheffé tests on target groups 2007 RSPM test scores (n = 224)

	North	**West**	**South**
North		.694	.043*
West	.694		.350
South	.043*	.350	

Note. * denotes significant difference

When the 2007 RSPM data were analysed using Scheffé tests, statistically significant differences were revealed between North and South. To shed more light on the differences between the three target groups figure 4.3 illustrates in graphic form the mean differences of the target groups across the three schools in reasoning skills.

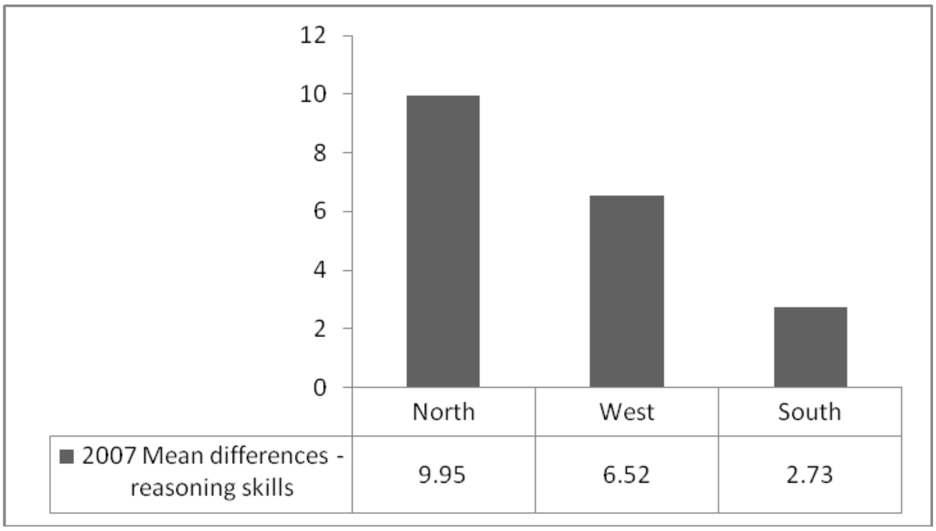


Figure 4.3 2007 Comparison across 3 schools: Reasoning skills mean differences

Figure 4.3 shows that the reasoning skills of the target group at North Primary School scored better than the target group at West and both schools scored better in reasoning skills than South.

When comparing the practical significance of the data of the target groups compared with the relevant control groups in each school during 2007, in North Primary School the target group achieved a large practical significance (d=1.26) as opposed to the control group's small practical significance (d=0.39). In West Primary school the target group achieved a large practical significance (d=1.80) as opposed to the control group's moderate practical significance (d=0.52). In South Primary School the target group achieved a small practical significance (d=0.44) as opposed to the control group's small practical significance (d=0.32). The differences between the three target groups were reinforced by the observations that took place in the target classes where variations in the style of teaching were observed. A description of the results of the observations appears in chapter 6. The results for the reasoning skills of the target and control groups in one school during 2008 will be reported next.

4.5 2008 pre-post mean differences in reasoning skills – one school

As above, the same reporting mechanism has been used as with the 2007 data – a table of mean differences between target and control mean scores, followed by the target and control d- values and practical significance. The graphs depict the effect gains of both target and control groups in 2008. In this year the focus was on four classes (two target and two control) in one school.

Table 4.11

2008 mean difference between target and control reasoning skills mean score changes (n = 179; target, n = 89; control, n = 90)

	$\Delta\bar{x}$ Target	**$\Delta\bar{x}$ Control**	**Mean difference**	**p**
Total	9.97	5.42	4.55	.000
A	2.22	1.48	0.74	.000
B	2.09	1.1	0.99	.000
C	2.09	1.2	0.89	.000
D	2.58	1.42	1.16	.000
E	0.98	0.22	0.76	.000

Note. A reported p = .000 implies p < .05

$\Delta\bar{x}$ denotes difference in means. A positive score implies that the post-test mean was higher than the pre-test mean. The mean differences in 2008 were all positive, which indicates that the target group gains were greater in all tests than the control group gains. The effect sizes, according to the d-values for target and control groups, are tabled below.

Table 4.12

2008 Reasoning skills pre-post comparison of practical significance (n = 179)

2008	**Target**		**Control**	
	d	**Effect**	**d**	**Effect**
Total	1.41	large	0.69	moderate
A	0.91	large	0.60	moderate
B	0.71	moderate	0.51	moderate
C	0.84	large	0.43	small
D	1.03	large	0.55	moderate
E	0.54	moderate	0.16	insignificant

d = Cohen’s d

When comparing the effect sizes of the target group with the control group in the one school, the practical significance calculated for the target group is large (d > 0.8) in all instances except for sections B and E, while the practical significance for the control group scores is moderate (0.2 < d < 0.5) except for section c (small) and E (insignificant).

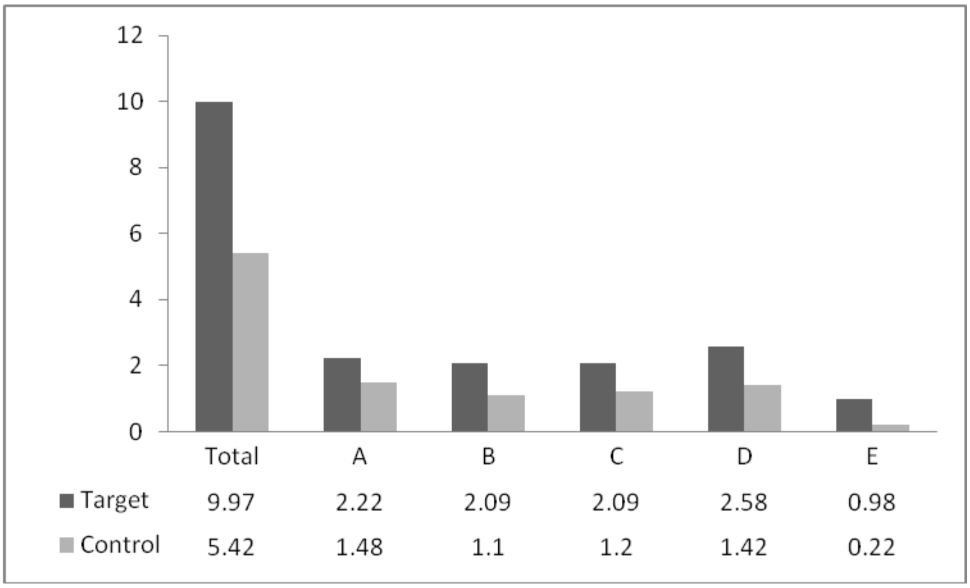


Figure 4.4 2008 graph of mean differences for the reasoning skills tests – one school

4.6 Overall study RSPM results compared with international scores

The RSPM percentiles for the overall study post-tests of the target groups were mapped against published percentiles from Kuwait and the United Kingdom. A Kolmogorov-Smirnov Goodness-of-Fit test showed that the target cohort scores were within the 0.05 limit thus the hypothesis that the target group scores are statistically equivalent to the Kuwaiti scores could not be rejected. However the scores generated in this study were not comparable with the United Kingdom scores, which are higher.

Table 4.13

Comparison of RSPM percentiles per country and per overall study target group post-test

Percentile	**United Kingdom**	**Kuwait**	**Overall Study: Target post-test**
95	53	50	47
90	51	47	46
75	47	45	43
50	42	40	37
25	38	33	29
10	32	24	22
5	27	19	18
n	174	827	89

This result is contrary to Abdel-Khalik and Raven's (2006) statement that black American and black African learners score well below their European counterparts. It indicates that if the learners reason in groups in their main language, their reasoning skills could improve to within the range of similarly aged Kuwaiti learners. The results of the numeracy skills tests will be reported in the next section.

5. MEASUREMENTS OF NUMERACY SKILLS BEFORE AND AFTER THE INTERVENTION

The following inferential statistics were obtained using the combined target and control data from the APAP Numeracy tests over both years combined (Table 4.14). As has been stated in the reasoning skills section, MS denotes the mean sum of squares; F denotes the sample statistic that is used to calculate p.

Table 4.14

Overall inferential statistics derived from numeracy tests (df = 400)

	MS	**F**	**p**	**Partial η^2**
Pre-Test	6468.56	39.75	.000*	.091
Year	2750.25	16.90	.000*	.041
ExpCon	820.03	5.04	.025*	.013

Note. * denotes p < 0.05

The p-values denote significant differences, thus the numeracy scores, as with the reasoning skills scores, were statistically significant when pre-test and post-test results were compared. There was also a statistically significant difference between the target and control groups. As there was also a statistically significant difference as regards “year” it can be deduced that there was a significant difference between the average post-test scores between the Year 1 (2007) and Year 2 (2008) groups.

The data generated by the numeracy test scores were treated statistically using ANCOVA and the results of the various views of the data are reported in tables 4.15 and 4.16.

5.1 Mean score numeracy changes and their statistical and practical significance

Table 4.15 maps the target and control groups’ numeracy test results for both years combined.

Table 4.15

Overall study target and control groups' numeracy pre-post change in mean score (n=403; target, n = 202; control, n = 201)

	Pre-	**Post-**	$\Delta \bar{x}$	**d**	**p**	**α**
Target	23.42	35.76	12.32	0.73	.000*	0.62
Control	25.10	33.74	8.57	0.58	.000*	

Note. $\Delta \bar{x}$ denotes change in mean scores between pre-and post tests.
A positive score implies that the post-test mean was higher than the pre-test mean;
d = Cohen's d;
* denotes $p < 0.05$;
α = Cronbach's α

Table 4.15 shows that there was a statistically significant difference between the mean pre-post scores of both the target groups as well as the control groups. This indicates that an improvement in numeracy skills took place in both target and control groups; however, the improvement in the target group was greater than in the control group although the practical significance of both the target group and the control group is deemed to be moderate ($0.5 < d < 0.8$).

5.2 Differences between target and control group changes in mean scores between pre- and post-tests of numeracy skills – overall study, 2007 and 2008

In the overall study spanning two years the difference between the pre-post means of the target group in the numeracy results was 12.32, compared with the control group difference of 8.57 (n = 403). The mean difference was thus 3.75. As $p < 0.05$ this represents a statistically significant difference between the target and the control group. The d-value for the target group, at 0.73, is close to the upper end of the 'moderate' band i.e. the practical significance of the target group is close to 'large', whereas the d-value for the control group, at 0.58, tends towards the lower end of the 'moderate' band i.e. the practical significance of the control group is close to 'small'. A value of α = 0.62 for Cronbach's α is close enough to the 0.7 threshold for the numeracy results to be considered statistically reliable.

In the 2007 section of the study the difference between the pre-post means of the target group in the numeracy results was 5.87, compared with the control group difference of 3.4. The mean difference was thus 2.47 (n = 224). As $p < 0.05$ this represents a statistically significant difference between the target and the control group. The d-value of the target group is 0.41 which tends towards the upper limit of a ‘small’ practical significance as defined by $0.2 < d < 0.5$. The d-value of the control group is 0.25, which tends towards the lower limit of the band; thus, although small, there was no practical significance between target and control mean scores.

A comparison was made between the three target groups’ numeracy skills results. As the scores were statistically significant Scheffé tests were conducted. The results are reported in table 4.16.

Table 4.16

Scheffé tests on target groups - 2007 numeracy test scores

	North	**West**	**South**
North		0.064	0.001*
West	0.064		0.485
South	0.001*	0.485	

Note. * denotes significant difference

When the 2007 numeracy data were analysed using Scheffé tests, statistically significant differences were revealed between North and South. Figure 4.5 illustrates the difference in means between the three schools in 2007.

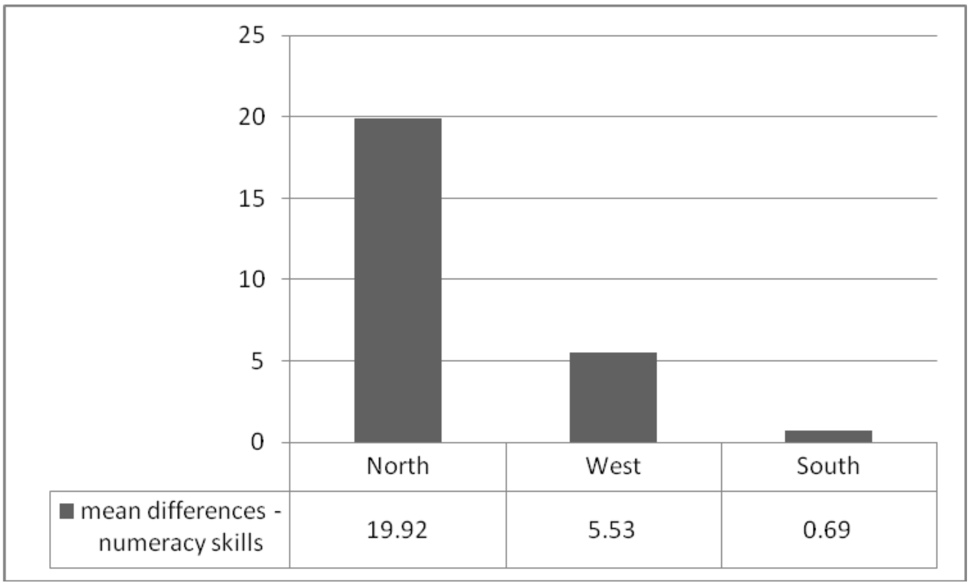


Figure 4.5 2007 Numeracy skills target groups' difference in means in three schools

The difference in means was greater in the target groups at North than the target groups at West. The target group at South had the smallest difference in means between the pre- and post-tests during 2007.

When comparing the practical significance of the numeracy data of the target groups compared with the control groups in each school during 2007, in North Primary School the target group achieved a large practical significance (d=0.82) as opposed to the control group's moderate practical significance (d=0.58). In West Primary school the target group achieved a moderate practical significance (d=0.74) as opposed to the control group's small practical significance (d=0.21). In South Primary School the target group achieved a small practical significance (d=0.45) which did not differ appreciably from the control group's small practical significance (d=0.32). As with the results of the reasoning tests, the differences between the three target groups were reinforced by the observations that took place in the target classes. The results for the numeracy skills of the target and control groups in one school during 2008 will be reported next.

In the 2008 section of the study the difference between the pre-post means of the target group in the numeracy results was 20.58, compared with the control group difference of 15.09 ($n = 179$). The mean difference was thus 5.49. As $p < 0.05$ this represents a statistically significant difference. The mean difference in 2008 was positive, which indicates that the target group gains were greater in numeracy skills than the control groups' gain. The effect sizes, according to the d-values for target (1.25) and control groups (1.11), were both large.

5.3 Skills Progress Maps

Both APAP Numeracy and English skills tests are criterion-referenced, that is a learner's performance is compared to a standard of proficiency, or mastery, rather than to another learner's performance. It is therefore possible to map a learner's progress before and after an intervention according to different categories. For the APAP tests the categories used are developing, expanding, functional and proficient. Each test has its own progress map of the four skills levels. By using progress maps I was able to map the progress of the target groups in the overall study as well as in 2007 and 2008 separately in order to visually predict the effect of the intervention on the target groups.

The criteria of skills that a learner should display in order to be classified into a particular numeracy (or English skills subsection) category are listed in Appendix B. The method of reporting the results of the APAP tests has been developed by Watson (2004a) from the Psychology Department of NMMU.

The percentages of target group learners falling into the four different categories before and after the intervention are graphed in Figure 4.6 for the overall study.

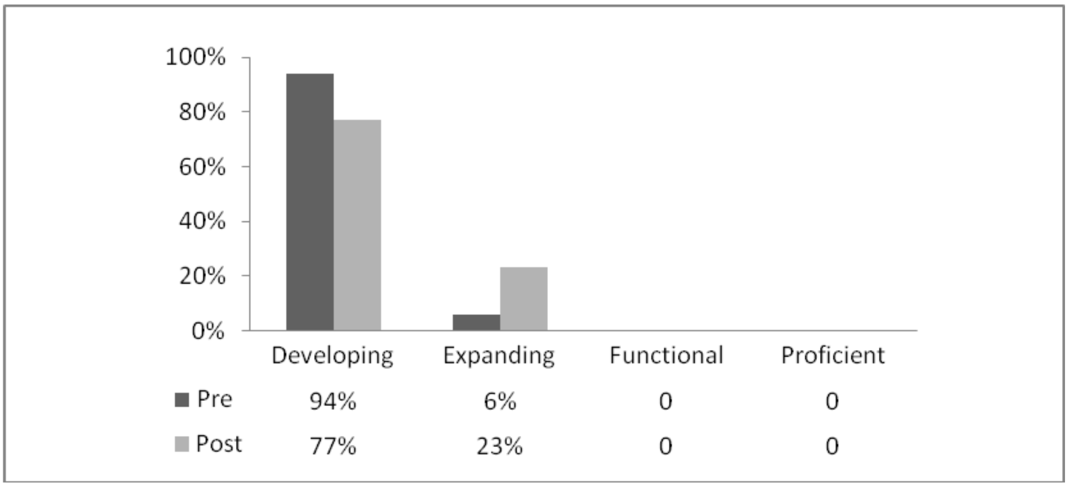


Figure 4.6 Numeracy Progress map categories – overall Study (n = 403)

It is clear that the number of learners who achieved numerically in the developing category was reduced in the post test and that there are more learners in the expanding category than there were in the pre-test. At the time of initial testing 94% of learners in the target groups had minimal arithmetic skills. They could perform simple calculations and operations, such as addition, multiplication, subtraction and multiplication (developing category). By the end of the post-test 23% of the target group could perform basic arithmetic skills, such as operations with whole numbers as well as fractions, decimals and percents (expanding category). All the target group learners both, before and after the intervention, fall into the lower two categories.

The graph of the overall study progress map can be compared with the 2007 data from three schools in figure 4.7 and the 2008 data from one school in figure 4.8.

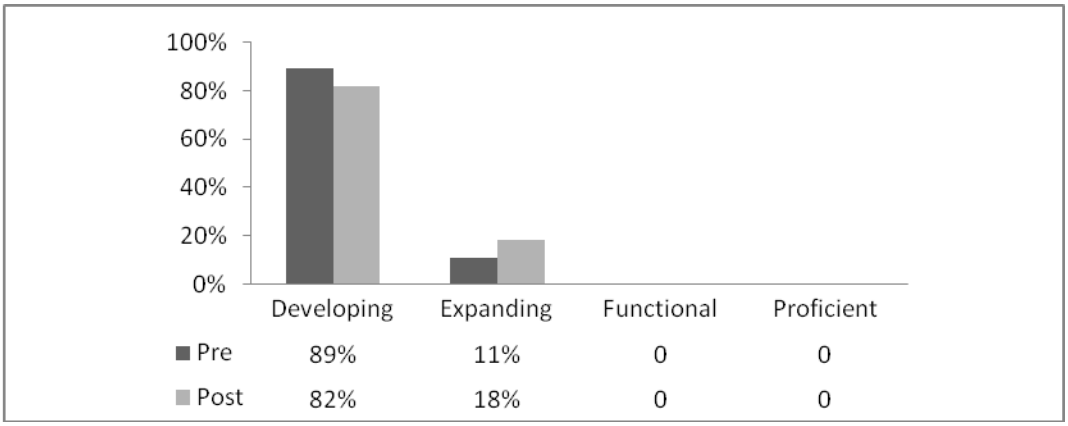


Figure 4.7 Numeracy progress map categories 2007 (n = 224)

During 2007 seven percent of the target group improved their numeracy skills from minimal arithmetic skills (developing category) to basic arithmetic skills (expanding category) and the majority of the learners exhibited skills found in the lowest category.

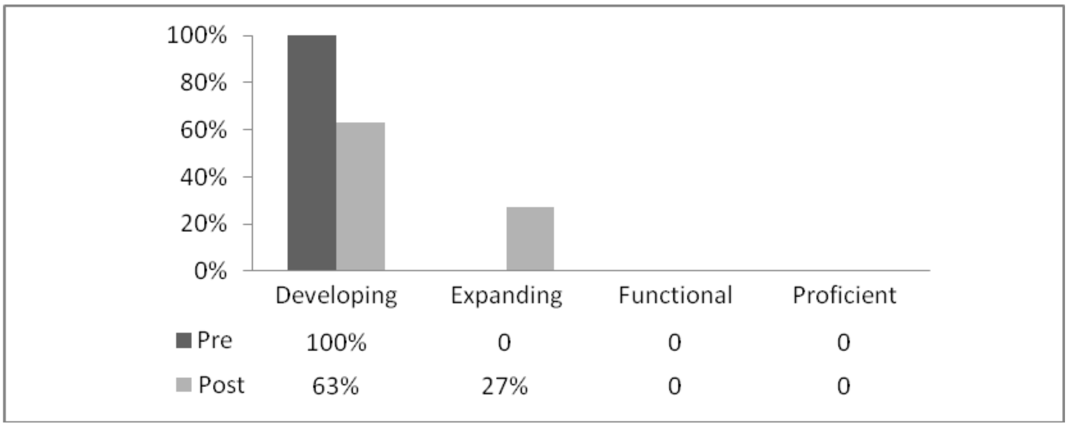


Figure 4.8 Numeracy progress map categories 2008 (n = 179)

In 2008 more than one quarter of the learners were considered to have improved from minimal arithmetic skills to basic arithmetic skills. There were no learners who fell into the categories functional or proficient.

6. MEASUREMENTS OF ENGLISH SKILLS BEFORE AND AFTER THE INTERVENTION

As with the reasoning skills and numeracy skills results, the following inferential statistics were obtained using the combined experimental and control data from the English skills tests and the subsections over both years.

Table 4.17

Overall inferential statistics derived from English skills tests (df = 400)

		MS	**F**	**p**	**Partial η^2**
Total	Pre-Test	34264.68	231.30	.000*	.366
	Year	210.29	1.42	.234	.004
	ExpCon	0.12	0.00	.977	.000
LU	Pre-Test	47674.94	143.53	.000*	.264
	Year	784.31	2.36	.125	.006
	ExpCon	92.39	0.28	.598	.001
RS	Pre-Test	18967.53	93.16	.000*	.189
	Year	200.96	0.99	.321	.002
	ExpCon	222.74	1.09	.296	.003
SM	Pre-Test	31209.01	88.77	.000*	.182
	Year	3251.34	9.25	.003*	.023
	ExpCon	220.69	0.63	.429	.002

Note. * denotes $p < 0.05$
MS = mean sum of squares
F = sample statistic used to calculate p.
LU = Language Use; RS = Reading Skills; SM = Sentence Meaning

Table 4.17 denotes that the only statistical difference was with regard to “Pre-Test”. This means that in the English skills tests there was only a statistically significant difference between the pre- and post-tests. In sentence meaning there was a statistically significant difference with regard to the “year”, therefore ANCOVA was applied.

6.1 Overall study mean English skills changes - statistical and practical significance

Table 4.18 maps the target and control groups’ English skills test results, including subsections, for both groups combined.

Table 4.18

Overall study target and control groups' English skills pre-post change in mean score (n=403; target, n = 202; control, n = 201)

		Pre-	Post-	$\Delta \bar{x}$	d	p	α
Total	Target	40.74	47.60	6.98	0.56	.000*	0.78
	Control	44.35	49.73	5.46	0.38	.000*	
Language Usage	Target	47.82	55.35	7.52	0.36	.000*	0.56
	Control	51.92	57.98	6.06	0.27	.000*	
Reading skills	Target	37.97	43.66	5.69	0.37	.000*	0.59
	Control	41.01	46.50	5.49	0.32	.000*	
Sentence meaning	Target	38.17	46.73	8.56	0.41	.000*	0.54
	Control	42.46	46.85	4.38	0.19	.000*	

Note. $\Delta \bar{x}$ denotes change in mean scores between pre-and post tests. A positive score implies that the post-test mean was higher than the pre-test mean.
* denotes $p < 0.05$
d = Cohen's d.
α = Cronbach's α

Table 4.18 suggests that there was a statistical difference between the mean pre-post scores of both the target groups as well as the control groups; however the practical significance for the target groups' overall English skills score is moderate whereas the practical significance of the control groups is small. A value of α = 0.78 for Cronbach's α for the total English skills score indicates that the scores are statistically reliable.

6.2 Overall study target and control group changes in mean scores - English skills

Differences between target and control group changes in mean scores between pre- and post-tests of the English skills and the subsections are reported in table 4.19.

Table 4.19

English skills overall study - mean difference between target and control mean scores (n = 403)

	$\Delta\bar{x}$ target	$\Delta\bar{x}$ control	mean difference	p
Total	6.98	5.46	1.52	.000
Language Use	7.52	6.06	1.46	.000
Reading Skills	5.69	5.49	0.2	.000
Sentence Meaning	8.56	4.38	4.18	.000

Note that a reported p = .000 implies p < .05
$\Delta\bar{x}$ denotes difference in means. A positive score implies that the post-test mean was higher than the pre-test mean.

The effect sizes of the pre-post comparison for overall English skills and the subsections is reported in table 4.20.

Table 4.20

English skills overall study pre-post comparison of practical significance (n = 403)

	Target		Control	
	d	Effect	d	Effect
Total	0.56	moderate	0.38	small
Language Use	0.36	small	0.27	small
Reading Skills	0.37	small	0.32	small
Sentence Meaning	0.41	small	0.19	insignificant

d = Cohen's d

The mean differences for the English skills tests in the overall study have been graphed below to visually illustrate the statistically significant change between target and control that occurred in the overall study. In all cases the mean difference for the target groups is larger than the mean difference for the control groups.

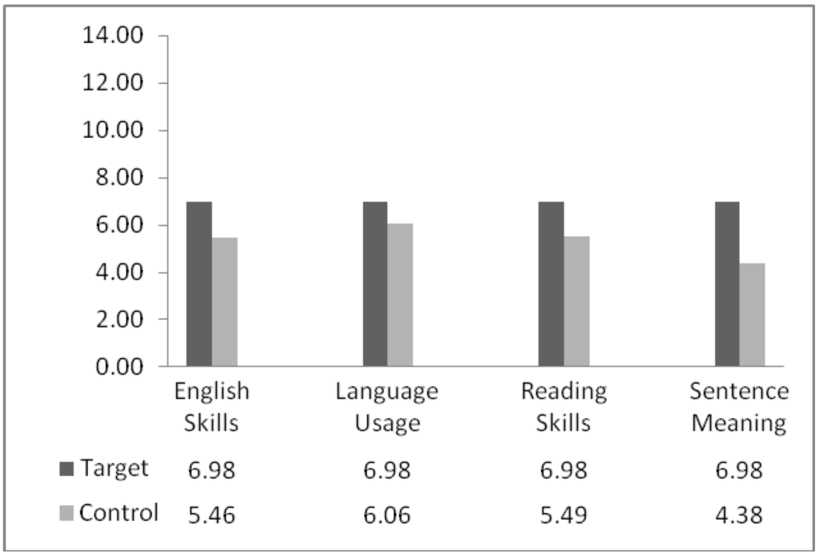


Figure 4.9 Graph of mean differences for English skills including subsections – overall study

6.3 2007 pre-post mean differences English skills – three schools

The following table repeats the format of the data reporting for the overall English skills study. I have drawn up a table of the mean differences between the target and control groups from the three schools that were tested in 2007.

Table 4.21

2007 English skills mean difference between target and control mean scores (n = 224)

	$\Delta\bar{x}$ **Target**	$\Delta\bar{x}$ **Control**	**Mean difference**	**p**
Total	7.94	5.75	2.19	.000
Language Use	8.07	3.3	4.77	.000
Reading Skills	5.79	6.47	-0.68	.000
Sentence Meaning	11.75	6.25	5.5	.000

Note. A reported p = .000 implies p < .05

$\Delta\bar{x}$ denotes difference in means. A positive score implies that the post-test mean was higher than the pre-test mean.

The control group mean difference score change for reading skills is higher than the target group mean difference. The d-values of table 4.22 describe the practical significance of the mean differences.

Table 4.22

2007 Comparison of practical significance for English skills mean score changes from pre-test to post-test (n = 224)

	Target		**Control**	
	d	**Effect**	**d**	**Effect**
Total	0.60	moderate	0.41	small
Language Usage	0.37	small	0.15	insignificant
Reading Skills	0.39	small	0.43	small
Sentence Meaning	0.57	moderate	0.27	small

d = Cohen's d.

The practical significance of the target group scores is moderate as opposed to the control group's small significant difference. The mean differences for English skills in 2007 are graphed in figure 4.10.

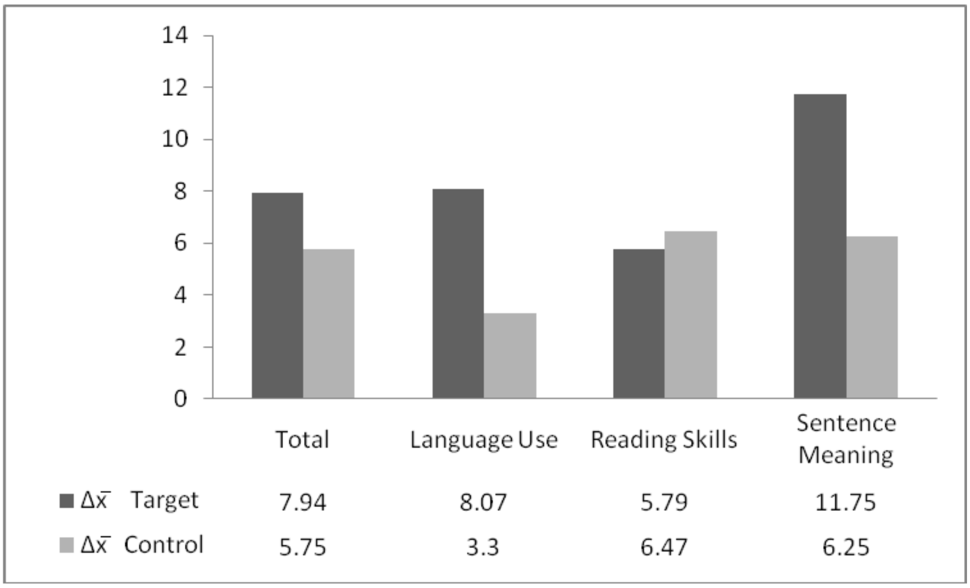


Figure 4.10 Graph of mean score changes in differences English skills including subsections – 2007

In the reading skills the control group change in score is greater than the target group change in score. In all other instances the target group mean score change was greater than that of the control group.

When comparing the practical significance of the data of the target groups compared with the control groups in each school during 2007, in North Primary School the target group achieved a moderate practical significance (d=0.70) as opposed to the control group's small practical significance (d=0.24). In West Primary school the target group achieved a large practical significance (d=0.82) as opposed to the control group's moderate practical significance (d=0.68). In South Primary School the target group achieved a small practical significance (d=0.39) which was not appreciably different from the control group's small practical significance (d=0.42). As with the reasoning and numeracy data, the quantitative results were reinforced by the qualitative results which are reported in chapter 6. The results for the English skills of the target and control groups in one school during 2008 will be reported next.

6.4 2008 pre-post mean differences – English skills at one school

Again the same reporting mechanism has been used with the 2008 data – the mean differences between target and control mean scores are reported in table 4.23. In this year the focus was on two target classes compared with two control classes at one school.

Table 4.23

2008 mean difference between target and control English skills mean score changes at one school (n = 179)

	$\Delta\bar{x}$ Target	**$\Delta\bar{x}$ Control**	**Mean difference**	**p**
Total	5.74	5.11	0.63	.000
Language Use	6.82	6.45	0.37	.000
Reading Skills	5.57	4.29	1.28	.000
Sentence Meaning	4.43	2.09	2.34	.000

Note. A reported p = .000 implies p < .05

$\Delta\bar{x}$ denotes difference in means. A positive score implies that the post-test mean was higher than the pre-test mean. The size of the effect score for the target and control groups for 2008 is reported in table 4.24 together with the target and control d- values and practical significance. The effect gains of both target and control groups in 2008 are tabled.

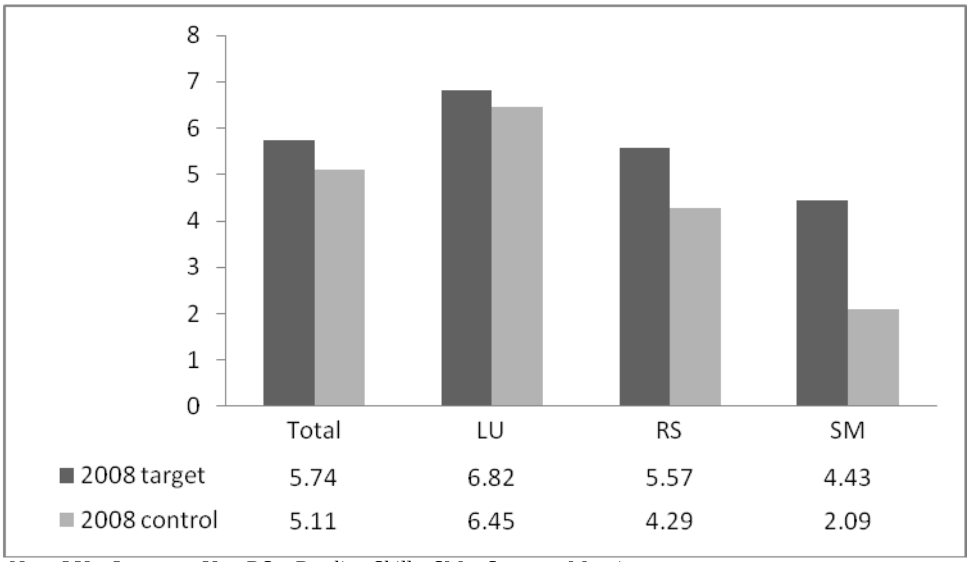
Table 4.24

2008 comparison of practical significance for English skills mean score changes from pre-test to post-test (n = 179)

	Target		**Control**	
	d	**Effect**	**d**	**Effect**
Total	0.51	moderate	0.34	small
Language Use	0.33	small	0.43	small
Reading Skills	0.34	small	0.22	small
Sentence Meaning	0.21	small	0.1	insignificant

d = Cohen's d.

The mean differences in 2008 were positive, which indicates that the target group gains were greater in English skills than the control group gain. The effect size for the total English skills was moderate (0.51) whereas the effect size for the control was small (0.34). The effect sizes for 2008 are illustrated in figure 4.11.



Note. LU = Language Use; RS = Reading Skills; SM = Sentence Meaning

Figure 4.11 Graph of mean score changes in differences English skills including subsections – 2008

In 2008 all the target differences were larger than the control group mean differences, which indicate that the target group gains were larger than the control group gains.

6.5 English skills progress maps

As with the APAP Numeracy skills tests, the APAP English skills tests are criterion-referenced. The percentage of learners that fall into the four progress map categories - developing, expanding, functional and proficient – are reported before and after the intervention. The criteria of skills that a learner should display in order to be classified into a particular English skills category are listed in Appendix B.

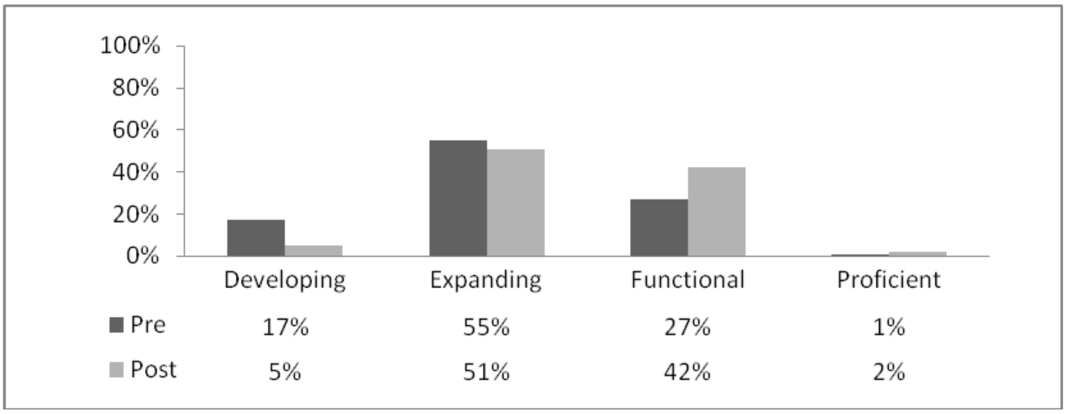


Figure 4.12 English Skills Progress Map Categories – Overall Study

From the pre-test to the post-test there were fewer learners in the lower two categories and more learners in the upper two categories. The majority of learners fell into the expanding band in both pre- and post-tests. Forty four percent of the learners had progressed to the functional and proficient categories after the intervention as opposed to twenty eight percent before the intervention.

7. CHAPTER SUMMARY

In this chapter I have looked at the results of the quantitative areas of this study. I analysed the responses to an open-ended questionnaire which asked educators to reflect on difficulties that they encountered through teaching in multilingual mathematics classrooms; to reflect on the solutions that they employed to help them in their teaching and to suggest strategies that they felt would be advantageous. They also had to choose which language they felt should be the LoLT in their schools; which language was the de facto LoLT and which language their learners would choose to be the LoLT, if they were given the choice. Their answers were analysed into themes and the resulting data were reported in tables with quotes to substantiate the students' numerical choices. These results will be used, together with qualitative results, to discuss the impact on objective one of the study.

The next areas of quantitative data to mine were the results of the pre-tests before the intervention and the post-tests, after the intervention, conducted on two cohorts of grade seven learners over two years. The tests included reasoning skills tests as well as numeracy and English skills tests. The constructs of reasoning, numeracy and English skills were measured and the differences in scores over the period of the intervention were noted. The data were combined to give an overview of the entire study, then the data for each year was arranged into tables and graphs for scrutiny, in order to tease out trends and differences that will be discussed in chapter six. In the next chapter I will report on the qualitative results of phase one of the study.

CHAPTER FIVE

QUALITATIVE RESULTS - PHASE ONE

1. INTRODUCTION

In the previous chapter I described the quantitative results of this study. The qualitative results reported in this chapter span the first phase of the study. The data include the results from two tasks given to the cohort of ACE:MST students. The students were asked firstly to reflect on their perceptions about teaching in multilingual classrooms and they were asked, secondly, to write a poem in order to explore the role language plays in their lives. The constructs that could be identified inductively from these instruments would inform objective one, namely, to identify Eastern Cape educators' perceptions about language strategies and language usage in multilingual mathematics classes;

The BEd Honours cohort completed tasks that were used to generate data during their contact sessions. They were asked to complete a questionnaire in which they described challenges they faced in teaching multilingual mathematics classes and the solutions and strategies that they implemented. They were also asked to elaborate on their personal choices of language usage in the classroom. They gave reasons for their personal preference for using English-only, isiXhosa-only or a mixture of using both isiXhosa and English as the de facto LoLT in their classrooms. These tasks were designed to inform objective one.

Data were also gathered from lecturer observations and discussions as the students experienced writing a numeracy test that was not necessarily in a language with which they were familiar. They were introduced to the tenets of exploratory talk and developed their own ground rules in groups so that they could experientially engage in exploratory talk. They used RSPM items and Concept Cartoons, given as part of the intervention, to trigger the development of exploratory talk. The students discussed a task concerning the use of different languages during different stages of a lesson, and lastly they wrote action research assignments on the introduction of exploratory talk in their own classrooms. The methods of gathering data have been described in chapter three. The constructs that could be identified from these data would be used to throw light on objective two and attempt to answer a sub question of this study, namely, Can dialogic strategies be promoted by means of an intervention for educators?

Together the qualitative and quantitative data provide an overview of the present position of educators and learners of mathematics in the Eastern Cape and allow the exploration of the notion that an intervention, covering the introduction of dialogue, could help both educators and learners in the teaching and learning of mathematics in multilingual classrooms.

2. PERCEPTIONS AND POETRY

Two sets of qualitative data were gathered from the ACE: MST cohort of students. Firstly, the students were asked to reflectively describe their school and community with specific reference to the language issues and problems encountered by educators and learners. Secondly, they were encouraged to write a poem about their inner feelings about language issues.

2.1 Educators' reflective writing about their school and community

At the start of the study the constructs for objective one had not yet been identified. The aim of tasks of reflective writing about the students' school situations and poetry was to gather data to address the objective, but the responses of the participants had to be analysed before themes began to emerge. The constructs identified are reported in table 5.1

Table 5.1

Constructs identified from reflective writing

External constructs	Internal constructs
Language diversity	Learners' lack of competence in speaking English
Marginalisation of dialects and disenfranchised languages	Learners' lack of confidence in speaking English
Poverty and disadvantaged circumstances	Exclusion and inferiority
Parental pressure to learn English	
Rejection of main language teaching and code-switching	

2.1.1 Language diversity

The diversity of languages was immediately apparent from the student responses. Sesotho is spoken mainly in the Western areas; isiZulu is spoken in the northern areas, and isiXhosa is the dominant language of those who live in the mid- Eastern Cape. Afrikaans was the language of learning and teaching in many schools in the southern region but with the increased admission of isiXhosa-speaking learners into these schools English is being introduced as LoLT. A teacher from a school in Paterson illustrated this point in the following extract from the student's reflective writing:

> My school is in the small town of Paterson. It is in a disadvantaged area because there are no job opportunities and 80% of the people live on government grant. The two dominant languages are Afrikaans and Xhosa. Our school has to accommodate learners from both communities but the language used for learning and teaching is English. Educators are facing a problem in their teaching especially the Afrikaans-speakers. They were taught their subjects in Afrikaans and now it is difficult for them to be acquainted with teaching the subject in English as a result they tend to use Afrikaans to explain concepts. For all the learners English is the additional language. Few of them get the opportunity to speak English at home especially the Afrikaans-speaking. When they communicate to educators they will speak their main language because they lack confidence in speaking English. As a result there is a high failure rate not because they do not know the subject matter but because they cannot express themselves in the language and cannot write the language – Port Elizabeth centre.

The educator seems to be more concerned about the Afrikaans-speaking learners and educators than with the fact that the isiXhosa-speaking learners are being taught in English by Afrikaans-speaking educators who cannot switch into isiXhosa when the learners don't understand. This issue is clearly spelled out in the case of a Port Elizabeth primary school teacher:

> The twenty-three educators in our staff all speak Afrikaans as their first language and English as a second language. We have only two educators in the junior primary section of our school that are competent in Xhosa. The switch to English as a medium of instruction comes as a huge challenge to most of us. Many of our learners have parents who speak different languages - mother Afrikaans and father isiXhosa and vice versa. Then we have some purely Afrikaans-speaking families and some purely isiXhosa-speaking families. To teach even in Afrikaans in such a linguistically diverse school and community presents a huge challenge. This problem is further complicated by the fact that some learners have completely mastered the skill of camouflaging their lack of understanding for the fear of being perceived as being stupid. Learners experience tremendous reading and spelling problems. – Port Elizabeth centre.

Even in rural areas the language demographics are changing and educators are faced with a multiplicity of languages in their classes. There have been an influx of people from other parts of Africa and the language problems related to this issue are a concern to some educators:

> The main problem is how to accommodate learners whose parents are Zimbabweans, siSwati and Nigerians in isiXhosa lessons as there are no educators from that area – Lusikisiki educator at Mthatha centre.

Schools that are located in areas where the dominant language is not isiXhosa, but which fall within the Eastern Cape, have different demographic problems:

> The school is in the rural area of Mount Fletcher. It has 375 learners which are Sesothos and isiXhosa. The dominant language in the area is Sesotho, which I think

ranges at 75% of the population of the area. The languages of instruction are English and Xhosa. Sesotho is not taught – Mthatha centre.

In some cases the school services many languages because of its proximity:

Kokstad is situated in North West of the Eastern Cape. On the west are the mountains of the Drakensberg and country of Lesotho where Sotho speaking people live and in the north is KwaZulu Natal where Zulu is spoken – Kokstad centre.

Educators are not trained to cope with multilingualism hence the need for an intervention that can train educators in the use and development of strategies that support learning through a second language, English.

2.1.2 Marginalization of dialects and disenfranchised languages

As one moves even further north into the 'former Transkei' the issue of isiXhosa being the standardized language and the marginalization of other dialects comes into focus:

AmaBomvana people don't speak proper isiXhosa – Mthatha centre.

Many dialects are spoken in an area:

In addition the people living in and around the area belong to a number of different groups who speak their own dialect, for example, isiMpondo, isiMpondomise, isiXesibe, isiBhaca, isiHlubi and others – Kokstad centre.

Educators comment on 'disenfranchised languages:

There are five hundred and nine learners at my school. IsiXhosa, isiBhaca, isiHlubi and English are the languages spoken by both educator and learners, but isiBhaca and isiHlubi are languages that have not been recognised as the languages to be used as languages at school since the beginning of schools in South Africa - Mount Frere educator at Kokstad centre.

Not only are the learners battling with competence in English, they cannot understand the isiXhosa spoken in the classroom either:

> Learners are speaking isiHlubi which is not taught at school. This is the first language problem. They have a problem with their taught main language which is isiXhosa because they do not speak it – Matatiele educator at Kokstad centre.

2.1.3 Poverty and disadvantaged circumstances

The learners have no opportunity to see or hear English anywhere else but in the school classrooms because of their location in isolated rural communities, but poverty further exacerbates the learners' problems as there are few, if any, resources which could expose them to English.

> The location of the school is in a deep rural area of Elliotdale where poverty is at its greatest. Also English is a problem because there is no electricity or television, which has an influence on language. – Mthatha centre.

Poverty is greatest in rural areas where there are no avenues for gainful employment:

> There are no job opportunities and 80% of the people live on a government grant – Kokstad centre.

The living conditions are basic in the extreme. English language competence falls low on the hierarchy of needs in these areas.

2.1.4 Parental pressure to speak English

Parents perceive the power of English and are determined that their children will learn how to speak the language.

> Parents force them to use English whereas they, the very parents, are not able to speak the language. We can teach successfully if we can inform the parents that the solution is to code-switch and use mother-tongue and English when teaching – King William's Town centre.

It does not always follow that learners learn to speak English if they are taught in English (Alidou, et al., 2006).

2.1.5 Rejection of main language teaching and code-switching

Many educators feel that teaching in the main language or code-switching is disadvantaging the learners:

> There are many language problems in our school. The headmistress often confuses them with culture, and in most cases we don't agree on things. She feels that it is totally wrong and is devaluing the school that learners code-switch when they work in groups or play outside. We on the other hand, feel that the children are being treated like prisoners – Queenstown centre.

Educators are under the impression that by teaching the learners in English they are teaching the learners English.

2.1.6 Learners' lack of competence and confidence in English

Moving further north into predominantly isiXhosa-speaking areas educators are concerned about the learners' lack of competence in English, which leads to feelings of inferiority and lack of confidence:

> My school is situated in a very small town called Alice. Most of the learners are from the rural areas. It is in the Xhosa-speaking community. Five percent of the enrolments are Afrikaans-speaking learners and the rest Xhosa–speakers. Educators are faced with the problem that they have no proficiency of English or Afrikaans. They have no confidence of speaking these languages. I think we can overcome this problem by in-service training and attend such courses. Learners are facing problems because they cannot understand, speak, read nor write English. They are very passive during learning. They cannot socialise in a group (group work) because they cannot express themselves in English. Some of them still spell phonetically. This language is a barrier to their learning because they cannot integrate language to other learning areas– King William's Town centre.

2.1.7 Exclusion and inferiority

One of the educators demonstrated a clear insight into the relationship between language and thinking, and the feelings of exclusion prevalent when one cannot communicate in a language:

> The LOLT in our school is English. The staff is a mixture of black and white educators. Language affects how we think, and how we perceive things. We use language to express our thoughts and feelings. When a strange language is used in your presence, you feel marginalised, excluded and inferior - Queenstown centre.

2.1.8 Summary of constructs

Because of the reflective writing tasks the educators were able to share their worlds with each other. In many cases their passion and pain for the learners were expressed in their descriptions. They spoke about both internal and external constructs that impacted on teaching and learning in their classrooms.

2.2 Poetry, Identity and Power

In order to encourage the ACE:MST educators to interrogate issues of language, the impact language has on identity and the power of language, they were asked to reflect on their own experiences and write a poem in which they shared their feelings about language issues in their experience. The educators were encouraged to write in any language they preferred. Because a translation would lessen the impact of the poetry, an isiXhosa-speaking academic, Kazeka, was asked to read the poems aloud and reflect on the emotions the poems evoked in her and the impact they made on her. The transcriptions of her commentary are reported verbatim after the poems that are written in isiXhosa.

The principal construct that threaded through the poems was the tension between pride in their home language and social, economic and political power of English. The positive and negative emotions expressed in the poetry about their home language form themes through the poems and are reported in table 5.2.

Table 5.2

Themes of positive and negative attitudes towards main language identified from poetry

Positives	**Negatives**
Identity	Exclusion
Pride	Inferiority
Cultural capital	Culture dissipated
Comfort	Disempowerment
Mother tongue	Inability to read or write competently

In some poems a variety of constructs were mentioned, so it has been difficult to separate the poems into themes. Perhaps the power of the educators' voices are sufficient to convey their message and emotion.

2.2.1 Tension between pride in the home language and the social, economic and political power of English

A common theme was the dichotomy between the pride in the main language and the hegemony of English. The pride in their main language is palpable, but also the sense that it is 'useless' as a tool in the search for social goods. The following two poems express, differently, the same emotions.

Bilingualism

I think and dream in isiXhosa
My home language
I love isiXhosa
Although I can't communicate world wide
It is my roots
My culture
My identity
It is my Ubuntu, I love my home language.

I study in English
Language international
Recognized world wide
Power, secret, comfort

Employment, status, relief
All represented in English
I respect my second language
It makes me feel literate.

Bilingualism, strange word
Existing within one me.

The tone of some of the poetry harks after the praise poetry in Xhosa oral tradition, where the *imbongi*, or praise singer, spontaneously lauds a dignitary.

Our Foreign Language
Oh English, our medium of instruction
What a good language it is
What a bad language it is
It is difficult for us to speak it
It is difficult for us to write it
Because it is not our mother tongue

Without it, no jobs
Without it, no education
Without it, no tourism
It is the medium of communication

Some feel inferior to others
Some feel unhappy to talk to others
Some criticise us for using our mother tongue
But out benefits belong to it.

Officials, educators, learners and stakeholders come together
Draw up a language policy which could help every South African child!

When writing in their mother tongue the educators expressed themselves lyrically using metaphors to express passion, but the underlying theme of disempowerment prevails. The question is implicit, is one only educated if one can speak English?

Isikhalo Somntwana
Ingaba ndinantoni?
Ndiva isikhalo,
Isikhalo somntwana,
Esithi andisiva 'isilungu'
Ndiva isiXhosa!
Ndiva isiXhosa!!

Kodwa mandifunde isiLungu
Mandifunde! Mandifunde!!
Ndoyaphi na?
Ndothini na?
Ngaphandle kwesilungu
Ulwimi lwezwe lonke.

Sona sikuvulela
Iingcango eziya
Enkululekweni.
Mandifunde! Mandifunde!!
The sky is the limit.

Commentary from Kazeka:

Basically this poem is saying, the cry of a child. '*Isikhalo somntwana'* is the cry of a child and this young man, in the first paragraph, is saying 'What will I be?' you know, I hear this cry of the child who is saying, 'this cry is I don't understand English'. But everyone keeps on saying I don't understand English but I understand isiXhosa - this is what I hear, I don't hear English I hear isiXhosa but everyone keeps on saying I must open, I must learn English because it will open the doors to opportunity, especially in a democratic situation. So when everyone is drumming in

> to him that he must be educated, be educated, and where will he go if he doesn't know this English - and then he says he must be educated, he must be educated and the sky is the limit. I would love to hear this writer because, does he mean that being educated is only in English? It is quite a… quite a … it moves you to your essence. It is that type of poem – Kazeka (English interpreter of the poems).

The following poem eloquently encapsulates a learner's struggle with mastery of English. Her metaphor of English as a key to a door of opportunity echoes sentiments expressed in previous poems.

Last Lesson on a Friday
Oh, it is English lesson again
I don't like the lesson
The tenses again?
Is – was , go – went, write – wrote
All in my head?
Oh, its very boring, especially on a
Friday afternoon.

But, what can I do without it?
Nothing.
It is the key to open the doors of life.
Come English come!
I want to learn more.

The disenfranchisement of the dialects was touched on by one poet:

My Language, My Life
Born of a father of the amaMpinga clan
Born of a mother of the amaBhele clan
Both of whom I never heard speaking English
Both of whom I always heard chanting isiXhosa
To my surprise my education is in English.

Another recurring theme expressed by the students is their pride in their language and the identity language provides:

My language – isiXhosa
Oh my beloved language
Oh my African language
Respected by the African speaking nation
amaXhosa, the sons of the African nation

I'm glad I'm black. I'm an African
I'm cheerful I can identify myself
I can write, read and speak isiXhosa
Awu axakekile amaXhosa ngengxoxo yakwaXhosa

My language, powerful, almighty language
You rose above whilst you were
Brutally murdered, tortured, destroyed
By those who were in power

Be strong my language, fear no one
Now is your time
The sky is the limit
IsiXhosa sama Xhosa – AkwaXhosana

Commentary from Kazeka:

Well, in my language isiXhosa, this poet .... is using both languages, I think that it also represents the contemporary identity of South Africa right now where he … I think it is in the second paragraph where he is '*axakekile amaXhosa ...'*. He is saying the isiXhosa speaking nation is busy talking and negotiating all the issues of isiXhosa tradition and then in the last paragraph where he says 'isiXhosa ...', he is saying the language isiXhosa ... '*samaXhosa* ...' meaning of the isiXhosa speaking people 'akwaXhosa' it is just an expressive idiom to say '*akwaXhosa'*, meaning it belongs to you. It belongs to you.

Ulwimi lwam

Ndiyintoni na?

Ngaphandle kolwimi lwam?

Ndizingca ngani na?

Ngaphandle kolwimi lwam?

Ndakuziva njani na

Ngaphandle kolwimi lwam?

Ulwimi lwam ngundoqo kum.

Ndiyazingca ngalo.

Commentary from Kazeka:

In this poem, *Ulwimi lwam*, he is saying, this person is saying, this poet is saying my tongue (my language) and he says in the first line, he asks this question, what am I? '*Ndiyintoni?'* What am I without my mother tongue? And then in the third line he says '*Ndizingca ngani na'*, What am I? What is my pride? '*Ngaphandle kolwimi lwa'*, without my tongue, *'Ndizakuziva njani na?'* How will I hear myself? And then he says in the last two lines '*Ulwimi lwam ngundoqo kum*'. Meaning my tongue is the essence of who I am and I pride myself with my mother tongue - Kazeka.

It is not only the isiXhosa-speakers who feel that their language is being superseded by English. Afrikaans - speakers share a sense of loss and betrayal:

My Verlore Taal

My ma het my leer praat

In 'n taal wat sy lief het.

In Afrikaans het sy gesê, "Staan op,"

Terwyl die polisieman sê, "Lê plat!"

My pa het jou gebruik om te leer sing.

"Slaap, my baba. Slaap soet," het hy snags gesing.

Ek het dit vir my kind snags sag gesing,

Maar hy het "Tula, Tata, tula !" hard gesing.

Afrikaans, jy is in my bloed en siel.
Vir jou sal ek my lewe af baklei.
Ek het jou van my voovaders gekry
En aan my kinders probeer oordra. Tog onsuksesvol.

Commentary from researcher:

The poet confides that his mother, who loved the language, taught him Afrikaans. He graphically mentions the Struggle where his mother was metaphorically holding her head high while policemen were harassing her ('Lie down flat on the ground'). His father sang him to sleep in Afrikaans, but when he sings to his son he is told to be quiet ('Tula'). Afrikaans is in his soul and he will fight to defend the language, as it comes from his ancestors, but he is unsuccessful in passing this pride on to his children.

The personification of a language indicates that the poet felt a kinship, tantamount to a friendship, with the language. The loss of a language is like experiencing the loss of a friend, it is keenly felt.

Afrikaans, my taal
Afrikaans praat met my,
Sing met my,
Dans met my,
Afrikaans waar is jy?

Jou stem is stil.
Jou kinders veg.
Weggeneem teen jou wil.
Ek's reg … jy's weg!

Commentary from researcher:

The poet compares Afrikaans with a friend and asks the language to sing and dance with him, but is bewildered as the friend's voice is quiet and he seems to have gone away. He concedes that there is strife in the friend's family and that Afrikaans has been forcibly taken away. He ends, I am right...you are gone!

As with the results of the questionnaires, educators feel that the emphasis on English dissipates the eloquence with which learners speak, read and write their main language. The effect thereof is not constrained to language only, as it insidiously seeps into a dissipation of history, culture and traditions.

Ulwimi LwakwaNtu
Yintoni midaka yakuthi ningalunakanga nje ulwimi lwenu
Ningasoze nisigqibe isivakalisi ningaphawulanga kulwimi lwesiNgesi
Abantwana abakwazi ukufunda ulwimi lwabo
Andisathethi ke ngokulubhala, kunzima

Ningakhe nijonge kwezinye iintlanga nje?
Kuba zona zineqhayiya ngeelwimi zazo.
Sesiyilahlile nemveli yethu
Kuba kaloku sisityeshele isiXhosa sethu.

Commentary from Kazeka:

> Ah, beautiful! This poet is saying '*Ulwimi lakwaNtu.*' '*kwaNtu*' is Bantu speaking people. He is basically saying in the first stanza, Why have we let this language go? Then, he says in our days it is difficult for even isiXhosa speaking people, not Xhosa, basically traditional speaking people to even finish a sentence without including English, and then he says in the third line, the children can't even read their own language, never mind to write it. He sort of, in exasperation, is saying you know it is difficult,' *kunzima*'. And then in the second paragraph he says why not look at other languages, you know, '*kuba zona zineqhayiya ngamalwimi alo'*, which means that the other languages, people from other languages, like German societies, for example, they pride themselves on their languages and he says that we have lost even our traditions, and our culture and our history because we are looking down on '*isiXhosa sethu*' (our Xhosa). We are looking down on our language. Very powerful, very powerful.

Re-iterating the sense of language being intertwined with one's identity, the following poem metaphorically equates mother tongue to the evocation of memories of smoky safety and satiation when one's mother cooked mealie-meal on the family hearth.

Umbongo Ngolwimi

Ulwimi lwenkobe sisiXhosa
Sinxibelelana ngolwimi
Isizwe ngasinye siyazingca
Ngolwimi lwaso

Zilishumi elinanye iilwimi
Ezisemthethweni apha eMzantsi Afrika.
Sifunda ngolwimi

Lwazi ulwimi lwakho!
Luxabise ulwimi lwakho
Luthethe ungagqwidizi!

Commentary from Kazeka:

Well… um… Mema here, she is just saying, *Ulwimi inkobe*, your mother tongue, if you had to translate mother tongue in, from direct English to direct Xhosa, it would actually mean '*ulwimi lwakwamamakho'* but it is not said like that. That is the wonderful thing about the Xhosa language, it is more experiential, they describe the experience and come up with the language so when they say *ulwimi lwenkobe, lwenkobe* is that corn that your mother makes usually in traditional society so, um, that mealie meal and those corns that your mom makes, so that is why it is *ulwimi lwenkobe* meaning your mother tongue. It is the experience, it is attaching the experience of making your corn with your mom. Isn't it beautiful? And then he goes on to say, she or he, goes on to say *lwimi lwenkobe sisiXhosa* is how we come to understand each other, it is how we come to communicate with one another and languages and *nations ngasinye .. olwimi lwabo*, meaning nations take pride in their languages and then he says in the second paragraph the poet says *Zilishumi elinanye*, meaning there are eleven languages under the constitution, under the law of South Africa, so language is part of our identity in that we study in language and then it goes in the last paragraph to just encourage you to know your language, value your language, speak it without shame.

Without spelling it out, the following poet suggests the political nature of language and the rallying cry that it can evoke:

isiXhosa

Lulwimi lwam lwenkobe

Luyandonwabisa ndakulila

Lundinika yonke endiyifunayo

Luyandithuthezele ndakuxakwa

Phambili ngesiXhosa phambili!

Commentary from Kazeka:

Well in this poem Luyisa is just saying (it is a lovely short poem and to the point.) '*Lulwimi lwam lwenkobe.'* This is my mother-tongue. It comforts me when I am crying. It gives me everything that I need, I take it spiritually. It, *ja*, it sort of paves the way of wisdom when I am sort of lost in my way, and then it says '*phambili ngesiXhosa phambili!'* Forward with this Xhosa forward. That sounds like an ANC rally. Well it goes to show that even language is politicised. It is a political discourse also.

The following poem brings the challenges into the classroom vividly and addresses the issues and difficulties so prevalent today.

What do you see in the picture?

What do you see in the picture?

No one answered

No one understands the question

What do you see in the picture?

Punish those blind fools, who do not answer,

Give them six lashes on the buttocks

Punish them again and again and again,

What do you see in the picture?

All books are wide open,

All eyes are looking at the book,

All minds know what is in the picture.

No one understands the question,

No one answers the question.
No one would have been punished
Had the question been phrased in Xhosa,
Had the answer been said in Xhosa!
Ubona ntoni emfanekisweni?

If the question, 'What do you see in the picture?' had been translated into isiXhosa, '*Ubona ntoni emfanekisweni?*' the poet maintains that the frustration and angst in classrooms would dissipate.

The poetry unlocked emotions that the educators had not necessarily dealt with in an open platform. Reading poems written by other educators and writing their own poems enabled students to feel that their own thoughts and feelings are valued. Poetry serves as a mirror creating self knowledge as well as a window through which the educators can view and participate in the hidden identities of others. Armed with this knowledge educators can engage with the learning and teaching of mathematics from a new perspective, moving from alienation to engagement.

3. EDUCATORS' PERSONAL CHOICE OF LANGUAGE AS THE LOLT

Qualitative data were gathered during contact sessions that I conducted with the BEd Honours cohort of 179 students in centres in Port Elizabeth, Mthatha, Kokstad, King William's Town and Ngcobo. A common 'wish' proposed by the BEd Honours educators who participated in this study is that code-switching be acknowledged as a desirable practice in the classroom. The data generated in this study reveal that code-switching is almost universally used in the participating schools, but that it is accompanied by a sense of guilt and inadequacy as educators feel they are depriving their learners of opportunities associated with the use of English.

The most frequently repeated reasons educators gave for selecting English-only, isiXhosa-only or a mixture of using both isiXhosa and English as the LoLT in their classrooms were as follows:

3.1 Reasons for teaching in English only

- Language of opportunity – access to further education, jobs and status;
- English is an international, universal language as opposed to localised vernacular;
- Language of education
  - Official language (many educators were under the impression that English had been selected as the LoLT by either the Government or the Department of Education;
  - English is the language of tertiary education;
  - Assessment tasks, examinations and textbooks are set in English;
  - Knowledge of English is seen as a sign of being educated;
  - Lack of Xhosa terminology in mathematics;
  - Cost of translating books into isiXhosa could be prohibitive;
  - Terminology of mathematics is difficult to translate into isiXhosa, particularly with different dialects;
- Pressure by parents to learn English for better employment;

The majority of students mentioned, in various ways, the hegemony of English, particularly in education.

3.2 Reasons for teaching in isiXhosa only

- Learners understand isiXhosa, especially abstract concepts;
- Learners think and communicate confidently in isiXhosa therefore they learn more effectively when taught in isiXhosa;

- Learners do not read and write fluently in their own language.

The constant themes that emerged were thinking and understanding in isiXhosa; however, the devaluing of the language has resulted in lack of proficiency in reading and writing in isiXhosa.

3.3 Reasons for teaching in both English and isiXhosa – including the introduction of code-switching:

- Code-switching must be recognised as acceptable practice;
- Ensures that everyone has access and deepens the understanding of the learners;
- Use isiXhosa prefixes to English words to encapsulate the properties e.g. i-angle, i- fraction to link concepts to words;
- Gives value to mother tongue

However the educators did mention a number of disadvantages of code-switching:

- It is time consuming;
- Could result in errors made because of mismatching when translating as there are no equivalent terms for some mathematical concepts in the main language;

Code-switching was accepted among the teachers as a universal practice; however they felt guilty because they perceived that they were depriving learners of the opportunity of speaking English. They did not realise that the mere hearing of English would guarantee that the learners learned to communicate in English. This exercise encouraged the students to think about their use of language in the classroom and to motivate their choices.

4. EXPERIENTIAL LEARNING AND ASSIGNMENTS

The students completed four additional activities, individually or in groups, during their contact sessions from which data were gathered for this study. The aim of these activities was to introduce the students to the power of dialogic teaching through experience rather than through theory only. The objectives of the activities were to facilitate discussion about the use of language in the classroom as a group follow-up to the questionnaire that they had completed in individually; to enable the students to experience the frustration learners feel when they cannot understand written questions, even though they know that they are capable of answering correctly; to enable the students to experience firsthand the power of exploratory talk in problem solving; and to experience the teaching of exploratory talk in their classes. Firstly they identified sections in a lesson where different languages could be used and discussed their choices in groups. Secondly, they wrote a numeracy test that was not necessarily in a language that was familiar to them. Thirdly, they experienced exploratory talk by using triggers such as RSPM problems or Concept Cartoons; and finally they completed written action research assignments on introducing exploratory talk in their classrooms. The themes that emerged from these exercises were: the positive aspect of implementing group work, the importance of ground rules in discussion; the advantage of using the main language or code-switching in teaching and learning.

4.1 Identifying when different languages could be used in a lesson

The BEd Honours students were given a description of a lesson on multiplying fractions (see Appendix E) in a contact session. They were asked to discuss the lesson in groups and report on which section of the lesson should be conducted in English; which section, if any, should be conducted in isiXhosa and when code-switching would be appropriate. The rationale for this exercise was to affirm together that the strategies of code-switching and using the main language are valid and acceptable (if not *preferred*) practices in the mathematics classroom. The data were collected from their written submissions as well as from observations of the videotapes of their discussions during the contact sessions in the various centres.

This exercise elicited similar responses from the BEd Honours students to the answers they wrote in their questionnaire dealing with language choices. In a sense it was a reliability check to see whether the students would give similar answers. The issue of revoicing was raised on many occasions. As learner-centred teaching has been emphasized, revoicing of mathematical English by the teacher seemed to be a contrary practice; however in multilingual classes it is a critical teaching function (Adler & Lerman, 2003; Moschkovich, 1999). The students thus had to rethink their own conceptions of learner-centred practice in the light of their own contexts.

The students debated the use of language in assessment. Is it useful to translate material and assessments into main language? What strategies do educators use to ensure that learners see the written word and not just hear the spoken word? What about the implications of the contextualisation of mathematics? Educators use metaphors, for example, 'rondavels' or balls to represent circles, but a different dimension is thus being brought into the conceptualisation. The discussion elicited topics that were not necessarily related to the exercise, but were nevertheless very relevant to the issue of teaching mathematics in multilingual classrooms.

The majority of the teachers felt that English only should be used when the educator reads a problem to the learners for the first time. The students also felt that English-only should be used when new terminology is introduced as "we are modelling a process as far as possible". They felt that the learners should write in their journals in English only as, "a learner needs to communicate his ideas in writing, and that is done in English. English is the official language that is common to everyone here in SA".

One educator from East London felt in the lesson described (see Appendix E) that the choice should be:

> English must be used during teacher talk, where the educator explains the procedure of the multiplication of fractions. The learners in the senior phase know the English terminology of fractions i.e. denominator, numerator. The educator explains only the procedure required for reaching an answer. For second and third language English learners it might be necessary to explain the procedure again in their mother tongue.

The students felt that the learners' main language should be used whenever they responded to questions and "when they are in conversation with others in the group, presenting their point of view". Learners could be allowed to use their main language in order to communicate with one another, as learner-to-learner communication could at times be more effective than teacher-to-learner communication because the learners relate to each other more openly. Other support expressed for using the main language included:

> The use of mother tongue by the learners in groups should not be frowned upon. This will allow learners who are not yet competent in English to enter the mathematics discourses – Port Elizabeth;

> Learners engage with each other in their main language in order to reach a decision – Mthatha;

> They may not yet be proficient enough in English to use it to express their ideas and reasoning. Nevertheless it is important for their conceptual development that they express their ideas in isiXhosa in order to learn from each other, find out faults in their own thinking and have their understanding and progress assessed by peers - Kokstad.

The majority of the students expressed the opinion that code-switching should be used when the multilingual learners converse in groups:

> All learners need to be on the same level of understanding the question. Those who understand better will explain using code-switching to each other. When something is not clear sometimes you understand it better when it is explained in your own language – Port Elizabeth.

They suggested that code-switching also be used when a new concept or new terminology was introduced by the educator – or when mathematical operations were being explained:

> I would suggest code-switching in the vernacular in these areas to ensure that learners understand concepts in words that may seem foreign to them to enable them to have clarity and insight as to what they have to absorb and solve. We have to bear in mind that they are learning English and main language.

One educator 'role played' the imagined group interaction in her written assignment. She personified the interactions between the learners in the section when the learners discussed the multiplication problem in groups. She emphasised the code-switching that could occur.

In this instance, and in later transcriptions, I have transcribed isiXhosa words in italics for clarity and to distinguish the English utterances from the isiXhosa utterances.

Jonas: John's father said a third is for the parents. I wonder how much is left for all the four children?

Kate: Let's see when we cut this apple into three equal parts. *Kuba i-third, sijonga i-denominator* cause the *denominator isixelele zingaphi ii-pieces* then *i-numerator isixelele zingaphi ii-pieces ezisebenzileyo or ezishiyekileyo.*

Bulelwa: It means *xa sibeka ecaleni i-third, abantwana bona bashiyeka nezimbini ii-pieces.*

Kate: Children will get smaller pieces than their parents *kuba banintsi bona.*

Bulelwa: No, *asikwazi kutsho* cause *asigqibanga ukuyi-calucate(a).*

Jonas: First we need to change the integers into fractions so that we can be able to calculate.

Bulelwa: We have $\frac{2}{3}$ for *abantwana abayi-4*. We can write it as $\frac{2}{3} \div \frac{4}{1}$.

Jonas: Then *kwi-division ye* fractions we cross multiply or change the last fraction i.e. denominator to be the numerator or the other way.

Kate: It will mean $\frac{2}{3} \div \frac{4}{1}$ cross multiply and $\frac{2}{12}$ *okanye* $\frac{2}{3} \times \frac{1}{4} = \frac{2}{12}$.

Jonas: Can't we simplify it $\frac{2}{12}=\frac{1}{6}$. Each child will get one sixth.

Kate: We have not yet finished calculating for the shares of the parents.

Bulelwa: How many parents are going to get

Jonas: *Haybo kanti bangaphi wena abakho abazali?*

Kate: There are always two parents per family so we will be dividing $\frac{1}{3}$ among two people.

Bulelwa: It will be $\frac{1}{3}\div\frac{2}{1}=\frac{1}{3}\times\frac{1}{2}=\frac{1}{6}$

Kate: If one parent will get $\frac{1}{6}$ and one child will get $\frac{1}{6}$ it will mean they all get the equal parts.

Even without translation a non isiXhosa-speaker can understand the learners' perceived reasoning, as the educator had imagined the interaction (This could have actually taken place in her class, but the scenario is not clear from her written submission). The learners themselves seemed to be comfortable using code-switching, and it seemed to aid their understanding of the mathematical reasoning.

This activity achieved the aim of affirming to the students that the strategies of code-switching and using the learners' main language are valid and acceptable practices in the mathematics classroom. The students' comments after this exercise confirmed this notion. The activity also led naturally to a discussion about the curriculum, and how to encourage collaborative, exploratory talk in the mathematics classroom by developing lessons, in the students' particular teaching phases, that include strategies to overcome language issues in the mathematics classroom.

4.2 Completing a mathematical task in a language other than the educators' main language

During the BEd Honours class contact sessions in each of the centres the students wrote numeracy tests. Some students received isiXhosa translations, some received English copies and yet others received both English and isiXhosa versions of the same test. Those students who were English first language speakers were given the isiXhosa copies, whereas those whose main language was not English were given the English or combined language copies. After the test the students were asked to reflect on how they had felt during the assessment. The rationale for this exercise was for the students to experience, either personally or through other colleagues in the contact sessions, what it feels like to write an assessment in an unfamiliar language. The rationale for this exercise was that teachers would realise and experience a situation that closely approximated their own realities.

4.2.1 English first language student experiences writing test in isiXhosa.

The English-speaking students were given the isiXhosa translations (see Appendix G). Their reactions were similar:

> "I totally disengaged";
> "I lost interest";
> "Not good";
> "I got on with other work";
> "Irritated, upset, you can't help yourself";
> "I was exhausted to work in a language I can't understand".

Their body language eloquently mirrored their frustration and boredom. One student commented.

> We now understand the importance of group work, and social work - peer learning, the importance of getting learners to talk. That's where real learning takes place. We know from this practical example. I now know why students just write out the exam

> paper during an examination, because you can't bear to be doing nothing. You don't want to stand out and look as though you are stupid. You want to be seen to be writing as though you know what you are doing.

The English-speaking students felt they were able to cope with the questions that involved numbers, e.g. questions 1.2 to 1.5 in the figure below; however when they tried question 1.6 most of them thought that they had to arrange the numbers in either ascending or descending order of magnitude, and they guessed which way the numbers should be written. In fact the question was, "Add (*dibanisa*) the following list of numbers: 213, 4 017, 1273, 2 198, 21". The English-speaking students were all incapable of answering question 1.1, which was translated from, "Write the following number in numerals: twenty thousand two hundred and six".

1.1	Bhala esi sivakalisi sibe linani. Amawaka angamashumi amabini anamakhulu amabini anesithandathu.
1.2	102 – 36 =
1.3	1 048 + 21 376 =
1.4	23 x 145 =
1.5	168 ÷12
1.6	Dibanisa olu luhlu lwamanani lulandelayo: 213, 4 017, 1273, 2 198, 21

Figure 5.1 isiXhosa translation of question 1

In question 2 in figure 5.2 the English-speaking students were able to surmise that the question had something to do with the measurement on the ruler, but they were unsure as to whether they had to give the reading from the ruler or the length of the pencil. Language support was offered by using a graphic.

2. Lo mzobo ungezantsi ubonisa ukusetyenziswa kwerula ukulinganisa ubude bepensile.
   - Ubude bepensile bungama-.... eesentimitha.

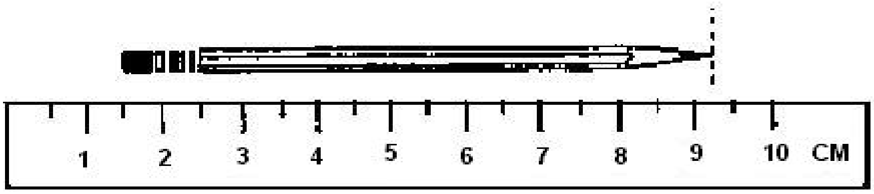
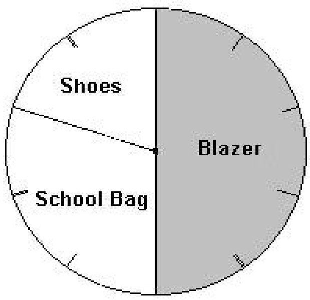


Figure 5.2 isiXhosa translation of question 2

Their confusion arose because both bepensile and kwerula, the objects in the drawing, which both have similar spelling and enunciation to the English, were in the same sentence in the question in figure 5.2. They could not distinguish whether the question referred to the pencil or the ruler. The meaning of 'bepensile' could be deduced from the sound, which is similar to the English phoneme, and the similar spelling. Someone who has seen written isiXhosa could surmise that the word meant 'pencil'. In fact the English question was, "The diagram below presents a ruler being used to measure the length of a pencil. The length of the pencil is _________ cm"

The English version and the isiXhosa translation of Question 3 are reproduced in figure 5.3.



3. Siseko's school uniform cost R250 altogether. The pie chart shows how much money was spent on the different items

3.1 What fraction of the R250 was spent on :

3.1.1 The blazer ____________________

3.1.2 The school bag __________

3.1.3 The shoes __________

3.2 How much money was spent on:

3.2.1 The blazer __________

3.2.2 The school bag __________

3.2.3 The shoes __________

3.3 What % of the R250 did the blazer cost? ___________

3. Impahla yesikolo kaSiseko ixabisa ama-250 eeRandi iyonke. Le tshati ibupayi ilandelayo ibonisa imali echithwe ngabazali bakhe kwisinxibo ngasinye.

3.1 Leliphi iqhezu lama-250 leeRandi elichithwe kwi:

3.1.1 Ibhatyi yesikolo______________

3.1.2 Ibhegi yesikolo __________

3.1.3 Izihlangu __________

3.2 Yimalini echithwe kwi:

3.2.1 Ibhatyi yesikolo __________

3.2.2 Ibhegi yesikolo __________

3.2.3 Izihlangu __________

3.3 Ithini ipesenti echithwe kwibhatyi yesikolo? __________

Figure 5.3 English and isiXhosa versions of question 3

The English-speaking students guessed that *'ibatyi'* would be the translation of 'blazer' because of the similarity to the Afrikaans word for blazer, *'baadjie'*. Using a process of elimination, in some instances, they were able to find the correct answers. This was one of the reasons for using English and isiXhosa instead of a foreign language, as these clues to meaning would not have been identified in a language such as Taiwanese. As the translation for Question 3.3 contained no mathematical symbols, the English-speaking students were unable to fathom the meaning of the question.

The following sequence from a Port Elizabeth contact session epitomizes the sentiments expressed by English-speaking students in the other centres.

Sequence 5.1: English-speakers' reflection on isiXhosa assessment

Lecturer:	The aim of this task was for you to experience what some of our learners experience in class. So how did you feel?
Melmud:	Lost!
Lecturer:	Lost? You were able answer some, weren't you? How?
Melmud:	Only the symbolic, language of symbols, so certain things we were able to do. The number ones, that was easy. We were able to do the number ones. Also if you read the language you get some words that are similar to the English and you can pick up …
Lecturer:	So you can pick up one or two words, and therefore you can perhaps get the sense. What about this one here with the pencil?
Melmud:	I couldn't read the instruction, but I gathered from the picture that I needed to read the length of the pencil.
Lecturer:	How did the rest of you feel?
Graham:	Frustrated – an inability to see what is required. You might know the answer, but you do not know the question.

The themes that emerged from the written submissions and discussions around this task were frustration, sense of unfairness, denigration.

4.2.2 isiXhosa- speakers writing isiXhosa assessment

In this exercise, contrary to my expectation, the isiXhosa-speaking students were not comfortable sitting for a test in their main language. After writing the test in isiXhosa, a student from Mthatha commented:

For Xhosa-speakers it was difficult because we have been conditioned. When we see a mathematical problem it is in English, not in isiXhosa. So we struggle to interpret what it really means from isiXhosa to English.

Many students said they felt the translation was incorrect, that they would have chosen different words. In East London, Port Elizabeth and Mthatha students claimed that if the learners wrote assessments in isiXhosa they would battle as they cannot read or write in the vernacular, although they speak it fluently. This resonates with the sentiments expressed in both the poetry and the reflective writing that, although learners communicate in isiXhosa, their reading and writing competence in the language is poor. The transcription of sequence 5.2 attests to this opinion:

Sequence 5.2: ***isiXhosa-speakers' reflection on isiXhosa assessment***

Xolile: Question 1.1 is still difficult. I am thinking of the language, when the students go to numbers is so easy for them but if they come to reading in isiXhosa it becomes difficult.

Lecturer: So we are saying that as long as the mathematics is expressed in numbers it is OK?

Xolile *Amawaka angamashumi amabini* … that one is difficult.

Lecturer: How do the learners learn how to count?

Xolile: In English,

Lecturer: They count in English?

Xolile: Yes

Lecturer: So are we saying that our learners do not know their own language and cannot read their own language sufficiently well to be able to write an exam in their main language.

Xolile: Yes. A lot of them, how can I say, they are illiterate in the sense, they speak the language and when I ask them if they want the instructions in the written form they say it is difficult to read Xhosa. So they may not be able to read it but they speak it. They are illiterate in their own mother tongue.

Lecturer: So our problem is that our learners cannot read Xhosa, and they also cannot read and understand English, is this what you are saying, so translating an exam paper is not going to help them because they cannot read at all?

Xolile: Yes.

Students compared the mathematics register in isiXhosa with the developed mathematics register in other languages ("Other countries, like France, they learn in French. They are able to do all kinds of things and concepts in mathematics in their own language"). They felt that the mathematics register should be developed in isiXhosa so that educators and learners could speak the language of mathematics in their main language. However, a caveat was raised about the different dialects of isiXhosa. They felt it would be difficult to come to an agreement about the correct isiXhosa word to use for a concept. For example, in Ngcobo a discussion developed about the translation of the operation of 'multiplication' into the isiXhosa word *phinda-phinda,* which can loosely be translated as 'repeated addition', and the use of *ukubulala* for 'subtract'. Sequence 5.3 is a transcription of this discussion. Again, for clarity, I have placed isiXhosa words in italics.

Sequence 5.3: Mathematical operations translated into isiXhosa

Lecturer: Would you say one half *phinda-phinda* five*?*

Yolisa: No, we wouldn't say that. Even in their homes they use to code-switch, more especially in numbers. Just the four basic operational signs we have in isiXhosa

Lecturer: But do you use the isiXhosa words?

Yolisa: You know some do – *uyhlula, dibanisa, thabatha, phinda-phinda.* But it is kind of difficult if you are using those terms because you will find that some educators, when you talk about subtraction, they talk about *ukubulala.* Now *ukubulala* means 'to kill'. Some would say *ukuthabatha, ukususa,* but some would say *ukubulala,* which means if something is killed 'that is that'. If you want to say five minus three, *ne*, equals to two, and you use the word *ukubulala,* then you can't say that you can change the subject of the formula to two plus three equals to five, because you said these three are 'killed'. You can't make them come back to life now and use them in a sum. If you are only dealing with one particular part then it is fine, but if you want to use the converse then they will say to you, "But you said it was dead!".

Lecturer: Then the word 'subtract is a more universal idea?

Yolisa: Yes, that is why we use the English word 'subtract'.

In this sequence the student uncovered the conceptual difficulties learners encounter when metaphors are used for mathematical operations during translation. If a learner is told that $5 - 2 = 3$ because two numbers have been 'killed' and only three are left, then it is difficult to conceptualise that the same equation can be written in a different way as $3 + 2 = 5$. To the learner two have been 'killed' and therefore cannot reappear in the equation.

This exercise used contextual clues from classroom realities to develop a language awareness of what is happening in multilingual classes. The themes the isiXhosa-speaking students uncovered were: they think about mathematics in English; Learners cannot read or write competently in their main language; the use of metaphors to explain concepts is problematic.

4.2.3 isiXhosa-speakers writing the test with English questions as well as the isiXhosa translation

The majority of the students who were given both the English plus the isiXhosa translation of the question paper started answering the English translations and only turned to the isiXhosa translation when they were unsure of a term: “Oh, *Leliphi iqhezu*… **that** is what is being asked! This question means ‘this’, so now I can understand and write it in English” – Ngcobo student.

Some of the educators did not even look at the isiXhosa version.

> Because I’m not familiar in answering in Xhosa, you see. That is a problem. Because you’ll find out that even some of the terms, even in isiXhosa, it is not easy to understand mathematically, you see, because we are not used to answering them in Xhosa – King William’s Town student.

A Port Elizabeth student expressed her misgivings as she said, “I know sometimes, when we look at these words that are translated from English into Xhosa, I was afraid I’d get a problem!” The student was concerned that the translation might not correctly embody the essence of the English question so she was not prepared to use the isiXhosa version. Another student said he thought about mathematics in English so did not bother to look at the translation.

The majority of the students were of the opinion that external examinations should be translated into the vernacular, but when challenged to issue their own internal examinations in both English and the main language, students hedged and skirted the issue. One educator who had experience of mathematical translations, noted,

> I do have experience of translating the grade five and the grade three maths, and I do find it difficult. The concepts for English are so huge that you cannot change them to the vernacular. The language tends to be longer than the shortened version of the English. For example, ‘a parent is twenty years older than a child’ – *mdala kunonyana wakhe ngeminyaka engamashumi amabini* - so you try to give clarity or interpret the question relevantly to what the English was stating – Port Elizabeth educator

The aim of this exercise was to allow the educators to experientially feel the difficulties and frustrations their mathematics learners are facing daily. As one student left the contact session in Ngobo she said, “Today has changed my mind set. Really. Totally. I will start to use isiXhosa more in my classes now.” This indicates that training sessions and interventions are necessary to change the mind sets of many more teachers, of isiXhosa-speaking mathematics learners, so that they are confident that code-switching and using the learners’ main language in mathematics classes is an advantage to the learners.

The third experiential learning exercise that the BEd Honours students completed was to experience exploratory talk in their own groups in the contact sessions.

4.3 Experiencing exploratory talk through triggers

Because the BEd Honours students taught in different phases in their schools it was not appropriate to use mathematics-based exercises, as some students could be intimidated by the standard of the questions whilst others could find the questions too easy. I needed to find tasks where they would all share the same degree of prior knowledge. I decided, therefore, to use triggers from outside their mathematical milieus to encourage them to experience the different types of talk - disputational, cumulative and exploratory – that we had discussed in theory (Mercer & Littleton, 2007). We had already negotiated the ground rules of exploratory talk in the contact sessions. I introduced RSPM items and concept cartoons as triggers to encourage dialogue. The students could hone their skills at differentiating, through experience, between the different types of talk.

The educators were initially ambivalent about working in groups, so in the contact sessions I conducted an exercise in class in an attempt to demonstrate to them that their reasoning skills increased when participants worked together and used a language in which they were fluent. At first the students were given a set of ten RSPM problems to solve on their own and afterwards were given a very similar set of RSPM problems to discuss and solve in groups. The collective group activity average result improved by 37% percent from the average individual score to the average group score. The largest improvement was a sixty percent improvement from an individual score to the group score in Port Elizabeth. It could be argued that continual exposure to similar items improved the marks, but the object was to convince the students that the social practice of using dialogue in order to solve a problem was beneficial. As such the exercise achieved its purpose as the students verbalised that they had been convinced that group work increased efficacy. In groups where isiXhosa was the main language of all participants, the educators spoke in the vernacular except when mentioning mathematical terms e.g., circle, rectangle, diagonal etc. Where there was a non-Xhosa speaker present in the group the discussion was exclusively in English.

In discussions afterwards the students concurred that working in the group decreased their anxiety as well as increased their effectiveness in solving problems. Mathematics anxiety is a researchable topic all of its own, so it was encouraging to discover that inadvertently the study had uncovered a means of reducing stress.

The first set of triggers used were items from the RSPM battery as they were language- and culture-free tests so the learners approached the problems with the same prior knowledge.

4.3.1 RSPM items used as triggers for exploratory talk

When the students attempted the easier problems in Section A of the RSPM test there was evidence of disputational talk within the groups. For example, with item A8 (see figure

5.4), the students gave answers which differed from one another without backing up their statements with reasons. An example is reported in sequence 5.4.

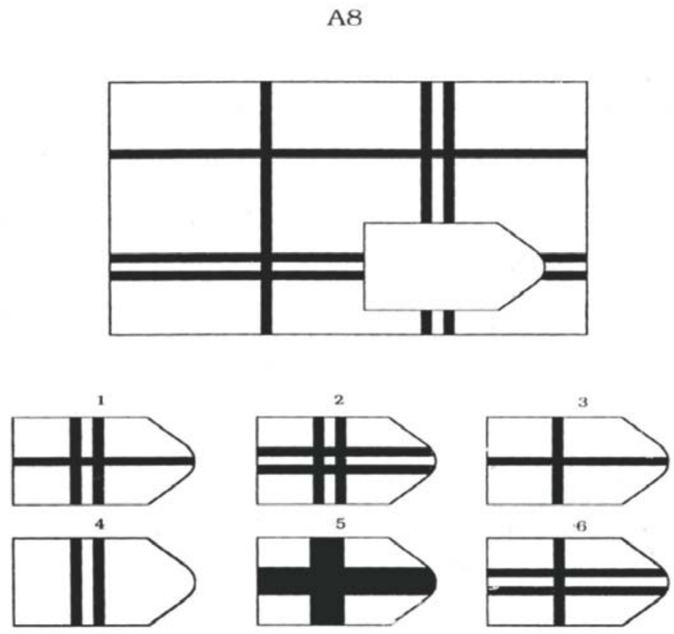


Figure 5.4 Item A8 from Raven's Standard Progressive Matrices test (Raven, Court & Raven, 1995)

Sequence 5.4: Example of disputational talk

Tomas: I know the answer to this one. The answer is 6.

Grace: No it's not. The answer is 2.

Perhaps the students felt that the answers were obvious and self-evident, so reasons were not necessary; however, the disputational exchange is typified by a paucity of reasons and an aggressive undertone.

As the items became more complex, the instances of cumulative talk increased as some students 'became lost' and would merely agree with their more vociferous colleagues without suggesting counter arguments or offering any alternative reasoning for the agreed-upon choice. Those who engaged wholeheartedly in the exercise realized that they could not merely guess an answer but had to substantiate and defend their reasoning. At times they had to be reminded of the ground rules of exploratory talk as in some cases the talk became loud and almost argumentative. In such instances they had to be reminded that the object of the exercise was not to find the correct answer, but to practice the type of talk required to promote mathematical reasoning.

An example of cumulative talk at the beginning of the sequence, leading towards exploratory talk, is reported in sequence 5.5 from the transcription of a group's discussion as they attempted to solve item D12 in figure 5.5 of the RSPM test.

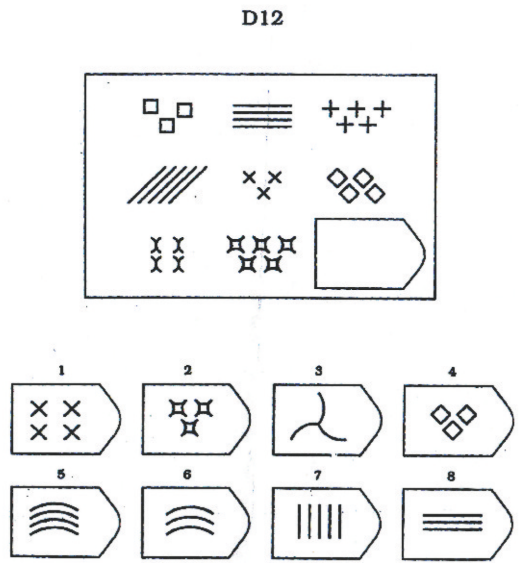


Figure 5.5 Item D12 from Raven's Standard Progressive Matrices test (Raven, Court & Raven, 1995)

Sequence 5.5: Using Raven's Standard Progressive Matrices as a trigger –item D12

George: Number 7 is going to be the answer because the lines are vertical. The top row has horizontal lines, the middle row has diagonal lines so the bottom row must have vertical lines

Sam: Yes, in the first diagram, there are the horizontal lines, in the second row the lines are skew, so I think the answer must be 7.

Gillian: We can go for 8 also because we have four lines in the top row and five in the middle row, so we can have three in the bottom row.

Xolisa: So we have a bit of a dispute here, we haven't come to full consensus. What do you think?

Kim: I think it is 6.

George: Why?

Kim: I'm talking about the boxes. By looking at the pattern starting from the top, there were three squares, then it went four in the middle row, then at the bottom it went to five. And the shape of the boxes, you see the shape in the second row has been moved and in the third step it has also been changed.

Sam : Yes, it has been turned, alright, rotated.

George : So it has to be three to fulfill the pattern.

Kim : But it must be curved because here we have got horizontal, diagonal, curved boxes as well as horizontal, diagonal, curved crosses and so I say it must, therefore, be 6.

Gillian: Now in terms of the straight lines, if you look at your third row, there are no straight lines therefore what she is saying is that you look for straight lines that have to be curved because .... laughter ....

Xolisa: We know what you are saying. The communication is clear, the straight lines must be curved!! So what do you feel now?

Sam: I want to change to 6.

Xolisa: Have you changed your mind? Have they been convincing enough by their argument?

Sam: Yes

Xolisa: Can you see how the discussion is moving? I think something… I think something else. Now let's see if we can, through talk and reasoning, come to a consensus.

George jumped to a conclusion. Although he did give a reason for his choice he had only looked at one aspect of the pattern – the orientation of the lines. Sam replied in typical cumulative talk fashion. He affirmed both the choice and the reason. Gillian gave an alternative answer and backed up her choice with a valid reason. Xolisa acted as 'chairperson' throughout the sequence. She pulled in other members of the group and gave general comments and summarized the progress; however, she did not offer any suggestions to solve the problem. Kim appeared to be prepared to be maverick and give a totally different alternative. When challenged, she displayed insight and applied logical reasoning, to the extent that the other members of the group followed her explanation and were able to expand on it, with the result that Sam was convinced to change his mind about his initial choice. The transcription indicates that the group adhered to the ground rules of exploratory talk in that they challenged each others' suggestions, but they backed each statement with a reason; gave each other a chance to air their views without ridicule; and eventually came to a consensus.

The groups in each centre were asked to solve RSPM item E12 (see figure 5.6). This was the last, and most difficult, item in the RSPM test. A transcript of the students' attempts at following the ground rules and implementing exploratory talk are reported in sequence 5.6.

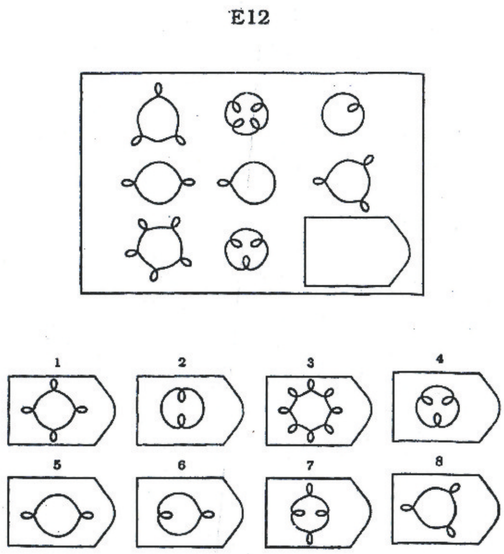


Figure 5.6 Item E12 from Raven's Standard Progressive Matrices test (Raven, Court & Raven, 1995)

Sequence 5.6: Using Raven's Standard Progressive Matrices as a trigger – item E12

Thelma: I looked at the pattern and I said that the first column had three projections outside, then two, then five. And then the next column had four, then one, then three. The last column has one then three.

Ntomboxolo: I wonder if the loop being inside or outside helps in looking for a pattern there?

Graham: Let us look at the numbers. In the middle row two plus one give us three, but in the top row three plus four. It is one. Maybe I am getting the answer! Then five plus three coming to an answer here. But it isn't working out vertically and it isn't working out horizontally…

Ntomboxolo: You have given us a starting point. And we can work from there. Or we might go on a different tack. I am not sure.

Mata: Something similar to that, but when I looked at it I found the number of loops. In the first row three plus one gave us four in the middle. In the second row two plus one gave us three at the end. Then in the third row five plus three will either give us eight or two. So it is either 3 or 5

Thembalethu: I also have 5

Ntomboxolo: Well, come let's hear! Because there are many ways to get to an answer mathematically, there is not only one way.

Thembalethu: I don't know if it is very simplistic, it is definitely the same thinking but the explanation is different. I think that if these little loops are outside we look at it as a positive value and if it is inside as a negative. In the top row three plus negative four equals negative one. So if it is negative, which it is, then the loop is inside. The second row is positive two plus positive one which equals positive three. Three on the outside because it is positive.

Mata: So the last row is positive five add negative three which is positive two. So it is 5!

Ntomboxolo: How do you feel about that?

Graham: Very good.

Mata: Succinct, mathematical, built on what we gave you, but actually very understandable. Well done! Is there anyone who disagrees that it has to be 5?

Thelma started the dialogue by describing what she saw on paper. At first the group floundered, but the fact that they were verbalizing their thought processes helped others to build upon former ideas until Thembalethu was able to encapsulate their reasoning in mathematical terms. The students were all moving in the same direction. The argument became more, and more refined – and more mathematical. As in the sequences, the students interspersed their colloquialisms with mathematical terms as they started talking about parallels, diagonals, vertical, horizontal and mathematical operations. Their reasoning and discussion progressed from informal talk to mathematical discourse. In a discussion after this exercise, the students in the East London group commented on how exploratory talk could help in solving geometry riders as they felt that each learner could bring a different gaze to a geometry rider and, through dialogue, they could reach a consensual conclusion by constructing their own meaning.

The students were introduced to a different type of trigger in the form of a concept cartoon.

4.3.2 Concept cartoons used as triggers for exploratory talk

The second type of trigger used was a mathematical concept cartoon. The rationale for using another type of trigger was to give the students an opportunity to practice their newly acquired knowledge concerning the practice of exploratory talk using a more mathematical scenario.

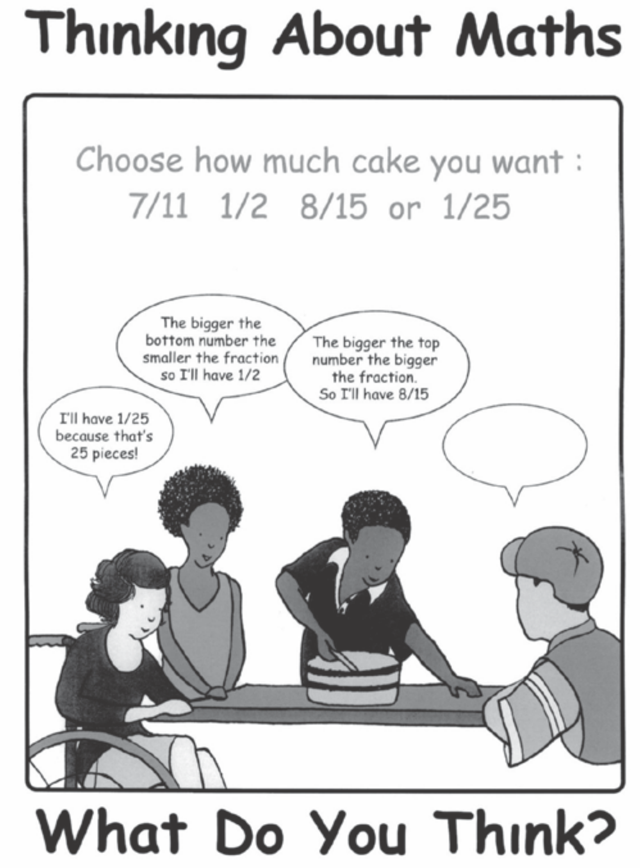


Figure 5.7 Example of concept cartoon (Dabell, Mitchell, & Barnes, 2007)

In the contact sessions the students were asked to discuss the misconceptions voiced in the concept cartoon. They had to decide which of the children's comments were valid and which were invalid, giving reasons for their choices. They then had to devise an acceptable mathematically correct statement for the blank bubble. The students then discussed how they would deal with concept cartoons in their classes by using group work and exploratory talk. In sequence 5.7 the transcript indicates that the students focussed more on their mathematical skills rather than their discursive skills.

Sequence 5.7: Using a Concept Cartoon as a trigger

Simon: Eliminate the ones it couldn't be and work out the others. $\frac{7}{11}$ and $\frac{8}{15}$ are bigger than one half and one twenty fifth, so we only have to compare two.

Adelaide: I think it is $\frac{8}{15}$

Ken: Why, why would they say $\frac{8}{15}$?

Adelaide: The denominator is bigger.

Ken: What would your learners do?

Simon: They would try to find a common denominator.

Lindiwe: So they would use a common denominator and use equivalent fractions?

Ken: What is another way you could use?

Lindiwe: Our learners would all make them into percentages. Make them into percentages first.

In this sequence the students focussed more on solving the problem mathematically, than being aware of the use of exploratory talk strategies. Ken challenged Adelaide to give a reason for her statement and instead of drawing attention to her erroneous answer, he turned the attention to other group members, and to other possible methods of finding a solution. Lindiwe expands on Simon's idea, but then introduces a totally different method as an alternative. The transcript illustrates that the students were adhering to the ground rules for dialogue that they had drawn up previously. In a discussion afterwards in all centres I explained that I had deliberately used RSPM items initially to introduce exploratory talk because, if I had introduced a mathematical problem, they would have used their prior knowledge of mathematics and there would perhaps have been no dispute as they could have come to consensus quickly. I emphasized that the rationale for triggers was that the learners experience the difference between disputational, cumulative and exploratory talk and then use their discussion skills with curriculum material, because the aim is to encourage the learners to use exploratory talk with mathematics in their classrooms.

The students were asked to report on the steps they went through in order to reach consensus for their group when using each trigger. Their reflections at the end of the workshops indicated that they were amazed at the depth of understanding that they had achieved through using the ground rules that they had developed for their own exploratory talk, which in turn were based on those of Mercer and Littleton (2007).

The exercises with triggers elicited the following themes: the advantages of group work; the advantages of developing and adhering to ground rules; the power of dialogue in the form of exploratory talk that helped students to solve problems that they were unable to do without the aid of a more-knowledgeable peer (Vygotsky, 1978). An added construct that emerged was the general feeling that group work decreased anxiety.

The last experiential activity that the BEd Honours students performed was an application of what they had experienced. They were asked to introduce exploratory talk into their classrooms and to document the process.

4.4 Action research assignments – introducing exploratory talk in classrooms

The BEd Honours students were tasked to use the insights gained in order to introduce exploratory talk in their mathematical classes. The action research assignments produced by the educators were of a varied standard. In some cases it was obvious that educators believed that any discussion between learners in a group constituted exploratory talk. In other cases, vignettes of authentic exploratory talk were transcribed and the learners' reflections recorded. I have reproduced four vignettes of exploratory talk that occurred in four different areas of the Eastern Cape to illustrate that the learners were able to engage in dialogic learning using exploratory talk after the educators had attended an intervention. The following four exemplar vignettes provided by the students give some insight into the different types of conversations that were generated when groups of learners were required to discuss mathematical problems bounded by the ground rules of exploratory talk.

4.4.1 Vignette 1

In one Grade 7 classroom in a primary school in the Port Elizabeth district the educator introduced the three types of talk in the first lesson by using short rehearsed dramatisations so that the learners could identify and classify which type of talk each actor represented. Key words and phrases, such as ‘because’, ‘agree’, ‘I think’, ‘why’, were used as triggers for developing instances of exploratory talk. The class discussed and agreed upon its own ground rules for exploratory talk. In the second lesson the learners were given problem solving activities to discuss. The educator insisted that they use English only. At the end of the discussions each group had to report back in English on how the members had solved their particular problem. The educator acted as monitor – listening to the groups, aiding language use and encouraging participation.

The following is a transcript of a group of his learners’ conversation when attempting to solve the following word problem:

> There are 21 cycles in a shop. Some are bicycles and some are tricycles. If there are 51 wheels altogether, how many are bicycles and how many are tricycles?

Sequence 5.8: Example of exploratory talk in Port Elizabeth - vignette 1 example 1

Lethu:	Do we all understand?
Sipho:	What?
Lethu:	What did educator say?
Maria:	Let’s find the number of bicycles and tricycles.
Lethu:	But how if we talk?
Maria:	This is easy, you see.
Limpho:	What?
Maria:	24 bicycles and 1 tricycle.
Limpho:	What?

Lethu: Did we talk – or did you just tell us?

Bongo: Yes, Maria is right. I can see 24 bicycles will be having 48 wheels *ne!* Plus three for the tricycle.

Maria: That's all!

Limpho: Okay.

Maria: Do you all see? (Murmurs of assent)

Commentary from the student:

> Of the ten learners only five participated in the exchange, with only Maria and Bongo addressing the question. Maria suggested an answer which was flawed and resulted in an incorrect answer as they were focussing on the number of wheels only and not the restriction that there were 21 cycles in the shop, yet the other learners agreed without engaging in the reasoning themselves. They felt they had found a feasible answer and did not try to find alternative solutions.

When the educator reported that he had asked the learners about their non-participation, one learner replied, "*Siyasibamba isiNgesi!*" ("The English is restricting us!"). At this stage the educator recognised that when the learners were engaging in talk using only English they had difficulty in expressing their ideas and reasoning, and that the few learners in the group who were proficient in English dominated the conversation, which tended to devolve into cumulative talk.

In a subsequent lesson the learners were given different problems and were told that they could discuss their reasoning in isiXhosa if necessary. Each group was given an object to pass around which they pretended was a microphone in order to remind the learners of the ground rules negotiated between educator that each member of the group take turns to speak and that they all listen when one learner speaks. It was also used to control the noise in the classroom. The following is a transcript of the discussion between the same group of learners when debating possible answers for the following problem:

> A family of 5 people need to cross a river. They have a raft which can carry a maximum of 100 kg. To save time they want to make as few trips as possible. Jabu's

mass is 57 kg. Khaba's mass is 85 kg. Linda's mass is 38 kg. Mandla's mass is 60 kg and Nandi's mass is 35 kg.

Sequence 5.9: Example of exploratory talk in Port Elizabeth – vignette 1 example 2

Limpho: I think Linda should go in the boat with Jabu.

Lethu: Why?

Limpho: I think it is because *kaloku imass yabo ngu* 93 kg so less than 100 kg.

Sipho: Why don't *sithathe uKhaba kuba ngoyena unzima?* (Why don't we take Khaba first because he is the heaviest?)

Maria: *Ibuye iboat?* (How will the boat return?)

Sipho: Oh! I see. *Liyabona.*

Bongo: What then?

Sinovuyo: Then Nandi goes with Linda, then Linda comes back again then goes with Jabu, then comes back, then Khaba gets on alone, and Linda comes back and gets Nandi – and then go together.

Ntombizondwa: Perfect! Just the trip!

Mcebisi: So I can report to the rest of the class?

Commentary from the educator:

Although the learners used English for the majority of the exchange, the instruction that they could use their main language appeared to allow the learners to relax physically, as I noticed from their facial expressions and body language. Limpho gave a suggestion in English, but justified it in isiXhosa. More learners in the group were prepared to express views and more were prepared to offer challenges. The trigger words, "why", "I think" and because" were consciously used in this short sequence. When Sipho gave an incorrect suggestion Maria asked a question which prompted him to clarify his thoughts.

In these vignettes the educator indicated that he had a developed sense of how to introduce exploratory talk to his mathematics learners. He formulated his own triggers and used innovative ides (like a mock microphone) to remind the learners about the exploratory talk ground rule of one person talking at a time. The following transcript illustrates that language can hamper the flow of dialogue if the learners do not understand the question.

4.4.2 Vignette 2

In the following excerpt from an assignment the educator was not convinced that the dialogue in sequence 5.10 represented exploratory talk. He commented, “It is evident from my observation that learners lack the necessary skill to constructively part-take in fruitful group discussion. However, with the sufficient guidance and clear instructions, they should and could do much better.” He explained that he had constantly reminded the boys to speak English and conceded that “they had to struggle with language first hence they were frustrated and took so long to solve the problem”.

The problem posed was:

> A recent soccer clinic drew 2600 entrants for the first tryout. Half of the entrants were disqualified as they were not in the age group 13-15 years old. One in five of the remainder made it to the second day of the clinic. How many entrants attended the second day of the clinic?

Sequence 5.10: Example of exploratory talk in Mthatha - vignette 2 example 1

Lulama :	Do we have to count or calculate using the 2600 entrants?
Trevor :	No, we can’t use the 2600 because half of them were disqualified.
Lubabalo :	So which number do we use ?
Sampies :	1300.
Lubabalo	How did you get the 1300?
Lulama :	Divide 2600 by 2.
Trevor:	No, multiply by a half.
Lulama :	But it's the same thing because at the end of the day we'll get the same.
Sampies :	Since when is multiplying and dividing the same?
Lulama:	*Meneer*, can't you help us here?

Commentary from the educator:

> So the discussion went on and on. I would say all three types of talk were displayed during the discourse. Mostly they used disputational talk. Everyone in the group

> wanted his word to be heard in the group without listening to the previous speaker. I had to guide them towards the right direction especially seeing that they were just shooting aimlessly at times. Some of the talk was absolutely irrelevant. After a lengthy discussion one of them came to the right track when he said "If you have 1 in 5, that means out of 10 learners 2 were selected, out of 15 learners 3 were selected and so on and so on". Again they started thinking. So in a way they were collaborating effectively even if they were at each other's throats at times, but still things were under control. Sometimes signs of impatience crept in because they couldn't get to the answer as quickly as they thought they would. Lulama was the main culprit here because he gave answers at times without thinking. Him being the big soccer star at school, he thought he could get to the solution as quick as possible than the others. Sometimes there was guessing involved because one of the group members said, "well if we can't add or subtract, let's try multiplying!" So this was plain guessing.

This sequence resonates with Setati et al.'s (2008) claim that language must become transparent in mathematical dialogue or it will become the focus and thus be a stumbling block rather than a resource.

In the second sequence (sequence 5.11) that the same educator reported, the learners did not engage with the language meaning of the problem at all but used different operations until they arrived at a suitable answer.

Sequence 5.11: Example of exploratory talk in Mthatha – vignette 2 example 2

Trevor:	What's the easiest and short way of getting to the answer here? With this method it's going take us age to come to the solution.
Lulama:	Add or subtract.
Babalo:	No! Subtraction and addition will take us nowhere.
Lulama:	Then what do you suggest.
Trevor:	Multiply what by what?
Babalo:	5 by 1300.
Lulama:	That's ridiculous because this will give us something over 6000. This is even more than the original number.
Trevor:	Then let's divide guys. Let's divide 5 into 1300. What will the answer then be?

Sampies: That will give us 260. And yes it has to be answer because if we multiply 260 learners by 5 we get to the original 1300.

Commentary from the educator:

So that's how they got to the solution. Although they got to the right answer there was still a lot of guessing taking place. Yes, exploratory talk was used in a way but not to my satisfaction as the educator.

The above exchange indicates that the context did not play a part in the learners' reasoning. They knew they had to use the numbers with an undetermined operation in order to get a correct answer, as expediently as possible.

4.4.3 Vignette 3

In the following vignette the educator gave a closed problem related to the curriculum that required answers that were either correct or incorrect. The problem was:

Two dice are rolled simultaneously. Write out all the possible combination numbers on the two dice that will result in the following outcomes.

The two numbers on the dice add up to one.

The two numbers on the dice add up to eight.

The sum of the two numbers on the dice is divisible by three.

Sequence 5.12: Example of exploratory talk in Ngcobo - vignette 3

Sipho: *Masiqale sazi ukuba zingaphi ii-outcomes esiza-kuzifumana xa si-rolla i-dice. Ziza kuba yi-12 kuba yi-2 la madice,enye inamacala ayi 6.*

(Let us first know how many outcomes we can get when we roll the two dice. The are going to be 12 because there are two dice, each having 6 faces.)

Thoko: No, Sipho *ziyi-36 because u 6x6 = 36 u-adishile u 6no6 waba ngu 12 la madice arolla simultaneously, so kufuneka si maltiplaye laa 6 ngo 6.*

(No Sipho it's 36 because 6x6=36, you have added 6+6=12 The two dice are rolled simultaneously so we have moved to multiplying 6 by 6.)

Pumla: *Masiphendule u (a), ezi numbers ziza kubangu 1 no zero, kodwa u-zero asinakufumana kwidice so ndicinga ukuba i-answer ngu-zero.*

(Let us answer (a), the two numbers will be 1 and 0 but no dice has zero, so I think the answer is zero.)

Lunga: *U- (b) ngu 2 no 6 benza u-8, masigqithele ku (c).*

((b)'s answer is 2 plus 6 = 8, so let's pass on to (c)).

Zinzi: *Hayi, asinakugqitha ayingawo odwa amanani enza u-8, akhona namanye like 5 and 3, 2 and 6, xelani amanye nani*.

(No, we can't pass on to (c) because it's not the only numbers which can be added together and give 8, there are others like 5 and 3 — 2 and 6, you must also mention others.)

Others: *Khange siyiqonde, masiqhube besicinga ukuba sigqibile*.

(We are not aware that we have not yet finished, let us go and finish.)

Piliswa: *U- 1 and 7 gives 8. 7 and 1 gives 8.*

Kaya: *Wakha wambona u-7 kwidice? Soze ibekho ke leyo. Kanene nina mantombazana aniwadlali amadice, ina lijonge*.

(Have you ever seen a 7 in any dice? This will never happen. You girls don't play with dice, take this one and have a look at it.)

Thando: *Asivumelani apha mna ndithi ezi numbers zi-multiples of 3 bayaphikisa abanye bafaka 00-7 no 5. Injalo"?*

(We don't agree with each other in this group, I say the numbers are the multiples of 3 but others want 7 and 5. Is it like that?)

Educator: Yes, it's multiplies of 3, show me the sum of two numbers, use 2 and 4.

Linda: *If si-addisha u 2 no 4 we get 6 and u- 6 uyakwazi uku-dividisha ngo 3 kungaphumi remainder*.

(If we add 2 and 4 we get 6 and 6 is divisible by 3 without any remainder.)

Thando: *Besicinga ukuba uthi ii-multiples zika 3 ngu 2 no 4 besilibele ukuba kuthethwa nge sum. Itheth'ukuthi masifunde iquestion siyi understande then siphendule*.

(We thought that he said the multiples of 3 are 2 and 4, we forgot about the sum. It means we need to read the question with understanding before we answer it)

Commentary from educator:

During the dialogue that took place between the learners, some learners tended to divert exploratory talk to disputational talk whereby a lot of disagreements were taking place and without any collective resolution. I had to intervene. Only one learner was talking and others were listening without any argument. In other groups, a little bit of cumulative talk was observed whereby the learners made a positive contribution. They were not critical to what others have contributed. Again, I referred the group to the rules were laid before starting to engage in exploratory talk where the learner must support his/ her argument by reasons.

In the dialogue above the educator was able to distinguish excerpts of exploratory talk from disputational and cumulative talk, although she noted that some learners in the groups participated fully while "there are those who will hide behind others". This resonates with the comments in the reflective writing, that some students are able to hide in groups and not contribute anything.

The last vignette illustrates how two groups can disagree and how the impasse is resolved in a plenary session.

4.4.4 Vignette 4

In this assignment the student describes problem solving in her classroom where two groups came to consensus, but they arrived at different answers. She differentiated between the type of talk exhibited by the participants and allowed them to showcase their reasoning in a plenary in order to highlight their misconceptions.

The problem, as in other assignments, incorporated a closed question:

> Two cinemas are giving special offers on their tickets, which usually cost R20 each. Star Cinema offers – Buy 3 tickets, get two tickets free. Rextro Cinema advertises – Buy five, get three free.

The student transcribed two groups' interactions. The first group rushed through the problem in an effort to find the answer as quickly as possible without actually engaging with the complexities of the two situations.

Sequence 5.13: Example of exploratory talk in Kokstad – vignette 4

Group 1

Dudu: I know the answer. Rextro cinema is offering a better deal.

Samkelo: Why do you say so?

Dudu: Because *uthola* 3 tickets *ngaphezulu on* Rextro *kanti ku Star* you get only 2.
(Because you get 3 tickets more at Rextro whereas at Star you only getting 2)

Nicholas: Yes you are correct Dudu.

Dudu: Can't you see *umntintilizo*? (It is a bargain)

Samkelo: But madam cannot give us 20 minutes to do this exercise if it was this easy.

Dudu: What is your problem because we did get the answer and we all agree is correct?

The second group gave reasons for their suppositions and challenged each other until they reached an acceptable consensus.

Group 2:

Thabo: When you buy from Star you pay R60 and get 2 tickets free but at Rextro you pay R100 for 5 tickets then get 2 free.

Dineo: I go for Rextro cinema because I am going to get more tickets and give it all members of my family because we are 8.

Sbusiso: No, Dineo, you are wrong.

Dineo: But why do you say I am wrong?

Sbusiso: If you go for Star cinema you spend less money but at Rextro you spend more money, compare R60 with R100.

Thabo: But we are comparing 8 tickets with 5 tickets. Let us try to calculate how much each ticket may cost.

Sbusiso: You mean divide R60 by 5 and R100 by 8?

Thabo: Yes, that's what I mean.

Dineo: What did you get?

Sbusiso: $\frac{60}{5}$ =12 and $\frac{100}{8}$ =12.50

Dineo: What does this mean?

Thabo: It means STAR cinema is cheaper than REXTRO cinema.

Dineo: Oh! I was only thinking of taking my family out, I didn't calculate how much I could spend to buy each ticket. It is true that STAR cinema has a better deal.

The student analysed the dialogue that she has transcribed by identifying which type of talk the learners had demonstrated during the sequence.

Commentary from the educator:

In Group 1 Dudu displayed some disputational talk because she is telling the members of the group what the answer was, but did not give any justification to her solution. She is displaying individual decision-making. Nicholas and Dudu also

> showed some cumulative talk when Nicholas confirmed Dudu's answer and again there was no counter challenge or proper justification as to why he agrees with her. Samkelo was just lost in this exercise because the other members Dudu and Nicholas did not give him a chance to explore further. Samkelo was suspicious about the time allocated for this exercise. He somehow doubted the answer because there was no mathematics done to arrive at the answer.
>
> In Group 2 Thabo recited the statement; he tried to make sense of it at first. Dineo displayed some disputational talk when she said "I go for Rextro cinema", she gave the group a supporting statement which was not related to the problem at hand. Sbusiso opposed Dineo's idea and he provided a reason for his opinion. That was somehow exploratory talk although his reasoning was incorrect. Thabo did not agree with Sbusiso, but he tried to involve the group in his way of thinking. He wanted the whole group to be convinced of whatever they agree upon. Sbusiso suggested they calculate the cost of each ticket. This also showed some exploratory talk and Thabo displayed cumulative talk when he agreed with Sbusiso's explanation but there was nothing critical he added on the conversation. Sbusiso then led the group in doing the calculation. After the calculation was done it was clear to Thabo which cinema was offering a better deal but Dineo showed that she was not sure which of the two cinemas was offering a better deal. She could not give meaning to the calculations, she was unable to compare the two answers. Thabo helped her to realize that they are now comparing R12 with R12, 50.

After group work, the educator led the discussion asking for feedback from different groups. The educator did not tell the class which groups were correct or incorrect, but let the class discuss their reasoning in whole class discussion until they reached consensus on the correct answer - the best offer. The educator led the class to the solution by questioning. The educator also emphasized the fact that some groups did not agree on a solution is because the ground rules of exploratory talk were not followed properly.

The students in the vignettes from their action research assignments above, showed, in varying degrees, that they understood the concept of dialogic teaching through introducing ground rules and the tenets of exploratory to their learners, but after the students completed the BEd Honours qualification there was no possibility of tracking the educators' practices in the classrooms to see whether the practice was sustained.

The main theme that emerged from this exercise was that educators were able to demonstrate that, after an intervention, they could introduce exploratory talk with varying degrees of success into their mathematics classes. As part of the action research assignment, educators were asked to reflect on their experience of the research and to elicit views from their learners about how they experienced exploratory talk.

5. EDUCATORS' AND LEARNERS' VIEWS ABOUT THE INTRODUCTION OF EXPLORATORY TALK

In the assignments educators reflected on their own experiences, and reported feedback from the learners, about the introduction of exploratory talk in their classrooms. The learners mentioned the collegiality and security that the group work afforded them:

> It does help because if I make a mistake someone in the group will correct me and show me how I went wrong. It helps to talk to other learners of your group and express your ideas to other learners. At the same time it gives you confidence to talk in front of, learners and in front of the educators;

> It makes us feel more confident if we're in a group.

They also reported that they concentrated and became engaged with the problems that they were tasked to solve. Exploratory talk aided their understanding:

> Exploratory talk helps me to be more focussed on what I am calculating. It makes me look at things in a different way and to read the questions carefully before answering it;

> It helps because you get to understand why things are the way they are. We are given a chance to be wrong and find out why you are wrong, and you are helped in understanding things much better. You are not just left to find for yourself but helped to understand what is going on.

The learners also took cognisance of the ground rules of exploratory talk:

> If one person's talking we can't barge in and talk in front of them.

The educators also voiced their opinions on exploratory talk. They mentioned particularly the use of the learners' main language during group interactions:

> Exploratory talk helped my learners to stimulate them to take part in the discussion by allowing them to use their own language of choice;
>
> They were code-switching whenever they feel like.

The introduction of ground rules together with exploratory talk had an effect on the learners' behaviour as well as critical thinking skills:

> It also improved their inter-personal relations as they paid respect to one another. Their interaction within the group improved the listening, leadership and communication skills of the learners as in the ground rules they were required to listen to each other and respect each other's ideas;
>
> By justifying the counter-argument by using valid reasons, the discussions were interesting and of a high quality. There was a joint thinking which was critically evaluated by all the members of the group. Ideas were challenged but at the end members of the group put suggestions and alternatives;
>
> Thinking skills are also enhanced through the use of exploratory talk.

Some educators were wary of the strategy and voiced misgivings. They were concerned about the fact that at some times learners reverted to disputational and cumulative talk:

> There were times when I had to intervene in a group, some learners turned the talk to either cumulative or disputational;

Once again the concern that some learners did not make any effort to participate in the group work was raised:

> Though one could think that everybody in a group participated fully there are those who will hide behind others;

The perennial arguments associated with group work, about time consuming practices and increased noise, were aired:

> It takes so much time.

> There is noise during exploratory talk.

One educator from East London touched on the difficulties learners had in sticking to the ground rules. She realized that both she and the learners were learning the strategy together as she comments, “When we attempted the second problem…” She identifies with her learners and shows solidarity with them.

Commentary from East London educator:

> It was interesting to watch mixed groups as they did different things. Two groups were dominated by girls. They used cumulative talk in the group. Two groups were using what they considered to be exploratory talk. After the first problem I asked them to reflect on their discussion and they realised that at most times they were not actually using exploratory talk. When we attempted the second problem they guarded themselves and they tried to implement exploratory talk although they were struggling to follow the ground rules. Most learners were able to understand what the others were talking about but when it came to writing they struggled to translate their ideas into mathematical language since they used their mother tongue during their discussion but they battled to translate the mathematical concept of compound and simple interest into mathematical words and symbols.

The educator also mentioned the difficulty learners had when moving from the spoken to the written word and the difficulty in translating from everyday isiXhosa to mathematical terminology.

6. CHAPTER SUMMARY

In this chapter I have described the qualitative results that were gathered during phase one of this study. The first target group was a cohort of ACE:MST students The data were collected in order to identify constructs that emerged from the educators' experiences and reflections. They wrote about their teaching scenarios and creatively wrote poems about their language experiences. The second target group was a cohort of BEd Honours students. They completed a questionnaire on challenges they encountered and strategies they implemented in multilingual mathematics classes. They were also tasked to give their personal language choices for teaching and learning in mathematics classes. The instruments were designed so that the responses of the participants could be sorted into themes and constructs that could address the first objective of this study, to identify Eastern Cape educators' perceptions about language strategies and language usage in multilingual mathematics classes. The development of the themes and constructs will be discussed in chapter seven.

For the second objective of this study, the same cohort of BEd Honours students was targeted for an intervention on dialogic practices. They were assigned four tasks that were designed to give them an experience of participating in groups by using exploratory talk to solve problems. They then had to transform their experiential learning into a practical application by introducing exploratory talk into their mathematics classes and writing an action research assignment on the experience. The instruments for this section of the study were designed specifically to elicit themes that could address the second objective; to research the design and implementation of an intervention for educators to promote the introduction of dialogic practices. The development of the themes for this objective will also be discussed in chapter seven.

In the next chapter I will report the results from phases two and three of this study – the classroom observations in three schools in one year, and the classroom observations in one school in the following year which were designed to identify themes that could address the third objective, to track educators' practice in multilingual mathematics classrooms before, during and after an intervention.

CHAPTER SIX

QUALITATIVE RESULTS - PHASES TWO AND THREE

1. INTRODUCTION

In the previous chapter I reported the qualitative results for phase one where the focus was on a cohort of ACE: MST teachers and a cohort of BEd Honours teachers in the Eastern Cape. In this chapter I report the qualitative findings from phase two, which took place during 2007 in three schools in Port Elizabeth, and phase three which operated in 2008 in one school with a selected grade seven educator. In phase two four classes (two in one of the three schools) were identified as target groups. The intervention included contact sessions aimed at training the teachers how to introduce exploratory talk in the classroom and to help them with their planning of lessons which included exploratory talk. The instruments used to gather data in phases two and three were an observation checklist and videotapes of the lessons observed. The data were used to identify themes which emerged during the interventions and observations.

2. PHASE TWO – THREE SCHOOLS

At the beginning of phase two each teacher was observed in their classroom in order to document examples of the teaching and learning styles that they used prior to the intervention. I met with the three educators of the target classes from the three schools to explain the scope of the research; to introduce them to the theoretical framework that informed this study; to discuss the challenges and difficulties that beset educators in multilingual mathematics classrooms; and to highlight possible solutions that could be implemented. The theory behind the concept of dialogic teaching was elucidated and, in particular, the strategy of exploratory talk using the learners' main language was explained. Together we worked through some of the examples given to the BEd Honours students (described in the previous chapter) so that the educators could experience and recognize the different types of talk. We discussed a possible work scheme to implement in their grade seven classes and arranged a timetable for classroom observation visits.

During this second phase of the study the target group classes were observed using a checklist (see Appendix H) and the lessons were videotaped for later analysis. The aim was to document changes over time in the educators' practices. Regular meetings with the educators, individually and as a group, were arranged in order to support them and to help to plan their teaching strategies. In this chapter the teaching and learning in the target groups of each school has been reported before the intervention began, to establish a baseline, then the teaching practices in the target groups of each school have been reported towards the end of the intervention. I have compared the three target classes by using an observation checklist that was devised as a guide for the observation of the teaching styles.

3. BASELINE OBSERVATIONS

The lessons observed in the schools, South, West and North, before the intervention began were necessary in order to gain a sense of common practice in the classrooms in order to gauge whether there was any change during and after the intervention. As noted earlier, the baseline observations were videotaped before the first intervention meeting with educators so that the teachers were not swayed in any way by the strategies that were explored. I have described the lessons using the following guidelines from the observation checklist (Appendix G), i.e. by topic; introduction; explanation of the task; educator's questioning; group work; whole class discussion; use of language and classroom climate. The descriptions are derived from the observation sheets which are, in a sense, field notes. In the summary for each lesson I have reported whether the educator used question-and-answer sequences to guide the development of understanding; taught procedures for problem solving and sense making; and envisaged learning as "a social, communicative process" and encouraged reasoning (Mercer & Littleton, 2007:40). I have also endeavoured to analyse the educator's purpose for using questions in relation to the stages in the lesson as they appear in the tick boxes of the observation checklist.

3.1 South Primary School baseline observation

Topic

Types of angles

Physical classroom environment

Learners sat two to a table facing the board. This was a kindergarten classroom and the tables and chairs were too small for the learners. The learners were physically unsettled.

Introduction

Mr Mzondo used twenty five minutes of the lesson to introduce different types of angles – right, acute, obtuse, straight, reflex and revolution. He used the board, gesticulated and encouraged chorus repetition of his statements. For example,

> "An angle - how can we define an angle? An angle is formed by two...? It is formed by...? by two...? By two what... ? By two...?"
>
> (The learners chorus) "Lines."
>
> " By 2 lines." (Mr Mzondo writes the definition on the board.)
>
> ".. And they meet at the point which is called a ....? Starts with a V ?"
>
> (The learners' murmured reply is inaudible)
>
> " A vertex. An angle is made by two lines which meet at a point called a what ? ...A vertex."
>
> (Learners chorus) "Vertex".

The purpose of all the questions posed in the introduction was to elicit prior knowledge.

Explanation of the task

After defining each type of angle, in similar vein, Mr Mzondo handed out a worksheet and asked the learners to match the following two sets. He said:

> You have got a, b, c, d, e, f, g, on your left hand side and on your right hand side you have got 1, 2, 3, the names of the angles. And it says match up ‘a’ with the name of an angle in the next column. A quarter turn will be what kind of an angle...? What name do we give to that angle...? That angle which has made a quarter turn...? Reflex, revolution, right or obtuse, straight angle, an acute angle – which one?

The learners were silent and put their heads down and wrote in their books. The purpose of the questioning was again to elicit prior knowledge.

Questioning

Mr Mzondo peppered the learners with close-ended questions, but then answered them himself before the learners had a chance to respond. All questions were aimed at finding out prior knowledge and required one word answers. He did not ask questions to clarify understanding.

Group work

Although the learners sat in pairs, they worked individually. There was no peer-to-peer and little educator-to-learner interaction. The learners murmured one-word answers to the questions posed.

Whole class discussion

No discussion took place during this lesson. The answers the learners gave were one-word answers or chorused readings from the board or a repetition of Mr Mzondo’s utterances.

Use of language

Mr Mzondo used English throughout the lesson, but code-switched towards the end of the lesson when he appeared to become annoyed with the learners' reticence.

Classroom atmosphere

The educator dominated the talk throughout the lesson. His demeanour was loud and brash, and the learners appeared to cower away rather than to participate. He raised his voice when the learners did not respond. The children were passive and demonstrated little engagement with the task. Their physical discomfort was mirrored by apparent emotional discomfort as they squirmed and seemed to attempt to avoid Mr Mzwzke's attention.

Summary

Mr Mzondo did not use any question-and-answer sequences to guide the development of understanding. The majority of his questions were answered by himself. He gave the learners no time to reflect on the questions. All the questions were convergent and were posed to discover what the class knew. Mr Mzondo did not teach for understanding and his instructions were confused and unclear. The exercise on the worksheet was a simple 'matching' task and the teacher did not encourage social interaction to take place.

3.2 West Primary School baseline observation

Topic

Multiplication of fractions

Physical classroom environment

The learners sat in groups of six, but all learners turned towards the board. There were posters on the wall and charts of achievement. This was their home class and they seemed comfortable and familiar with the environment.

Introduction

Ms Zondani started the lesson with two worked example on the board $3\times\frac{2}{3}=?$ and $\frac{2}{3}\times\frac{7}{8}=?$ She asked the learners how they would do each step. They put up their hands and answered individually. She reiterated the steps verbally as she wrote the sums on the board.

Explanation of the task

Similar examples were written on the board and the learners were given an opportunity to complete them in their exercise books. Ms Zondani moved around the class correcting their work. She asked individuals to go to the board to write up their solutions. If an answer was wrong another learner was asked to go to the board to erase the incorrect version and rewrite it.

Questioning

There were no probing questions, the questions were all convergent. One-word, chorused answers were required. The questions elicited learners' prior knowledge but at no time were the learners required to give reasons for their answers.

Group work

The learners worked individually and covered their work with their arms so their neighbours could not see.

Use of language

Mrs Zondani spoke in English when she was working on the board and expected the learners to answer in English; however, when she moved to help the learners individually she spoke to them in isiXhosa. There was no interaction among the learners.

Classroom atmosphere

The learners were prepared to put up their hands and volunteer to write their answers on the board. They were not reticent to put up their hands or when they wrote on the board or gave an incorrect answer. They seemed to be familiar with the modus operandi in the classroom.

Summary

Ms Zondani did use question-and-answer sequences, but they were used to simply to elicit prior knowledge rather than to develop understanding. No reasons for the steps were required or given. The exercises were procedural and required no conceptual insight. There was no problem solving evident. The examples were all calculations with fractions. Ms Zondani endeavoured to elicit learners' responses, but as the questions were convergent there was no social communicative process evident.

3.3 North Primary School baseline observation

Topic

Comparison of fractions

Physical classroom environment

The classroom was overcrowded with three columns of desks running the length of the room with learners on either side of each desk. There was noise from the class next door coming through the large door that separated the classrooms. There were posters on the walls,

Introduction

Mr Hlam started the lesson with a question, "What do we say about things when we compare them?" He posed a question that would lead towards the subject of the lesson. He illustrated the answer with an everyday example by asking how the learners would compare the height of two girls he pointed out, "Zuki is taller than Yolisa". He clarified that the outcome of the lesson was that by the end of the lesson the learners would be able to compare fractions, for example they would be able to compare a half and a quarter. He then asked the learners to describe a fraction and asked for examples. These questions were posed to elicit prior knowledge. He gave each learner a sheet of paper which they folded into four horizontally to represent a ‘fraction ruler’. One folded row represented one whole; the next row was divided into two halves, the next row was divided into four quarters, and the bottom row was folded into eight eighths. He used this manipulative throughout the lesson to physically compare the size of fractions.

Explanation of the task

Mr Hlam introduced the word ‘denominator’ and wrote it on the board. The learners chorused the sound. He challenged the learners to think, “Because eighths are smaller than a half, will halves always be greater than a number of eighths? Why? Will five eighths always be bigger than one half? Why?” His questions were posed to encourage reasoning and logical thinking. The visual manipulation of a sheet of paper into fraction strips gave the learners a physical measure with which to compare sizes. He then moved from the concrete to mathematical manipulation by explaining that one could not always use a physical tool but had to know how to multiply fractions,

“What do you do mathematically to get from $\frac{3}{4}$ to $\frac{6}{8}$?”

His question aimed at discovering if learners understood his train of thought. He emphasised that they should multiply by one, but that the number one could be written in many guises.

Questioning

Although long exchanges did not take place, Mr Hlam asked questions continually to stimulate their thinking and he encouraged participation pausing to allow a learner to react, if only by giving a one-word answer. “What do other people think?” and “Do you agree with that or don’t you agree with that?” and “What do you think about what she has just said?” He used questions to maintain interest and alertness and to discover if the learners understood what he was teaching. The learners did interact with the educator as they had to continually field questions that required them to think, not just to reiterate the teacher's utterances.

Group work

At one stage he asked a question and instructed "all those who have their hands up should tell those who don't have their hands up what you have done." The learners spoke to each other in isiXhosa and leaned physically towards each other, pointing to their work. There were no other instances of organized group work, but the learners chatted to each other informally as they worked.

Use of language

Mr Hlam used English to teach from the floor; however, he spoke individually to the learners in their main language. The learners answered his questions in English, but spoke to each other in isiXhosa. Mr Hlam introduced mathematics terminology by using everyday examples before using the same terminology with fractions. When he introduced new vocabulary he wrote it on the board and asked the learners to read it aloud. He thus combined aural and visual recognition.

Classroom climate

The learners were relaxed and attentive. They smiled and laughed. Mr Hlam interacted easily with the learners. There was a relaxed, friendly atmosphere.

Summary

In this baseline lesson Mr Hlam did use questions to guide the development of understanding. Many of the questions were convergent, but he encouraged the learners to think about each others' contribution. In this way he engendered a sense of collegiality. He used a familiar context (height of girls) to lead into the lesson topic and used paper folding so that the learners could make sense of the physical size of the fractions. There was interaction between the learners although it was only for a short period.

4. POST-INTERVENTION OBSERVATIONS

Although the schools were visited regularly during the intervention, I shall only present the analysis of one lesson from each school that I felt best typified the differences that occurred in the pre- and post- intervention lessons in each school. All three educators used the same concept cartoon as a trigger for exploratory talk in the classes that were observed. The object of these descriptions below is to document differences (if any) that manifested themselves after the intervention.

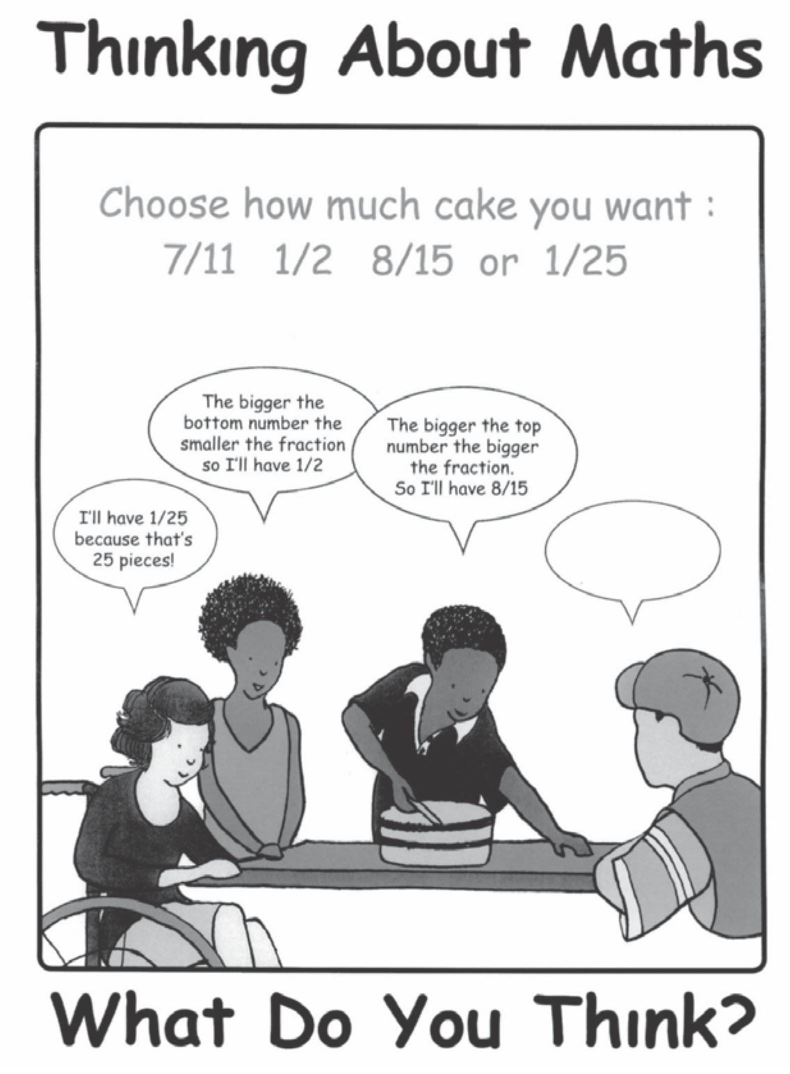


Figure 6.1 Concept cartoon used in lessons (Dabell, Mitchell, & Barnes, 2007)

4.1 South Primary School observation lesson after intervention

Topic

Concept Cartoon **–** comparisons of fractions

Physical classroom environment

The lesson took place in the same classroom as the baseline lesson which was furnished with small tables and chairs. As they came into the class the learners were told to sit in threes. The educator had to hunt for chalk and a blackboard duster before he could write on the board.

Introduction

Before the learners had settled down, the educator when began talking. He referred to the ground rules of exploratory talk by saying "What is important *ke* (isiXhosa expression equivalent to 'then') is for us to talk, each and everyone in the group must get an opportunity to talk". He then handed out a copy of the concept cartoon to each group and told the learners: "I want us to look at that picture *ne.* Think about maths. We are promoting talking in the maths class". The educator explains, "They are trying to share this cake" and follows this with instructions to, "decide *wena, nina"* ('you' singular, and 'you' plural) which portion do you want to have and give a reason why". The educator gave the learners three minutes to discuss the cartoon in their groups.

During the educator's introduction of the activity to the learners there was no attempt to establish the learners' understanding of the instructions for the task. Mr Mzondo did not reflect on the maths knowledge and strategies that might be required to make an informed choice. He did not model the language that the learners could use in their discussions and feedback, nor suggest procedures that learners might use in their discussions. In fact the educator gave no guidance to the learners at all. Learners were expected to participate in an activity which was new to them in an unfamiliar, unstructured environment without any routines to fall back on. The educator dominated the ‘talk’ and the learners were asked to contribute only in one-word, chorused answers, mainly, “Yes, Teacher.”

Questioning

In this lesson Mr Mzondo again answered his own questions without giving the learners time to reflect and think. Although he asks “Why?” in many instances, he makes no attempt to elicit any answers from the learners.

Group work

The learners spoke isiXhosa in their groups, but the talk in the groups was inaudible so it was not possible to establish what kind of talk learners were using. Mr Mzondo made no effort to engage with the groups in order to give guidance and encourage thinking. After approximately three minutes the educator continued with the lesson. The short time the learners had to engage may well have contributed to their lack of participation in whole class discussion.

Whole class discussion

The educator interrupted the group discussions to read the words in the speech bubbles printed on the concept cartoon and paraphrased what was written. He then called on learners to report to the class. The learners’ contributions were inaudible but the educator restated them as they responded:

> This child will choose this one, $\frac{1}{25}$? Why? Because you will have many pieces if you choose one twenty fifth. And this child will choose a half? Because each one will get two pieces of cake?

It is at this point that the educator realized that some of the learners were not working on the problem posed by the concept cartoon but were attempting to share the cake equally among the four children depicted in the cartoon. He clarified what they should have been doing, "What portion wena (you) would want, it is not that you are sharing this cake. … so you want *iportion enkhulu*" (a big portion). Learners were not given time to discuss this new development in their groups but were called on to continue telling the class which fraction they had chosen. In most cases the educator repeated learners' answers without questioning their reasoning. When he did ask a question he did not wait for the answer before he moved on, for example, "You say they choose a half because it is bigger than the others. That is what they are saying? OK next group."

He accepted some wild guesses, for example: "8/15 makes one cake"; "8/15 because they will have a spare cake" and, "They choose 7/11 because it is the only number that is left." The method he used to arrive at the correct mathematical answer was to score the number of groups that chose the same answer. The scoring was written up on the board.

> Let us pause, let us look at the scores on the board. Three groups have chosen 1/25 stating their reason. Some are saying they would choose a half because one half is the biggest fraction.

It is only after scoring each group's choice that he began to explore how much cake each fraction represented. Only a few groups chose $\frac{8}{15}$ and $\frac{7}{11}$ so he did not deal with those fractions at all. He talked learners through the logic of which of the fractions $\frac{1}{2}$ or $\frac{1}{25}$ would be the larger fraction and concluded that, "Out of those two which one was right? The second one was right because if you choose a half you will get a bigger portion of this cake". He had not given a sufficient mathematical reason for his answer and the use of 'second one' confused the learners. He was not explicit.

Use of language

Despite attending workshops, there was no indication of the development of any kind of peer dialogue or exploratory talk over the duration of the study. The educator spoke exclusively in English and expected the learners, when they made utterances, to do so in English too. The educator dominated the talk throughout the lesson with learners reluctant to participate and share thoughts. This reluctance on the part of the learners at times angered the educator. The educator spoke English almost exclusively occasionally slipping into isiXhosa for 'emphasis' rather than 'explanation'. The issue of what language the learners could use was not discussed but, as mentioned above, they used isiXhosa in their groups but attempted to answer the educator in English. The learners were for the most part passive and demonstrated few signs of engaging with the task.

Classroom atmosphere

The learners displayed no enthusiasm for or enjoyment of the activity. In many instances the educator made fundamental mathematical errors in his calculations. The classroom atmosphere was stilted and over the course of the observations there was no observed change in the classroom atmosphere. Both the physical environment of the classroom and limitations of the educator impacted negatively on the lessons.

Summary

Mr Mzondo asked questions, but still perpetuated the practice of answering his own questions without giving the learners time to reflect. He mainly prompted group chorus answers; this gave the learners who were unsure of the answer the opportunity to 'hide' behind their peers' answers. He, thus, was judged to have not developed techniques towards guiding the learners' understanding. He used the concept cartoon as a trigger, but appeared to have not prepared the lesson beforehand and was himself confused by the problem – and he gave the learners the wrong answer. He did not understand the task set out in the concept cartoon. This may have been due to a number of factors. Either he did not study the concept cartoon before presenting the lesson; his competency in English was insufficient to enable him to interpret what the cartoon required; or he could not make the relevant connections among the different portions of the cartoon - the question, the responses printed in the thought bubbles and the question on the sheet, ‘What do you think?’ There was no attempt to make sense of the problem, he asked them to vote for the correct answer rather than to reason out the problem and the misconceptions expressed in the concept cartoon. As he himself demonstrated no problem solving procedures, he was unable to guide the learners towards sense making in problem solving. The learners only had three minutes for social interaction throughout the lesson, so there was very little opportunity for social communication that encouraged reasoning.

The impression gained was that the educator had little insight into the process which he had been asked to introduce and had not made the connection between the concept and how it linked to the mathematics knowledge of the learners, or how it might enhance their ability to think and solve problems in mathematics.

General impression of progress throughout intervention - South

There appeared to have been no development in the teaching practice of Mr Mzondo despite attending the intervention sessions. Based on the lesson descriptions one could make the assumption that the educator had insufficient mathematics knowledge to deal with mathematical problem solving. He was not in a position to encourage learners to make their thoughts, reasons and knowledge explicit and share them with the class as he himself was on shaky ground. It is clear, then, why he could not use question-and-answer sequences to guide the learners thinking. If the educator himself was unsure of the procedures for solving problems then he would neither be able to model the language required nor explain the reasoning involved. The one-to-one interview between the educator and the researcher arranged at the end of the study was not attended by the educator concerned and he remains elusive. His avoidance techniques are perhaps an indication of his lack of commitment to the programme. I felt that the Mr Mzondo had ‘gone through the motions’ when I visited the classroom but little had changed in the interim. Under these circumstances an intervention such as the introduction of exploratory talk had little chance of making an impact on learners' achievement in mathematics at his school.

4.2 West Primary School observation lesson after intervention

Topic

Concept Cartoon – comparison of fractions.

Physical classroom environment

Learners were working in their own classroom seated in groups of six. This appeared to be the normal classroom arrangement of furniture so the learners were familiar with the environment and with sitting in groups.

Introduction

The groups had copies of the concept cartoon on their tables. Ms Zondani referred to the cartoon and explained the task in English only. She read the statements aloud in the speech bubbles but did not read the question, 'Choose how much cake you want : $\frac{7}{11}$; $\frac{1}{2}$; $\frac{8}{15}$ or $\frac{1}{25}$.' The link between this question and the statements in the speech bubbles was not clarified. The educator focussed on the statements in the thought bubbles:

> She says she wants one piece out of 25 pieces *ne* ? The second one wants the half, what about these three ne? Is it right or wrong? What about this one *ne*? So I want you to discuss as a group *ne*? Give the solution to this problem because this is a problem *ne*? (The educator points to the empty speech bubble)

During the educator's introduction of the activity to the learners there was no attempt to establish the learners' understanding of the instructions for the task. There was also no reflection on the maths knowledge and strategies or procedures that might be required to make an informed choice. Ms Zondani did not model the type of language which the learners could use in their discussions, nor give them guidance regarding the language to be used for group discussion or feedback.

Questioning

Ms Zondani exhorted the learners to solve the problem, but the rationale behind the problem is faulty. Instead of comparing the sizes of the pieces of cake each child would receive, and choosing the biggest portion, Ms Zondani simplified the task to a moral – the learners decided to share the cake equally so each person received one quarter. The questions become irrelevant time-fillers rather than triggers. Ms Zondani's questions were aimed at eliciting procedural knowledge. She did not assess conceptual understanding.

Group work

The educator allocated fifteen minutes to group talk. Each group was instructed to elect a recorder to write down their responses, and a speaker to verbally report back in a plenary. It was at this point that it became clear that the educator had not understood the purpose of the task: "Don't forget if you say, 'No this guy is unfair,' give a reason for that *ne*?" In her interaction with the groups produced further confusion. She asked: "Is it right, the bigger the top the bigger the fraction, eight over fifteen, that means eight pieces out of fifteen, is it right to have eight pieces? No. Why?" This lead to a learner telling her group that: "It is not right because all of them must get an equal piece." The terms 'right' and 'wrong' are applied in the moral sense and not in the sense of mathematically 'correct' or 'incorrect'. Turning the problem into a moral issue simplified the problem and provided the learners with a very obvious fair solution - four learners means four equal pieces of cake. This error negated the mathematical problem of finding which fraction would ensure that one child would receive the largest piece of the cake, thus she avoided the use of mathematical knowledge to explore a range of mathematical procedures.

Whole class discussion

Ms Zondani insisted that the learners write their answer on a piece of paper in English. This restricted discussion, thus limiting the opportunities for learners to make longer contributions in which they might have expressed their understanding of the problem,

An example of learner feedback is,

> Girl number one*:* She wants one piece of cake, she is not right because they must share.
>
> Girl number two: It is unfair because she must not take a half of cake because there are many people. Girl number 3: She is not right because she must not take eight pieces of cake. Girl number 4: You must have equal pieces of cake.

Ms Zondani brought the lesson to a close by declaring:

> Girl number two, she wants half of the cake. She can't have half of the cake. What about the others *ne*? They must share equal pieces *ne*? A quarter, a quarter. So it is fine.

Her own misconceptions of the task hampered her ability to guide her learners in sense making. She encouraged talk, but required a written answer in English so the majority of the group discussion was spent in crafting a short English sentence rather than discussing the problem.

Use of language

Some groups spoke in English and others in isiXhosa, but code-switching predominated. Because learners were asked to write in English there was pressure to translate into English in order to report back in that language. In one group a girl, who speaks very good English, dominated and persuaded the group that the cake should be divided in four.

Classroom atmosphere

The atmosphere in the classroom appeared congenial for discussion. Learners participated in the group discussion quite freely.

Summary

Ms Zondani's questions were aimed at eliciting procedural knowledge rather than developing understanding. She did not assess conceptual understanding. Her own misconceptions with the task hampered her ability to guide her learners in sense making. She encouraged talk, but required a written answer in English so the majority of the group discussion was spent in crafting a short English sentence rather than discussing the problem.

General impression of progress throughout intervention - West

Although Ms Zondani was totally committed to the research and planned her lessons according to the schedules we drew up together, she was not able to develop spontaneous dialogue in her classroom. She was intent on the correct answer rather than the reasoning on the way to achieving the correct answer. She insisted that the learners wrote out their answers in English for each problem that she set them. This took up a great deal of the groups' time and the result was that the answers and reasons from each group were stereotyped, similar and constrained by the English that the learners knew. She reminded the learners continually about the ground rules of exploratory talk and had the learners write them on posters and dotted them around the walls. There was a marked increase in learner interaction between the beginning and the end of the intervention. At the interview at the end of the intervention, Ms Zondani once more expressed her commitment to the process of introducing exploratory talk in her classes and has since attended a series of workshops on language and mathematics at NMMU.

4.3 North Primary School observation lesson after intervention

Topic

Concept cartoon – comparison of fractions.

Physical classroom environment

Learners were seated in columns down the length of the classroom, facing each other; four were allocated to a group. The arrangement was not ideal but it was clear that learners were familiar with working in groups and in pairs based on this arrangement. This was their home classroom and they are familiar with the environment.

Introduction

The learners had a copy the concept cartoon in front of them. The educator made the problem inherent in the cartoon accessible to the learners by contextualising it, thus empowering the learners to feel comfortable in agreeing or disagreeing with the statements:

> These ideas are ideas from other children. Maybe the same age as you are. These are ideas from children in England. So they are just as you are. OK? You might find that you thought this one was right, or this one was right, so your ideas could be the same as those of children everywhere else, which is very good. Now let's get a few reports from some groups. For me, remember, it doesn't matter if you are wrong. What does matter is that you are able to say what you think, and you tell us why you think that. OK?

He effectively minimised the authority of the text and opened it up for interrogation by the learners. He made it clear that the learners' ideas might be good, but they would be probed and supporting reasons would need to be provided. It was clear from his instructions that the educator had understood the requirements of the cartoon:

> We want you to be selfish! Just choose the one you want and give us the reason. I want you to choose your idea and talk to us. You must understand what is being said.

The educator introduced learners to a possible strategy for deciding which fraction of the cake they would choose. He suggested that they should write each fraction as a decimal and then as a percentage. It would appear that the learners had done some work previously on fractions as Mr Hlam asked them to reflect on what they had done the day before, "Go back to the common fractions. What did you say before, what do you think now? Compare"

Questioning

Mr Hlam continually used a question-and-answer process to guide learners' thinking, "What does this mean to you?"; "OK, don't just agree. What is she saying?"; "So why is what she is saying true?"; "How much do you understand about fractions?" His questions were open-ended. He dissuaded them from using cumulative talk by merely agreeing with what had been said, but rather to challenge the ideas put forward. "So what do you think? Why do you think this?"; "So what do you think we should do?"; "It is not about being wrong but about asking them what they mean by their ideas."

The educator was modelling exploratory talk in the whole class context in order to encourage the learners to use the same type of talk in the group discussions. His questions at times were directed at individual learners and he made eye contact and leaned towards them. He maintained their interest by walking around the class and by targeting different groups with questions. He used open, divergent questions to encourage the learners reasoning and logical thinking.

Group work

Mr Hlam's approach was learner-centred as he used group work effectively. He paid attention to learners' contributions and engaged learners in the process of knowledge construction and making meaning. His learners were encouraged to be independent and were able to read and follow instructions, with him mediating only when the learners requested assistance. This strategy seemed to be part of his teaching pattern as it occurred continuously. Learners were expected to read instructions from a worksheet and be able to follow them without a great deal of input from the educator. He moved from group to group checking understanding and clarifying where necessary. He engaged with the learners in their groups and listened intently to their questions and suggestions and gave them feedback by means of further questioning or by reinforcing their ideas with positive comments.

The learners converted common fractions to decimals and then multiplied by a hundred to convert the fractions to percentages. They worked in groups and their body language mirrored their involvement. They reached over the desks to point at each other's books and looked into the interlocutor's eyes while she or he was talking.

Whole class discussion

The lesson took the form of a dialogue between the educator and the learners. He asked for a response to a question and followed it with another question. He modelled exploratory talk throughout the lesson by emphasising that, "It doesn't matter if you are wrong. What matters is that you are able to say what you think".

A learner commented on the statement in one of the bubbles and the educator encouraged exploration of the suggestion by saying, "It is their opinion. What do other people think? Do you agree with that or don't you agree with that? What do you think about what she has just said?" As the learners shared their ideas about the cartoon statements the educator continued to draw them out and encouraged them to find reasons for their answers: "What have they actually done to the fraction?"; "Do we want to do this?"; "So what do you think of that?"; " I can see the idea. Why?"

Even when the learners expressed incorrect logic Mr Hlam was encouraging and gently led the class to the right answer, "Do you agree with them - how they are solving the problem? No? So what do you think we should do?"; "Let us get another answer. It is not about being wrong but about asking what they mean by their ideas"; "Now listen to what they are going to say, and we are going to ask them questions about what they said." The learners were attentive and interested and readily shared their ideas.

Use of language

Mr Hlam used English to give instructions to the whole class and the groups and to provide explanations, but the learners seemed to feel free to use isiXhosa in their groups.

Classroom climate

Mr Hlam encouraged the learners by responding positively to their suggestions with comments such as: “We are doing very well. I think that was a bright idea.” He used ‘we’ and ‘us’ to express solidarity and to build their confidence. The learners were allowed to move around the class and often one learner would spontaneously move to another group to find out how they were solving the problem. This freedom of movement epitomised the relaxed but focussed atmosphere in the class.

Summary

Mr Hlam used questions to answer questions. He did not give definitive, answers but led the learners to think about their reasoning and to develop their understanding. He used the concept cartoon correctly to make the learners challenge their own misconceptions and solve the problem by giving reasons for each of their statements. He encouraged social interaction and believed that communication encourages reasoning.

General impression of progress throughout intervention - North

Mr Hlam created a classroom climate conducive to the practice of exploratory talk, as the learners were encouraged to make explicit their thoughts, reasons and knowledge and to share them. He was at ease with the learners who responded enthusiastically to his teaching style. He not only scaffolded the terminology and the language that could be useful to the learners, but also scaffolded their critical thinking through his questioning techniques. Mr Hlam had a good grasp of the demands of the curriculum and the content knowledge and language strategies that facilitate learning. His lessons were not in isolation but formed part of a planned continuum aimed at teaching a concept and ensuring understanding through practice. The activities he developed drew on previous maths knowledge and language acquired enabling them to engage in directed, meaningful exploratory talk.

Mr Hlam treated learning as a social, communicative process as he used group work continually and encouraged learners to talk to each other and give reasons for their views and express their ideas confidently. As mentioned, the lessons took the form of a dialogue between teacher-and-learners and learner-and-learner. He was sufficiently confident of his own knowledge and experience to guide learners using the strategies that would create opportunities for learners to engage in exploratory talk.

5. COMPARISON OF THE OBSERVATIONS IN THE THREE SCHOOLS

Mr Hlam used questioning skilfully to tease out his learners' thinking along critical lines. He seldom answered a question that was asked of him, but turned the question back onto the learners until they came to their own conclusion. In contrast Ms Zondani and Mr Mzondo were far more content-driven and asked closed questions requiring simple answers. They did not expect reasons or reasoning, but focussed on right or wrong answers, often dismissing the learner who had given an incorrect answer.

Mr Hlam scaffolded the vocabulary, the critical thinking and the mathematical procedures of his learners. He taught procedures for problem solving. He used contextual examples so that the learners could make sense of the problems. Ms Zondani and Mr Mzondo were more procedural and emphasized methods of manipulating fractions and correct terminology for angles without encouraging the learners to verbalise their thought processes.

In the North observations it was clear that dialogue was taking place in a social, communicative manner, whereas there was only educator-talk at South. At West Ms Zondani did encourage her learners to speak, but in a far more formalized way. It was evident from the transcriptions of the observations that Mr Hlam was able to develop a fundamental sense of exploratory talk in his learners, which they practiced in their groups in their main language. However Ms Zondani was less successful despite her zeal and enthusiasm for the intervention in her class. Her learners' dialogue was stilted and constrained by first being written in

English before it was verbalized. The learners had difficulty in expressing their reasoning through exploratory talk. Mr Mzondo was disinterested in the reasoning and mathematical development of his learners. His learners showed no development of talk beyond one-word answers and chorused repetition of his utterances. The observations in phase two suggest that it is possible to track educators' practices in multilingual mathematics classrooms before, during and after an intervention with the result that some educators embrace new strategies and are able to implement them more successfully than others can.

6. PHASE THREE – ONE SCHOOL 2008

The fact that instances of dialogic teaching were observed in phase two suggested that the intervention was able to effect change in teacher practice, but it was also clearly apparent that this change varied considerably between individuals. As such, the logical next step was to look closer at the teaching strategies of a teacher who was able to introduce exploratory talk most effectively in the mathematics classroom.

Because I had built up a rapport with the North school principal, the staff members, and Mr Hlam, in particular, it seemed that it would be a natural progression to repeat the intervention with another cohort of grade seven learners in 2008 in Mr Hlam's classes. This was done to test whether the results could be replicated with another sample of learners and to interrogate the phenomenon further. As such the 2008 research was a repeat of the study in 2007, except that there was no need to implement the initial training on the issues of teaching mathematics in multilingual classrooms and the theoretical background to introducing exploratory talk in the classrooms. Instead more time was spent on planning lessons that incorporated dialogue. Four lessons which best reflect Mr Hlam's successes are described below and further extracts describing exploratory talk that took place in his lessons are provided.

6.1 Initial lesson – introduction of group work

Although Mr Hlam was well versed in dialogic practices the grade seven learners were not, so the first observation lesson was an introduction for them.

Topic

Introduction to group talk in mathematics

Physical classroom environment

All the lessons in 2008 took place in their home room, i.e. the same classroom in which the observations took place in 2007. Although it was crowded and the noise from the next door class still filtered through the large door, the learners managed to make groups of either four or two by physically leaning in towards each other and forming their own private spaces with their bodies and arms.

Introduction

Mr Hlam asked the learners when and where they could use mathematics other than at school. He said, "This is not just about numbers. Do you use mathematics out of school?"

The learners chorused "Yes, Teacher."

In the introduction he used questioning to establish human contact, to assist in introducing a topic, and to pose problems that will lead to the subject of the lesson. He had asked a convergent question which requires either a 'yes' or 'no' answer, so he asked a further question "Tell me about situations when you use mathematics?" His learners have to think about their own contexts and situations in order to answer. These kinds of questions are called divergent, or open-ended, as they have many possible responses and enable learners to think for themselves. A learner suggested that one uses mathematics when catching a bus:

> The bus? Yes. You have to pay money on the bus. Yes, when you are going to work too. So mathematics is not just for the classroom. What we are going to do here is we are going to work in groups. What we expect of you is to discuss the problem. Talk,

> talk, talk as much as you can. OK? How do you work together to solve the problem that you have?

In this way Mr Hlam attempted to move the mathematics from the domain of a difficult school subject to an ordinary, everyday experience, which can be made accessible to everyone. The learners opened their textbooks to an exercise and Mr Hlam coached the learners through the steps required for solving maths problems. All the steps involved language and thinking skills and created a climate in which learners were enabled to engage in exploratory talk.

> What I want you to do is to read the problem first, discuss what it is about. OK? And think of ways that you can use to solve the problem. OK? And then solve the problem together in a group. Then the second problem, you are going to first discuss the problem. OK? Understand the problem and then solve the problem alone. I will be coming around the groups to listen to you. OK? If you need to talk in isiXhosa, talk in isiXhosa, all you need to do is to understand the problem first.

Mr Hlam repeatedly modelled the language and processes that learners should engage in during problem solving. He set out the steps to be taken in order to solve problems by using phrases such as:

> "We are going to work in groups";
>
> "… discuss the problem …";
>
> "… work together to solve the problem".

The use of 'we' and 'us' suggests a sense of togetherness and solidarity. As he exhibited this trait in the previous year, it is obvious that it is a strategy he uses unconsciously. He never uses control, but does not employ authoritarian techniques. He scaffolded the strategy, language skills, mathematical knowledge and critical thinking skills that he required the learners to utilise. He made it clear that, "What I want you to do is:

"…..read the problem first."	This is a language skill that is emphasised;
"….discuss what it is about."	Again a language skill is required;
".....understand the problem."	Mathematical knowledge and critical thinking are necessary;
"... think of ways that you can solve the problem."	Critical thinking is targeted;
"... solve the problem together in a group."	A shared approach is recommended;
"....if you need to, talk in isiXhosa."	Language support is offered.

Questioning

Mr Hlam encouraged the learners to give reasons for all their statements. He did not belabour the point that it is one of the ground rules for exploratory talk. Learners, in this instance, were asked to find word problems relating to calculations based on everyday experiences.

> "Now you have to give us a reason why you have written that kind of number sentence on the board. Why you have used numbers like that, that sort of number sentence?"
>
> "What I want now is a different way of doing that same problem";
>
> "Now, let us compare what they have done. What is the difference?"
>
> "Which one is quicker and why is it easier?"

Mr Hlam created the opportunity for learners to think aloud and form reasoned conclusions. They were taught how to analyse problems and to make up problems of their own.

Group work

In their groups the learners read the sum as a chorus. They therefore read the mathematical terms and English words in written form as well as heard them aurally. At the same time they practiced the pronunciation of mathematical vocabulary. A buzz of group talk in isiXhosa broke out as the learners engaged with the problem. In some groups the talk appeared to be disputational as short answers were exchanged without reasons. Mr Hlam moved between the groups. At one stage Mr Hlam could be heard to exclaim, “Big dispute!” and both educator and learners shared a laugh. This typified the relaxed, friendly atmosphere in the classroom. Mr Hlam identified himself with the learners and not as an authoritarian figure as he said, “I will be coming around the groups to listen to you,” not to ‘judge’ in any way. Mr Hlam encouraged them to create their own questions, “Do not forget the last question is 'make up your own problem.' Then we can share them among us.” He brought mathematics into the realm of the learners’ own experience and links the exercise with the contextualization of mathematics in the introduction. In asking the learners to make up their own problems they were drawing on their experience; background knowledge; mathematics knowledge; thinking skills; language skills; English; isiXhosa and mathematical language.

Whole class discussion

He reminded them of the lesson that they had the day before so that the group discussions would be purposeful. Mr Hlam said:

> Yesterday we tried to work out the rules that we need to follow when we are working in our groups. OK, OK, I see some of you breaking those rules so, please, every time you work think about those rules.

Not only did he ask questions, but he encouraged the learners to formulate their own questions: He noted that “You ask them questions about their methods and so on. They must give us reasons.” The questions are intended to lead the children to make observations and draw inferences for themselves;

Use of language

Mr Hlam used English in whole class discussion and group discussion. He occasionally explained in isiXhosa to an individual if he sensed there is misunderstanding.

The learners spoke to the educator in English, but spoke isiXhosa to their peers during group work.

Classroom atmosphere

At no stage did Mr Hlam act in an authoritarian or overbearing manner. He laughed with the learners without ever losing their respect and regard. They showed this in the way they spoke to him and paid attention to what he said. Their attention, participation and body language (as seen in the videos) attested to the fact that they enjoyed his classes.

6.2 Lesson 2 – find a fraction of an amount

Topic

Finding a fraction of an amount

Introduction

Mr Hlam taught mathematics and language in all lessons, carefully creating situations that built on one another both in the demands on mathematical knowledge and language skills. He started with a concrete, hands-on activity by giving the learners eighteen stones in each group. He asked them to find one half of the stones. They piled them into two groups of nine. He asked them to describe what they had done mathematically. Once he had elicited the answer he wrote on the board $\frac{1}{2}\times\frac{18}{1}=\ldots$ and moved on to a lesson about multiplying fractions.

The skills needed to complete the exercise he gave them require the following competencies: reading mathematics word sums; understanding the problem statement; discussing/interrogating the problems using exploratory talk in both isiXhosa and English; recording the mathematics calculations they have used as written text; critically investigating the possibility of there being different ways of reaching an answer. He did not merely coach the mathematical procedures, but he says, "We want you to discover how to do it on your own. How do you get to find a faction of that amount?"

He uses their previous experience of success with easier fraction examples to move to more complicated examples e.g. $\frac{1}{6}\times\frac{18}{1}$ = … then $\frac{5}{6}\times\frac{18}{1}$ = …

Each presentation and explanation moved smoothly into a textbook activity, much like the activities that would be set in tests and examinations. In this way the learners could take the language and thinking skills that they had gained by doing the exercises in groups, into the individual activity of completing maths tasks in a formal environment, like an examination.

Questioning

Mr Hlam moved from the concrete and visual aid of manipulatives to more formal mathematics: "When you had to find a $\frac{1}{2}$ of your pile of 18 stones, how did you get 9 ? I want you to get to the mathematics."

He seldom answers a question directly, but redirects the learners' thinking by answering their question with a question of his own: "So what do you think?". His questions are geared towards encouraging reasoning and logical thinking.

Group work

The learners used isiXhosa in their groups. They were encouraged to record the mathematics as written text using mathematics symbols and to repeat it on the board during whole class discussion: "Write it in your books while you are working in groups, and then we will have someone report back on the board."

Whole class discussion

The learners were asked to write their calculations on the board and to use mathematical language (in English) to explain to the class what they were doing. They were challenged to find more than one way of reaching an answer: "Can you find another way of doing the sum and finding the same answer?"

Use of language

Throughout the lesson Mr Hlam modelled the language he was expecting the learners to use: "We change the 'of' to 'multiply'." He repeated what a learner had said and re-voiced their statements:

Mr Hlam:	Divide into groups? A very important word. Those groups should be … ? Yes, *buthi*?
Learner:	Equal.
Mr Hlam:	All those groups should be equal.

Finally they read word sums from a textbook which required much the same problem solving strategies as the stones activity but without the concrete, hands-on part of the activity.

Mr Hlam pointed to more than one way of working out the sums by putting the onus on the learners to discover alternative solutions:

> "Is there another way of working it out?"
>
> "Do you see the difference between... ?"
>
> "Can you do it in the quickest and easiest way?"

Classroom atmosphere

The learners were keen to answer questions; they did not seem afraid of making errors; and they did not wait passively for the educator to give the answer. Their behaviour displayed active participation and engagement with the activities presented by the educator. It was quite clear, from the way they smiled and leant towards each other and engaged with the problems, that they enjoyed the activities. When some groups were quick to complete an activity, Mr Hlam praised them, by clapping his hands and saying, "Well done, well done!"

The learners were visibly pleased with themselves and smiled and used positive gestures and body language, as could be seen in the video clips.

6.3 Lesson 3 – Identifying geometric shapes from their properties

Topic:

Identifying geometric shapes from their properties

Introduction:

Mr Hlam gave the learners cut-out quadrilaterals on cardboard and a sheet of different quadrilaterals drawn in different orientations. He gave them manipulatives that could be translated and rotated, and visuals with which to compare properties of quadrilaterals.

> What I want you to do class is to look at the page with the shapes that have been labeled. Study those shapes. I am sure that you can recognise some of them. You know most of them. Talk about them with your partner and then identify the shapes on the other page, on the blank page. Link them to those other shapes and then write down what you have decided. If you decide that this one, for example, is an octagon write the name down on the unlabelled octagon.

Explanation of the task

Once the learners had identified properties of quadrilaterals Mr Hlam gave the learners dotted paper on which to draw their own figures. They had handled the shapes and matched them to drawn shapes. He then asked them to draw their own quadrilaterals using the dotted paper as a guideline.

> I am going to give you one shape at a time that you are going to discuss. Then draw on that dotted page. Look at the opposite sides. What do the sides say to you? If I have a rhombus here, a big one, and I have a small rhombus here, and I have another rhombus here, look at the three of them. See what is common amongst them.

He thus used different strategies to entrench the notions in the learners' understanding. He also gave them an opportunity to compare quadrilaterals with different sizes.

Questioning

Mr Hlam modelled the discursive methods he wanted them to use: “Now, how do you discuss this shape? You look at all the ideas that I gave you. Look at opposite angles - what can you say about those opposite angles, about the sizes of those opposite angles?” He guided the progression of their thinking,

> Take one idea and then talk about that idea. If you are looking at the opposite sides look at the opposite sides of all your parallelograms. Is it the same in all parallelograms? The opposite sides, do they have the same relationship?

He required the learners to form reasoned conclusions about the shapes and their geometrical properties.

Group work

The learners code-switched while discussing the properties of the shapes in their groups. A pair of boys discussed the drawings and shapes.

Boy 1: *i-Square. i-Square ine* two opposite sides *ne yabona*.
(He demonstrates with his hands the width and breadth of two straight sides)
Nale (indicating the top one with his hands);
nale ezantsi – (indicating the bottom one with his hands)
Two pairs *ja* two pairs.

Boy 2: O*kanye, ibe i-parallelogram, zilele,*
(He demonstrates with his body indicating the sideways slant of the sides)
silele nje.

Boy 1: So *yona ihamba* straight

Boy 2: I*hlala.* Straight
(He indicates the top and bottom using his hands)
(Boy 1 labels the drawing)

Boy 2: Zi-adjacent
(He and indicates with his hands and arms, bringing his hands together in front and moving them away from his body).

Boy 1: *Madoda ithi lena i*-octogon *inee* sides *ezi* eight. *Ena* eight sides.
(The other two boys agree, nodding their heads as they write)

Boy 2: *Ndithi le -itriangle – i-triangle* mos i-always *ne ina* three sides. Three sides. *I-tri* - *itri – le-tri* - *ithathatba tree* holds up three fingers. and then *ke ngoku le* angle *i-angle. I-triangle*. Three points *besithi tri.* (Because it gives you three points.)

Boy 1: *Madoda.* Wow, wow, wow!

Boy 2: *i- isosceles* triangle. Two are sides are equal. One side is not equal.

The boys' gestures were as eloquent as their words. Mr Hlam sensed this and had given them manipulatives which encouraged them to move. The movement and gestures gave the learners the means to express their thoughts, even if they did not yet have the mathematical vocabulary to do so verbally in either language.

Use of language

Mr Hlam scaffolded the language and vocabulary he wanted them to use in their groups and when they reported back in a plenary:

> I am going to give you some vocabulary which you must use. (He holds up words written large on paper)
>
> Because I can hear you say *'la macala athe nca'*. I would like you to use now the correct vocabulary. So I will be distributing the vocabulary in your groups. But continue with the discussion.

Again he gave each group their own lists so they could take ownership of their new knowledge. They had something tangible to work with that held their attention.

Classroom atmosphere

The learners were very engaged in the task. They held the shapes and turned them around and over. They pointed to sides and angles and physically put their heads together. This lesson was an example of how the use of manipulatives could aid learners' understanding of concepts. By giving each group their own tools they engaged more closely with each other and with the mathematical context.

6.4 Lesson 4 - Identifying geometric shapes on a map

Topic

Identifying geometric shapes on a map

Introduction

Mr Hlam gave each group a map of the area around the school. He had named the streets after the educators at the school. A sense of fun and camaraderie was engendered as the learners chuckled when they recognised the names. The context was part of their world. On the map he had also written the vocabulary that the learners required for the lesson, so they not only heard the words, but they could also see them and recognise them. He explained:

> We have a map here. Now, on the map I have named the streets after your educators, so you have January Street, Tambo Street and so on. What I have also done is written here the words that you have used in geometry. I want you to use these words in relation to this map.

Explanation of the task

Mr Hlam scaffolded the language and the type of answers he required:

> If I have 'is opposite' I want you to be able to find streets which are opposite each other. I want you to be able to say, ‘This street is opposite to a certain other street’. So these are all your geometry words that you have met over the past weeks. So you will write them - two of you working in pairs - write down as many as you can.

His instructions were clear. He set short tasks and then asked for a report back from the groups. This way the learners’ concentration was not allowed to lag. They understood exactly what was required of them. In this exercise the educator required the learners to identify and recognize rather than problem solve. He encouraged social participation, as he had always done in previous lessons.

Questioning

Mr Hlam prompted learners to give reasons for their statements:

"Why is it not a square?"

The learners by now knew the type of reasoning that was expected of them:

"Because a square has four equal sides and with that 'square' only the opposite sides are equal."

He prompted, "So what is this orange figure then?"
"It is a rectangle".

He re-voiced for emphasis, to ground the concept in the learners' minds, "It's a rectangle! Can you show us where a square is? Can you find a square there?' He used questioning to lead the learners to make observations and draw inferences for themselves. He was also testing the extent of the learners' understanding and assimilation of the lesson taught.

> What do we know about a trapezium? ... What is special about a trapezium? One pair of opposite sides is parallel? Good. ... Can you find another trapezium there? Go and point it out. ... Where are the parallel sides?

Mr Hlam used questioning to clarify whether the learners understood the task. By using questions at the close of the lesson, he revised the main points of the lesson.

Group work

Learners identified streets that are opposite, perpendicular, parallel and adjacent to one another. They wrote sentences - Doga street is opposite to January Street - as instructed. This lesson consisted mainly of group work. From this activity they moved into a geometry exercise from the text book.

Use of language

Mr Hlam often re-voiced the learners' sentences; modelling the correct language and correct grammar, but without drawing attention to the mistake. The repetition also reinforced the concept.

Learner: January Street and Shini street, they are parallel.

Mr Hlam: January Street is parallel to Shini Street.

Classroom atmosphere

Learners were engaged and involved in the learning process. They were used to interacting in groups and communicate in code-switching or in isiXhosa. They knew that they are expected to give reasons for their statements.

7. TWO EXPLORATORY TALK EXTRACTS FROM OTHER LESSONS

The following two transcripts are examples of exploratory talk that took place during other lessons that were observed in Mr Hlam's classroom during the intervention. Exploratory talk was manifested in many ways above and beyond the key words suggested by Mercer and Littleton (2007). The learners did not always use the format "I think... because...", but they challenged each other's ideas and gave reasons for all their statements.

7.1 Transcript 1:

A farm consists of 2 200 hectares. 5/11 of it cannot be ploughed. How many hectares of land can the farmer plough?

Girl 2: I think that we should ask how many hectares. How many hectares can the farmer not plough? I think it is 200 because 11 divides into 2200 and the answer is 200. So we need to subtract that 200 from the 2 200.

Girl 1: What about that 5?

Girl 2: Alright 5 x 200 is ...

Girl 1: 1000

Girl 2: Yes. And now we need to subtract that 1000 from the 2 200. What do you think?

Girl 1: I think so too. Because the 5/11 of 2200 is 1000 so we must find how many hectares of land the farmer can plough. So we are going to work that out by using 2 200 minus 1000, which is 1 200 hectares.

7.2 Transcript 2:

There was a clear progression in this transcript from cumulative and disputational talk at the beginning of the intervention, towards the use of exploratory talk. This transcript was made towards the end of the intervention.

Gugu and Lethu: (chorus reading)

> Sophia was very excited when she saw that a dress she wanted was on sale. The price of the dress was R180, but it was marked down to 1/3 of its original price. How much did she save?

Gugu: The question is how much did she spend - and then we find R60.00. I think R60.00 is the money she spent.

Lethu: I decide otherwise because it is marked down. That R180.00 is marked down 1/3 so it was R180.00 but it is down R60.00. Now how much did she save - R60.00? I get it!

Gugu: She paid R60 for the dress so how much did she save? We are going to subtract that R60 from that R180.00.

Lethu: I disagree because this thing is saying this dress was R180 and then they marked it down one part of that R180.

Lyn: Now look at the language there. Look at the language. It was marked down TO 1/3 of its original price.

Lethu: Then it is R60. Now how much did she save?

Lyn: Now I can see where you are coming from. Gugu, you are saying the new price is 1/3 *of* the old price and Lethu, you are saying they took 1/3 off the old price. Now read it again and see if you can decide?

Gugu: It means they marked down the 1/3 of R180. Because if you divide R180 into three pieces, one of those pieces, it is R60. So they took one of those three pieces, so that is R60, off.

Lethu: I disagree with you. The money she bought that dress with is R60. One of the three pieces is R60, and she took that R60 to buy that dress so how much money did she save? That says that we must subtract the R60 from the R180 so we can find the change that she got from the shop. It is R120.

Gugu: I still disagree, because to me I think they marked down the R60 I don't think that she paid R60 for the dress. She paid R120.

Lyn: Read the question again and see what you decide, It was now marked down *to* 1/3 of its original price, marked down *to* 1/3 not marked down *by* 1/3.

Lethu: Yes, I agree with you.

Gugu: Ok. Ok. I understand now.

Lyn: You see how the language makes a difference. Just that one little word ‘to’ if you changed it to ‘by’ you would be right, Gugu.

Lethu: Yes that is right, so the money she saved it is R120.00.

Gugu: Yes I agree now.

The exchange was in English, mainly because the researcher was standing next to the girls, but the difficulties the girls encountered with the meaning of the question is apparent. They have to make meaning of the language in context before they can make meaning of the mathematical content. Exploratory talk interrogates the problem for meaning as much as it explores possible ways of arriving at a solution to the problem.

The dialogue among learners reveals that understanding the language of a word problem impacts on the ability of the learners to access their maths knowledge and experience in reaching a solution. The issue in the first sum is the misreading of the preposition. Learners and later the educator have replaced ‘to’ in the text with the phrase that they are most familiar with hearing or seeing ‘reduced by’. The context of the question could change the question entirely and could lead to confusion. It takes close reading of the text to get the correct meaning. This example illustrates how assumptions are made based on familiarity with a particular phrasing in the context of sales talk. The question is misunderstood and time is wasted on carrying out incorrect maths calculations which have, in fact, little to do with assessing the learners’ mathematical knowledge or competence but is a question of language being a barrier to learning and successfully completing maths tasks.

8. REFLECTIVE DISCUSSION WITH MR HLAM

At the end of the intervention, the researcher and the research assistant had an informal and relaxed reflective discussion with Mr Hlam. We wanted to know if he felt that there had been any difference in the classroom climate of the target classes that he had taught. The 7A and D classes, that he had taught, had been identified as target classes and the 7B and C classes had been control classes He admitted that he had been nervous of subjecting the target classes to the intervention as they were difficult classes, both academically and behaviourally:

> In the beginning the 7D class behaved badly and the A class was a problem. The 7C class had a lot of bright children and the 7B class had some bright children but in the 7D and 7A classes you could find just one or two.

The difference between two classes, the control class 7C and the target class 7D, was ascribed to the active participation in the 7D class:

> The difference with the 7D class is that they are very talkative after the intervention. They participate actively in the class; there is life in the classroom. With the 7C class there are many gifted children but they don't participate they just keep quiet. They have not learned exploratory talk!

During the intervention there was a marked improvement in the behaviour and learning patterns of the 7D class:

> There was a great improvement in the 7D class in terms of their enthusiasm for work, their attitude towards speaking in the class, for presenting a job well done. They are able to work on their own - something which at the beginning of the year was quite difficult for them to do.

The introduction of exploratory talk had given the learners confidence to speak in English and this had resulted in improved English skills:

> What I really noticed with d is that actually they are quite able to express themselves in English now, much better than at the beginning of the year. By switching from

> isiXhosa to English and using code-switching, they have got more confidence now in speaking English.

Mr Hlam felt that the introduction of exploratory talk had increased the enthusiasm in the classes. There willingness to engage in dialogue meant that he had a clearer idea of what they understood:

> You can see they are enthusiastic. They want to know. They think. And as soon as they talk you know what they know and what they don't know. When they keep quiet you don't know whether they understand or not.

Mr Hlam was extremely positive about his experience during the intervention:

> Just becoming aware of this process of using language, specifically language, to get them into a deeper understanding of what they are doing. This procedure is something that you just need be aware of and use as a strategy continuously. I did see it working. It is just the realization that this concept can work - you know, just realising that this concept can work!

Having observed Mr Hlam's teaching strategies during previous sessions, it can probably be said that dialogic teaching is an integral part of his teaching toolkit. The reactions of the learners showed that the strategies were familiar to them and that dialogic learning had taken place.

9. OVERVIEW OF MR HLAM'S PRACTICE

Mr Hlam integrated the tenets of exploratory talk from the beginning of the intervention. It became the norm in his class: learners became used to working in groups, respecting each others' opinions, explaining their understanding in isiXhosa or through code-switching, giving reasons for all their statements and reaching consensus if possible. The learners became familiar with the practice and began to apply the principles unconsciously.

There were other secondary themes that emerged from observing Mr Hlam's teaching practice during the two interventions. He demonstrated a sound knowledge of the mathematics content of the curriculum as well as a sound knowledge of pedagogical content knowledge. In a very real sense he facilitated learner-centred learning. These attributes gave him confidence in his own ability to teach mathematics. He was at all times authoritative, but not authoritarian.

In addition he demonstrated sound knowledge of teaching strategies for multilingual classes. He encouraged the learners to speak in their main language in groups; he re-voiced their ideas in English and scaffolded the learners reasoning. He taught language skills when he gave the learners the vocabulary necessary for the mathematics they were doing, both orally and in writing on the board or on handouts. He also reinforced sentence structure and terminology in an unobtrusive way. He was, thus, giving them the tools to communicate in mathematical English, not just speaking mathematics to them in English. Mr Hlam used questioning skills to teach the learners to think critically. He more often than not answered a question with a question. When observing his classes using the observation checklist, the majority of the stated purposes of questioning were ticked for each lesson. He, thus, used questioning to guide the learners' understanding of mathematics.

He contextualised the problems to relate to the learners' everyday lives and realities and then he moved from the concrete to mathematically abstract curriculum problems. This made the mathematical problems relevant to the learners. At times he walked the learners through the procedures for solving the problems set. At other times he gave them worksheets and expected them to proceed independently by using exploratory talk in their groups. He, thus, taught procedures for problem solving and sense making.

Perhaps the most appealing aspect of visiting Mr Hlam's classes was the warm, welcoming buzz that pervaded the classroom atmosphere. Learners were eager to make contributions in their groups; they were quick to put up their hands to volunteer to report back on the board; they asked questions of Mr Hlam, and each other; they communicated in a social communicative manner. The constructs designed into the observation checklist were, thus, attained in each of Mr Hlam's multilingual mathematics classes.

10. CHAPTER SUMMARY

In this chapter I have recorded the results of the qualitative sections of phases two and three of the study. I attempted to track educators' practice in the classroom before and after the implementation of an intervention. I looked at the practices of the three target group teachers in phase two and identified certain elements from the observation checklist that could be used as measures of comparison among the teachers: the way the teachers introduced the lesson; the explanation of the task; the means of using questioning; group work; the use of different languages in the class and the classroom atmosphere. I have described a baseline lesson conducted by each teacher during 2007 and a lesson using the same concept cartoon as a trigger after the intervention.

During 2008 four lessons Mr Hlam conducted were described using the same constructs. Detailed transcriptions of talk in the classroom were reported as well as excerpts of exploratory talk from other lessons. A reflective discussion with Mr Hlam at the end of the intervention showed that he was convinced of the efficacy of dialogic teaching in his mathematics classes. I have attempted to tease out themes from Mr Hlam's teaching strategies in phase three which could inform an intervention aimed at foregrounding 'best practices' in multilingual mathematics classrooms. In the next chapter the results of this study will be discussed.

CHAPTER SEVEN

DISCUSSION OF RESULTS

1. INTRODUCTION

In the previous chapter I reported on the qualitative results of phases two and three, i.e. the findings when tracking teachers' practice in multilingual mathematics classrooms before, during and after the intervention. In this chapter an overview of the qualitative and quantitative results is presented and each objective of the study is discussed in relation to the conceptual plan of the study shown in figure 7.1. Lerman's (2001) suggestions for interrogating qualitative data are used and the findings are considered in the light of the literature review presented in chapter two.

2. OBJECTIVES REVISITED

At the commencement of this study the problem that I identified was the apparently low, or in some cases non-existent, level of dialogue between teacher-and-learner, and learner-and-learner, in many Eastern Cape multilingual mathematics classrooms. Because sociocultural research indicates that learning is a social practice and social practices are discursively constituted (Lerman, 2001; Wegerif, Mercer & Dawes, 1999; Sfard, 2008; Vygotsky, 1978) it follows that if social practices such as collaborative learning (Barron, 2000; Cooke, 1998; Johnson et al., 1993) and dialogic teaching and learning (Alexander, 2004; Barwell & Kaiser, 2005) are practised in mathematics classes, then competence in, and understanding of, mathematical concepts could be the result. However, in multilingual mathematics classrooms there is an added dimension of language use, as illustrated in figure 7.1 which summarises the main constructs that were identified from this study.

I have taken each of the four objectives in turn and discussed the results that emerged. The four objectives of this study are reiterated for easy reference:

1. To identify Eastern Cape educators' perceptions about language strategies and language usage in multilingual mathematics classes;
2. To research the design and implementation of an intervention for educators to promote the introduction of dialogic practices;
3. To track educators' practice in multilingual mathematics classrooms before, during and after an intervention;
4. To ascertain whether introduction of dialogic practices, particularly exploratory talk, increase reasoning, numeracy and English skills in grade seven multilingual mathematics classrooms?

In the following sections I shall take each objective in turn and discuss the results of the implementation of the instruments that were designed to address each objective.

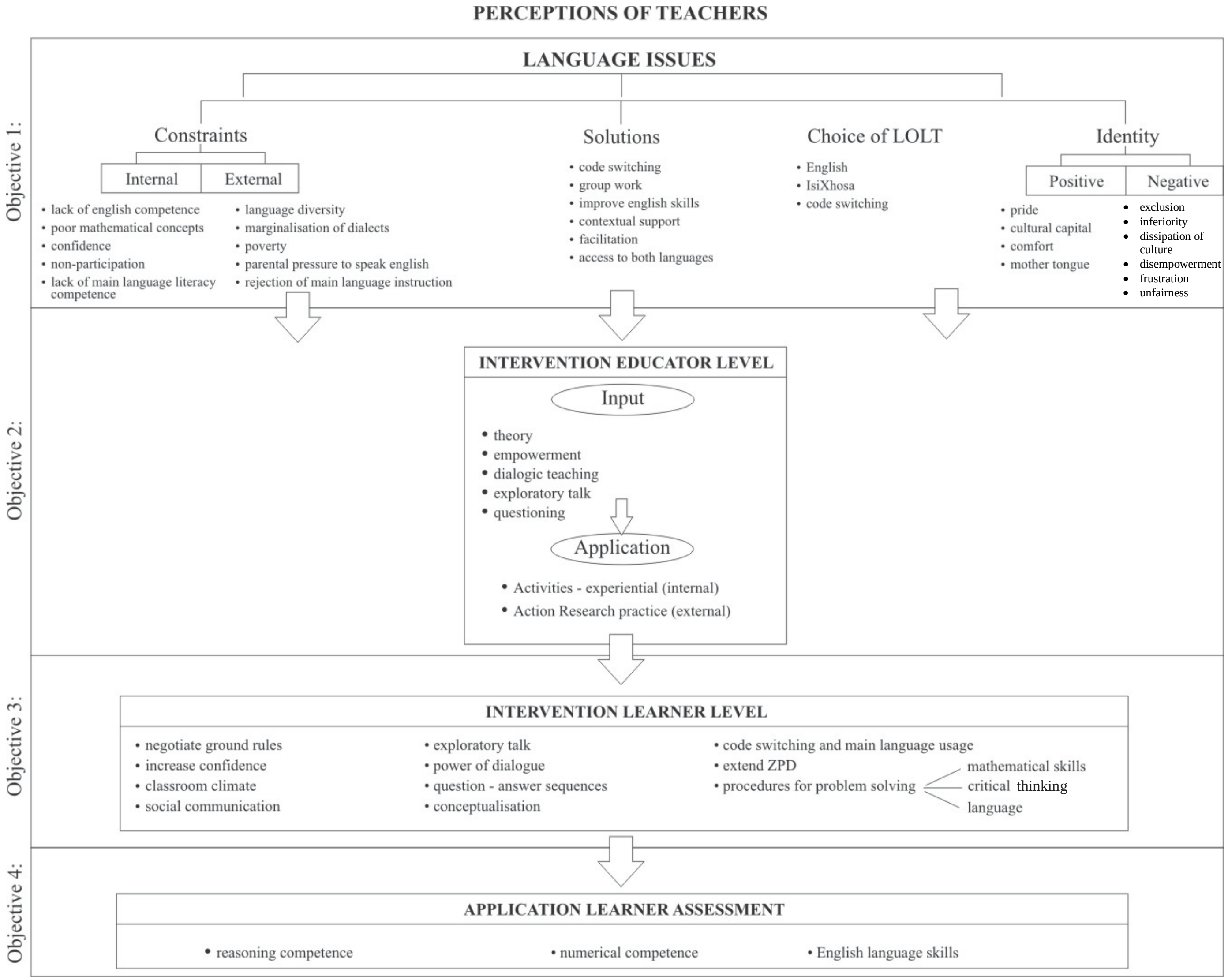


Figure 7.1 Researcher's overview of study

2.1 Objective 1: To identify educator's perceptions about language strategies and language usage

The initial construct that overarched the study was educators' perceptions about teaching mathematics in multilingual mathematics classes. I felt that it was necessary to uncover educators' worldviews about constraints, solutions, choice of LoLT and their own identities before an intervention could be designed to make an impact on teaching and learning in multilingual mathematics classrooms. It was my perception that the issue of language dominated their opinions.

To interrogate objective one, four investigations were undertaken: educators were asked to describe, in a questionnaire, the challenges/strategies/solutions that they experienced in their multilingual mathematics classrooms. They were also asked in a questionnaire to state their personal language choices in their classes. This gave an overview of what was happening in the Eastern Cape before the intervention. The remaining two assignments were a reflective writing exercise and the writing of poetry, which enabled the teachers to move from the left brain, rational view of education and mathematics, to use right brain creativity to explain their worlds at a deeply personal level through their own language. The poetry, particularly, gave them the confidence to explore their experiences at an intimate level, recognizing their identity and acknowledging the value of their language.

2.1.1 Educator's perceptions of challenges/strategies/solutions

The challenges that the educators experienced in the Eastern Cape can be divided into internal challenges (lack of English competence; poor mathematical concepts; confidence; non-participation in class; lack of main language literacy competence) and external challenges (language diversity; marginalisation of dialects; poverty; parental pressure to speak English; rejection of main language instruction).

Gee (1994) and Rogoff's (1990) note that cultural models, including language usage, exclude multilingual learners from participating in academic discourse. The most prevalent challenge mentioned by the educators in the questionnaire was learners' poor competence in English, something that has also been highlighted by Adler (2001), Vorster (2008), and Webb & Webb (2008b). It would be simplistic, though, as noted earlier, to blame poor mathematics results, in terms of national and international mathematics assessment, on lack of English competence only, and to view the situation as a deficit model (Adler, 2001; Lerman, 2001; Setati & Barwell, 2008). Gee (1994), Adler (2001), and more recently Lerman and Zevenbergen (2004), have all emphasized the complex nature of discourse in mathematics classes. Poor English competence was mentioned by nearly eighty percent of the teachers. Learners' difficulties in understanding mathematical content were mentioned by approximately a third of the teachers, who also intimated that poor English ability was a challenge (Vorster, 2008; Webb & Webb, 2008a). Setati's (2005a) claim that the power of English, and the access it affords to social goods superseded the importance of mathematics as an entrée to future success is thus supported, as educators in the Eastern Cape felt that English language skills were a priority over mathematical skills.

Learners' lack of participation in discussions in class was identified by the teachers as a challenge, which suggests that they do try to be facilitators in class and to use learner-centred teaching methods in accordance with both the Department of Education's outcomes-based policies and recent research findings (Department of Education, 2003; Mercer & Sams, 2006). This challenge could be linked to learners' lack of English competence and to learners' lack of confidence as indicated in research conducted by Alidou, et al. (2006) and Setati and Barwell (2008). Educators in the Eastern Cape seem to be aware that the construction of mathematical knowledge cannot take place if there is little reasoning and argumentation between learner-and-learner and educator-and-learner (Alexander, 2004; Webb & Treagust, 2006).

The poetry and the experiential exercises confirmed the perception that the lack of main language literacy competence was an obstacle to effective teaching and learning. Heugh (2008), Alidou (2006) and Alexander (as quoted in Westcott, 2004) maintain that in order to develop competence in a second language it is imperative to have a sound literacy competence in the learners' main language. The teachers in this study feel that their language has been marginalised and devalued to such an extent that their learners are not interested in learning to read or write in their main language. The educators therefore choose to assess in English as they feel the learners would not understand assessments in their main language. Perceptions of marginalisation were expressed by both isiXhosa and Afrikaans-speaking educators, particularly in the poetry, where they eloquently mourned the lack of pride their children have for their mother tongue.

The parents have expectations for their children, and they perceive that these expectations can be achieved only through competence in English (Adler, 2001; Setati, 2005a), so they insist on English as the LoLT. The findings of this study support Setati's (2005a) contention that English is seen as a gateway to opportunity, and that the inability of learners to read and write competently in their main language is a contributing factor towards the dominance of English in many schools. Because of the language diversity of the Eastern Cape it is often not possible to teach in 'standard' isiXhosa only as many learners speak a different dialect of isiXhosa or even a different African language.

The most popular solution used to overcome the challenges, that the educators mentioned in the questionnaires, was code-switching between the main language and English (Moschkovich, 1999; Vorster, 2008). As the majority of students mentioned the strategy of code-switching it does not appear that they feel the guilt formerly associated with the use of code-switching as reported by Setati (1998, 2002), but have embraced it as part of their toolkit for teaching mathematics (Vorster, 2008). The findings of the study suggest that teachers now view code-switching as a positive resource and are prepared to acknowledge that they use the strategy in class.

The emphasis on group work and collaborative learning in the participating teachers' classes suggests that they are aware of the concept (Cooke, 1998), something that is promoted in the South African curriculum (Department of Education, 2003). However in this study there was evidence that some learners sat in groups, but did not communicate with each other. As Alexander (2004) and Dawes & Sams (2004) noted, if learners sit together it does not mean they make meaning together. The learners kept their focus on the educator and did not seem to be engaged in a coordinated, continuing attempt to solve a problem or, in some other way, construct common knowledge (Mercer & Littleton, 2007). Nevertheless, in Mr Hlam's classes there was continual evidence of group work and collaboration, where the learners took responsibility for their own learning (Barnes & Todd, 1977). The strategies Mr Hlam used in his class included contextual support and facilitation, which were other solutions mentioned by educators (see figure 7.1). This indicates that after specific training learners are able to participate in groups effectively and educators can facilitate and give effective contextual support. The participating teachers expressed a need for training in strategies that could help them teach mathematics effectively in multilingual classes.

At this stage it should be noted that the study appears to have achieved the objective of eliciting educators' perceptions about constraints to learning mathematics and solutions they implement in their classes; however the results are a snapshot of their opinions across the Eastern Cape at a particular moment in time. A similar survey would have to be implemented to ascertain whether the perceptions are stable over time and space.

2.1.2 Educators' personal language choice

Language is an educator's most flexible, creative, meaning-making pedagogic tool and learning involves special ways of using language (Mercer & Littleton, 2007; Moschkovich, 1999). However effective use of this tool presupposes that both educator and learner share a similar fluency in the LoLT used. This does not always happen in multilingual mathematics classes where both educators and learners face the dual task of making sense of ordinary English (OE) as well as mathematical English (ME) (Monaghan, 1999; Setati, 2005a). The data generated by the questionnaire, used in the study and designed to obtain a snapshot of language usage, revealed that the teachers chose to teach mathematics predominantly in English (87%) but for clarity they changed to isiXhosa used code-switching between the languages, as noted by Vorster (2008) and Webb and Webb (2008a). An added slant to the questionnaire was to put the educators in the learners' shoes and to consider what the learners' choice would be. In answering this question the teachers were ambivalent as more than half chose English (54%) and approximately half chose isiXhosa. Despite Heugh (2008) and Alexander's (as quoted in Westcott, 2004) plea for mother tongue education, the educators themselves believe that by speaking to the learners in English they will learn how to communicate in English. This study suggests that by using dialogic practices in the learners' main language for part of the lesson, and with the educator revoicing the mathematical concepts in English, a balance between the goal of both English competence and mathematical reasoning could be achieved (Alexander, 2004; Moschkovich, 1999, 2007).

2.1.3 Reflective writing

Because some of the ACE: MST students were in remote parts of Eastern Cape, written assignments were used to generate data about their perceptions. The open-ended tasks in the assignment were designed to delve deeper than a questionnaire into their challenges and solutions experienced in multilingual schools. The constructs could not be identified beforehand owing to the inductive nature of the qualitative research, so the reflective writing was analysed for themes that were repeatedly mentioned in the submissions. The most prominent themes that emerged were linked to responses the educators gave in their questionnaire. The students felt that learners' lack of confidence, and thus non-participation, was linked to the learners' lack of competence in communicating in English (Webb & Webb, 2008a) which resulted in feelings of inferiority and exclusion from the dominant discourse (Webb, 2002). Because of the hegemony of English parents pressurised teachers to teach in English and rejected main language teaching or code-switching, as noted by Alexander (as quoted in Westcott, 2004). Again the teachers mentioned the learners' lack of literacy in their main language, which they attributed to the learners' perception that their home language was not useful to them for social and entrepreneurial mobility, again similar findings to those of Alexander (in Westcott, 2004). Exacerbating factors mentioned were the extreme poverty and lack of resources in many parts of the Eastern Cape coupled with the language diversity represented by different dialects that were marginalised because they did not reflect standardised isiXhosa (Nomlomo, 1999). As the constructs that emerged from the reflective writing echo the constructs that emerged from the questionnaire, the data elicited from the different instruments appear to be valid.

2.1.4 Poetry

The final assignment designed to gather data to shed light on objective one revealed the most about the inner lives and conflicting tensions in the students. Benton & Fox (1990) note that the writing of poetry has a profound effect on the poets themselves. By sharing their stories the students were able to create a common ground among their tutors and themselves where there was a sense of safety and trust. They could risk being honest. The exercise helped them to engage in a dialogue in which they used their own language experience to write poetry which gave voice to their deepest feelings about the role of language in the power relationships in which they found themselves in the wider society and in the learning and teaching situation. The poems written revealed to both themselves and the research the deeply suppressed suffering which the marginalisation and disempowering of their mother-tongue has had on their identities. With this came the realisation of how they were colluding in the distancing of learners from their own identities and from the learning process through their insistence on English and denial of the academic value of isiXhosa.

The poetry elicited both positive and negative themes. The positive themes included owning their own identities; expressing pride in their heritage; acknowledging their cultural capital; feeling secure and comforted by the familiarity of their language. On the one hand the negative themes included a sense of exclusion and inferiority. Once again the students mentioned the dissipation of the value of both Afrikaans and isiXhosa. Their culture was being eroded by English to the extent that their children were incapable of communicating without interspersing English words in the conversation. In the poetry commentaries in chapter five the poet implies: "He is unsuccessful in passing pride in his Afrikaans language on to his children" and Kazeka paraphrases, "He is basically saying in the first stanza, 'Why have we let this language go?' Then, he says '... it is difficult for ... traditional speaking people to even finish a sentence without including English', and then he says in the third line, 'the children can't even read their own language, never mind to write it'."

The themes gathered from this exercise echo da Ponte's (2009) view that it is imperative that teachers balance knowledge, practice and identity. If they do not have a strong sense of their values, norms and ways of being, the balance is tipped and the common ground for optimum teaching will be lessened. The poetry powerfully exposed the political nature of language (Heugh, 1997; Gee, 1994; Webb, 2002) and the asymmetric, hegemonic power of English (Fairclough, 2001; Setati, 2005a). Once again the students mentioned the dissipation of the value of both Afrikaans and isiXhosa to the extent that the learners do not want to be literate in their mother tongue (see commentaries in chapter 5). Overall the poetry conveyed the perception that competence in English exerts a sense of power, control and authority that impacts negatively on the students' identities. Albertyn, et al. (2005) maintain that to be empowered the locus of control must move from the 'powerful other' to within the empowered persons. It is a future challenge to design interventions that could enable this to occur.

2.1.5 Objective one overview

Lerman (2001) warns that people choose to reveal only what they want to reveal, so there is always a danger of collecting skewed data. It was for this reason that data was collected using four different instruments. Of the four investigations conducted to address objective one, the poetry in particular gave the students a voice and enabled them to reflect on their own lived experiences. In comparison to questionnaires which require immediate feedback and can represent the emotion of the moment; reflective writing and the poetry need a measure of soul-seeking. The descriptive words used by the students indicated that they were endeavouring to express their emotions clearly and accurately. In the poems the expressions of pride and dignity with which they described their main languages (mainly isiXhosa or Afrikaans), and their sense of loss that the language was devalued and marginalised, appear authentic. Across all four exercises (see figure 7.1) the pervading theme was that English competence is sought and desired by educators, learners and parents. However it was further acknowledged that learners do not read and write competently in their main language. As research has shown (Heugh, 2008; Westcott, 2004) that competence in the learners' mother tongue enhances developing competence in a second or third language, this could have far reaching implications for education and for the cultural heritage of the Xhosa nation of the Eastern Cape.

2.2 Objective 2: To research the design and implementation of an intervention for educators to promote dialogic practices

Objective one sought to elicit educators' perceptions as well as to make them sensitive to their own identities and to define their ways of being. Objective two sought to fill da Ponte's (2009) circles of educator knowledge and educator practice. The knowledge taught as part of the intervention included Vygotsky's (1978) theory of the ZPD, Vygotsky's view that language makes authentic dialogue possible, and Mercer and Littleton's (2007) extension of the ZPD into an IDZ. The theory of dialogic teaching and learning (Alexander, 2004; Kutnick, 2005) as opposed to the prevalent Initiation-Response-Evaluation (I-R-E) practice (Sinclair & Coulthard, 1975), the theory of different types of talk (Barnes & Todd, 1977; Mercer & Littleton, 2007; Truxaw & DeFranco, 2007), the theory of exploratory talk (Mercer, 1995); the theory of contextual collaborative learning in multilingual classes (Cooke, 1998) and the value of questioning (Lerman & Zevenbergen, 2004; Paul & Elder, 2008) were also discussed. The circle of 'educators' practice' was filled in the contact sessions by using four experiential investigations (Rooth, 2000) that were aimed at empowering the educators to implement both the theory and practice that they had learned and experienced in their classrooms in the form of an action research project. Much of the data were collected in situ during contact sessions and through observations and video recordings.

2.2.1 Numeracy test in English and isiXhosa

At first I thought I had made an error with this activity. Perhaps I should have translated the test into a totally unfamiliar language, so that all the students would have been in the position of the 'unknowing'? However, after the intervention I realized that this exercise gave the students a very rich experiential gaze into the realities that are current in their classrooms. The teachers shared the frustration of their learners as they looked for language clues to scaffold their meaning (Cooke, 1998). The students discussed at length in their groups the language support offered in the test by the graphic of the ruler and pencil. They recognised contextual clues, for example ‘pencil’ can be translated from ‘*bepensile*’, and discussed how they would be able to implement similar support in their own classes (Cooke, 1998). An unexpected outcome was their insistence that learners would not be able to answer a test in their main language as their literacy competence in their primary language was so poor. As mentioned, this is a new finding that has great implications for South African education. The hegemony of English is usually propounded as the reason for choosing English-only over mother tongue education (Setati, 2005a), but it seems that the hegemony of English has marginalised the mother tongues insidiously so that the language (either isiXhosa or Afrikaans) is devalued to the extent that learners are no longer, and do not wish to be, literate in these languages. This sentiment was echoed in the results of the investigations for objective one. This means that there is both an internal motivation for the choice of English only (illiteracy in mother tongue) and an external motivation (the lure of social goods).

The teachers also mistrusted translations because of the variation in dialects. They felt that they were conditioned to think mathematically in English so that thinking mathematically in isiXhosa would be an added struggle. Through this exercise, they not only experienced the realities of their classroom (Rooth, 2000), but they also learned the value of scaffolding mathematical problems by using language skills and graphic organisers (Cooke, 1998).

2.2.2 Experiencing exploratory talk with triggers

This exercise was designed so that the teachers would have no prior knowledge or preconceived notions about how to solve RSPM items. This was done so that they could focus on the development of exploratory talk in their groups (Mercer, 1995). As such, it achieved its purpose as examples of disputational talk; cumulative talk; and exploratory talk were evident during the contact sessions. The students realised in their groups how difficult it was to apply the ground rules of exploratory talk (Mercer & Littleton, 2007) when they were trying to solve a problem and realised that they would have to coach their learners continually (Dawes & Sams, 2004). The investigation enabled them to experience the value of training the ground rules of exploratory talk – and the difficulty in adhering to them. Often the voice level of their conversations increased as they tried to shout each other down; they did not listen to each other as they wanted to get their own point heard; and they focussed on the correct answer rather than giving reasons for their statements, issues which they would have to control in their classrooms.

The teachers were also able to use divergent questioning (Mercer & Littleton, 2007; Paul & Elder, 2008) in their groups and put into practice the theory that they had learned. Through the experience of participating in the same exercises that they could use in turn with their learners, they became aware of the objectives of the exercise; interacted together to reach a solution; and practised the tenets of exploratory talk (Rooth, 2000). They were able to experience in practice Vygotsky's (1978) concept of the ZPD when a more capable peer could guide them towards a solution. The exercise also showed them experientially how much more comfortable they felt discussing their reasoning in their main language than in English (Setati et al., 2008); and how much the discussion enabled them to reach informed consensus on the answer (Alexander, 2004; Mercer & Littleton, 2007).

The concept cartoons (Dabell, Mitchell, & Barnes, 2007) highlighted common misconceptions in basic mathematics which were printed as statements attributed to the children in the cartoon. Exploratory talk enabled the students to question the authority of the text as some of the statements by the learners printed in the cartoon were incorrect. This exercise again gave the students an insight into the problems faced by their learners. They engaged actively with the material while negotiating the answers and reaching consensus (Rooth, 2000). They could identify with Vygotsky's (1978) development of the ZPD and

Mercer & Littleton's (2007) extension into a more fluid IDZ as their ideas were used to scaffold their group reasoning. They could also experience the power of dialogue and collaborative learning in their groups (Alexander, 2004; Barnes & Todd, 1977, 1995; Cooke, 1998; Dawes & Sams, 2004).

2.2.3 Identifying when to use different languages in a lesson

This exercise was designed so that the students could reflect on what actually happens in mathematics classrooms and develop awareness of how language and content can be taught simultaneously. The teachers were given a text with which they engaged so they could experience how a lesson could include content as well as language interventions in the form of exploratory talk to ensure that the concept taught was grasped by the learners (Cooke, 1998). In retrospect the exercise achieved the objective as the teachers said that they felt that it was permissible to use code-switching and isiXhosa in class as they had themselves experienced the power of using their main language in groups to solve problems (Adler, 2001; Moschkovich, 1999, 2007).

2.2.4 Action Research assignments

The action research assignments were designed to give the students exposure to the plan-act-observe-reflect cycle of action research. They were required to introduce exploratory talk using the learners' main language; they implemented the lessons in their classrooms; they observed the learners' engagement with different types of talk; and they reflected on the lesson in their written reports (Albertyn, 2009). The results indicate that they were able to implement the strategy in their multilingual mathematics classrooms with varying degrees of success. Perhaps some teachers embellished the success of their own interventions in the classroom as the exercise was for assessment. As noted earlier, Lerman (2001) warns that students tell only that which they want the reader to know, but by writing up the interactions it became clear that, at least, they had genuinely engaged experientially with the strategy (Rooth, 2000).

2.2.5 Objective two overview

The four investigations that were designed to address objective two were aimed at providing an opportunity for the students to put the theory they had learned into practice and give them the confidence to implement the strategies in their classrooms. This was done in order to complete da Ponte’s (2009) trilogy of intersecting circles of knowledge, practice and identity, so that the common ground of optimum teaching and learning could be experienced. The teachers were sensitised, through personal experience, to the frustrations some learners feel when being assessed in English. They demonstrated how to use language and contextual clues to scaffold meaning (Cooke, 1998); learned how to scaffold mathematics problems by using language skills (Mercer & Littleton, 2007); and experienced the practice of exploratory talk (Mercer, 1995). They saw experientially how Vygotsky’s (1978) ZPD could be developed and sustained as an IDZ (Mercer & Littleton, 2007) and they realised the power of using their main language in dialogue in their groups (Alexander, 2004; Setati, et al., 2008). They could experiment with using open-ended divergent questions (Mercer & Littleton, 2007) and thus gained confidence to experiment and use similar practices in their classrooms (Albertyn, et al., 2005). The results gathered from the four exercises suggest that objective two has been achieved – a reflection was conducted on the intervention that had been designed and implemented. The results suggest that the intervention provided opportunities for educators to promote dialogic teaching.

2.3 Objective 3: To track educators' practice in the classroom before and after an intervention

In this section of the study the attention moved from the lecture hall to the classroom. Could the teachers, who had experienced an intervention, implement it successfully? Three teachers were introduced to the concepts of dialogic teaching and different types of talk, particularly exploratory talk (Alexander, 2004; Mercer, 1995). They discussed methods of negotiating ground rules with the learners so that the practice could be owned by, and not imposed on, the learners (Mercer & Littleton, 2007). Time was spent on assessing the educators' views on the use of code-switching and the learners' main language (Adler, 2001; Setati et al., 2008). Vygotsky's (1978) theory of the ZPD and scaffolding were interrogated, particularly the importance of allowing more competent peers to aid other learners in the groups. As a group we discussed the development of a positive classroom atmosphere that would imbue confidence in the learners so that they would engage in dialogue, particularly the development of a social community of practice through divergent questioning (Gee, 1994; Lerman & Zevenbergen, 2004). Problem solving through using mathematical skills; critical thinking skills and language skills was emphasised (Cooke, 1998). The results of the observations, as mentioned in the results chapter, were varied.

2.3.1 Personal observation and video recording during phase two

Before the teachers' practices were observed in the classroom an observation checklist was designed based on Mercer and Littleton's (2007:40) recommendations for dialogic teaching (see Appendix H). The aim of the observation checklist was to interrogate teachers' use of questioning, the content of tasks and discussions, the kind of explanations and instructions the educator gave and the extent to which learners talked together (Mercer & Littleton, 2007).

According to the checklist analysis, Mr Mzondo had little success in developing dialogic teaching in his classroom as he did not allow the learners the opportunity for meaningful interaction, either teacher-to-learner or learner-to-learner. He was unable to effectively use language or questioning to create a shared ZPD during the activities that he introduced in his classroom (Vygotsky, 1978). His questioning was convergent and did not aid the development of dialogue (Mercer & Littleton, 2007). The learners' quantitative scores for the RSPM and numeracy tests are correspondingly low.

Ms Zondani tried to introduce the ground rules of exploratory talk but the implementation was hampered by her stereotyped reporting system where the learners had to write their answers in English on paper before they reported back. There was little discussion as the learners spent their time crafting sentences in English. They seldom gave reasons for what they wrote as they concentrated on getting the correct answer. Her learners' quantitative scores for the RSPM and numeracy tests are higher than those of Mr Mzondo; however, the scores are lower than those of Mr Hlam's learners.

In contrast Mr Hlam's learners were encouraged continually to use dialogue in their groups and to apply the ground rules of exploratory talk. He was able to create a ZPD where more able learners helped others in groups. His questions were divergent and he often answered a question with another question to spur the learners to a higher level of thinking. He gave the learners access to problem solving strategies by drawing on prior mathematical knowledge, encouraging critical thinking skills and modelling language skills in whole class discussion, and by encouraging the use of exploratory talk in groups where learners could make the reasoning underpinning their strategies explicit (Mercer & Littleton, 2007). In both the RSPM and numeracy tests Mr Hlam's learners achieved the highest scores of the three target groups.

2.3.2 Personal observation and video recording during phase three

Having identified that Mr Hlam could introduce exploratory talk in his multilingual mathematics classes, it seemed reasonable to investigate further the impact of the successful implementation of exploratory talk on the reasoning, numeracy and language skills of his learners. The examination of his practices led to the emergence of the following constructs: questioning, coaching problem solving procedures, and creating a social and communicative environment.

Lerman and Zevenbergen (2004:27) claim that questioning is an integral part of classroom practice and note that different types of questioning influence the acquisition of knowledge and social interaction in the classroom. Alexander (2004) also stresses the importance of questioning in dialogic teaching and Wenger (1998) states that learning is about participation in practices. Mr Hlam used both divergent questions and Socratic questioning, where a question is answered by a question (Paul & Elder, 2008). Setati (2005a) claims that English is usually used for procedural discourse in mathematics, whereas the learner's home language is usually used for conceptual discourses. Mr Hlam encouraged the learners to explore ways of reasoning in their main language in groups and report their findings in a plenary in English. He created an opportunity to re-voice their reasoning in English and reinforce the terminology and ideas. He used English for both procedural and conceptual understanding, but allowed the learners to use their main language for conceptual understanding. One of the most noticeable attributes of Mr Hlam's classes was the positive atmosphere that he created in which learners developed the confidence to voice their opinions in any language they wished. A dialogic space was created where there was an inclusive environment in which learners explored ways of reasoning through dialogue by using their main language (Mercer & Littleton, 2007). In this way they could gain confidence in mathematical reasoning as well as (re)gain a sense of pride and cultural capital in their own language and value it as a useful tool in the classroom.

2.3.3 Objective three overview

This study has shown that under certain circumstances it is possible for Eastern Cape multilingual mathematics classes to become environments for the comparison of sociocultural practices. By introducing teaching based on the notion of “language as the principal cultural and psychological tool for building knowledge” (Mercer & Littleton, 2007:6) it has been possible to compare the use of language and the subsequent impact on mathematical reasoning in different mathematics classes. The results suggest that the objective of tracking educators’ practice before and after an intervention in the classroom has resulted in new knowledge being gained from the observations of the two cohorts of teachers. Where there was evidence of dialogic teaching exploratory talk was observed among the learners (Alexander, 2004; Mercer & Littleton, 2007; Truxaw & DeFranco. 2008). The use of the learners’ main language as an aid to mathematical reasoning may seem to be a way to rekindle in the learners a sense of pride in their main language as it becomes more academically valued. This study suggests that the introduction of dialogue in the learners’ main language may not only increase mathematical reasoning skills; but may also redress the balance of the English-isiXhosa tension in the Eastern Cape.

2.4 Objective four: To test the effect of dialogic practices on reasoning skills, numeracy skills and English skills

In this study there was a statistically significant positive difference between the mean scores of the pre- and post-tests of the experimental over the comparison group in terms of RSPM scores, numeracy and, to a lesser extent, English skills. These data suggest that the intervention had a positive effect on the target participants as reasoning competence, numeracy competence and English competence improved consistently when there was evidence of exploratory talk in the classroom. The statistical data obtained show statistical significance, practical significance and reliability.

2.4.1 Reasoning skills test

The RSPM results echo the findings of previous studies (Mercer & Littleton, 2007; Rojas-Drummond & Mercer, 2004; Webb & Treagust, 2006). This suggests that training the learners in the ground rules for effective dialogue, and teaching them the tenets of exploratory talk, in this case in the learners' main language, does improve their reasoning skills. The overall study target learners' RSPM mean score was assessed at a very low level for the pre-test (26 out of 60), but improved to a mean of 35 out of 60 at the post-test. The median for the overall study target group was 37. The significance of this result can be considered in the light of the published means for twelve year old children for the United Kingdom, Kuwait, United States and India (Abdel-Khalek & Raven, 2006)

Table 7.1

Comparison of RSPM percentiles from different countries

Percentile	**UK**	**Kuwait**	**USA**	**India**	**Overall Study: Target group post-test**
95	53	50	51	52	47
50	42	40	40	40	37
5	27	19	22	22	18

Although the pre-test scores were low, it can be seen that the post-test scores of the target group in this study were comparable with those from other countries after the intervention. This is found despite Abdel-Khalek and Raven's (2006) statement that unpublished data records that "blacks in the USA and South Africa, many Native American groups, and other groups lacking a tradition of literacy" have scores far below the published norms from other countries (Abdel-Khalik & Raven, 2006: 175). Further research could ascertain whether these scores are retained over a longer period of time if dialogic teaching and learning is maintained as common practice in their mathematics classes.

If, as has been referred to in chapter two, the RSPM tests are a valid test of general intelligence, referred to as Spearman's *g* (Jensen, 1998; Lynn, et al., 2004; Mercer & Littleton, 2007), then this study has shown that general intelligence can be improved by an intervention that introduces and encourages the use of dialogic teaching in the form of exploratory talk in mathematical classrooms. This result has major implications for mathematics teaching in the Eastern Cape. If dialogic practices can improve scores of general intelligence over a relatively short period of time, what could be attained if dialogic practices were implemented, and sustained for longer periods, in many more multilingual mathematics classes?

2.4.2 Overall study numeracy skills test

As mentioned earlier, there was a statistically significant difference between the overall study pre-test numeracy skills percentages (23,4%) and the post-test numeracy scores (35,7%) after the intervention. This indicates that the intervention of introducing dialogic practices had a positive effect on the target groups, despite the fact that during 2007 one target group achieved minimal gains. This was compensated by the gains of the other target groups during 2007 and 2008. As the numeracy test included questions expressed in mathematical English, the improvement in scores could indicate that both the numeracy as well as literacy improved because the learners were exposed to an intervention that used dialogue with external triggers as well as curriculum textbooks. The learners thus had to read mathematical English in their groups in order to make sense of the problems tasked. This study suggests that reading mathematical English in groups increase literacy and comprehension of mathematical texts as the learners are able to negotiate meaning through dialogue in their groups.

2.4.3 English skills test

The intervention targeted talking and did not include reading and writing skills. However, as mentioned, the numeracy tests included mathematical reading which the learners had to understand in order to answer the questions. The English skills test was a test of general English competence. It is not surprising, then, that an intervention that targeted mathematical English specifically, did not have a greater impact on the overall English skills scores; however, there was an improvement, which suggests that the teaching strategy of exploratory talk may have had an influence on English competence.

2.4.4 Objective four overview

The results of the quantitative tests revealed that where dialogic teaching and exploratory talk in groups were evident there was a statistically significant increase in the scores for reasoning skills, numeracy skills and, to a lesser extent, English language skills. However, as has been mentioned, the English tests were on general English and the intervention targeted mathematical English. The fact that the numeracy scores improved also suggests that there may have been development in the learners' mathematical English. A most significant result is that this study shows that an intervention introducing dialogic practices and exploratory talk can increase learners' general intelligence scores to be comparable to the international scores published from research on RSPM tests in other parts of the world.

During 2007 although three teachers experienced the same input and training, there was a difference in the three target group scores. This opens up a question concerning the readiness of teachers and their commitment to the implementation of innovative strategies. The teacher at North Primary School embraced the strategies and there was a corresponding statistically significant improvement in his target learners' scores. Based on the qualitative analysis, the results at South Primary School were unsurprising because of the teacher's level of take-up and commitment to the project. The teacher at West Primary School was committed to the project and worked hard to make the transition towards dialogic teaching. Her target learners' results fell between those of North and South and were significantly better than the results of the control groups in her particular school. Although the qualitative data were not gathered with the comparison of target groups in mind, the issues that led to the differences could be the focus of further research.

3. LERMAN'S APPROACH TO QUALITATIVE RESEARCH

In the previous section of this study I have discussed the results in relation to the objectives set. To focus my gaze on the qualitative data being generated in this research, I have kept in mind Lerman's (2001) suggestions, mentioned in chapter two, for researching discursive teaching and learning which include: intersubjectivity and internalisation; Vygotsky's zone of proximal development; the functioning of discursive practices, including positioning and 'voice'; the social relationships in the context; mathematical artefacts; and development as a process of thinking/speaking mathematics (Lerman 2001:101-107).

3.1 Intersubjectivity and internalisation

Lerman (2001:102) posits that intersubjectivity occurs "before interaction and requires the examination of resources, through language, that the teacher, texts, peers and others supply, as well as the ideas that emerge through joint activity". In this study intersubjectivity has been addressed through focusing on the resources supplied by eliciting perceptions teachers have (challenges, choices, solutions, strategies), studying texts and theory that underpin this research, empathising with peers' shared worlds in contact sessions, and through encouraging joint activity through group work, both in the contact session and the teachers' classrooms. Internalisation can be identified from the teachers' and learners' use of "language as an artefact" in doing mathematics (Lerman 2001:102). In mathematics classes this study has encouraged the educators to overlay (re-voice) the students' language with the correct language of mathematics (Moschkovich, 1999). Lerman (2001) maintains that this is another example of intersubjectivity and internalization.

3.2 Vygotsky's Zone of Proximal Development (ZPD)

Lerman (2001) posits that one should consider interactions between learners as discursive contributions that could pull others in the group towards greater participation in mathematical communication and draw them into the ZPD via a more competent teacher or peer. Lerman (2001) senses the ZPD as a symbolic space which incorporates individuals, their practices and the circumstances of their activity. Both teacher and student can be pulled into their ZPDs and learn from the interaction. The results of this study suggest that an important issue for teachers to make working in the ZPD possible is the ability of a teacher to facilitate the class in the way that opened up, rather than closed down, the space for thinking. The use of open as opposed to closed questions seemed to encourage working in the ZPD. In this study a disturbing aspect was the observation that some teachers do not have adequate mathematical knowledge to act as the more able facilitator in mathematical classrooms.

The emphasis on using exploratory talk enables learners to share their knowledge and discover, in an unthreatening environment, who the more knowledgeable peer is in each group situation. Mercer & Littleton (2007) introduced the Intermental Development Zone (IDZ) (see chapter two) to conceptualise how teachers and learners can create a dynamic, shared communicative space through talk and joint activity. The IDZ is constantly reconstituted and negotiated. In this study the design of sharing ideas and working on exercises in groups enabled teachers to experience the phenomenon of being in the zone and being coached by a more competent peer. They were then encouraged to do likewise in their mathematics classes.

3.3 The functioning of discursive practices, including positioning and 'voice'

According to Lerman (2001:105) the notion of "voice" has two aspects: the expression of individuality (elements of the unconscious) and the mathematical voice as a particular register. In this study both aspects were addressed. Firstly the students were able to come to terms with their own identities through sharing previous experiences, personal goals, needs and interests, for example poetry and reflective writing, which, Lerman (2001) maintains are key features for the development of identity. Secondly, the educators practised the mathematical register through the group activities, particularly when using the concept cartoons, and were tasked to develop the register in the classrooms in their action research as well as during phases two and three.

Albertyn (2005) maintains that empowerment is achieved through: an environment of role modelling; uncritical group support; solidarity and trust; providing a secure environment; allowing freedom of expression; humility; not fostering dependency; the ability to identify strengths; genuine respect; identification with learners; and the ability to listen and reflect. People are positioned as powerful or powerless according to the structure of the discourse and the personal histories of the participants (Lerman, 2001) As far as was possible an empowering, caring environment was established using Albetyn's (2005) constructs in the contact sessions. This can be attested to by the sharing that occurred among the teachers as well as the quality of submissions, for example the poetry.

3.4 The social relationships in the context

Lerman (2001) maintains that disadvantaged groups do not perform as well as others and the source of the disadvantage is located in different linguistic codes. These are not deficit models but the result of different opportunities (Lerman, 2001; Zevenbergen, 2000). In earlier chapters I have discussed the marginalization of learners who speak dialects and the disenfranchisement of some languages in the Eastern Cape. In this study the majority of the participants were from a previously disadvantaged background and I have explained the measures taken to empower them in this study. The scores in the RSPM tests indicate that through effective dialogic teaching and the use of their main language, the gap between advantaged and disadvantaged learners could well be lessened.

I was aware that I was receiving a snapshot of perceptions and the students and teachers were perhaps telling me what they thought I wanted to know (i.e. that they did introduce exploratory talk and reported it in their action research assignments), or that they were telling me only what they chose to tell. In order to gather a far-reaching and deep picture of multilingual mathematics teaching in the Eastern Cape the following measures were implemented: different cohorts of teachers were sampled from many areas of the Eastern Cape; their views were elicited in different ways to triangulate their responses; left-brain and right-brain activities were structured to suit students different personalities and learning styles; two researchers observed classroom interactions and triangulated their results; and the classroom observation was repeated in two successive years to validate data collected. Success was seen to be achieved in Mr Hlam's classroom, which was social and relaxed. The participants interacted spontaneously and were not restricted to one language. Considering all of these measures I believe I can infer that the data collected through written, spoken and observed actions are a valid reflection of the students' and educators' perceptions and opinions.

3.5 Mathematical artefacts

Artefacts are the physical tools, such as diagrams, graphs and manipulatives which aid students to think and speak mathematically (Lerman, 2001). In this study triggers such as RSPM items and concept cartoons were used to encourage social interactions and in the classroom Mr Hlam used maps, charts and cut-out quadrilaterals to scaffold his learners' understanding. I stretch Lerman's (2001) definition to include language as a cultural artefact in this study. In Mr Hlam's classes the learners were encouraged to use their main language as a useful, valued, cultural tool. As has been mentioned, the devaluing of the main language has led to learners neglecting the development of reading and writing competence with the result that their literacy levels have dropped. This was a factor that was mentioned in all phases of this study. By imbuing isiXhosa with value in multilingual mathematics classes, this tendency could be addressed.

3.6 Development as a process of thinking/speaking mathematics

Learning school mathematics is initiation into the practices of school mathematics, hence the central role of the initiator, the teacher (Lerman, 2001). In this study the focus has been on the teacher and the development of dialogue as a resource in the classroom. Learning mathematics or learning to think mathematically is learning to speak mathematically (Lerman 2001), therefore it is imperative that teachers and learners are given an opportunity to talk in class. In this study the teachers and learners were encouraged to use either their main language or code-switching to be able to 'speak mathematics' authentically. The tutor acted as a discourse guide to lead the teachers (and hopefully, in turn, their learners) to increasing sophistication of mathematical language. However, Adler (2001) warns that often the journey from informal talk to mathematical talk is truncated. In this study Mr Hlam used language support to aid his learners to start on the journey. Mercer and Littleton (2007) suggest that the monologic mode of classroom talk can be broken by teachers using certain strategies in the classroom. These include soliciting learners' views, responding to learners' ideas, asking divergent questions and deliberately not giving evaluative feedback. These are all traits that Mr Hlam demonstrated effectively in his teaching.

4. COMMON GROUND

In chapter two I used da Ponte's Venn diagram to illustrate the common ground between educators' knowledge, practice and identity (knowing, doing, being). The results of this study indicate that it is when educators have knowledge, ability to put that knowledge into practice and a sense of their own identity and culture that they are empowered to enhance mathematical learning in multilingual classes. This study shows that educators need to know the theory concerning dialogic practices and exploratory talk; they need to practice the strategies that best support multilingual learners in multilingual mathematics classrooms; and they need to be empowered, enthused and changed so that they have confidence to make, sometimes radical, changes in their teaching practices in order to enhance learning.

The metaphor of common ground can be applied to the results of this study. As discussed, research has shown that normal practice in Eastern Cape classrooms was teacher-centred I-R-E teaching (Webb & Treagust, 2006; Webb & Webb, 2004), while in this study it was possible to meld teaching, learning and cognitive development through dialogue, as is depicted in figure 7.2.

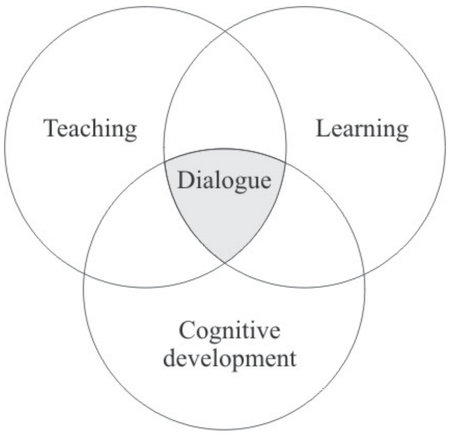


Figure 7.2 The centrality of dialogue in teaching, learning and cognition

From the results discussed I believe a common ground can be found in Eastern Cape multilingual mathematics classrooms by introducing dialogue between teacher-and-learner and learner-and-learner in a language that both educators and learners fully understand and in which they are fluent.

5. CHAPTER SUMMARY

In this chapter I have looked at the results, as reported in chapters four, five and six, in the light of the objectives set at the outset of the study. I took each objective and discussed the inferences from the results that emerged after the application of each investigation. From the analysis of the results it can be inferred that each of the objectives has been achieved. Certain themes recur throughout the study. The hegemony of English and consequent striving for English competence is contrasted with the disenfranchisement of the main language (which is isiXhosa for the majority of the educators and learners in the Eastern Cape) and the consequent lack of main language literacy among learners. Educators indicate that code-switching is an accepted language resource in the Eastern Cape, although they overwhelmingly chose English as the LoLT.

The classroom observations over two years indicate that dialogic practices can be introduced in multilingual mathematics classes if the learners' main language is encouraged. This has a dual advantage as competence and comprehension is improved and the main language is afforded value and usefulness.

Another noteworthy result is that this study shows significant statistical evidence that the introduction of dialogue in the learners' main language increases reasoning, numeracy and English language skills. This has implications for teaching mathematics in the Eastern Cape in multilingual classrooms.

I have looked at the results from the perspective Lerman (2001) suggested to isolate identifiers for the analysis of data. From this perspective, too, the objectives have been achieved. This study suggests that the use of dialogue can increase the common ground between teaching, learning and cognitive development, particularly if the dialogue is in the learners' main language. In the next chapter I will draw conclusions for this study in the light of the questions posed in chapter one.

CHAPTER EIGHT

IMPLICATIONS OF THE STUDY

1. INTRODUCTION

In this chapter the main findings of the study are identified. They address the four objectives, which are repeated below:

1 To identify Eastern Cape educators' perceptions about language strategies and language usage in multilingual mathematics classes;

2. To research the design and implementation of an intervention for educators to promote the introduction of dialogic practices;

3. To track educators' practice in multilingual mathematics classrooms before, during and after an intervention;

4. To ascertain whether the introduction of dialogic practices, particularly exploratory talk, increase reasoning, numeracy and English skills in grade seven multilingual mathematics classrooms.

In doing so I considered the gap in knowledge that existed before the commencement of this study and how attempting to fill the knowledge gap has contributed to a better understanding of the issues Eastern Cape educators face in multilingual mathematics classes. I have briefly revised the rationale and design of the study and presented the main findings. A model informed by these findings is suggested which could provide a guide for future interventions of this nature. The limitations of the study which are pertinent to the aim of the research are presented and suggestions for further research are made. Finally, a postscript positions the thesis within the most recent comments of an authoritative South African researcher in the field of multilingualism.

2. RATIONALE AND DESIGN

The gap in knowledge that I identified before the outset of this study was that mathematics educators in the Eastern Cape did not appear to have the knowledge or skills required to teach mathematics effectively to multilingual learners using a dialogic teaching and learning approach. The problem seemed to be related to both language use and pedagogical strategies, as reflected by an observable lack of dialogue in the targeted teachers' classrooms. One of the reasons suggested was that the majority of these educators, and their learners, are second language English-speakers. As such, I designed a study which aimed at investigating whether a strategy for teachers, which aimed at empowering teachers to effectively introduce dialogue in the learners' main language, would promote reasoning, numeracy and English language competence in their learners. However, before designing the intervention it was necessary to ascertain what the educators' perceptions were about their language practices – the challenges they faced, the solutions they employed and the language choices they made in their classes - as it was necessary to establish the status quo.

In order to conduct valid and reliable research on the effects of the strategy, a concurrent triangulation approach design was planned in three phases (Cresswell, 2009). The first phase elicited the perceptions of educators about language issues, after which they were introduced to appropriate dialogic practices for multilingual mathematics classrooms. The second phase tracked the introduction of dialogic practices, particularly exploratory talk, by three grade seven mathematics educators and pre- and post-tests were administered to the learners before and after the intervention. The third phase repeated the intervention and testing of grade seven learners of one educator in one school. Each intervention phase took place over six to nine months in three consecutive years.

3. MAIN FINDINGS

The main finding of this study is that in the classes in which dialogic practices, especially the introduction of exploratory talk in the learners' main language, were effectively implemented there was a statistically significant increase in reasoning competence, numeracy skills and English language skills. In the classes where exploratory talk was introduced with marginal success, the score differences between the pre- and post-tests were reduced and, where there was no evidence of dialogic teaching and learning, the increases in competencies were minimal. This result could have major implications for teacher training interventions designed for both accredited qualifications and educator training workshops. As a result of this main finding a possible model to guide future interventions is described in a later section of this chapter.

Another main finding was that creative right-brain methods, such as poetry, could be used in an essentially left-brain field, such as mathematics, to elicit educators' deep perceptions about their cultural identities, worldviews and ways of being. The constructs that emerged inductively from the instruments designed for the study, namely the questionnaire, reflective writing, and poetry were repeatedly mentioned so that patterns could be identified. A continuous theme was that the teachers considered it necessary to enhance English competence in their learners even if it was done so at the expense of developing their mathematical competence. The data also revealed that educators believe the devaluing of the learners' mother tongue (in this case isiXhosa) has resulted in learners not developing their main language literacy competence sufficiently for academic learning.

Another main finding was the identification of essential traits that an effective multilingual mathematics teacher should display in order to introduce dialogue effectively to promote learners' mathematical cognition. Strategies for teaching in multilingual classrooms are different from strategies employed in monolingual classrooms. Not only is a sound mathematical content knowledge, pedagogical content knowledge and knowledge of dialogic practices necessary, but also knowledge of second language teaching practices.

Teachers in multilingual mathematics classes should be trained in code-switching skills and, as mathematical language is specialized, effective use of code switching and metaphors between the main language and English need to be formalized to provide clarity and avoid confusion. A sound knowledge of questioning techniques is also a necessary prerequisite for effective teaching as the results of this study suggest that where convergent questions are used dialogue is shut down; however where divergent or Socratic questioning is used dialogue is developed, with consequent increase in reasoning skills. An effective multilingual mathematics teacher requires confidence in diverse ways - of one’s capabilities and knowledge; of owning one’s cultural heritage and language identity; of having the capacity to listen to learners as they struggle to make meaning of mathematics; of being empowered and authoritative (but not authoritarian); of being fully aware of importance of English without being intimidated by it; of creating a classroom climate where learners are encouraged to contribute; and of maintaining a learner-centered atmosphere. Figure 8.1 illustrates how an effective teacher can be positioned in the common ground between knowledge, practice and identity (da Ponte, 2009).

Figure 8.1 Researcher's perception of the components of an effective teacher

It is suggested by the results of this study that an effective educator should balance academic and mathematical knowledge with sound conceptions of identity as well as creative efficient second-language practices in order to teach mathematics in a multilingual setting. The 'absolutist' and 'fallibilist' ends of the beliefs' continuum could thus both be utilised (Ernest, 1989; Lerman, 1986).

The findings that addressed the four objectives mentioned in the introduction to this chapter suggest that the objectives of the study have been achieved – Eastern Cape educators' perceptions about language strategies and language usage have been identified; an intervention has been developed that has the potential to successfully introduce educators to dialogic practices. The teaching practices of educators in the classroom have been tracked before, during and after an intervention and the introduction of dialogic practices resulted in statistically significant positive differences in learners' reasoning, numeracy and English language skills in the target groups. A timely caveat is that the implementation and success has proved to be varied with achievement dependent on the skills and commitment of the educator. Nevertheless, the study reveals what can be achieved by training educators in dialogic practices. A dual role for educators in teaching mathematics competence as well as teaching English competence might be addressed through careful planning and implementation of an intervention. The findings in this study have contributed to a more formalized and theoretically supported design of a model to guide further interventions of this nature which is presented below.

4. RECOMMENDATIONS FOR A MODEL TO GUIDE FUTURE INTERVENTION

In order to promote the introduction of dialogic practices in multilingual mathematics classes the following possible action research intervention strategy is suggested.

Research question:

What strategies can be implemented by educators of multilingual learners to enhance mathematical expertise?

Aim of study:

Design and implement an intervention to expose educators to possible strategies they can use to teach mathematics to multilingual learners.

Objectives:

- What are educators' perceptions about the challenges and solutions that they face in teaching mathematics to multilingual learners?
- Can educators develop strategies to facilitate mathematical expertise in multilingual classes?

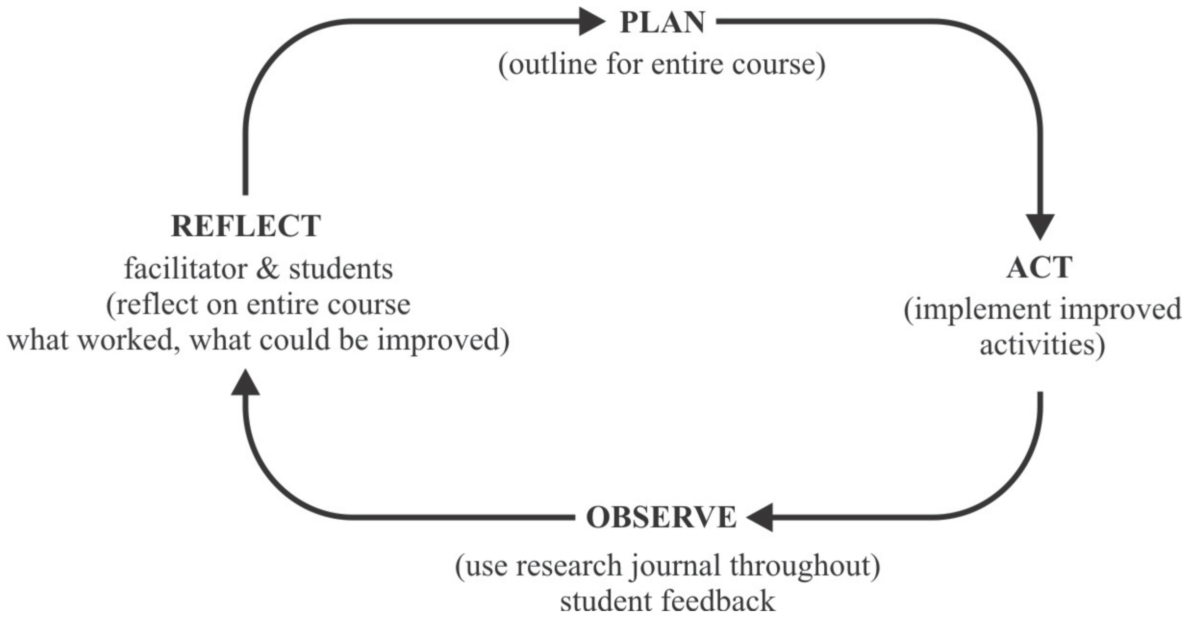


Figure 8.2 Action Research Cycle (adapted from Zuber-Skerritt, 2002)

Figure 8.2 illustrates the cycle planned for the action research intervention with a more detailed plan outlined in figure 8.3. After each activity has been implemented and observed it will be necessary to reflect on the effectiveness of the activity and perhaps amend it, or re-orchestrate a further activity. Observation and feedback should be used to inform each investigation, as well as the intervention as a whole. The plan described herein requires minimal resources and, as such, could be implemented in poor urban and rural areas in South Africa, and possibly beyond.

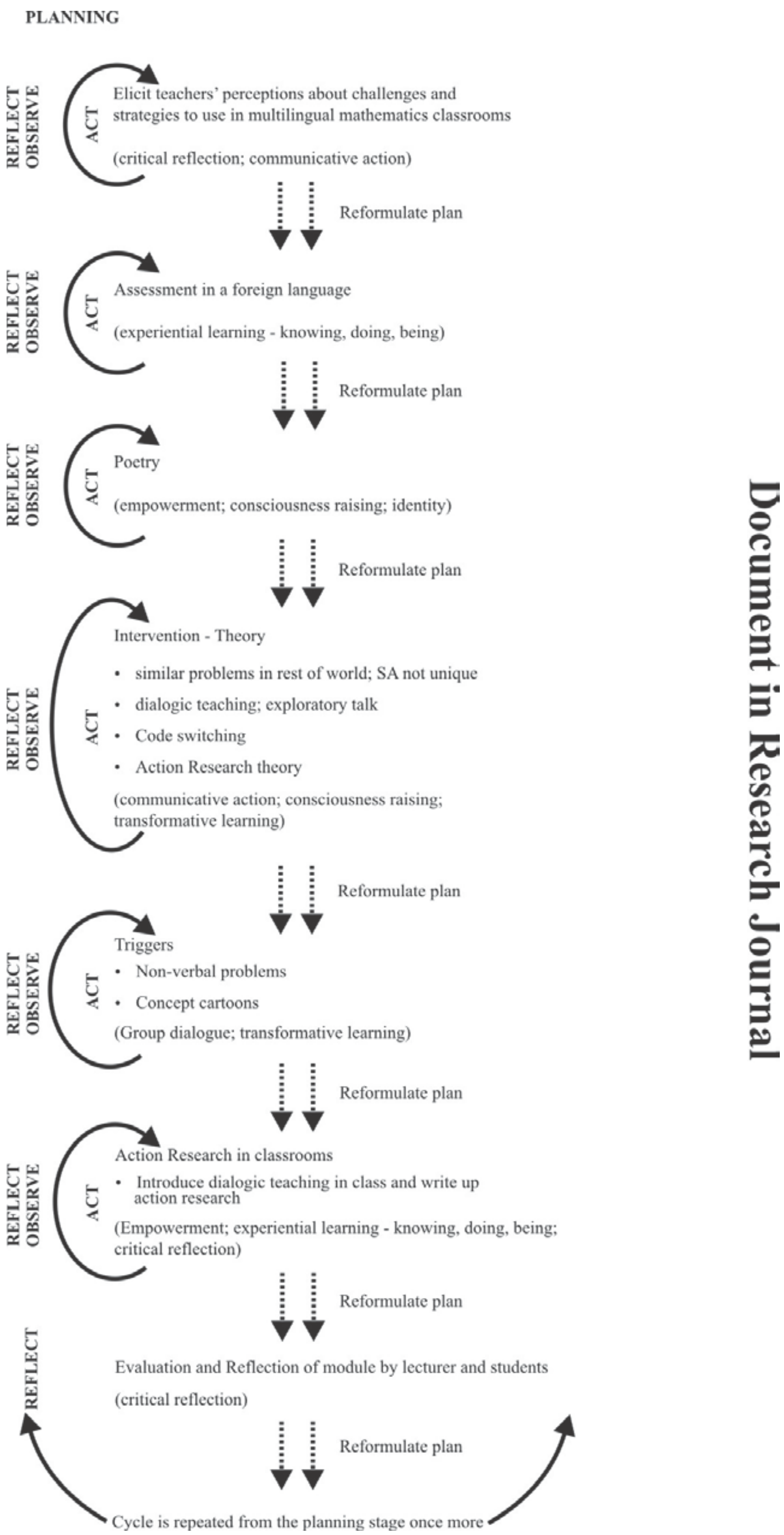


Figure 8.3 Researcher's planning cycle of action research – multilingual mathematics teaching strategies that could enhance mathematical reasoning

5. LIMITATIONS OF THE STUDY

The study has certain limitations. The intervention focussed on the introduction of dialogic practices only. The effects of the intervention could be improved if the complementary skills of reading, writing and critical thinking are addressed as well.

Secondly, the translations were criticized by some isiXhosa–speakers who felt that dialect differences could be misleading. Although I arranged for the numeracy test to be translated into isiXhosa by an isiXhosa-speaking linguist at the University, each time that I presented the translated test at a contact session the teachers pointed out sections that were 'badly' translated, and in many cases they suggested different interpretations. This gives credence to the educators' caveat that there could be problems when trying to translate English texts into isiXhosa because of the number of dialects involved. I also asked two isiXhosa specialists to check the grammar and the spelling of the isiXhosa transcriptions made in this study; and each time there were changes in interpretation. The translations were fraught with nuances and possible pitfalls. However, there was sufficient consensus within the research team for the transcriptions to be used, albeit with care.

6. SUGGESTIONS FOR FURTHER RESEARCH

The next step could be to embark on a study that researches the effect of an intervention that includes, either jointly or severally, talking, reading, writing and critical thinking in order to ascertain whether reasoning, numeracy and English competence can be further improved.

Another avenue for research would be to conduct a study in multilingual mathematics classes on the impact of the sustained use of dialogue in the learners' main language. This could help ascertain whether perceptions about the value of isiXhosa and literacy competencies in the language are improved, as well as researching issues of problem solving, numeracy and English literacy development.

Despite undergoing the same training and receiving the same amount of support, there were differences in the achievements of the three target groups during 2007. Further research could be embarked on into the reasons for the differences, and into the implications for further design and implementation of programmes aimed at developing exploratory talk and improving mathematical understanding. Insight gained from further research into this issue could improve understanding of professional development and inform future programme design so as to ensure teachers take-up and the implementation in the classrooms of techniques and strategies that are taught in the interventions.

A suggestion for a further study could be to develop criteria for identifying the emergence of zones of proximal development so as to be able to analyse the teaching-learning process in the classroom that enables learners to work within the ZPD.

7. POSTSCRIPT

During the time that I was completing the writing up of this study, I attended the International Conference on language policy, planning and support in Higher Education: Challenges of Multilingualism in Stellenbosch, South Africa from 17 – 20 November 2009. Professor Vic Webb, a keynote speaker, who has been cited in this research, summed up current trends in multilingualism in South Africa. He stressed in his address that some of the reasons for increased use of English in second-language schools are:

- The social, economic and political power of English and the a-symmetrical power relations between other languages in South Africa;
- The limited socio-linguistic capacity of African languages;
- Lack of financial support by government for multilingual education;

He pointed out that the advantages of multilingualism are that **l**anguage plays a fundamental role in educational development and cross-cultural communication and he recommended that the authorities:

- Decide on strategies and mechanisms with which they can establish a multilingual language mindset;
- Promote the training of teachers in multilingualism and implementation of language policies;
- Take a bottom-up approach towards bi/multilingual education so teachers own the process and take responsibility for its success;
- Continue to evaluate the status of African languages which need to be valued and promoted as languages of education for socio-cultural and socio-psychological promotion of communities.

He noted that the task is immense and complex and that it is idealistic to think of short-term successes and that the process needs to be planned and managed in a systematic and well-informed way. It was encouraging to realise that many of his insights are echoed in the findings of this study which resonate with current multilingual research in areas other than mathematics and in vicinities other than the Eastern Cape. It would be simplistic to presume that the introduction of dialogue in the learners' main language will be an immediate panacea for all mathematics woes in the Eastern Cape, but there has been progress – and we should stand on the shoulders of previous successes.

"Can dialogic strategies be experienced and implemented by Eastern Cape educators of multilingual learners in order to enhance reasoning, numeracy and English skills?" The findings of this study suggest that the main question posed has been answered in the affirmative and the study further suggests a model as a possible guide for future interventions that could lead to a systemic improvement in mathematics teaching and learning in the Eastern Cape.

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APPENDICES

APPENDIX A

Description of terms and abbreviations used in this study

(Adapted from Airey, 2009; Alrø & Skovsmose, 2004, Sfard, 2008)

Bilingual education	Education where two distinct languages are used for teaching.
Code-switching	The use of two or more languages in the same utterance or conversation.
Common ground	The shared space of learning between educator and student with respect to the intended object of learning.
Communication	A communicative interaction in which one person plays the roles of all the interlocuters.
Constructivism	Model of learning based on the premise that knowledge cannot be unproblematically transferred from one person to another. One must always, to some extent, construct one's own individual understandings of the world.
Dialogue	An inquiry process which includes an exploration of participant perspectives as well as a willingness to suspend one's pre-understandings. A dialogue cannot include given answers to questions beforehand.
Disciplinary discourse	The complex of representations, tools and activities in a discipline.
Discipline	Used in this study to mean an accepted, separate institutional site in society, a community with its own particular ways of knowing the world and a unique order of discourse.

Discourse (with a capital 'D') a social identity. An accepted association among ways of using language, of thinking, feeling, believing, valuing, and of acting that can be used to identify oneself as a member of a particular group (adapted from Gee, 2004).

discourse Ways of referring to or constructing knowledge about a particular topic of practice. A cluster of ideas, images and practices, which provide ways of talking about, forms of knowledge and conduct associated with, a particular topic, social activity or institutional site in society. Can be divided into *primary discourse* –ways of talking and acting acquired through primary socialization in the family – and *secondary discourses* – specialized ways of talking and acting in specific sites in society outside the home, acquired by building on and extending *primary discourse.*

Epistemology Student or educator beliefs about what constitutes knowledge and thus, by association, what constitutes learning.

EAL English additional language learners.

Experience Used in the phenomenographic sense i.e. how we conceptualise, understand, perceive and apprehend various phenomena in, and aspects of, the world around us.

First Language/main language/mother tongue/L1

The language a person learns first. The person could be called a native speaker of the language. Usually a child learns the basis of their first language from their family, as opposed to *second language*, which is any other language other than L1 typically used for geographical, social or political reasons.

Immersion Teaching where a *second language* is the sole means of communication, the person's first language is never used.

Language of Learning and Teaching/Language of instruction/LoLT

Language used to teach a subject.

Multilingual classes	Classes in which two or more distinct languages are used for learning and teaching.
Thinking	The individualized version of interpersonal communication.
Tools	Used in this study to mean specialized, disciplinary specific, physical objects that members of a discipline draw on to create disciplinary *ways of knowing.*
Ways of knowing	The coherent system of concepts, ideas, theories that have been created to account for observed phenomena in a *discipline.*

APPENDIX B

Progress maps for APAP Numeracy and APAP English skills

PROGRESS MAP: Numeracy

	Score	Skills Demonstrated
Proficient	93 - 100	Learners at this level have substantial arithmetic skills. These learners can: • Find equivalent forms of fractions • Estimate computations involving fractions • Solve simple percent problems of the form p% of ? = r • Solve word problems involving the manipulation of units of measurement • Solve complex word problems involving percent, average and proportional reasoning • Find the square root of decimal numbers • Solve simple number sentences involving a variable
Functional	75 – 92	Learners at this level have adequate arithmetic skills. These learners can: • Estimate products and squares of decimals and square roots of whole numbers and decimals • Solve simple percent problems of the form p% of q? and ?% of q = r • Divide whole numbers by decimals and fractions • Solve simple word problems involving fractions, ratio, percent increase and decrease and area
Expanding	46 - 74	Learners at this level have basic arithmetic skills. These learners can: • Perform basic arithmetic operations of addition, subtraction, multiplication and division using whole numbers, fraction, decimals and mixed numbers • Make conversions among fractions, decimals and percents
Developing	0 - 45	Learners at this level have minimal arithmetic skills. These learners can: • Perform simple operations with whole numbers and decimals (addition, subtraction, multiplication) • Calculate an average, given integer values • Solve simple word problems • Identify data represented by simple graphs

PROGRESS MAP: Language Use

	Score	Skills Demonstrated
Proficient	83-100	Learners at this level can demonstrate the following additional skills: • Recognise the following: • irregular verb forms such as “draw/drawn” • fairly unusual idioms such as “couldn’t get over it” • indirect object structures such as “gave her one” • Handle questions involving: • transformations of declarative sentences into questions • the conditional mood • parallelism • Choose appropriate structures to state complex ideas, often in complex sentences using subordination or coordination.
Functional	67 - 82	Learners scoring at this level can demonstrate the following additional skills: • Handle a variety of complex structures such as: • comparatives at the phrase level such as “so tall that” • relative clauses • structures at the clause level such as: “not only … but also” • simple subordination • Function at the whole-sentence level.
Expanding	42 - 66	Learners scoring at this level can: • Recognise basic grammatical structures such as subject-verb agreement, pronoun case and form, noun forms (including recognising subject, case, and number), and verb forms. • Handle questions involving word order, prepositional phrases, and simple clauses.
Developing	0 - 41	Learners scoring at this level can: • Sometimes recognise basic grammatical structures. • Sometimes handle questions involving word order, prepositional phrases, and simple clauses.

PROGRESS MAP: Sentence Meaning

	Score	Skills Demonstrated
Proficient	88-100	Learners at this level can demonstrate the following additional skills: • Handle vocabulary in sentences with complex structures that are characterised by abstract statements or idiomatic expressions. • Demonstrate knowledge of idioms that are two-word verbs or the use of idioms to express the appropriate meaning.
Functional	71 - 87	Learners at this level can demonstrate the following additional skills: • Handle vocabulary in sentences that have compound or complex structures, or present more complex situations than the sentences at the previous level. • Handle the following kinds of vocabulary: • two-word verbs • adverbs of comparison • more extended idiomatic expressions • longer descriptions. • Select appropriate vocabulary in sentences that provide a single contextual clue.
Expanding	51 - 70	Learners at this level can demonstrate the following skills: • Handle sentences with simple structures characterised by everyday subjects and simple vocabulary, including common nouns, adjectives, and verbs. • Select the appropriate vocabulary in sentences that provide multiple contextual clues.
Developing	0 - 50	Learners at this level can demonstrate the following skills: • Handle sentences with very simple structures and simple vocabulary. • Sometimes select the appropriate vocabulary in sentences that provide multiple contextual clues.

PROGRESS MAP: Reading Skills

	Score	Skills Demonstrated
Proficient	83 - 100	Learners at this level can demonstrate the following additional skills: • Answer questions that require dealing with a passage as a whole or manipulating the information presented in the passage. • Making generalisations on the basis of the information in the passage, recognise what was implied, and answer questions about the author's tone and purpose.
Functional	67 - 82	Learners at this level can demonstrate the following skills: • Answer questions that require: • drawing conclusions on the basis of the information presented in the passage • making inferences from the information presented. • Recognise the main idea of a passage even when presented with wrong answer choices mentioned in the passage as supporting information.
Expanding	46 - 66	Learners at this level can demonstrate the following skills: • Locate information in a passage by answering literal comprehension questions on even the longest passages, if the question posed and the answer to that question are in the same sentence or in close proximity to each other. • Answer questions in which the wording in the answer is very similar to the wording in the passage or uses minimal paraphrasing. • Answer some questions requiring small inferences (including questions asking for the main idea of the passage) if the options do not require fine distinctions.
Developing	0 - 45	Learners at this level can demonstrate the following skills: • Locate information in short, simple passages by answering literal comprehension questions. • Answer simple questions where the wording in the answer is the same as that of the passage.

APPENDIX C

Examples of collaborative mathematical exercises based on Cooke's principles of matching, sorting; sequencing and ranking skills

1) Below is a list of some of the key words commonly used in English in word problems. Arrange the words into the columns below by matching the words with the mathematical operation.

Minus, twice, subtract from, more than, product, less than, ratio, the same as, gives, combine, take away, sum, times, increased by, less, is, difference, and double, half, decreased by, differ, times, plus, quotient

ADD	SUBTRACT	MULTIPLY or DIVIDE	EQUAL TO

When you have completed this activity discuss in your groups what your preference is in your classroom, i.e. do you use the English terms or do you use the equivalents terms in your own language. Report your conclusions back to the whole class.

2) A word problem is usually presented in the form of a paragraph. The paragraph is made up of a series of statements that describe the problem. Every word, term and symbol is significant and must be understandable. When you write a story sum it is important that you make sure that the statements that you write have the same meanings as the equation on which the word sum is based.

If you currently translate word sums into the language most frequently used by your learners then write the word sum in this language.

Write a word problem for the following equation 7 + 4 = 11. The story you write should meet two criteria

a. it ends in a question;

b. the question can be answered by solving the equation.

3) In pairs write down as many geometrical terms as you can with a focus on the grade that you teach at school. Write them in the blocks below and translate them into your most familiar language:

English	isiXhosa / Afrikaans

APPENDIX D

Identifying language challenges and solutions in your school

- List some of the challenges that languages present at your school;
- List some of the solutions to the challenges that languages present at your school;
- List some strategies that you have found help multilingual mathematics learners understand mathematical concepts;
- Which language do you believe should be the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?
- Which language is actually the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?
- Which language would your learners choose to be the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?

APPENDIX E

ACTIVITY: Multiplication with fractions

Educator sets the scene and reads the problem

John's father bought a big watermelon and told John to cut off ⅓ of the melon and leave it for his parents. The rest, he said, should be shared equally among the four children. How much watermelon did each person get?

Learners talk in groups in order to clarify the meaning of the instruction.

Discuss:

What part (fraction) did each child get?

What part (fraction) did John's father get?

Who got the bigger part, a child or a parent?

Educator's talk - Explanation of mathematical operation

We multiply any two fractions by multiplying the numerators and the denominators, for example:

$$\frac{2}{3} x \frac{4}{7} = \frac{2 x 4}{3 x 7}$$

$$= \frac{8}{21}$$

If we multiply a fraction by any integer, we can write the integer as a fraction with 1 as denominator and multiply, for example:

$$\frac{3}{4} x\ 5 \quad = \quad \frac{3}{4} x \frac{5}{1}$$

$$= \frac{15}{4}$$

$$= 3\frac{3}{4}$$

In pairs – Learners talk in pairs in order to consolidate mathematical knowledge

Explain to your partner how you found a fraction of a fraction.

Can you do this by multiplying the two fractions?

How would you multiply two fractions?

Would this also be true if you multiplied a fraction by an integer?

Individual writing in learners' journals

In this unit we have learned to multiply a fraction by a fraction in the same way as we multiply a fraction by a natural number: numerators are multiplied together and denominators are multiplied together.

QUESTIONS TO ANSWER - Provide reasons for your decisions.

English could be the Language of Learning and Teaching (LoLT) in your school. However, it is not the main language of either educators or learners. Code-switching and translation are used in the classroom in order to make sure the learners understand instructions, answer questions, and use talk to make meaning.

1. Which parts of the lesson might be conducted in English only?
2. In which parts of the lesson might code-switching be used?
3. Which parts of the lesson might be carried out using the learners' main language?

APPENDIX F

Summary of Research Design

Phase	Objective	Sample	Number of participants	Instrument	Data	Construct
One	To identify educators' perceptions	ACE: MST students	176	Reflective writing	Qual	Identify from submissions
				Poetry	Qual	Identify from submissions
	Language strategies	BEd Honours students	179	Questionnaire section: challenges/strategies/solutions	Quan + Qual	Identify themes: present challenges and strategies
	Language usage			Questionnaire section: LoLT	Qual	Language choice
One	To research the design and implementation of an intervention for educators to promote dialogic practices	BEd Honours students	179	Experiential test in unfamiliar language	Qual	Identify from submissions
				Triggers to practice exploratory talk	Qual	Identify from submissions
				Different languages in a lesson	Qual	Identify from submissions
				Action research assignments	Qual	Identify from submissions
Two and Three	To track educators' practice in the Classroom before and after an intervention	Phase two: 3 teachers	3	Personal and video observation	Qual	Identify themes:
		Phase three: 1 teacher	1	Personal and video observation	Qual	Questioning, classroom climate,
						Language usage, group work
						Whole class discussion
Two and Three	To test the effect of dialogic practices on -Reasoning skills -Numeracy skills -English skills	Phase two: 3 teachers	3	Raven's Standard Progressive Matrices	Quan	Reasoning competence
		4 target classes	114	APAP Numeracy Skills	Quan	Numeracy competence
		4 control classes	112	APAP English skills	Quan	English competence
		Phase three: 1 teacher	1			
		2 target classes	89			
		2 control classes	90			

APPENDIX G

Numeracy test in isiXhosa

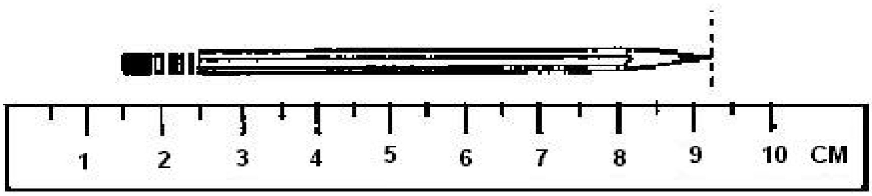
UBUCHWEPHESHE BOBUGCISA KUMANANA NEZIBALO

<u>ICANDELO 1 : UBUCHWEPHESHE BOBUGCISA KUMANANI</u>

1.1	Bhala esi sivakalisi sibe linani. Amawaka angamashumi amabini anamakhulu amabini anesithandathu.
1.2	102 – 36 =
1.3	1 048 + 21 376 =
1.4	$23 \times 145 =$
1.5	$168 \div 12 =$
1.6	Dibanisa olu luhlu lwamanani lulandelayo. 213, 4 017, 1273, 2 198, 21

2. Lo mzobo ungezantsi ubonisa ukusetyenziswa kwerula ukulinganisa ubude bepensile.

- Ubude bepensile bungama-.... eesentimitha



3. Impahla yesikolo kaSiseko ixabisa ama-250 eeRandi iyonke. Le tshati ibupayi ilandelayo ibonisa imali echithwe ngabazali bakhe kwisinxibo ngasinye.

a. Leliphi iqhezu lama-250 leeRandi elichithwe kwi:
   i. Ibhatyi yesikolo
   ii. Ibhegi yesikolo
   iii. Izihlangu

3.2 Yimalini echithwe kwi:
   i. Ibhatyi yesikolo
   ii. Ibhegi yesikolo
   iii. Izihlangu

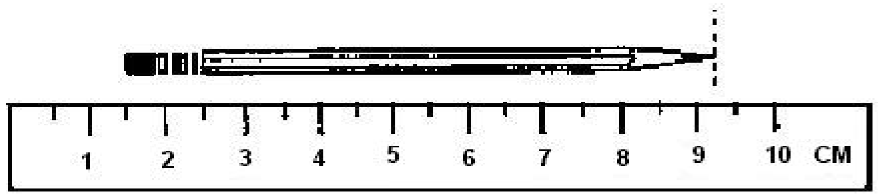
b. Ithini ipesenti echithwe kwibhatyi yesikolo?

Numeracy test in English

1.1	Write the following number in numerals: twenty thousand two hundred and six.
1.2	102 – 36 =
1.3	1 048 + 21 376 =
1.4	23 x 145 =
1.5	168 ÷12
1.6	Add the following list of numbers: 213, 4 017, 1 273, 2 198, 21

2. The diagram below represents a ruler being used to measure the length of a pencil.

- The length of the pencil is __________ cm.



3. Siseko's school uniform costs R250 altogether. The following pie chart shows how much money her parents spent on the different items.

3.1 What fraction of the R250 was spent on :

3.1.1 The blazer ____________________

3.1.2 The school bag __________

3.1.3 The shoes __________

3.2 How much money was spent on:

3.2.1 The blazer __________

3.2.2 The school bag __________

3.2.3 The shoes __________

3.3 What % of the R250 did the blazer cost? ___________

APPENDIX H

Grade 7 Exploratory Talk Classroom Observation Checklist

Observer: ____________________________ Grade and class: 7_____

School: ______________________________ Date: _____________

Teacher: _____________________________

Trigger used: ____

Math topic: ____

Criteria				
Physical class environment	Rows	Pairs	Groups	
Introduction	Not clear	Need clarification. Some confusion.	Clarification given but still a little confusion	Clear instructions. No confusion
Explanation of task	Not clear	Need clarification. Some confusion.	Clarification given but still a little confusion	Clear instructions. No confusion
Teacher's Questions	Require one word or chorused answers	Closed. Require first order thinking answers	Some reasoning and explanation required	Open ended. Require higher order thinking
Group work	Learners work on own	Some talk between peers	Reasonable amount of talk between peers	A great deal of talk between pairs
Whole class discussion	Teacher-to-learner talk only	Learners chorus or one sentence answers	Learners interact with teacher reasonably	Two-way participation.
Teacher's use of language	All English	Mainly English	Mainly isiXhosa	All isiXhosa
Learners' use of language in whole class	All English	Mainly English	Mainly isiXhosa	All isiXhosa
Learners use of language with individual peers or teacher	All English	Mainly English	Mainly isiXhosa	All isiXhosa
Classroom climate	Authoritarian atmosphere; no interaction	Little interaction	Some social, communication	Relaxed, conducive to learning
Ground Rules for exploratory talk	None adhered to	Some adhered to	Most adhered to	All adhered to

Did the teacher use question-and-answer sequences to guide the development of understanding? Comment

____

____

Did the teacher teach procedures for problem solving and sense making? Comment

____

____

Was learning a social communicative process that encouraged reasoning? Comment.

____

____

	Purpose of questioning	Tick box	Comments
	Did the teacher ask convergent questions?		
	Did the teacher ask divergent questions?		
Introduction	to establish human contact		
	to assist in introducing a topic		
	to discover what the class knows		
	to revise previous work		
	to pose problems		
Explanati on	to maintain interest and alertness		
	to encourage reasoning and logical thinking		
	to discover if learners understand		
Whole class	Focus and clarify		
	Lead learners to make observations and draw inferences		
	Clear up difficulties and understandings		
	Help individual learners		
Conclusion	Revise main points of lesson		
	Test learners understanding		
	To suggest further problems and related issues		
	to test the results of the lesson		