GRADE 9 SECOND-LANGUAGE LEARNERS IN TOWNSHIP SCHOOLS: ISSUES OF LANGUAGE AND MATHEMATICS WHEN SOLVING WORD PROBLEMS

by

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Submitted in fulfilment of the requirements for the degree of

Philosophae Doctor Educationis

in the Faculty of Education

at the Nelson Mandela Metropolitan University

Port Elizabeth

South Africa

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November 2010

DECLARATION BY CANDIDATE

I, Johannes Percy Sepeng, hereby declare that this thesis, submitted for the qualification of *Philosophiae Doctor Educationis* in the Faculty of Education at the Nelson Mandela Metropolitan University has not previously been submitted to this or any other university. I further declare that it is my own work and that, as far as is known, all material used has been recognised.

Signature: Percy Sepeng

Date: November 2010

ACKNOWLEDGEMENTS

Firstly, I wish to thank God the Almighty for giving me wisdom and strength to complete this PhD. The writing of this thesis was a unique experience in which many people contributed in a unique way and are worth mentioning:

My deepest appreciation and gratitude goes to Professor Paul Webb, my supervisor, for his invaluable guidance, support, scholarly insight, encouragement, and guidance throughout this study.

Special thanks go to the following people: Professor E.M. Lemmer of the University of South Africa, who edited this text; Danie Venter of the Department of Statistics; Marina Ward and Maggie Breda, Senior Librarians; Vernon Naidoo, Tata Patrick Mbokodi, Siya Libi, principals, mathematics teachers and learners who participated in this study.

I further acknowledge the support that I received from my colleagues, Dr Jeff Ilsley, Prof Hugh Glover, Dr Lyn Webb, Dr Andre du Plessis, Dr Raj Kurup, Dr Lonnie King, Dr Mary Grace Villanueva, Dr Sindi Mbokodi, Clyde Felix, Vukile Tshazibana, Nokhanyo Mayaba and all who have contributed to the ongoing dialogue that has helped me shape my thinking.

I am especially grateful to my wife and better-half, Pauline, for her love and sacrifice throughout the completion of this degree. Many thanks go to my son and daughter, Resego and Neoentle, your patience and understanding made it possible for me to be ‘away’ while at home. I could not have made it without you. Enjoy reading this work.

Lastly, I would like to record special thanks to my siblings and parents, especially my mother, who encouraged me throughout my educational endeavours. You are our true heroine.

ABSTRACT

Second language (English) learning of mathematics is common in South African mathematics classrooms, including those in the Eastern Cape Province of South Africa where isiXhosa speakers are taught in the language that is not spoken at home by both teachers and learners. The purpose of this research was to investigate issues of language, both home (isiXhosa) and the language of learning and teaching (LoLT), i.e. English, when 9th grade second language learners engage in problem-solving and sense-making of wor(l)d problems in multilingual mathematics classrooms. In addition, the aim of the study was to explore whether the introduction of discussion and argumentation techniques in these classrooms can ameliorate these issues. The study used a pre-test – intervention – post-test mixed method design utilising both quantitative and qualitative data. The data collection strategies for the purpose of this study included interviews (learners [n=24] and teachers [n=4]), classroom observations, and tests (experimental [n=107] and comparison [69]) in four experimental and two comparison schools in townships of Port Elizabeth. This study is framed by socio-cultural perspective which proposes that collective and individual processes are directly related and that students' unrealistic responses to real world problems reflect the students' socio-cultural relationship to school mathematics and their willingness to employ the approaches emphasised in school.

Analysis of the data generated from pre- and post-tests, interviews and classroom observation schedule suggest that the interventional strategy significantly improved the experimental learners' problem-solving skills and sense-making abilities in both English and isiXhosa (but more significantly in English). The statistical results illustrate that the

experimental group performed statistical significantly ($p < .0005$) better in the English post-test compared to comparison group ($\Delta\overline{\chi} = 29.14$ vs. $\Delta\overline{\chi} = 8.13$). The data also suggests that the interventional strategy in this study (discussion and argumentation techniques) positively influenced the participating learners' word problem-solving abilities. The experimental group appeared to show a tendency to consider reality marginally better than the comparison group after the intervention. In particular, learners seemed to make realistic considerations better in the isiXhosa translation post-test compared to the English post-test ($\Delta\overline{\chi} = 0.69$ vs. $\Delta\overline{\chi} = 0.47$). A large practical significant ($d = 0.86$) difference between the experimental group and the comparison group was also noted in the isiXhosa translation compared to a moderate practical significance ($d = 0.57$) noted in the English tests after the intervention. As such, the results of the study suggest that the introduction of discussion and argumentation techniques in the teaching and learning of mathematics word problems had a positive effect on learners' ability to consider reality during word problem-solving in both languages.

Analysis of learners' interviews suggests that, although English is the preferred LoLT, they would prefer dual-use/parallel-use of English and isiXhosa for teaching and learning mathematics. There was also evidence of the benefits of code-switching throughout most of the lessons observed, coupled with instances of peer translation, and/or re-voicing. Overall results in this study illustrate that number skills displayed and mathematical errors made by learners seem to be directly related to language use in the classroom.

KEYWORDS: Argumentation; Bi/Multilingual; Code-switching; Colonial language; learner; Disconnect; Discourse; Discussion; Language; Learner; Mathematics; Problem-solving; Realistic considerations; Real-wor(l)d problems; Sense-making.

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ABBREVIATIONS

ABBREVIATION	MEANING
ANOVA	Analysis of Variance
CERTI	Centre for Educational Research, Technology and Innovation
DoE	Department of Education
EI	English-isiXhosa
ISDI	Integrated School Development and Improvement
IE	isiXhosa-English
LoLT	Language of Learning and Teaching
LiEP	Language-in-Education Policy
NCCRD	National Centre for Curriculum Research and Development
NCTM	National Council of Teachers of Mathematics
NCS	National Curriculum Statement
NMMU	Nelson Mandela Metropolitan University
NR	No Reaction
OR	Other Reaction
PS	Problem-Solving
RR	Realistic Reaction
PWRC	Real-life Mathematical Word problems Without Real Context
PWRM	Real-Life Mathematical Word problems Without Real Meaning
SASA	South African Schools' Act
TIMSS	Third International Mathematics and Science Study

DEDICATIONS

This thesis is dedicated to my wife and better-half, Pauline, my son, Resego and my daughter, Neoentle, for their sacrifice and support over the period of study. Without your encouragement, it would have not been possible.

Also to my beloved parents, Mr. & Mrs. Sepeng: You emphasised the value of education and had a great influence on my life.

CHAPTER ONE

INTRODUCTION AND OVERVIEW

1. INTRODUCTION

Despite the fact that South Africa is a democratic, multilingual, and multicultural country, the majority of its learners learn mathematics in English, which is a second or foreign language to them (Secada, 1992) and which appears to negatively influence their mathematics achievement (Setati, 1998). A number of mathematics education researchers (Adler, 2001; Brenner, 1994; Cocking & Mestre, 1988; Gutiérrez, 2002; Khisty, 1995; Moschkovich, 1999, 2002; Secada, 1992; Setati, 1998; Setati & Barwell, 2006; Warren, Ogonowski, Rosebery, & Hudicourt-Barnes, 2000; Webb & Webb, 2008a) have offered a variety of interpretations or explanations for the low mathematics achievement found among English second language learners. The supposition that low mathematics achievement is because learners cannot read and write in English and do not understand their school's medium of instruction provides a unifying thread throughout. In particular, understanding the language of mathematics and/or word problems entails contexts which require a deeper understanding of English than is often found in English second language classrooms (Brown, 2001).

Moschkovich (2002) suggests that students' mathematical sense making is grounded in their everyday discourse practices, which originate in the home and within local communities. Furthermore, teachers do not attend to the gestures, representations, and everyday descriptions that second language learners draw on to create and communicate meaning; thus, they inadvertently miss the multiple, rich resources that students bring to the classroom (Na'lah, Hand & Taylor, 2008). Such explanations raise questions regarding the role of language proficiency, the importance of the language of instruction, and the notion that mathematics can be learned independent of language skills. As such, this study investigates issues of language, both home and language of learning and teaching, when ninth grade English second language learners engage in problem-solving and sense making of wor(l)d (word problems in a real-world context) problems in the multilingual mathematics classrooms of marginalised township secondary schools.

2. LANGUAGE USE IN SOUTH AFRICAN SCHOOLS

There is a continuing debate in South African education regarding language use for teaching and learning in multilingual classrooms (e.g., Güles, 2005; Howie, 2003, 2004). This debate centres on the language that should be used for teaching, learning, and assessment. In this country an overwhelming majority of township and rural schools officially use English as a language of teaching and learning and for assessment purposes, despite the fact that the learners in these schools often have little contact with and access to English (Taylor & Vinjevold, 1999). The learners often have low reading, speaking and writing abilities and struggle to comprehend texts that are written in English (Mayaba, 2009).

Barkhuizen (2002) points out that English has often been stated as the language of progress, power and economic success and suggests that the African languages, despite large numbers of speakers, simply cannot compete with the status of English, a situation which challenges the aim of setting up a truly multilingual society in Africa. Constitutionally, the South African government promotes multilingualism through its Language-in-Education Policy (LiEP), which allows schools to use more than one LoLT (Setati, Adler, Reed & Bapoo, 2002). However, the LiEP has encountered implementation constraints and has been censured by language experts (Granville, Janks, Mphahlele, Reed, Watson, Joseph, & Ramani, 1998), who suggest that it may not succeed in altering the prestige and power of

English. Reports (see for example, Taylor & Vinjevold, 1999; National Centre for Curriculum Research and Development [NCCRD], 2000; Setati, 2008; Mayaba, 2009) have shown that most schools are not opting for their learners' home languages as their LoLT. Consequently, there is an increase in English language instruction and a decrease in primary language instruction in South African classrooms.

The importance of language in learning is well established (Vygotsky, 1978). How language in mathematics classrooms mediates meaning making and instructional practice (Cobb, Wood, & Yackel, 1993; Forman, 1996; Lemke, 1990; Lerman, 2001; Van Oers, 2001), as well as differential access for second language learners (Brenner, 1994; Gutiérrez, 2002; Khisty, 1995; Moschkovich, 1999, 2002) has been the focus of significant research during the past few decades. Within these discussions language has been conceived in countless ways and related to the nature of mathematical talk in the classroom, the discourse practices entailed in the learning of mathematics and the challenges and opportunities of linguistically and culturally diverse mathematics classrooms.

Researchers (Secada, 1992; Setati, 2002; Setati, Chitera & Essien, 2009) have provided an extensive overview of research on *bilingual* education and *mathematics achievement*. They pointed to findings of a significant relationship between the development of language and achievement in mathematics. Howie's (2003 & 2004) analysis of the performance of South African learners in the Third International Mathematics and Science Study (TIMSS) of 1995, identified learner proficiency in English as a strong predictor of success in mathematics. Contrary to Howie's findings, recent reports suggest that poor performance in mathematics cannot be solely attributed to the learners' limited proficiency in English in isolation from the pedagogic issues specific to mathematics as well as the wider social, cultural and political factors that ingrain schooling (Setati et al., 2009).

3. PROBLEMS IN MATHEMATICS EDUCATION IN SOUTH AFRICA

A review of South African research in mathematics education during the past decade (see Setati et al., 2009) provides seemingly contradictory messages, such as that learner proficiency in English translates to gaining epistemological access and conversely, that teachers should be encouraged to draw on the learners' home language as a resource. Although there are suggested teaching strategies and/or techniques (such as code-switching, translation, re-voice, etc.) that draw on and promote the use of the learners' home language(s) as a resource in South African multilingual classrooms, reports (e.g., Akindele & Letsoela, 2001; Setati, 2005b) indicate that teachers make gross errors in their attempts to code-switch and translate from LoLT to the home language of learners. Chitera (2009) argues that translation in a multilingual mathematics classroom is inevitable as most of the classrooms follow prescribed textbooks and other learner support materials that are written in English. Nevertheless, in so doing, mathematics classrooms are faced with challenges of implementing these proposed techniques without diluting or filtering the mathematics content that is taught – something to be considered in the light of the fact that learning mathematics in a language that is not the learners' first, main or home language (Setati et al., 2009) has been criticised as being both a vehicle of acculturation and an easily recognisable trait for maintaining privilege (Barwell, Barton & Setati, 2007).

3.1. Solving word problems

Problem-solving and integrated assessment are seen as the cornerstones of school mathematics and the Principles and Standards for School Mathematics (National Council of Teachers of Mathematics [NCTM], 2000) called for mathematics instruction and assessment to focus more on conceptual understanding than on procedural knowledge or rule-driven computation (Hamilton, 2004; Kilpatrick, Swafford & Findell, 2001). Major arguments for including word problems in the school mathematics curriculum have always been the potential role to promote realistic mathematical modelling and problem-solving and for the development in learners of the skills in being aware of when and how to apply classroom mathematical knowledge and everyday-life knowledge when solving problems.

Some students perform poorly in mathematics and have concurrent reading difficulties, whereas others perform poorly in mathematics yet relatively well in reading, (Gross-Tsur, Manor & Shalev, 1996). Students may struggle concurrently with reading and mathematics due to weak phonological processing skills (Hecht, Torgesen, Wagner & Rashotte, 2001; Robinson, Menchetti & Torgensen, 2002), whereas mathematics difficulties that occur without concurrent reading difficulties may be due to poor number sense (Robinson et al., 2002). Word problems may be challenging due to the variety of skills needed to solve these problems (Parmar, Cawley, & Frazita, 1996). That is, to solve a word problem, students must use text to identify missing information, construct a number sentence and set up a calculation problem for finding the missing information (Fuchs, Seethaler, Powell, Fuchs, Hamlett & Fletcher, 2008).

Research demonstrates that denotative teaching in both story grammar and story mapping has positive effects on the reading comprehension skills of elementary and secondary students with and without learning disabilities (e.g., Boulineau, Hagan-Burke & Burke, 2004; Dimino, Gersten, Carnine, & Blake, 1990; Gardill & Jitendra, 1999). Story grammar and story mapping can serve as tools to aid students in organizing and representing the internal structures of stories and therefore improve their comprehension (Sorrell, 1990). Other studies have found systematic differences in children's word problem–solving performance levels (Judd & Bilsky, 1989; Lewis & Mayer, 1987; Moreno & Mayer, 1999). Judd and Bilsky (1989) conclude that comprehension is the most important source of problem difficulty and individual differences in children's mathematical problem performance, because children do not yet have a repertoire of highly automatised schemata for representing the different problem types.

3.2. Discussion and dialogue in mathematics classrooms

There is now a prominent body of empirical and theoretical grounds that demonstrates the good outcomes of participating in mathematical dialogue in the classroom (e.g., Forman, Larreamendy-Joerns, Stein, & Brown, 1998; Fraivillig, Murphy, & Fuson, 1999; Goos, 2004; Hicks, 1998; Kazemi & Franke, 2004; Lampert & Blunk, 1998; Manouchehri & Enderson, 1999; McClain & Cobb, 2001; Mercer, 2000; O'Connor, 1998; Sfard & Kieran, 2001; White, 2003; Wood, Williams, & McNeal, 2006). What these researchers have demonstrated is that effective and quality instructional practices demand students' mathematical talk. Unfortunately, little authentic discussion has been seen in South African classrooms (Moschkovich, 1999; Taylor & Vinjevold, 1999; Webb, 2006, Webb, 2010).

Wood (2006) found variation in students' ways of seeing and reasoning, and these were assigned in the first place to the particular differences established in classrooms early in the year pertaining to *when* and *how to contribute* to mathematical discussions and *what to do as a listener*, consistent with findings reported by a number of other researchers (e.g., Dekker & Elshout-Mohr, 2004; Ding, Li, Piccolo & Kulm, 2007; Gillies & Boyle, 2006; Webb, Nemer & Ing, 2006). Moreover, participation obligations put boundaries around the opportunities for students to share their ideas and to engage in mathematical practices (Ding et al., 2007; Fuchs, Fuchs, Mathes, & Simmons, 1997; Veenman, Denessen, van den Akker & van der Rijt, 2005; Webb et al., 2006).

Webb, Williams and Meiring (2008) suggest the value of introducing concept cartoons and argumentation writing frames in South African schools within the current curriculum to promote classroom discussion and argumentation. In usual textbook word problems the students are required to make meaning out of symbolically described situations whereas, through cartoons, researchers (Lesh & Doerr, 2003) want learners to make symbolic descriptions out of meaningful situations. The concept cartoons, which are cartoon-style drawings showing different characters arguing about everyday situations, are not meant to be humorous but are designed to provoke discussion and stimulate thinking (Webb et al., 2008).

4. PROBLEM STATEMENT

Perhaps the most difficult task or challenge that faces educators today is the ability to employ a variety of strategies-based approaches in the use of language (LoLT and/or home) as a resource and pedagogies that will enable them to teach learners to become efficient problem-solvers in multilingual mathematics classrooms. Given the complexity of teaching mathematics in multilingual classrooms of marginalised schools where the LoLT is not spoken at home, connection between classroom mathematics activities and everyday-life knowledge and/or experiences of both teachers and learners is far from being accomplished. As a result, the real-life application of mathematics and sense-making of verbal problems to solve problem situations in the real world, otherwise referred to as 'mathematical modelling', is viewed as a complex process that cannot be achieved in township classrooms. This view is a product of conventional curricula, which emphasises only procedural understanding and declarative knowledge, at the expense of conceptual knowledge, and focuses on computational skills rather than applying mathematics to real-world situations (Montague, Warger & Morgan, 2000).

This study is embedded in the assumption that learners' poor problem-solving and tendency to relegate or suspend sense-making of word problems is a result of learners' socio-cultural backgrounds and teachers' inability to teach mathematics through problem-solving using effective pedagogies. It is therefore against this background that the study sought to investigate issues of language and realistic considerations when learners solve word problems in secondary mathematics classrooms.

5. RESEARCH QUESTIONS

This study is framed by a socio-cultural perspective (Cooper, 1998) which proposes that collective and individual processes are directly related, and students' unrealistic responses to real world problems reflect the students' socio-cultural relationship to school mathematics and their willingness to employ the approaches emphasised in school. From a socio-cultural perspective, modelling or problem-solving implies engaging in inter-semiotic work. In other words, one has to decide about the appropriate and useful manners of coordinating linguistic categories and mathematical expressions and operations in order to come to a solution problem (Säljö, Riesbeck, & Wyndham, 2009). In inter-semiotic meaning-making, the truth value of statements and arguments are established on the basis of analytical considerations of how a particular usage of concepts fits into the universe of meaning that is mathematical discourse.

As such the research seeks to investigate issues of language, both home and LoLT, when ninth grade English second language learners engage in problem solving and sense-making of wor(l)d problems in multilingual mathematics classrooms of marginalised township secondary schools. The study further aims at exploring whether the introduction of discussion and argumentation techniques in these classrooms can ameliorate these issues, and to answer the following research question:

> What issues of language (home and LoLT) play a role in grade 9 second-language learners' mathematical problem solving abilities in township schools

and can these issues be ameliorated by promoting discussion and argumentation techniques in mathematics classrooms?

In order to address the research question, the following research objectives were identified:

- Identify the language used by both the teacher and learners in a sample of township schools in Port Elizabeth, South Africa, when teaching and learning takes place in multilingual mathematics classrooms;
- Design and implement an intervention at teacher level to promote the introduction of discussion and argumentation as teaching strategies to improve effectiveness of classroom participation and discourse;
- Track problem solving abilities and sense-making of both teachers and learners before, during and after an intervention in the classrooms; and
- Check whether the introduction of discussion and argumentation into classroom practice has an influence on learners' sense-making and problem-solving abilities.

The sub-questions, which emanate from these objectives and the research question are:

- Do the learners solve word problems better in their first language or the LoLT?
- Are the number (algebraic) skills and errors that the learner's exhibit related to the language used or are they generic?
- Does the introduction of discussion and argumentation into classroom practice influence learner's sense-making and/or the problem solving abilities?

6. METHODOLOGY

Both quantitative and qualitative methods were used following a pre-test – intervention – post-test design. The study can be viewed as a mixed method design with quantitative data informing the qualitative results (Babbie & Mouton, 2008). Quantitative data were gathered from the baseline and post-testing of sense-making problem-solving abilities of learners. Six township secondary schools were chosen as a convenience sample of a cluster of similar schools in Port Elizabeth. The sample consisted of ninth grade learners (n=176) from four experimental (n=107) schools and two comparison (n=69) schools. Half of the experimental group and half of the comparison group wrote the test in isiXhosa translation first and then immediately repeated the test in English; the other half wrote the same test in English and then in isiXhosa. The test helped me to establish how the learners use language (and the problems they experience) to solve mathematics problems in isiXhosa (learners' home language) and English (language of learning and teaching) and what problems they may have mathematically.

The teacher intervention took place over 6 months period in the form of teacher workshops on word problem solving, language used in word problems, and aimed at improving teachers' content knowledge and pedagogical content knowledge in the teaching and learning of real wor(l)d problems. Teachers attended the workshops at the Missionvale campus of the Nelson Mandela Metropolitan University (NMMU) in the afternoons, and face-to-face workshops were also conducted at teachers' schools.

A sample of grade nine learners (focus group) was interviewed after the pre-test (the questions asked were informed by the results of the pre-test) to find out where they had problems and why they solved the word problems the way they did. The focus group interview, together with classroom observations and semi-structured teacher interviews, generated qualitative measures. The semi-structured interviews at both teacher and learner levels, aimed at understanding their experiences and the meaning they make of those experiences. The interviews were also used to measure the extent at which the language policy in their schools influences their current practice regarding the use of languages in their multilingual mathematics classes.

The classroom observation schedule data, supported by field notes, produced both qualitative and quantitative results. The baseline observations were done just before the beginning of the intervention, with the object of understanding the nature of instruction in the multilingual classrooms of the experimental group. The information collected from these observations informed and advised the planning and implementation of the intervention in this study. The observations during and after an intervention were done with the aim of measuring teachers' implementation of the strategies that they have learnt during the teacher workshops. Teachers from experimental schools were trained on how to get learners discussing, arguing, and writing about their views and experiences when they solve mathematics word problems.

The sample and setting, research design, and methodologies used in this study are discussed in greater detail in chapter three.

7. ETHICAL ISSUES

Both teachers and learners were assured of confidentiality and anonymity, that participation was voluntary, and given a guarantee that they could withdraw from the study at any time and that no personal details would be disclosed. Confidentiality of information collected in the schools was also ensured, and that no portion of the data collection would be used for any purpose other than this research. Informed consent from participants was requested and obtained after prior permission to conduct this research, as part of the

Integrated School Development and Improvement (ISDI) project offered by the Centre for Educational Research, Technology and Innovation (CERTI) at NMMU, was granted by the Education, Research Technology, and Innovation Committee (ERTIC) of the NMMU.

8. CHAPTER SUMMARY AND THESIS OUTLINE

In this chapter the research problem, the aim of the research, the research objectives to be achieved in this study, and the research questions were presented. The nature of multilingual classes in South African contexts where the language of learning and teaching is not easily accessible and is very limited in terms of both teachers and their learners was discussed. The theoretical orientation of this study, research methodology, sampling and data collection instruments used were outlined and the organisation of the study was presented.

In chapter two literature relevant to the research topic is reviewed in terms of recent debates on real-wor(l)d problem-solving, sense-making of word problems in general, and connecting classroom mathematics teaching and learning to the everyday real-life experiences in multilingual mathematics classrooms. Both historical and mathematical contexts of language issues in South African schools, in terms of pre- and post-apartheid eras, and during colonial times were discussed. The literature review about Language in Education Policy (LiEP) in South Africa highlights the discourses on the appropriate language to be used as LoLT in schools, and its implications for the teaching and learning of mathematics in multilingual classrooms.

Chapter three presents an account of the theory that frames this study, the research design and methodology, and the rationale for selecting mixed-methods. Ways were discussed in which the sample for this study emerged as well as the procedures for data collection through baseline testing, focus group discussions, interviews and classroom observations used, and how data were analysed and interpreted. In this chapter issues of validity and reliability were considered in greater depth than has been done in this chapter.

Chapter four reports on the quantitative and quantitative data that were generated in this study and the results of the data analysis and findings of the research are examined and triangulated. In chapter five the results reported in chapter four are interpreted and discussed, with reference to the research objectives outlined in chapters one and three, respectively. The results of each subsidiary question are addressed in terms of the theoretical underpinnings stated in prior chapters.

Chapter six presents the relevance and implications of the findings of this study discussed in chapter five for the intervention strategy introduced to a limited number of teachers during the intervention. Recommendations and implications for both future research and practice are outlined in this chapter.

CHAPTER TWO

LITERATURE REVIEW

1. INTRODUCTION

The aim of this chapter is to provide a review of research about the issues of language and mathematics in multilingual classrooms. The study is framed by communicative and socio-cultural perspectives (Lemke, 1995; Mercer, 1995, 2004; Vygotsky, 1978) and includes ideas on teachers' perceptions on the use and choice of language of learning and teaching in schools where the LoLT is not the learners' home language. Issues of bilingualism, mother tongue instruction, code switching, discussion, argumentation, and concept cartoons are explored in the light of the current language patterns in South African mathematics classrooms.

The chapter is divided into six sections. The first section focuses on literature that provides insight into studies about mathematics achievement in South Africa and elsewhere in the world. The second section reviews literature about the implementation of LiEP in South African schools. The third section explores the benefits of promoting discussion and argumentation in classrooms, while literature related to the use of concept cartoons is presented in the fourth section. The fifth section discusses mathematical word problem-solving in multilingual mathematics classroom settings, and finally, the results and implications of the research documented so far are assessed in the light of the current study.

2. MATHEMATICS ACHIEVEMENT

Factors associated with achievement in general include motivation (Skuy, Schutte, Fridghon & O'Carrol, 1996); personality characteristics (Van Eeden, De Beer, & Coetzee, 2001); gender (Adadayo, 1999; Van Rooyen, 2001); race (Walker & Plata, 2000); and home-language (Paras, 2001; Van Rooyen, 2001); student intelligence (Flynn, 1991; Lynn, 1991), self-esteem and self-efficacy (Leung, 2002; Stevenson, et al., 1993; Wilkins, 2004); academic expectations and effort (Chen & Stevenson, 1995; Chiu, 1987; Johnson, 1996; Tuss, et al., 1995); family education values, expectations, and support (Crystal & Stevenson, 1991; Hess, et al., 1987; Huntsinger, et al., 2000; Patterson, et al., 2003); as well as language clarity, word structure, and patterns (Geary et al., 1993; Han & Ginsburg, 2001; Li & Nuttall, 2001; Miller, Major, Shu & Zhang, 2000; Miura, Kim, Chang, & Okamoto, 1988; Rasmussen et al, 2006) have been shown to have an effect on mathematics achievement. As this study focuses on issues of language and mathematics when learners in previously disadvantaged 'Black' schools solve word problems, the possible relationships between school, teacher, race and language are discussed below.

2.1. School level factors related to achievement

Previous research has identified a number of school level factors that influence achievement. A review by Greenwald, Hedges and Laine (1996) reveals that class size has a minor effect on achievement. Leadership, organisation and management have been identified as important factors by school effectiveness researchers, whilst school improvement researchers (Gray, Hopkins, Reynolds, Wilcox, Farrell & Jesson, 1999) have concentrated on decision-making, within-school hierarchy and communication. However, other findings in school effectiveness studies (e.g., Sammons, 1999; Teddlie & Reynolds, 2000) show that school-level factors influence achievement far less than do factors at the class-level. Rather, textbooks, teacher quality and time have been identified as key factors emerging from school instructional effectiveness research (Creemers, 1996; Darling-Hammonds & Sykes, 2003; Johnson & Kritsonis, 2007; Riddell, 1997).

2.2. Teacher level factors related to achievement

The instructional practices of teachers who are highly qualified and who have strong pedagogical and mathematical knowledge are of a higher quality than those who do not (Darling-Hammonds & Sykes, 2003). Students in schools in the United States (US) with large numbers of Black students and low-income populations have fewer qualified teachers than schools that have largely White populations (Darling-Hammonds & Sykes, 2003). These findings suggest that minority students in the US are less likely to be taught by teachers with strong pedagogical and mathematical knowledge, which could be a contributing factor to the mathematics achievement gap in other countries like the US (Johnson & Kritsonis, 2007).

2.3. Race and achievement in mathematics

A number of researchers suggest that lower achievement by Black students may be a result of the curriculum and instruction that these students receive (Johnson & Kritsonis, 2007). Lubienski (2001) found that the gaps between Black and White students were more attributable to race than socio-economic differences. Ferguson (1998) believes that teachers' expectations, perceptions and behaviours sustain and even expand the Black-White achievement gap, and that these effects accumulate from kindergarten through high school.

It has been found that, generally, teachers form different expectations of students as a function of race, gender and social class, and these expectations seem to be established in different ways (Baron, Tom, & Cooper, 1985; Secada, 1992). Jussim, Eccles, and Madon (1996) reported that teacher expectations and perceptions had a significant effect on sixth grade students' grades and performance on a standardized mathematics assessment. They found that teacher expectations were almost three times greater for Whites than for African-American students, and that the effects were larger for girls and low-income students. In his study on teacher expectations and the achievement gap, Ferguson (1998) concluded that effects of teacher expectations could be substantial if the effects accumulate from kindergarten to high school. Similarly Berry (2003, 2004) reported that African American male middle school students experienced lowered expectations from their mathematics teachers. He contended that these lowered expectations affected their achievement in mathematics and their opportunities to gain access to high-level mathematics courses.

2.4. Language and achievement in mathematics

The mathematics achievement gap between English Second Language learners and English First Language speakers has been well documented (Secada, 1992; Strutchens, Lubienski, McGraw, & Westbrook, 2004; Tate, 1997). Internationally and in South Africa, there is no long history of research into the specific mathematics schooling experiences of English second language learners. However, in the past few decades a growing number of scholars in the (mathematics) education community have suggested expanding the sphere of mathematics education research into the socio-cultural arena in order to understand the schooling and mathematics outcomes of these learners more fully (e.g., see Atweh, Forgasz, & Nebres, 2001; Boaler, 2000; Burton, 2003; Gates & Cotton, 1998; Powell & Frankenstein, 1997; Secada, Fennema, & Adajian, 1995; Walshaw, 2004). Such research originates outside the realm of 'traditional' mathematics education research and theory and supports Weissglass' (2002) assertion that the historical contexts and the socio-cultural structures in which mathematics and mathematics teaching and learning are embedded have a significant effect on students' mathematics learning and performance, especially on those students who have been historically marginalised.

In South Africa, as in many previously colonised countries in Africa and Asia, there is an added level of complexity in terms of learner achievement in mathematics (Alidou & Brock-Utne, 2005). This added level of complexity hinges on the fact that mathematics is both taught and learned in a second language (English) in a majority of schools in both rural and urban areas (Taylor & Vinjevold, 1999; Fleisch, 2008). For this reason issues of second language learning of mathematics are an integral part of this study and are discussed below.

3. LANGUAGE POLICY IN SOUTH AFRICAN SCHOOLS

This section provides a description of literature and some of the debates on the preferred language use for teaching and learning mathematics in South Africa, and its implications for mathematics pedagogy. The LiEP in South Africa is also discussed.

3.1. Language use in pre- and post-Apartheid South African schools

In South Africa, prior to Nationalist Rule in 1948, there was a relatively loose policy of ‘mother tongue instruction’ which varied from province to province (Hartshorne, 1992). After the Nationalist Government took over power in 1948, legislation was passed and the resources necessary to establish Afrikaans alongside English as a fully fledged official language of teaching and learning (LoLT) in South African schools were extended (Adler, 2001). All learners in minority white, coloured and Indian schools were required to take both Afrikaans and English throughout the basic education of their schooling, one language spoken at home as first language, and the other either at first or second language level.

The Bantu Education Act of 1953 changed the language policy in South African schools which fell under the government’s segregated Department of Education and Training schools (i.e., schools for Black children) in order to extend the use of mother tongue and Afrikaans. By 1959 all eight years of primary education were done in mother tongue and secondary education used English and Afrikaans for instruction in a ratio of 50:50 in these schools. In order to implement this new policy all teachers in Black schools were given five years to become competent in Afrikaans via the intensive in-service Afrikaans language courses that were offered by the government (Hartshorne, 1992). This official language-in-education policy was specifically and explicitly designed to serve the apartheid state, but it met with fierce resistance culminating in the 1976 Soweto Revolt (Kane-Berman, 1978).

The new South African constitution adopted in 1996 for a democratic South Africa has given the country eleven official languages, with nine African languages (Setswana, Sepedi, Sesotho, Tshivenda, siSwati, Xitsonga, isiNdebele, isiZulu and isiXhosa) being added to English and Afrikaans, the only two languages that enjoyed official status during the apartheid period. The constitution encourages the government of the day to take practical and positive measures to elevate the status and advance the use of indigenous languages which were previously disadvantaged and marginalised by the apartheid government (Constitution of the Republic of South Africa, 1996). The constitution states that everyone has a right to receive education in the official language/languages of their choice in public educational institutions where practicable and multilingualism has been given educational weight by the South African Schools' Act (SASA) which promotes ongoing language-in-education policy initiatives (Adler, 2001).

The government passed legislation on the use of mother tongue instruction (Department of Education, South African Schools Act, 1996) and in 1997 the LiEP (Department of Education, 1997) encouraged schools to promote multilingualism in various ways including using more than one language as the language of learning and teaching (Department of Education, 1997). Adler (2001) points out that not only can South African schools now choose their LoLT, but there is a policy environment that is supportive of the use of other languages other than one favoured LoLT in schools, and so too of language practices like code-switching. The policy also gives the power to the school governing bodies (SGBs) to decide on the language policies of their schools.

3.2. Language of Learning and Teaching: colonial vs. home language

As noted earlier, the importance of language in learning (Vygotsky, 1978) and the mediating role of language in meaning making and instructional practice (Cobb, Wood, & Yackel, 1993; Forman, 1996; Lemke, 1990; Lerman, 2001; Van Oers, 2001) have been the focus of significant research during the past few decades.

There are ongoing debates among scholars on the appropriate language to be used as LoLT, and the implications or gains of using colonial languages (e.g., English in South Africa) or language(s) used by learners at home (e.g., isiXhosa). According to Chitera (2009), some are in favour of colonial languages; others prefer use of home languages. She argues that the use of colonial languages is perceived to offer more benefits for the learners because these languages are commonly used widely elsewhere in the world. Moreover, these languages are seen as a symbol of power, status, prestige and access to social goods (Baldauf & Kaplan, 2005; Gutiérrez, 2002; Setati, 2005a; Tollefson, 1991).

Other researchers (Setati, Molefe & Langa, 2008) call for pedagogical strategy that employs the use of learners' home languages deliberately and transparently (or invisibly) in order to solve real-world mathematics problems in primary classrooms of South Africa. They argue for the increased use of the learners' home language, along with use of English, through dialogue and discussion in order for learners to acquire mathematical reasoning skills.

3.3. Teachers' and learners' perceptions: English vs. isiXhosa

Studies (e.g., Barkhuizen, 2002; Webb, 2010) conducted amongst isiXhosa first language learners throughout the Eastern and Western Cape provinces reported that most learners articulated the belief that speakers of African languages, such as IsiXhosa, do not need to study their home languages because they can speak the language already.

In South Africa, the newly democratic elected government, through the LiEP policy, promotes multilingualism by allowing the schools to use more than one language of learning and teaching (Setati, Adler, Reed, & Bapoo, 2002). In reality the LiEP has met significant field constraints. Reports (Taylor & Vinjevold, 1999; NCCRD, 2000) have shown that most schools are not opting for home languages as LoLT policy and practice, and that there is a consequent increase in English language instruction and decrease in primary language instruction in South African classrooms.

3.4. Implications of LiEP on the teaching and learning mathematics

It is also widely acknowledged that education policies and language-in-education policies are determined by economic interests and political ideologies (Vinjevold, 1999). The LiEP in South Africa implies that mathematics teachers and learners have to negotiate, agree, and decide which language to use, how and when to use it, in the teaching and learning of mathematics in multilingual classrooms. In previously marginalised schools of South Africa, mathematics teachers may prefer to use English, which is the learners' second language, but which they believe provides learners access to power, social goods and prepares them for tertiary education (Setati, 2005a).

Adler (2001) points out that learners whose language of learning and teaching is not their home language tend to communicate in their home language when solving group mathematics tasks in multilingual classrooms. In these classroom settings, teachers have to make a decision whether to promote code-switching between the two languages with the purpose of developing meaning or just to disregard the LiEP, and continue to use English only as LoLT. Setati's (2005b) study in multilingual classrooms of South Africa reveals that teachers are more concerned with providing the best instruction possible that will give learners access to social class, power, higher education and employment. She argues that mathematics teachers feel guilty to code-switch as a teaching strategy because it may deprive their learners of an opportunity to acquire proficiency in English

Therefore, mathematics teachers may be faced with the challenge of disregarding and relegating the LoLT as defined in the LiEP, and rather use whatever they deem to be helpful to their learners.

4. DISCUSSION AND ARGUMENTATION

In mathematics education studies language has been conceived and examined in a number of ways including the nature of mathematical talk or discussion and argumentation in the classroom, the discourse practices entailed in the learning of mathematics, and the challenges and opportunities within linguistically and culturally diverse mathematics classrooms. This section describes literature related to studies in argumentation and talk in general. Different perspectives on classroom interactional pedagogy and discursive psychology are discussed.

4.1. Argumentation and discussion in mathematics classrooms

Argumentation in classroom contexts 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 et al., 2008). The use of discussion as a tool to increase reasoning has gained emphasis in classrooms worldwide, consistent with earlier reports (Yore, Bisanz & Hand, 2003). Discussion, however, requires scaffolding and structure in order to support learning (Norris & Phillips, 2003).

Wood (2006) found variation in students' ways of seeing and reasoning, and these were assigned in the first place to the particular differences established in classrooms early in the year pertaining *when* and *how to contribute* to mathematical discussions and *what to do as a listener*, consistent with findings reported by a number of other researchers (e.g., Dekker & Elshout-Mohr, 2004; Ding et al., 2007; Gillies & Boyle, 2006; Webb et al., 2006). Moreover, participation obligations put boundaries around the opportunities for students to share their ideas and to engage in mathematical practices (Ding et al., 2007; Fuchs et al., 1997; Veenman et al., 2005; Webb et al., 2006).

4.1.1. The Toulmin model and questions of context

Toulmin's *The Uses of Argument* (1958) outlines the double nature of his model for argumentation. On one hand, Toulmin develops a field in variant model applicable to most fields of argument (such as law, mathematics, science, ethics, and "everyday" topics). It contains six interrelated elements:

- a *claim* or the conclusion to be argued for (p. 96);
- *data* or "the facts we appeal to as a foundation for the claim" (p. 97);
- a *warrant* or a "hypothetical" statement that bridges the data and claim and "authorise[s]" the claim drawn from the data (p. 98);
- *qualifier(s)* or a word such as "necessarily," "probably," and "presumably" that indicates how strong a warrant entitles the claim to be (p. 100-101);
- *rebuttal(s)* or the "circumstances in which the general authority of the warrant would have to be set aside" (p. 101); and
- *backing* or field dependent statements that support the warrant linking the data and claim (p. 103-107).

Textbook writers such as McMeniman (1999) have offered *discourse community* as a replacement for *field*. However, Harris (1997) has criticized the term as a naïve phrase, one that emphasizes constructs that people share, but minimizes the serious conflicts that are also present in human interactions. Porter (1992) likewise has argued that a discourse community is only very temporary, best witnessed by its forums (such as publications) in which participants have left traces of their former interactions.

Goodwin and Duranti (1992) perhaps summarize the problem best when they suggest that a single, precise, technical definition of context may not be practicable. Drawing on Ochs' (1979) work, they list several broad categories of contextual attributes, each with a list of possible components:

- setting, or the social and spatial framework within which encounters are situated;
- behavioural environment, such as body language;
- language as context, in which talk itself both invokes context and provides context for other talk; and
- extra-situational context, such as background knowledge and discursive rules.

4.1.2. Toulminian studies

Much research on Toulminian models favours his stable definitions of context over accounting for the participants' understandings of the contexts they co-construct. Several theorists (e.g., Crammond, 1997, 1998; Gasper & George, 1997; Wangerin, 1993) are primarily interested in developing a better abstract description of argumentation or reasoning, and so they avoid questions of context for questions of representation. They may offer different, specific examples of arguments, but their applications of Toulminian models are generally from a single viewpoint - their own (Naylor, Downing, & Keogh, 2001).

In addition, researchers (e.g., Bugallo-Rodriguez, & Duschl, 1997; Carlsen & Hall, 1997; Chinn & Anderson, 1998; Jimenez-Aleixandre, Bugallo-Rodriguez, & Duschl, 1997; Ye & Johnson, 1995) often adopt the model as a static lens for examining arguments in conversations and written texts. Even though they may alter Toulmin's original model for their analyses, they tend to construe these adaptations as stable sets of criteria for coding argumentative utterances.

Most Toulminian studies do not address several key issues which are important for teachers using Toulminian models: how interpretations of the model are dynamic; how students' changing constructions of their contexts define for them what momentarily counts as, for example, a claim; and how these understandings affect their applications of Toulminian terms to their writing. Specialised, limited use of Toulminian models are found in studies (Connor, 1987, 1990; Connor & Lauer, 1988; Ferris, 1994; Knudson, 1992a, 1992b; McCann, 1989; Thornburg, 1991) that have been primarily quantitative and evaluative.

Issues of interest to mathematics educators, such as, knowing, can be examined from the perspective of participants in interaction, rather than as underlying cognitive processes which can be used to explain what people do and say (Edwards, 1997). As Edwards and Potter (1992) acknowledge, this is not to say that people explicitly talk about these things. As Sacks showed, these patterns of interaction arise through the social actions of the participants, actions which bring about the on-going organisation of their talk (see Sacks, 1987). For discursive psychology, the social action through which interaction is organised takes precedence over other aspects of interaction, so that the psychological structures and functions of language became shaped by language's primary social functions (Edwards, 1997).

Edwards and Potter (1992) suggest that such actions might include describing and reporting interesting events, making plans and arrangements, coordinating actions, accounting for errors and absences, accusing, excusing and blaming and refusing invitations. These researchers argue that in mathematics classrooms, such actions might also include describing, explaining, justifying, conjecturing, refuting or having an idea.

Talk is about more than its surface content. Every utterance, for example, also constructs the identity and reflects the interests of the speaker, who may present themselves as, loud or polite, knowledgeable or uncertain, biased or neutral. Each utterance, therefore, reflects the partiality or interest of the speaker (Antaki, 1994). Amongst empirical studies of foreign language attainment, a focus on recycling in local classroom communities can be found in the work of Rampton (1999) who indicated how foreign language teaching is recycled in peer group interactions and participation among adolescents as substantial resources in performance-based identity work. Rampton (2002) points out the role of recurrent routines or rituals in classroom life. Researchers (e.g. Kanagy, 1999; Lunsford, 2002) agree that daily classroom routines provide frameworks for young learners' participation in classroom conversations that go beyond their present level of linguistic competence.

4.2. Classroom interactions

4.2.1. Dialogue and discourse practices

A prominent body of empirical and theoretical findings demonstrates the good outcomes of participating in mathematical dialogue in the classroom (e.g., Forman et al., 1998; Fraivillig, Murphy, & Fuson, 1999; Goos, 2004; Kazemi & Franke, 2004; Lampert & Blunk, 1998; Manouchehri & Enderson, 1999; McClain & Cobb, 2001; Mercer, 2000; O'Connor, 1998; Sfard & Kieran, 2001; Simon & Blume, 1996; White, 2003; Wood, Williams, & McNeal, 2006). What these researchers have demonstrated is that effective and quality instructional practices demand students' mathematical talk.

Quality teaching, then, is a joint enterprise, founded on material, systems, human and emotional support, as well as on the collaborative efforts of teachers to make a difference for all learners (Coburn, 2005). In making a difference through classroom discourse, teachers shift students' cognitive attention toward making sense of their mathematical experiences, rather than limiting their focus to procedural rules. According to Yackel and Cobb (1996), students become less engaged in solutions to problems than in the reasoning and thinking that lead to those solutions. Through the patterns of interaction and discourse created in the classroom students develop a mathematical disposition—ascribing meaningfulness to one another's attempts to make sense of the world. Learning about other ways to think about ideas, to reflect, and to clarify and modify thinking is fundamental to moving learning forward. Carpenter, Franke, and Levi (2003) maintain that the very nature of mathematics presupposes that students cannot learn mathematics with understanding without engaging in discussion and argumentation. More talk in classrooms does not necessarily enhance student understanding. Better understanding is dependent on particular pedagogical approaches, purposefully focused on developing a discourse culture that elicits clarification and produces consensus within the classroom community.

A variety of situations might arise in which the outcome is not fully realized. For example, a number of studies have reported that some students, more than others, appear to thrive in whole-class discussions. In their respective research, Baxter, Woodward, and Olson (2001) and Ball (1993) found that highly articulate students tend to dominate classroom discussions. Typically, low academic achievers remain passive; when they do participate visibly, their contributions are comparatively weaker, and their ideas sometimes muddled.

Nevertheless, pedagogical practices that create opportunities for students to explain their thinking and to engage fully in dialogue have been reported in research undertaken by Steinberg, Empson and Carpenter (2004). In a study from their Cognitively Guided Instruction Project, classroom discussion was central to a sustained change in students' conceptual understanding.

Honouring students' contributions is an inclusive pedagogical strategy. Yackel and Cobb (1996) found that classroom teachers who facilitate student participation, elicit student contributions and invite students to listen to one another, respect one another and themselves, accept different viewpoints, and engage in an exchange of thinking and perspectives exemplify the hallmarks of sound pedagogical practice.

Teaching for inclusion ensures that participation in classroom discussion is safe for all students. Lubienski (2002), as teacher–researcher, focused on the inclusive aspects of classroom dialogue when she compared the learning experiences of students of diverse socioeconomic status (SES) in a seventh-grade classroom. She reported that higher SES students believed that the patterns of interaction and discourse established in the classroom helped them learn other ways of thinking about ideas.

The discussions helped them reflect, clarify, and modify their own thinking and construct convincing arguments. However, in Lubienski's study, the lower SES students were reluctant to contribute, stating that the wide range of ideas contributed to the discussions confused their efforts to produce correct answers. Their difficulty in distinguishing between mathematically appropriate solutions and nonsensical solutions influenced their decisions to give up trying. Pedagogy, in Lubienski's analysis, tended to privilege the ways of being and doing of high-SES students. In a similar way, Jones' (1991) study showed that the discursive skills and systems knowledge that are characteristic of high-SES families align them favourably with the pedagogy that is operationalised within school settings.

For example, in their exploration into the teaching practice of one teacher, McClain and Cobb (2001) reported that although the teacher in their study honoured students' differing ideas, strategy sharing within the classroom community was used as an end to itself. The practice did not attempt to differentiate between the mathematical integrity of students' ideas. These findings support the earlier work reported by Doyle (e.g., Doyle & Carter, 1984) on classroom participation. Specifically, Doyle found that teachers use the strategy of accepting all answers as a way of simply achieving student cooperation in an activity.

In contrast, Mercer (1995) demonstrated that a pedagogical practice that does not attempt to synthesize students' individual contributions tends to constrain the development of mathematical thinking. A pedagogical approach that is able to move students' thinking forward involves significantly more than developing a respectful, trusting, and nonthreatening climate for discussion and problem-solving. It involves socializing students into a larger mathematical world that honours standards of reasoning and rules of practice (Popkewitz, 1988). O'Connor and Michaels (1996) put it this way:

> The teacher must give each child an opportunity to work through the problem under discussion while simultaneously encouraging each of them to listen to and attend to the solution paths of others, building on each others' thinking. Yet she must also actively take a role in making certain that the class gets to the necessary goal: perhaps a particular solution or a certain formulation that will lead to the next step.... Finally, she must find a way to tie together the different approaches to a solution, taking everyone with her. At another level—just as important—she must get them to see themselves and each other as legitimate contributors to the problem at hand. (p. 65)

Effective pedagogy is inclusive and demands careful attention to students' articulation of ideas. Franke and Kazemi (2001) make the important claim that an effective teacher tries to delve into the minds of students by noticing and listening carefully to what students have to say. Yackel, Cobb, and Wood (1998) provided evidence to substantiate the claim. They reported on the ways in which one Year 2 teacher listened to, reflected on, and learned from her students' mathematical reasoning while they were involved in a discussion on relationships between numbers. Analyses of the discussion revealed that her mathematical subject knowledge, and her focus on listening, observing, and questioning for understanding and clarification, greatly enhanced her understanding of students' thinking.

4.2.2. Classroom practices: learner participation

Yackel and Cobb (1996) made the important observation that the daily practices and rituals of the classroom play an important part in how students perceive and learn mathematics. These practices and rituals include the rights and obligations of mathematical participation. Cobb, Wood, and Yackel (1993) reported that students create insider knowledge of mathematical behaviour and discourse from the norms associated with those daily practices. This knowledge evolves as students take part in the socially developed and patterned ways (Scribner & Cole, 1981) of the classroom. By scaffolding the development of those patterned ways, the teacher regulates the mathematical opportunities available in the classroom.

However, it is a major challenge for many teachers to include classroom discourse as an integral part of an overall strategy of teaching and learning (Lampert & Blunk, 1998). How and when does the teacher set up practices that will enable students to participate in mathematics discussions? Wood (2002) researched six classes over a two-year period, investigating the patterns of interaction in the classrooms. From data collected on a daily basis during the first four weeks of school, Wood examined the ways in which the six teachers set up the social norms for classroom interaction. Further data were gathered at a later date to compare and contrast discursive interactions when the same instructional activity took place in different classrooms. Wood found variation in students' ways of seeing and reasoning, and these were attributed in the first place to the particular differences established in classrooms early in the year concerning when and how to contribute to mathematical discussions and what to do as a listener.

The discourse principles propping up classroom participation regulated the selection, organization, sequencing, pacing, and criteria of communication. Consistent with findings reported by a number of other researchers (e.g., Dekker & Elshout-Mohr, 2004; Ding et al., 2007; Gillies & Boyle, 2006; Webb et al., 2006), Wood's analysis showed that varying classroom expectations and obligations served to create marked differences in the cognitive levels demanded of the students. Furthermore, participation obligations put boundaries around the opportunities for students to share their ideas and to engage in mathematical practices (Ding et al., 2007; Veenman et al., 2005; Webb et al., 2006).

5. CONCEPT CARTOONS

A cartoon is a graphical media that can either be in the form of a single picture or a series of pictures as in the form of a comic strip, captioned or non-captioned, that are printed in magazines, newspapers and more currently in books (Wai Bing & Hong, 2003). Cartoons are visual tools which combine exaggeratedly drawn characters with dialogues related to everyday real-life contexts in a humorous and satirical mode (Keogh & Naylor, 2000; Naylor et al., 2001; Stephenson & Warwick, 2002; Coll, 2005). Numerous methods are being developed in order to promote the construction of knowledge. One of these methods is concept cartoons (Keogh & Naylor, 1999) and numerous studies in literature relate to the use of cartoons in science and mathematics education (Chambers & Andre, 1997; Uğurel & Moralı, 2006; Kabapınar, 2005). In this study, mathematical concept cartoons were used to stimulate discussion and argumentation that is high in quality when students solve mathematical problems in the classrooms.

Webb et al. (2008) suggested that there is value of introducing concept cartoons and argumentation writing frames in South African schools within the current curriculum. In regular textbooks, students are required to make meaning out of word problems through symbolically described situations, whereas, through cartoons, researchers (Lesh & Doerr, 2003) want learners to make symbolic descriptions out of meaningful situations. The concept cartoons, which are cartoon-style drawings showing different characters arguing about everyday situations, are not meant to be humorous, but are designed to provoke discussion and stimulate thinking (Webb et.al, 2008).

According to Webb (2010), cartoons which consist of simple drawings and minimal text can empower the participants in the group discussion such that they do not have to 'own' the misconceptions displayed. She points out that 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.

As noted earlier, Webb et al. (2008) conducted a study in primary classrooms of the Eastern Cape province of South Africa and reported positive improvement in the learners' use of exploratory talk when concept cartoons were used as a trigger. However, they caution practitioners that the process takes time and that teachers must have a sound knowledge of what constitutes genuine discussion, argumentation and exploratory talk before they can carry out these strategies in the classroom.

The teaching approach of using concept cartoons, as suggested by Keogh and Naylor (1999), has a direct and immediate impact in the classroom. They seemed to promote a purposeful approach to practical work – a hands-on and minds-on approach. Wai Bing and

Hong (2003) point out that concept cartoons are intended as a starting point to stimulate discussion and for eliciting ideas from the learners. They claim that to illustrate this point, students can be provided with an illustration and questions that require them to consider their thoughts, feeling and form opinions about the situation portrayed. The questions asked consist of: *What do you see?* (facts); *What do you think?* (opinions); and *What do you feel?* (feelings). This makes it an extremely valuable exercise to use with groups because it encourages open discussion (Wai Bing & Hong, 2003).

The cartoons used in this study fit the descriptions discussed in this section, and were merely used to stimulate discussion in the classroom during word problem-solving. As such, the cartoons chosen were rich in mathematics content and discourse, which afforded learners with the opportunity to use their everyday-life knowledge to solve word problems that are taken from everyday life examples presented in an argumentative manner.

6. SOLVING WORD PROBLEMS

Word problems have been defined differently in different studies. For the purpose of this study, the definition provided by Verschaffel, Greer, and De Corte (2000) is used. These researchers define word problems as “textual descriptions of situations assumed to be comprehensive to the reader, within which mathematical questions can be contextualised”. They also highlight that word problems “provide, in convenient form, a possible link between the abstractions of pure mathematics and its applications to the real-world phenomena” (p. ix). According to Palm (2009), mathematical word problems include pure mathematical tasks “dressed up” in a real-world situation that require that the students “undress” these tasks and solve them.

6.1. Understanding word problems: reading comprehension

Story grammar and story mapping has positive effects on the reading comprehension skills of elementary and secondary students with and without learning disabilities (e.g., Boulineau et al., 2004; Dimino et al., 1990; Gardill & Jitendra, 1999). Story grammar and story mapping can serve as tools to aid students in organizing and representing the internal structures of stories and therefore improve their comprehension (Sorrell, 1990). Although story grammar has been substantially researched in reading comprehension (Boulineau et al., 2004), word problem story grammar has not been explored in mathematics word problems' understanding and solving. It is readily apparent that comprehending verbal math problems involves processes different from those involved in comprehending other types of discourse, such as stories (Bilsky, Blachman, Chi, Mui, & Winter, 1986).

A number of studies have found systematic differences in children's word problem–solving performance levels (Judd & Bilsky, 1989; Lewis & Mayer, 1987; Moreno & Mayer, 1999). Judd and Bilsky (1989) conclude that comprehension is the most important source of problem difficulty and individual differences in children's mathematical problem performance, because children do not yet have a repertoire of highly automatised schemata for representing the different problem types.

Loranger (1997) argues that not much has changed in comprehension instruction in elementary classroom since Durkin (1978) raised the awareness of the status of comprehension instruction. Durkin observed several fourth-grade classrooms and discovered that very little time was spent on comprehension instruction, and where instruction did occur, teachers only monitored learners' comprehension by asking questions after they had finished reading a text, instead of teaching specific strategies to help learners to develop comprehension skills (Swanson & De La Paz, 1998). In 1982, Duffy and McIntyre, made similar observations when they visited some primary school teachers in grades one to six. Kilfoil and Van der Walt (1997) express similar concerns by stating that quite often the teacher makes no effort to treat the comprehension text as communication in which learners can develop strategies or abilities that will enable them to make sense of comprehension texts as communication.

6.2. Reading comprehension of English second language speakers

However, Crandall (1987) argue that seeming fluency in communicative situations can be deceptive, as students are not able to deal with the more abstract, formal, contextually reduced language of texts, tests, lectures or discussions of science or mathematics. In multilingual primary school classrooms, learners' achievement in reading comprehension strategies becomes a necessity when learners interpret word problems, and the efficacy of instruction in reading comprehension strategies is widely documented (Case, Harris & Graham, 1992; De La Paz & Graham, 1997; Hugo, 1993; Kilfoil, 1999; Klingner & Vaughn, 1996; Loranger, 1997; Snow, Burns & Griffin, 1998; Swanson & De la Paz, 1998).

Padron (1985) taught English second language reading comprehension strategies, and this improved learners' reading comprehension. Jonassen (2004) points out that story problem-solving requires not only calculation accuracy but also the comprehension of textual information, the capacity to visualise the data, the capacity to recognise the semantic structure of the problem, the capacity to sequence their solution activities correctly, and the capacity and willingness to evaluate the process that they use to solve the problem.

Studies on second language reading (e.g. Phillips, 1984; Sutton, 1989) report that effective reading can be taught and thus may help learners become better readers. A standardized thought is expressed by Klinger and Vaughn (1996) who found that learners' reading comprehension improved after they received reading strategies instruction. They concluded that comprehension strategy instruction is one of the promising approaches to improve learning opportunities for English second language, especially those with learning disabilities.

In their study, Cummins, Kintsch, Reusser and Weimer (1988) found that much of the difficulty children experience with word problems can be attributed to difficulty in comprehending abstract or ambiguous language. They point out that structural recall, both correct and erroneous, provides clear evidence that children's problem-solving strategies are determined by their comprehension of the problem stories. Moreover, frequently observed conceptual errors were related to story miscomprehension in systematic ways. Cummins et al. (1988) assume that when a child recalls a problem, he or she describes the problem representation he or she constructed during a solution attempt.

6.3. Wor(l)d problem-solving: socio-cultural and linguistic factors

A further methodological issue, which socio-cultural approaches have yet to satisfactorily address, arises from the increasingly multicultural nature of mathematics classrooms. Students' interpretations of mathematics classroom interaction relate in part to their different social, cultural and linguistic backgrounds. Analysis of classroom interaction needs to find some way of taking account of this diversity, or it risks imposing a single cultural perspective, that of the researcher. Discursive psychology has the potential to address some of the above-mentioned issues.

Ellerton and Clements (1991) agree that while the process children use to solve word problems are clearly a psycholinguistic concern, much research in this area has been conducted by the persons primarily interested in the cognitive processes of problem-solving, and they have not focussed on the language of the problem or of the problem solver. The overlap between 'psycholinguistic' and 'problem-solving' was the subject of comment by

Rosenthal and Resnick (1974), who describe word problems in arithmetic as tasks which require the integration of linguistic and arithmetic processing skills. They argue that in word problems, a situation is described in which there is some modification, or combination of quantities.

Riley, Greeno and Heller (1983) demonstrated three information-processing models that simulate children's different levels of performance on change, combine and compare problems, and applied these models to a sample in North America. This and other similar research (e.g., Adetula, 1989; De Corte & Verschaffel, 1989) has received acclaim with the result that in the US large teacher professional development programs are based on it. However, Clements and Del Campo (1987) present Australian data which could rarely, if ever, be caused by the strategies hypothesised by Riley et al. (1983), and a similar deduction was obtained by Lean, Clements and Del Campo (1990). Lean et al. showed that the differences in performance were clearly associated with sociolinguistic factors, arising from the questions being in English, which was, for almost all of the Papua New Guinea sub-sample, a second, third or even fourth language. Research (Bishop, 1998; Clements & Del Campo, 1987; Harris, 1997) has shown that further investigations into cultural factors, including studies of the language and thinking patterns used by parents and teachers when they interact with young children, are needed.

Hater, Kane and Byrne (1974) and Newman (1983) have pointed out that, although teachers have often assumed that incorrect solutions to word problems have arisen from lack of understanding of mathematical concepts or a deficiency in computing skills, in fact, the errors have been caused by an inadequate understanding of the language of mathematics. Briars and Larkin (1984) presented a model of problem-solving ability that simulates solution performance characteristics. Although somewhat tempered with "set language" and memory resource constraints, the primary mechanisms contributing to solution performance in this model are deficiencies in conceptual knowledge. Unlike Riley et al. (1983), however, this conceptual knowledge includes such things as the ability to understand subset equivalences and the ability to understand that things can be undone in time.

Cummins et al. (1988) argues that the linguistic development view holds that certain word problems are difficult to solve because they employ linguistic forms that do not readily map onto children’s existing conceptual knowledge structures. Importantly, the linguistic development view implies that word problems that contain certain verbal forms constitute tests of verbal sophistication as well as logico-mathematical knowledge. Accordingly, solution errors on these problems may reflect deficiencies in semantic knowledge, logico-mathematical knowledge, or both. To test the contributions of each, several researchers (De Corte, Verschaffel, & De-Winn, 1985; Hudson, 1983) have manipulated problem wording and observed its effects on solution performance. Results showed that a simple change in wording improved performance dramatically, consistent with results of studies in language manipulations (Hudson, 1983). Results such as these suggest that word problem difficulties may be akin to reasoning fallacies (Cummins et al., 1988).

A major source of difficulty with mathematical word problems is the fact that the language of mathematics and the language of common English usage often differ in important ways (Ellerton & Clements, 1991). According to Kane (1968) there are four key difference between the two languages: (i) there are fewer redundancies in the language of mathematics; (ii) names given to mathematical objects usually have only a single denotation in mathematical language; (iii) adjectives are usually unimportant in mathematical language; and (iv) the grammar and syntax of mathematical language are far less flexible than is the case for general English. However, despite such differences being well-known, many children still encounter challenges in reading and writing mathematics because not much has been done by teachers to counter this (Durkin, 1978).

6.4. Word problem-posing and problem-solving

The South African National Curriculum Statement emphasises not only in the teaching of problem-solving, but pleads for (more) instructional attention to the acquisition of problem-posing skills (Department of Education, 2005). In developed countries, such as the US, there is also a growing interest among researchers in problem-posing (see e.g., Brown & Walter, 1993; English, 1998a; Kilpatrick, 1987; Silver, 1994; Verschaffel, Van Dooren, Chen & Stessen, 2009).

According to Verschaffel and his colleagues (2009), the most cited motivation for instructional and curricular interest in problem-posing is its perceived potential value in assisting students to become better problem solvers. To explore this potential value, several studies (Cai & Hwang, 2002; Ellerton, 1986; Silver & Cai, 1996) have been set up to investigate the relationship between word problems solving and word problem-posing. In these studies, students were given opportunities to generate a few problems starting from a situational description, a cartoon (or picture), and afterwards, the quality of the mathematical problems produced by the students was compared with their ability to solve problems.

In their recent international comparative study, Cai and Hwang (2002) worked with a sample of grade six students from China and the US respectively and administered three pairs of problem-solving and problem-posing tasks. Each pair of problem-solving and problem-posing tasks involved one mathematical situation (e.g., the first three figures of an increasing square dot pattern consisting of 9, 16, 25 dots respectively). The problem-solving task for this situation included three word problems built around this situation, whereas the problem-posing task required students to generate one easy, one moderately difficult, and one difficult problem starting from the same situation. Their results revealed a close relationship between word problem-solving and word problem-posing. The close relationship was more evident among Chinese students because the variety of problems posed was clearly associated with their problem-solving success; furthermore, the difficulty of the self-generated problems was positively associated with the use of abstract problem-solving strategies. For the American students, the relationship between problem-posing variety and type, and problem-solving success was much weaker. Chai and Hwang (2002) point out that the stronger link between problem-solving and problem-posing for Chinese students might be attributed to the fact that the American students used less abstract problem-solving strategies.

Other studies (English, 1997a, 1997b; Verschaffel, De Corte, Lowyck, Dhert, & Vandeput, 2000) have since revealed that having students engage in some activities related to problem-posing may have a positive influence not only on their word problem-posing abilities but also on their problem-solving skills and their attitude towards mathematical problem-solving and mathematics in general.

6.5. Teachers' and students' conceptions of real-wor(l)d problems

This topic of real-world knowledge and realistic considerations in students' solutions of arithmetic word problems has attracted the attention of many researchers in mathematics education. Several studies (Cai & Silver, 1995; Greer, 1993; Silver, Shapiro, & Deutsch, 1993; Verschaffel, De Corte, & Lasure, 1994) have addressed this issue by looking at students' approaches to, and solutions of *non-standard* or *problematic* arithmetic word problems wherein the appropriate solution or mathematical model is neither obvious nor indisputable, at least if one seriously takes into account the realities of the context evoked by the problem statement.

An increasing number of researchers have consistently suggested that current school instruction given for arithmetic word problems is likely to develop in students' tendency to exclude real-world knowledge and realistic considerations from their solution processes (Cooper & Harries, 2005; Green, 1997; Moreno & Mayer, 1999; Verschaffel et al., 1999; Yoshida, Verschaffel, & De Corte, 1997).

For many children in elementary school, emphasis has been put on syntax and arithmetic rules rather than treating the problem statement as a description of some real-world situation to be modelled mathematically (Xin, 2009). For example, studies (Liu & Chen, 2003) conducted on 148 Chinese students from 4th and 6th grade, reported that only one fourth (26%) of the students' solutions of problems were from a realistic point of view (attending to realistic considerations). Almost half (48%) of the responses revealed a strong tendency to exclude real world knowledge, and in the rest of the cases, no answer was given.

Cooper (1994, 1998) offers a different explanation for the reason behind the *unrealistic* solutions, arguing that it stems from the socio-cultural norm of schooling that emphasises de-contexualised, calculation exercises. It is further reported that students tend to give less unrealistic answers if a real wor(l)d problem is presented as a social studies problem, rather than a mathematics problem (Säljö & Wyndhamn, 1993).

According to Inoue (2009), the *unrealistic* solutions may not simply stem from mindless or procedural problem-solving, but could originate in students' diverse efforts to make sense of the problem situation and the nature of the problem-solving activity in socio-cultural contexts. In actual fact, Verschaffel et al., (2000) have suggested that many students whose problem-solving did not seem to reflect familiar aspects of reality are known to defend their answers when their attention is drawn to the issue. Inoue (2005) argues that looking into students' justifications of their seemingly unrealistic answers can inform us of the various ways in which students interpret and make sense of the problem situation as well as the nature of problem-solving activity.

According to Lave (1992), word problems-solving describes stylised representations of hypothetical experiences separated from the students' experiences. In word problem-solving, students' minds could be torn between two types of knowledge systems that the word problem activates – one developed in the traditional mathematics classroom and the other developed through real-world experiences (Inoue, 2005). Inoue claims that in traditional schooling, students are not asked to examine different sets of assumptions for solving mathematical word problems.

Word problem-solving in school contexts serves as a game under tacitly agreed rules of interpretation (Greer, 1997). According to Gatto (1992) and Waller (1932), these agreed rules are internalised in the students' minds through the socio-mathematical norm, or hidden curriculum of traditional schooling that could influence many aspects of the intellectual activities in schools.

Inoue (2009) suggests that instead of dismissing students' computational answers and examining different sets of assumptions for solving word problems can provide rich opportunities for students to learn how to use their mathematical knowledge beyond school-based problem-solving. Inoue points out that this could help the students conceptualise word problem-solving in terms of meaningful assumptions and conditions for modelling reality, rather than the assumptions imposed by textbooks, teachers, or authority figures.

7. RATIONALE FOR THIS STUDY

The National Curriculum Statement (NCS) of South Africa advances a learners-centred and problem-based approach to the teaching and learning of mathematics

(Department of Education, 2005). However, anxiety towards promoting such an approach in multilingual classrooms of the Eastern Cape province may possibly be attributed to the fact that many mathematics teachers possess very little knowledge, skills and/or training of how to employ innovative and effective teaching strategies in order to implement this in their classrooms. Research conducted in South African schools suggests that teachers who lack experience in teaching, confidence and general pedagogic content knowledge will resort to methods of expository teaching, rote learning and the avoidance of classroom situations where something might go wrong (Taylor & Vinjevold, 1999).

While this approach to teaching places a greater focus on the mastery of skills, attitudes, values and content, it places less emphasis on the development of effective classroom discourse. In fact, classroom practice experiences teacher dominated talk, which reduces learner-learner and teacher-learner discussions in the classroom. The study explores various teaching strategies that aim at increasing classroom interaction, learner participation, and in the process empower mathematics teachers with necessary skills and knowledge to teach mathematics word problems through problem-solving. Moreover, the intervention strategy introduced to grade 9 mathematics teachers aims at promoting the use of language as a resource in multilingual classrooms.

8. CHAPTER SUMMARY

This chapter presents literature and on-going debates on issues of language and mathematics among English second language speakers in primary school classrooms. Drawing from the literature discussed in this chapter, it can be acknowledged that the teacher education system in South Africa and elsewhere in the world have not yet developed multilingual training for teachers in primary school classrooms. Studies conducted in South

Africa endorse the need for proper implementation of the LiEP to encourage learners' home languages in the teaching and learning of mathematics.

Communicative and socio-cultural perspectives (Lemke, 1995; Mercer, 1995, 2004; Vygotsky, 1978), for analysing dialogical interactions between the teacher and learners and among learners themselves in multilingual classroom settings, frame this study and are discussed. Furthermore, the fact that primary school multilingual mathematics classrooms in the Eastern Cape province of South Africa are embedded with mathematical discourse that reflects classroom culture and linguistic capital is highlighted.

It is for this reason that, this study attempts to explore and promote strategies that can be used by mathematics teachers to use language(s) as a resource in their practice. The next chapter presents the research design and the methodology used in this study.

CHAPTER THREE

METHODOLOGY

1. INTRODUCTION

The aim of this chapter is to present the research design employed in this study. Research paradigms are discussed, followed by an interrogation of the use of qualitative, quantitative and mixed methods. Thereafter, the data generating instruments are discussed and the data analysis techniques explained. Issues of sampling, validity and reliability are considered and the instruments used for this study are described, explained and motivated. The notion of ethical research is broached and the ethical stance taken in this study is described.

2. RESEARCH PARADIGMS

Mertens (2005) describes research as a systematic investigation whereby data are collected, analysed and interpreted in some way in an effort to understand, describe and predict a phenomenon. Research is influenced by the researcher’s mental framework referred to as a paradigm. The term paradigm is defined by Cohen and Manion (1994) as the philosophical intent or motivation for undertaking a study, whereas MacNaughton, Rolfe and Siraj-Blatchford (2001) view a paradigm as a belief about the nature of knowledge, a methodology and criteria for validity. Morgan (2007) defines a paradigm as the set of beliefs and practices that guide a field and argues that paradigm can be used to summarise the beliefs of researchers. Guba and Lincoln (1994) view a paradigm as a set of basic beliefs which represent a world view that guides the inquiry. The definitions mentioned above suggest that the paradigms in which the researcher operates, consciously or subconsciously set the motivation for, and expectations of, the research.

2.1 Positivist and post positivist paradigms

The positivist paradigm predominates in the physical and biological sciences and assumes that science quantitatively measures independent facts about a single apprehensible reality (Healy & Perry, 2000). Positivists believe that the goal of knowledge is simply to describe the phenomena that we experience and that observation and measurement are at the core of the scientific endeavour (Krauss, 2005). The object of study in this paradigm is independent of researchers, knowledge is discovered and verified through direct observations or measurements of phenomena and facts are established by taking apart a phenomenon to examine its component parts (Krauss, 2005). Positivists aim to test a theory or describe an experience through observation and measurement in order to predict and control forces that surround us (Mackenzie & Knipe, 2006). According to Neuman (2003), positivism sees social science as a structured method for combining deductive logic with precise empirical observations of individual behaviour in order to discover and confirm a set of probabilistic causal laws that can be used to predict general patterns of human activity.

Positivism was superseded by post-positivism after the Second World War (Mertens, 2005). Cook & Campbell (1979) point out that the post-positivists work from the assumption that any piece of research is influenced by a number of well developed theories apart from, and as well as, the one which is being tested. Post-positivists see the world as ambiguous, variable and multiple in realities, what might be the truth for one person may not be the truth for another (O'Leary, 2004). Within a post-positivism framework, both qualitative and quantitative methodologies are seen as appropriate for researching the underlying mechanisms that drive actions and events. The post-positivism approach implies that subjectivity is inherent, and should be acknowledged and that total and pure objectivity is impossible and should never be claimed. It also emphasises multiple measures and observations because all measurement is fallible and the purpose for research is to improve practice (Cohen & Manion, 1994).

2.2 Interpretivist/constructivist paradigm

While the positivist approach is that there is a single objective reality that is orderly and predictable, researchers who work within an interpretivist paradigm believe that each individual constructs their own view of the world based on experiences and perceptions. In this form of research, “the researcher tends to rely upon the participants’ views of the situation being studied and recognises the impact on the research of their own background and experiences” (Creswell, 2003, p8). Krauss (2005) refers to the constructivist researcher as most likely to rely on qualitative data collection methods and analysis or a combination of both qualitative and quantitative methods.

2.3 Pragmatic paradigm

Pragmatist researchers focus on the ‘what and how’ of the research problem (Creswell, 2003, p.11). They are against the positivist position that truth about the real world can be accessed solely by a single scientific method (Mertens, 2005). Tashakkori and Teddlie (1998), describe the pragmatic researcher as one who decides what one wants to research guided by one’s personal value systems, that is, one studies what one thinks is important to study. Such researchers also conduct their studies in anticipation of results that are congruent with their value system (McLaughlin, 2003).

In the positivist philosophy findings based on the study of representative samples can be used to make generalisations, making statistical analysis a useful tool for this form of research (Popper, 1968). However, although use is made of statistical data in this study, it does not rely on positivist philosophy as it recognises the value of working directly with the experiences and understanding of others and makes use of both structured interviews and questionnaires.

In this study the objective is to attempt to measure the effect of promoting and advancing discussion, argumentation and concept cartoons as teaching technique and/or strategies for learning generic word problem-solving and word problem-posing skills. Tests, observations, semi-structured interviews and a language survey are used to assess the outcomes of the use of these strategies. Therefore both the positivist and interpretive paradigms seem appropriate frameworks within which to show the intent, motivation and expectations of this study. However, the study is pragmatic in its approach and attempts to shed light on how research approaches can be mixed in ways that offer the best opportunities for answering important research questions (Hoshmand, 2003; Johnson & Onwuegbuzie, 2004). In doing so this study acknowledges Creswell's (2003) opinion that the pragmatic paradigm places the research problem as central, and that it applies all approaches to understanding the problem at hand.

3. QUALITATIVE METHODS

Qualitative research may be described on being naturalistic in that the researcher enters the world of the participant as it exists (Locke, Spirduso, & Silverman, 2007). According to McMillan and Schumacher (1993), qualitative research is based on what they call a naturalistic phenomenological philosophy, which assumes that there are multiple realities and that these realities are constructed socially through individual and collective definitions of the situation.

The classroom, within which this research occurs, is a natural setting where human behaviour and events occur (Creswell, 2009). Mathematics teachers and learners define their own situations and perceptions about realities in multilingual mathematics classrooms and what language should be used when solving mathematical wor(l)d problems, in order to provide reality. As such, this study incorporates concepts of field research, naturalistic enquiry as well as ethnographic research in the natural setting of the teachers and learners in marginalised township schools.

Henning (2004) suggests that the qualitative researcher wants to discover how human interactions take place, and why these interactions happen in the manner in which they do in certain situations. The study followed an interactional approach that allowed the researcher to understand, discover and examine the nature of interactions in multilingual classroom settings. Henning stresses that the researcher examines the qualities, characteristics, or properties of a phenomenon in order to grasp, comprehend and explain their world, while Rudestam and Newton (2001) argue that the qualitative researcher seeks an in-depth understanding of phenomena as they occur naturally and that no attempt is made to manipulate the situation.

In this study the researcher entered the world of the people under study through physical proximity for a period of time as well as through development of closeness in the social sense of shared experience and confidentiality and had the opportunity to obtain a rich understanding of their world as they experience it (Babbie, 2007; Creswell & Plano Clark, 2007). Denzin and Lincoln (2003), argue that researchers observe both human activities and physical settings in which such activities take place. Meaning and interpretations are negotiated with the research participants as it is the subjects' realities that the researcher attempts to reconstruct (Lincoln & Guba, 1985).

3.1. The interpretive approach

The object of this study is to engage teachers and learners in dialogue in order to understand them in their own classroom settings and to actively engage stakeholder participation through the principles of *inclusion* and *dialogue.* According to Howe (2009), inclusion is a general methodological principle that serves to control bias by ensuring the representativeness of samples. But for the purpose of this study, it provides a room for a democratic dimension: attempting to ensure that all relevant voices are heard. Howe (2003) argues that the principle of dialogue adds an interpretivist dimension to inclusion and thickens its democratic dimension. Interpretivism emphasises understanding people in their own terms, in their own social settings. As in the case of inclusion, there are both methodological and democratic justifications for employing dialogue. The deeper and more genuine the expressions of beliefs and values that emerge through dialogue, the more accurate the description of views held and the more *un*distorted democratic deliberation are fostered (Howe, 2003).

The intent is to better understand the views of participants on a specific phenomenon from the perspectives of Creswell and Plano Clark (2007). In simplest terms, it is a method of inquiry that is systematic and interactive, and is employed to give an exposition of the life experiences of the participants and to give meaning to them (Eisner, 1998; Mouton, 2001).

In this study, teachers and learners interacted and shared their experiences with the researcher as a participant observer. This made possible for the participants to frankly give their views, feelings, opinions, interpretations, and explanations on the meaning they attach to issues of language and mathematics when they solve problems in multilingual classroom settings. These meanings were then explained and interpreted with an attempt to make sense of within participants own world views. Howe (2003) suggests that qualitative research methods such as participant observation, interviews, focus groups, and the like are well suited for promoting dialogue. This study involves some form of interaction between the researcher and research participants that permits the researcher to get below surface appearances to obtain a richer and more nuanced understanding of their life experience.

3.2. The descriptive nature of qualitative research

In general, the main purpose of qualitative research is to provide an in-depth description and understanding of the human experience (Lichtman, 2010), its purpose is to describe and understand human phenomena, human interaction, or human discourse. Lichtman stresses that many believe that it is the role of the researcher to bring understanding, interpretation, and meaning to mere description.

As the purpose of qualitative research is to investigate, unearth and uncover more about the specific phenomenon, and then provide detailed, comprehensive and rich descriptions (Struwig & Stead, 2001; Wisker, 2001), this study investigates the lived experiences of participants in their own words, thereby gaining an in-depth understanding of their human perspectives at the individual level (Ponterotto, 2002). The research provided understanding of the challenges and frustrations of learners who, after 16 years into a democratic government, continue to learn mathematics in English, a language which is not their mother tongue. The meanings drawn from these descriptions assisted the researcher in understanding what strategies teachers use in their classrooms in order to improve learners' poor performances in solving mathematical word problems. The study also introduced the educators to strategies that could help them teach mathematics word problems more effectively using contexts which are familiar to the learners.

The focus of this study is to explore the use of *discussion* and *argumentation writing frames* when teaching and learning mathematics word problems in multilingual mathematics classes and the teachers' understandings of implementation of these strategies in their lessons.

3.3. Qualitative data gathered

Qualitative researchers tend to collect data in the field at the site where participants experience the issue or problem under study (Creswell, 2009). In this study, the researcher attempted to gather close information by actually engaging or interacting with, talking directly to people, and seeing them behave and act within their context, which Creswell (2009) refers to as a major characteristic of qualitative research. In the natural setting of this study, the researcher had face-to-face interaction with the participants over period of time, viz. a school semester. In the entire process of this study, the researcher kept a focus on learning the meaning that the participants hold about language issues and problem-solving, not the meaning that the researcher and assistant brought to the research, or that of other mathematics educators as expressed in the literature (Marshall & Rossman, 2006; Creswell & Plano Clark, 2007).

According to Creswell (2009), qualitative researchers collect data themselves through examining documents, observing behaviour or interviewing participants. In this study, in order for the research to lead to meaningful results (Le Voi, 2002; Patton, 2002), the researcher attempted to sensitise himself and his assistants to their own prejudices of which they might not have been aware of, such as stereotypes, expectations and privileges

(Ponterotto, 2002) as, although qualitative researchers may use protocol – an instrument for collecting data - they are the ones who actually gather information (Creswell, 2009).

What is involved in an interview is the description of the experience and the reflection on the description (De Vos, Strydom, Fouche, & Delport, 2005). Babbie (2007) and Berg (2001) define an interview as a conversation between the researcher and research participants, the purpose of which is to gather information. Interviews were conducted in this study in order to understand participants' experiences and the meaning they make of those experiences. Denscombe (2008) argues that an interview is much more than a conversation, but rather an active interaction between two or more people, because it involves assumptions and understandings that would not normally be present in a casual conversation. Babbie (2007) suggests that the researcher has a plan through which certain topics will be covered and thereby acts as the moderator of the conversation. The abovementioned researcher's understandings provided the framework for the interview process in this study.

Qualitative observations include those in which the researcher takes field notes on the behaviour and activities of individuals at the research site (Creswell, 2009). Gibson and Brown (2009) argue that observational research can be conducted for many reasons, but it is very often a part of a general interest in understanding, for one reason or another, what people do and why. In this study classroom (or lesson) observations were done by the researcher and his assistant and field notes were kept. As such, multiple forms of qualitative data were gathered rather than relying on a single data source. The data gathering instruments used are discussed in greater detail in the research design section of this chapter.

4. QUANTITATIVE METHODS

As noted earlier, quantitative approaches follow a positivist view that science quantitatively measures independent facts about a single apprehensible reality (Healy & Perry, 2000). It also holds that reality is constituted by observable, measurable and quantifiable facts that can only be observed objectively (Walker, 2005; Golafshani, 2003; Seers & Critelton, 2001). Quantitative methods allow for deductive thinking, scientific testing of hypotheses and standardized data collection, usually from a large number of respondents which are amenable to statistical analysis (Johnson & Onwuegbuzie, 2004).

Quantitative purists (Maxwell, 1992; Schrag, 1992) believe that social observations should be treated as entities in much the same way that physical scientists treat physical phenomena (Johnson & Onwuegbuzie, 2004). They also suggest that the observer is separate from the entities that are subject to observation and maintain that social science inquiry should be objective. That is, time- and context-free generalizations are desirable and possible, and real causes of social scientific outcomes can be determined reliably and validly (Nagel, 1986). According to this school of thought, educational researchers should eliminate their biases, remain emotionally detached and uninvolved with the objects of study, and test or empirically justify their stated hypotheses (Johnson & Onwuegbuzie, 2004). Quantitative research emphasises facts and the causes of behaviour (Golafshani, 2003). Its major focus is on populations and thus it seeks to discover general patterns for a population, rather than for particular individuals (Seers & Critelton, 2001).

Although this study employs some quantitative techniques, its shares none of the positivist assumptions described above. The object of the quantitative aspects of the study is to provide data for triangulation with the qualitative data generated in order to attempt to answer the following sub-questions on problems with language use:

- Do learners solve word problems better in their first language or the LoLT?

- Are the number (algebraic) skills and errors that the learners' exhibit related to the language used or are they generic?

5. MIXED METHODS

The rationale for mixing both kinds of data within one study is grounded in the belief that often neither quantitative nor qualitative methods are sufficient by themselves to capture the trends and details of a particular situation (Ivankova, Creswell & Stick, 2006). Researchers (Caracelli & Greene, 1993; Miles & Huberman, 1994; Green & Caracelli 1997; Tashakkori & Teddlie 1998) agree that when used in combination, quantitative and qualitative methods complement each other and allow for a more robust analysis, taking advantage of the strengths of each.

Many reasons can be provided for conducting a mixed method study. For the purpose of this study and its design, the main rationales proposed for undertaking a mixed method study, adapted from Bryman (2006), are as follows:

Triangulation: this allows for greater validity in a study by seeking corroboration between quantitative and qualitative data.

Completeness: using a combination of research approaches provides a more complete and comprehensive picture of the study phenomenon.

Answering different research questions: Creswell and Plano Clark (2007) argue that mixed methods research helps answer the research questions that cannot be answered by quantitative or qualitative methods alone, and provides a greater repertoire of tools to meet the aims and objectives of a study

Explanation of findings: mixed methods studies can use one research approach (i.e., quantitative or qualitative) to explain the data generated from a study using the other research approaches. This is particularly useful when unanticipated or unusual findings emerge. For example, findings from a quantitative survey can be followed up and explained by conducting interviews with a sample of those surveyed to gain an understanding of the findings obtained.

Illustration of data: using a qualitative research approach to illustrate quantitative findings can help paint a better picture of the phenomenon under investigation. Bryman (2006) suggests that this is akin to putting 'meat on the bones' of dry quantitative data.

Instrument development and testing: a qualitative study may generate items for inclusion in a questionnaire to be used in a quantitative phase of a study. These points identify the usefulness that a mixed methods research approach can have in answering a particular research question(s) and provide a rationale for using mixed methods in this study.

5.1. Mixed methods approaches

The main aim of this study is to explore issues of language (English and/or isiXhosa) that play a role in grade 9 English second language learners' mathematical problem-solving abilities in township multilingual classrooms. To address the above aim, a mixed method approach was used, viz. by gathering quantitative and qualitative data using tests, semi-structured interviews and observations. These data were triangulated in order to make a stronger case in terms of the explanatory quality of this study (Tashakkori & Creswell, 2007), provides better argument (Creswell, 2008; Wilkins & Woodgate, 2008) and produce better understanding and verification (Creswell & Garrett, 2008; Creswell & Plano Clark, 2007; Wilkins & Woodgate, 2008)

Mixed methods approaches intertwine both qualitative and quantitative methods in the same study (Lichtman, 2010) and combine elements of both qualitative and quantitative research approaches. They are not parallel, but are an attempt to meld the best of quantitative and qualitative research designs (Lichtman, 2010). (Gilbert, 2006) suggests that a mixed methods approach intensifies the effect and enriches the adaptability of the research design.

It is proposed by some that mixed methods may be the ‘third paradigm’ capable of bridging the gap between the quantitative and qualitative positions (Johnson & Onwuegbuzie, 2004). These authors feel that the field of mixed method research not only moves beyond sterile quantitative versus qualitative arguments, but makes explicit the usefulness of fusing ‘competing’ paradigms and helps identify how these approaches can be used together in a single study to maximise the strengths and minimise the weaknesses of each other (Johnson & Onwuegbuzie, 2004).

The study follows a mixed method concurrent triangulation design with both qualitative and quantitative collection of data in order to build on the strength of both the qualitative and the quantitative results (Creswell, 2009) and complements the strengths of the resulting combination without overlapping weaknesses (Brewer & Hunter, 2006).

5.1.1. The triangulation design

Concurrent triangulation design (Creswell, Plano Clark, Gutmann & Hanson, 2003) implies that the qualitative and quantitative phases occur at the same time, with both methods usually given equal weighting (Doyle, Brady & Byrne, 2009) and being equal status designs In other words, researchers use both the quantitative and qualitative approaches equally to understand the phenomenon under study (Tashakkori & Teddlie, 1998). Data are collected at the same time from two separate sets of data and they are then merged by either combining the data in the analysis stage, or by bringing the separate results into the interpretation (Creswell & Plano Clark, 2007).

Doyle et al. (2009) explain that within the data transformation model the quantitative and qualitative data are gathered concurrently. After the initial analysis, the data are transformed either by quantifying qualitative data or by qualifying quantitative results. In this study commitment to the equal representation of qualitative and quantitative approaches is not guaranteed. Instead of attempting to distribute the qualitative and quantitative contributions artificially to the mixed method design chosen for this study, a position or stance of equal value is adopted (Morse, 1991). From this stance, neither approach inherently overrides the other because the contributing methodologies are equally valued throughout the research process.

5.1.2. The explanatory design

The explanatory design described by Creswell (2003) as 'sequential explanatory design' consists of two distinct phases, beginning with the quantitative phase and then followed by the qualitative phase, which aims to explain or enhance the quantitative results (Creswell & Plano Clark, 2007). In this design, a researcher first collects and analyses the quantitative (numeric) data. The qualitative (text) data are gathered and analysed second in the sequence and help explain, or elaborate on, the quantitative results obtained in the first phase (Ivankova et al., 2006). The intent for this approach is that quantitative data and their subsequent analysis provide a general understanding of the research problem.

According to Wilkins and Woodgate (2008), the quantitative results could be used to develop themes for the coding of qualitative data. Creswell and Plano Clark (2007) point out that explanatory design begins with the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data. This design has found application in both social and behavioural sciences research (Ceci, 1991; Kinnick & Kempner, 1988; Klassen & Burnaby, 1993). Although considered to be the easiest method to implement, the explanatory design requires a longer implementation time due to the sequential nature. Because of this limitation the explanatory design was not used in this study to collect and analyse data.

5.1.3. Quasi-experimental design

According to Creswell (2009), in quasi-experiments, the researcher uses comparison and experimental groups but does not randomly assign participants to groups. A pre-test and post-test is administered to both groups, but only the experimental group receives treatment. In this study, teachers from four experimental schools received training at the Nelson Mandela Metropolitan University. Teachers at these schools were introduced to intervention strategies to be employed when teaching word problem-solving in their multilingual mathematics classrooms. These strategies where used particularly to improve learners' problem-solving skills, mainly through talking, discussing and arguing about concepts that are taught in the classroom. Two schools, which were not part of the intervention, were used as comparison groups.

6. RESEARCH DESIGN

A research design is a plan that indicates how the researcher intends to investigate the research problem (Denzin & Lincoln, 2006; Huysamen, 2001, Mouton, 2002). In this study the researcher used a pre-test – intervention – post-test design. Firstly, he investigated what the situation was in terms of language and problem-solving abilities of ninth grade English second language learners. The pre-tests helped him establish how the learners use language (and the problems they experience) to solve mathematics problems in isiXhosa (learners' home language) and English (LoLT) and what problems they may have mathematically. A sample of learners (focus group) was interviewed after the pre-test (the questions were informed by the pre-test) to find out where they had problems and why they solved the word problems the way in which they did.

Then the researcher wanted to see if introducing *discussion* and *argumentation* had any effect on language use and/or problem-solving abilities. An observation schedule was used to observe classroom interactions between the teacher and learners, and between learners themselves. Observation of learners' attempts at discussion and argumentation helped to see the structure of language use and reasoning. Learners' interviews immediately afterwards assisted in drawing a reasonable conclusion. The post-tests, which were exactly the same as pre-tests, investigated if there were any changes and possibly why there were changes. The intervention strategy used to promote discussion and argumentation in the teaching and learning of word problems is presented in the next section below.

6.1. Design type

In this study an intervention strategy has been used that investigated the effect of introducing discussion and argumentation on language use and/or problem-solving abilities of grade 9 second language learners. The intervention focused on writing to learn and solve word problems, discussion and argumentation. Concept cartoons in mathematics were used as triggers to stimulate discussion when they solve problems. The purpose of introducing discussion was to help learners seek, share and construct knowledge when engaging in word problem-solving. In promoting discussion, learners were expected to disagree with one another, engage critically on issues and build positively on what others have said.

The intervention then focused on writing to learn and solve word problems, and introducing argumentation in mathematics multilingual classrooms. In order to achieve this, writing frames were used to help support learners' ability to write appropriately for a particular task, guide their mathematical thinking and argue to learn mathematical word problems. These writing frames consisted of skeleton outlines that helped learners use the generic structures and language features of recount, report, procedure, explanation, exposition and argumentation.

The intervention also focused on the language of mathematics embedded within word problems. Simple translations were provided for phrases that are often used in mathematical word problems to simplify the meaning of these problem statements. Table 3.1 shows some examples of easy translations used.

Table 3.1

Translations of word problem phrases (Zhang & Anual, 2008)

In a math word problem this phrase:	Usually means you will need to:
"How many more?"	subtract the smaller number from the larger number
"How many altogether?"	Add
"What is the difference?"	subtract the smaller number from the larger number
"How many are left?"	subtract the smaller number from the larger number
"each" in a problem with the phrase "How many altogether or total"	multiply
"each" as in "How many do they each have?"	divide
"least"	select the lowest value (number)
"most"	select the highest value (number)
Find the sum or the total	Add
Find the product	multiply
Find the difference	subtract
Find the quotient	divide

6.1.1. Pre- and post-testing

Creswell (2003) defines a pre-test as an instrument providing a measure on some attribute or characteristic that one assesses for participants in an experiment before they receive a treatment, whereas a post-test is a measure on some attribute that is assessed for participants in an experiment after a treatment.

In this study tests were administered at the same time of the day in the same order in all classes so that there was uniformity in application. An assistant researcher (an independent retired isiXhosa-speaking senior lecturer of mathematics education at the University of Fort Hare) assisted in translating the English test to isiXhosa, which was checked by mathematics specialists at the provincial Department of Education (DoE) and mathematics teachers to quality assure the standard of the test.

Half of the experimental group and half of the comparison group wrote the test in isiXhosa first and then immediately repeated the test in English; the other half wrote the same test in English and then in isiXhosa. This technique was applied in order to inform the researcher on how much effect that having already seen the test in another language has on the pre-test scores. The assistant researcher and trained practitioners invigilated all the test sessions in all the participating experimental schools and comparison schools, and they were on site to clarify any emerging questions and/or problems encountered on either the language or context in content used in both languages.

The structure of the pre-test (and post-test)

The pre- and post-tests consisted of three sections with a total of five tasks (or questions), namely: *Problem-solving(PS) tasks* (three tasks), one task each under *Real-life mathematical word problems without real meaning (PWRM),* and *Real-life mathematical word problems without real context (PWRC)* sections respectively. The three PS tasks were coded using a schema that was an elaboration of the classification schema developed by Verschaffel et al. (1994). The classification schema comprised fourteen categories, the categories were reduced to three general categories: *realistic reaction (RR), no reaction (NR), and other reaction (OR).* These categories are explained and described later in this chapter.

6.1.2. Semi-structured interviews

As noted earlier, interviews were conducted in order to understand participants' experiences and the meaning they make of those experiences through their description of the experience and their reflection on the description (De Vos et al., 2005). Face-to-face focus group interviews, with a maximum of six interviewees in each group, were held. These interviews involved semi-structured and generally few open-ended questions that intended to elicit views and opinions from the participants (Creswell, 2009). The interviews were recorded on tape, with the permission of all participants. The researcher also took field notes that were compared with the transcriptions in order to maintain accepted level of accuracy.

The process was flexible with regard to the sequence of topics that were addressed (Denscombe, 2008).

6.1.3. Classroom observations

Gibson and Brown (2009) argue that observational research can be conducted for many reasons, but it is very often a part of a general interest in understanding, for one reason or another, what people do and why. In this study the structured observation schedule was piloted in two different multilingual mathematics classroom settings in order to satisfy the following requirements (e.g. Gibson & Brown, 2009):

- Check that they are sensitive and pick up the required forms of data;
- Check that they are no issues that may be relevant and are not included in the observation schedule; and
- Make sure that they can be easily interpreted and followed by both the researcher and an assistant researcher.

The external and independent isiXhosa expert observer provided the study with broader insights into the interpretation of all observed behaviour and activities in the classroom, particularly where the communication takes place in the learners' home language (isiXhosa). Classroom observations in this study were done before, during, and after the intervention, with at least three observations made of each teacher in the experimental schools, but only tests were administered in the two comparison schools. In so doing, the effect and/or impact of the treatment given to experimental schools could be easily measured and gauged against the score obtained by the comparison schools because the latter were not exposed to intervention strategy of this study.

The baseline observations were done just before the beginning of the intervention, with the object of understanding the nature of instruction in the multilingual classrooms of the experimental group. The information collected from these observations informed and advised the planning and implementation of the intervention in this study.

The observations during and after the intervention were done with the aim of measuring teachers' implementation of the strategies that they have learnt during the teacher workshops. Teachers from experimental schools were trained on how to get learners *discussing*, *arguing,* and *writing* about their views and experiences when they *solve mathematics word problems*. The aim of promoting these strategies in their teaching was to develop and improve their approaches to the teaching and learning of *word problem-solving* in multilingual classrooms.

The purpose of discussion was to help learners engage in talk through sharing, seeking and constructing their own knowledge when solving mathematical word problems. The discussions took the form of dialogue and talk (formal and informal) in both English and the learners' home language. The researcher used concept cartoons as a stimulus or trigger, to initiate and practise the skills required for the development of talk that is high in quality and sound in quantity.

In promoting argumentation, learners are expected to disagree and/or agree with one another, providing verbal and written evidence to back up their claims. The introduction of argumentation writing frames assisted learners' mathematical writing and level or quality of arguments between teacher and learners, and between learners themselves, when they engage in problem-solving of word problems.

6.1.4. Sample in this study

Sampling refers, in broad terms, to the points of data collection or *cases* to be included within a research project (Gibson & Brown, 2009). These points of data collection may be a person, a document, an institution, a setting, or any instance of information or data gathering. In quantitative studies, it refers to the selection of people to participate in a research project, usually with the goal of being able to use these people to make inferences about a larger group of individuals (Creswell, 2009).

A sample is a subset of the population (Howell, 2004). A population is the entire collection of events or objects in which the researcher is interested (Howell, 2004). The intention of sampling in quantitative research is to select individuals that are representative of a population, to ensure that the results can be generalised to a population and that inferences can easily be drawn (Creswell & Plano Clark, 2007). A *random* sample is a sample where every member of the population stands the same chance of being included in the sample (Collins, Anthony, Onwuengbuzie & Jiao, 2007; Howell, 2004). Gibson and Brown (2009) argue that where the *generalisation* of research findings is a key concern, then the issue of *representativity* can become important as the sample *stands for* and is used to *speak about* a broader population. Random sampling was not used in this study as there was no intention to attempt to generalise from the relatively small sample size that could be realistically included to allow for in depth findings and no direct link between the sample and the broader population to which it refers is claimed.

The main aim of the sampling in this study is, among others, to select possible research participants because they possess characteristics, roles, opinions, knowledge, ideas or experiences that may be particularly relevant to this research (Gibson & Brown, 2009). The sample consisted of grade 9 learners and their teachers in six township secondary schools, four of which were experimental schools and two of which were comparison schools (where no intervention took place). The six schools chosen were a convenience sample of a cluster of similar schools in Port Elizabeth. All the schools are situated in the Nelson Mandela Metropole and are functional (as opposed to dysfunctional – which is the case in many instances in South Africa), have similar characteristics in their approach to teaching and learning contexts and are public and previously marginalised schools. The schools draw learners from low economic status. isiXhosa is the mother tongue of the learners, i.e. the language that they use at home and when they play and communicate informally at school. The two comparison schools were chosen randomly within the group identified.

Grade 9 learners were chosen as they had already switched over from mother tongue to English as their formal language of learning and teaching (LoLT) for four years at the beginning of this study, a period in which they should have developed the necessary skills in English to solve the word problems used in the research. This language pattern in schools is a result of the educational model that is commonly used, namely one where learners are moved out of their main (home or mother tongue) language into an official LoLT after a period of mother-tongue instruction. The participating teachers in the experimental schools were introduced to and trained in strategies to improve their pedagogical content knowledge and their ability to promote teaching and learning of mathematics when solving word problems.

6.2. Data generating instruments

The data collection instruments described below were used in an attempt to address the primary research question. Quantitative data were gathered through pencil and paper pre- and post-tests (appendices B and C) and a language survey (appendix E). A classroom observation schedule (appendix D) was also used to generate both qualitative and quantitative data. Qualitative data were collected through semi-structured teacher and learner interview schedules (appendices F and G). The secondary questions which underpin the main research question are also addressed by these instruments, which are further discussed in the next sections below.

6.2.1. Pre-and post-tests

As noted earlier, the pre-test was divided into three sections with a total of five tasks (or questions), namely: *Problem-solving (PS) tasks* (three tasks), one task each under *Real-life mathematical word problems without real meaning (PWRM),* and *Real-life mathematical word problems without real context (PWRC)* sections respectively. The questions used in the test were adapted from Verschaffel, et.al. (2009) and satisfy the assessment standards as reflected in the South African National Curriculum Statement (NCS). The questions are standardised, criterion-referenced measures of problem-solving skills with proven reliability and validity devised and verified (Maxwell, 1992).

Apart from producing a numeric solution, learners were asked to write down the solution process and/or some explanations for each problem-solving (PS) task. Learners' answers to the three PS tasks were coded using a schema that was an elaboration of the classification schema developed by Verschaffel, et al. (1994). The classification schema comprised fourteen categories, but for the purpose of this study, the categories were reduced to three general categories:

- *Realistic reaction (RR):* comprises all cases wherein a learner either gave the (most) correct numerical solution that also took into account the real-world aspects of the problem context, as well as cases wherein there was a clear indication that the learner tried to take into account these real-world aspects, without giving the mathematically and situationally (most) accurate numerical answer. The realistic reaction responses give a clear picture of the abilities of learners to make sense (or meaning making) of the problem statement in their solution processes.

- *Other reaction (OR):* all those cases without any indication that the learner was aware of the realistic modelling difficulty, for example, mathematically correct but situationally inaccurate and/or incorrect or inappropriate responses, computational errors, etc. This category also provides a measure of the word problem-solving abilities of the learners.

- *No reaction (NR):* are all cases wherein a learner did not provide a numerical response and did not give any further written comment that indicated that the learner was aware of the realistic modelling difficulty that prevented them from answering the problem, as well as instances where learners generated incorrect responses with mathematical (or computational) errors.

The purpose of the pre-test was to help the researcher establish how the learners use language, and the problems they experience, when solving mathematics word problems prepared in isiXhosa, learners' home language and English, language of learning and teaching. Moreover, it assists the researcher to identify problems they may have mathematically (how they go about solving the problem) and situationally in response tasks with real-world contexts. The post-test investigates if there are any changes after the treatment on the experimental group, and possibly why there are changes.

6.2.2. Semi-structured interviews

The researcher conducted interviews in two different sub-phases: the focus group learner interview of six participants, who were purposefully selected by the teacher and learners - one from each school. The researcher, at this stage, did not have measurable qualitative constructs, and therefore, used the interview responses to analyse inductively the emerging real-life constructs.

The open-ended unstructured and semi-structured interviews, which are described below, were then undertaken to clarify and understand issues emerging from the pre-test results. Both the teachers and learners were purposefully selected by the researcher and his assistants after capturing the results of the pre-tests. The following questions were asked:

- If the same thing happens to you, would you respond in the same way in real life as you did in solving the problem? Why?

- Your solution may not work in real life because of realistic considerations. Why did you answer that way?

- Please think about on what condition your answer could become realistic. Could you come up with any assumptions or explanations that can make your answers justifiable?

- Do you think the contexts used in the content of tasks (or problems) that you solved in the pre-test are familiar and/or relevant to your everyday life experiences? Why?

Issues of language of learning and teaching, language spoken at home, language in mathematics and word problem-solving, addressed in this study, form the basis of the research questions and sub-questions (Creswell & Plano Clark, 2007). The open-ended interview questions were also used to measure the extent at which the language policy in their schools influences their current practice regarding the use of languages in their multilingual mathematics classes. The questions were as follow:

Teacher Level

- Which language(s) do you use to support communication in your classroom and why?
- Which language do you prefer to use when clarifying concepts that are being taught in the classroom? Why?
- Which language do learners use as a resource in order to understand word problem-solving? Why?
- Do you provide learners with opportunities to talk, discuss, argue and engage in dialogue when you teach? How?
- Which language do you mostly use to teach word problem-solving? Why?
- Which language is actually the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?

Learner Level

- Which language do you use to communicate in your classroom? Why?
- Which language (s) do you prefer to use when you solve word problems? Why?
- What problems do you usually have when understanding and solving word problems?
- Which language do you prefer to be taught mathematics with? Why?

- What difficulties did you experience when solving word problems in isiXhosa test? What about English test? Why?
- Which language will you choose for your assessments (e.g., tests and examinations)? Why?

The interview process was divided into two levels: teacher and learner questions as the researcher wanted to distinguish between and compare the perceptions of the two groups of participants so that the results of the survey could guide and influence the planning of the intervention for (or treatment on) the experimental group. Interview responses were sorted into themes that are discussed in the qualitative results section of this study. The reasons that were provided by both teachers and learners on their personal language preferences and/or choices were analysed qualitatively. A classroom observation schedule was also used to triangulate the qualitative data gathered from interviews, and is described in the next sub-section.

6.2.3. Classroom observation schedule

Qualitative observations are those in which the researcher takes field notes on the behaviour and activities of individuals at the research site (Creswell, 2009). In this study, classroom (or lesson) observations were done by the researcher and his assistants and field notes were taken.

Qualitative researchers tend to collect data in the field at the site where participants experience the issue or problem under study (Creswell, 2009). In this study, the researcher has attempted to gather up-close information by actually engaging or interacting with, talking directly to people, and seeing them behave and act within their context, which Creswell

(2009) refers to as a major characteristic of qualitative research. In the natural setting, the researcher had face-to-face interaction with the participants over time.

In the entire process of this study, the researcher kept a focus on learning the meaning that the participants hold about the language issue and problem-solving, not the meaning that the researcher and his assistants brought to the research, or as writers express in the literature (Creswell & Plano Clark, 2007; Marshall & Rossman, 2006). The classroom observation schedule focused on the following:

- Use of language by the teacher (asking questions, teaching, giving feedback, explanation of mathematical terms and concepts);
- Uses of language by learners (seek clarification, elaborate and solve problems, pose questions, build upon a previous response);
- Learners' use of language with individual and/or group peers (problem-solving, talk, argue, dialogue);
- Learner writing (use of Writing Frames, writing comprehension); and
- Teacher promoting discussion (collaborative tasks – paired activities, group presentation, arguments);
- Learner responses (individual, group, paired, hands-up, at the board, verbal, in writing, negotiation of meaning, etc.);
- Learner work in groups.

The researcher used a four point scale in the design of the instrument (observation schedule), with spaces made available for the observer to record the name of the school, name of the teacher, grade level, topic to be taught, number of learners in the class, the date of observation and comments on key issues observed.

6.2.4. Language survey

The survey was adapted from a form that was designed by personnel at the Nelson Mandela metropolitan University (NMMU) for the purposes of assisting the students in collecting data from their schools for a language policy assignment (Webb, 2010). The object of using the language survey in this study was to give the researcher information and knowledge about the extent of multilingualism at both school and home of the research participants, and their perceptions about implementation of language in education policy in their classrooms.

6.3. Data analysis

The process of data analysis involves making sense out of the data (Creswell, 2009); which requires the skill to depict the understanding of the data in writing (Henning, 2004). In other words, data are analysed and interpreted via a process which involves preparing the data for analysis, conducting different analyses, moving deeper and deeper into understanding the data, representing the data, and making interpretation of the larger meaning of the data.

6.3.1. Qualitative data analysis

According to Creswell (2009), qualitative data analysis can be conducted concurrently with gathering data, making interpretations, and writing reports. In this study, qualitative data analysis followed Creswell's steps from the specific to the general, involving multiple levels of analysis. Figure 3.1 shows a linear, hierarchical approach building from the bottom to the top. Creswell (2009) views this approach as being more interactive in practice, interrelated and not always visited in the order presented. In this study, qualitative data analysis involved gathering open-ended data, based on asking both learners and teachers general and specific questions. A qualitative analysis was developed from the information supplied by the participants.

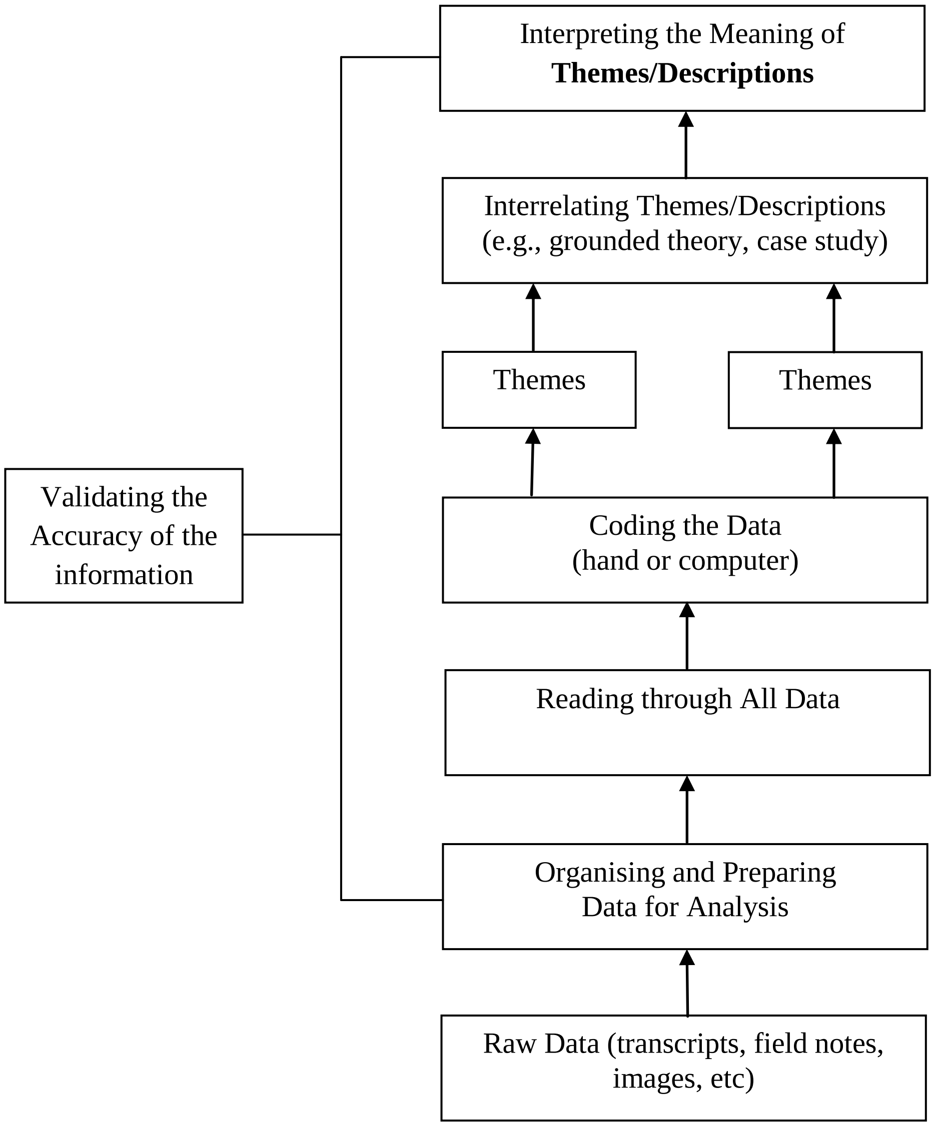

Figure 3.1
Data Analysis in Qualitative Research (Creswell, 2009, p. 185)

In order to reduce and organise the content of qualitative data to become manageable and meaningful, the researcher was guided by the following process as cited in Creswell (2009) and adopted from Tesch (1990):

1. The researcher organised and prepared the data for analysis. This involved optically scanning all the observations, field notes and transcribing both learners' and teachers' interviews.
2. The researcher then read through all the data, in order to obtain a general sense of the whole information and to reflect on its own overall meaning.

3. The researcher chose one outstanding and interesting interview, from both learner and teacher interviews, carefully read through it and in the process gaining knowledge about its meaning.
4. After repeating the procedure in 3 above for all participants (or transcriptions), the researcher then drew a list of all themes, with similar themes grouped together.
5. The themes were arranged and then coded next to the appropriate segments of the text. This was done in order to determine possible emergence of new categories.
6. The researcher then identified the most descriptive wording for my themes and placed them into categories.
7. The researcher decided on the abbreviation and numbering of all categories.
8. The data material for each category was put together in one place and preliminary analysis was done.
9. Then existing data were re-coded where necessary.

According to Creswell (2009), these steps above engage a researcher in a systematic process of analysing textual data. As was explained earlier in this chapter, the research assistants were employed as independent qualitative coders and they accepted the responsibility of independently coding the data concurrently with the researcher and through the guidance of the supervisor of this study. All the parties involved in coding met to discuss and finalise the list of emergent categories. The coding process followed Creswell's (2009) encouragement to qualitative researchers to analyse their data for material that can address the following:

- Codes on topics that readers would expect to find, grounded on previous or existing literature;
- Surprising codes that were not predicted at the beginning of the study;
- Codes that are strange, and that are of abstract pursuit to readers; and
- Codes that cover a prominent theoretical perspective in research.

For the purpose of coding in this study, a combination of predetermined and emerging codes was used by the researcher and his assistant.

6.3.2. Quantitative data analysis

Quantitative data were initially examined and organised according to categories, using a schema that was an elaboration of the classification schema developed by Verschaffel, et al. (1994) in order to obtain descriptive statistics of the mean, mediation, mode, and standard deviation. Minimum and maximum values and graphs were presented in this part of statistics for experimental and comparison schools involved in this study.

The quantitative statistical data generated from the pre- and post-tests (n=176) and the classroom observations (n=16) instruments in this study, were captured in a Microsoft Office Excel spreadsheet and subjected to analysis of variance (ANOVA) techniques to provide both descriptive and inferential statistics. Where necessary, the statistical technique of Matched-Pairs t-Tests was computed for comparing the mean scores of the comparison and experimental groups.

7. VALIDITY AND RELIABILITY

Quantitative and qualitative methods rely on different degrees of validity and are subject to different threats. Creswell (2005) defines threats as the problems that threaten our ability to draw correct cause and effect inferences that arise because of the experimental procedures or the experiences of participants. Babbie and Mouton (2008) depict different notions of reliability and validity compactly in Table 3.2:

Table 3.2
Quantitative and Qualitative notions of objectivity (Babbie & Mouton, 2008)

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

In this study, both quantitative and qualitative techniques were used and both notions of validity and reliability came into play.

7.1. The pre- and post-tests

The reliability of quantitative (test) results can be gauged according to whether a test returns the same results repeatedly. The reliability of the results of this study was measured using Cronbach α scores and the instruments have undergone rigorous validation over several years, since 2002 (see Cai & Hwang, 2002) until recently (e.g., Verschaffel et. al., 2009).

In this study, the data gathering followed a simple pre-test, intervention and post-test design, aimed at the experimental group and pre- and post-test design administered on the comparison group. A possible threat to the validity of this design was that participants might have remembered responses on the post-test from the pre-test. However, because of the time gap between the two tests it is probable that this was not the case, and even if it was, it was as applicable to the comparison group as to the experimental group. Another possible weakness could be that when the comparison school and experimental school teachers communicated with each other, the comparison school teachers learned information about the intervention. However, this possibility was unlikely to affect the outcomes of the intervention as merely passing on information would not be sufficient (compared to the highly structured treatment or intervention workshops given to the experimental group) to threaten the validity of the exercise. Moreover, the comparison group was not part of the project schools linked to this study. Consequently, none of the comparison teachers were aware of the existence of the experimental schools that were part of this study.

7.2. The language survey form

The survey form was adapted from a language survey that was designed by personnel at the Nelson Mandela metropolitan University (NMMU) for the purposes of assisting students in collecting data from their schools for a language policy assignment (Webb, 2010). The form accumulated information from the research participants about their perceptions about language issues in their schools, particularly language challenges that they face in the teaching and learning of mathematical word problems and problem-solving abilities of learners in multilingual mathematics classrooms.

7.3. The interviews

Qualitative researchers perceive validity (e.g., truth value, credibility, dependability, trustworthiness, generalisability, legitimation, authenticity) as being an unclear and ambiguous concept (Dellinger & Leech, 2007). At least seventeen terminolgies for validity in quantitative research descipline have been documented (Lather, 1993; Guba & Lincoln, 2005; Maxwell, 1992), but there is no agreed-on definition of validity in qualitative research (Dellinger & Leech, 2007). However, according to Maxwell (1992), validity refers to the degree to which the findings described by the researcher are the real representation of the data gathered.

Golafshani (2003); Creswell (2009) and Oppenheim (1992) agree that reliability has to do with the consistency of the measurement or the degree to which an instrument measures the same way each time it is used under the same circumstances. In this study, the researcher used semi-structured learner interviews adapted from, and based on the interview protocol developed by Inoue (2005). During the interviews, the interviewers probed unclear responses to gain an in-depth understanding of the learners' interpretation, as suggested by Ginsburg (1997). Judgments as to the degree of validity and reliability attained in this study are based on Creswell's (2009) perspectives.

7.4. The observation schedule

As mentioned earlier, the researcher and his assistant piloted the structured observation schedule in two different multilingual mathematics classroom settings in order to satisfy the requirements suggested by Gibson and Brown (2009). The observation schedule used in this study is a modified version of the classroom observation schedule used and validated in a number of other studies (Mayaba, 2009).

7.5 Overview of reliability and validity in this study

In order to assess the acuracy of the findings and convince readers of such accuracy, the researcher incorporated the use of multiple validity strategies as recommended by Creswell (2009):

- *Triangulated* various data sources of information by testing evidence from the sources and using it to build a strong justification for themes. This process added value to the validity of this study because themes were established based on converging several sources of data and perspective from participants;

- The researcher used *member checking* to determine the accuracy of the qualitative findings through specific rich descriptions and themes (only polished products and not all transcriptions) by referring findings back to the participants to find out if they agreed with the accuracy of findings. This procedure was done through follow-up (focus) interviews with participants in the study and giving them an opportunity to comment on the findings;
- The researcher used a *peer debriefing* to enhance the accuracy of the account through an external peer debriefer in the field of this study, who reviewed and asked questions about the qualitative part of this study;
- A *prolonged time* was spent at the research site and *repeated observations* were made to further develop an in-depth understanding of the phenomenon under study. This procedure enabled the researcher and his research assistant to obtain more experience with the participants in their natural setting, which gave the researcher more accurate or valid qualitative findings; and
- The researcher clarified the *bias* that is brought to the qualitative phase of the study. The researcher has commented about how the interpretation of findings is shaped and/or influenced by his background, such as culture, history, socio-economic origin, etc.

The primary strategy utilised in this study to ensure external validity was the provision of thick, rich and detailed descriptions so that anyone interested in transferability will have a solid framework for comparison (Merriam, 1988). Nixon and Power (2007) point out that warranting of claims must fulfill the criteria of trustworthiness, soundness, coherence, plausibility and fruitfulness. Trustworthiness refers to the quality of qualitative data collected (Anastas, 2004); and in the sense of neutrality in the findings or decisions of the study (Guba & Lincoln, 2005).

Reliability is the degree to which the instrument measures whatever it is measuring consistently (Best & Kahn, 2003; Ary, Jacobs & Razavier, 1990). According to Silverman (1999), reliability refers to the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions. Neuman (2003) suggests reliability has to do with the issue of dependability. Dependability of data in this study, was established by capturing all the interviews and observations on a tape and video recorder, and was transcribed both manually in writing and using computer software. Attempts were made to reproduce the interview scripts as accurately as possible to eliminate possible threats to reliability of the instruments used in this study. Creswell (2005) defines threats as the problems that threaten our ability to draw correct cause and effect inferences that arise because of the experimental procedures or the experiences of participants.

The researcher followed the following procedures, as suggested by Gibbs (2007), in order to ensure reliability in this study:

- The researcher checked all the transcripts for possible mistakes made during the initial transcription;
- During the process of coding, the researcher ensured that definition and meaning of codes were consistent throughout the entire qualitative data analysis, by regularly comparing data with the codes and by writing memos about the codes and their definitions; and
- The researcher cross-checked codes developed within the existing literature by comparing results that are independently derived.

The researcher made an attempt to include these procedures as evidence that he strove to obtain consistent results in this study. The assistant researchers had the role of independently cross-checking the codes through the process of intercoder agreement (Creswell, 2009) between the researcher and his assistant.

8. ETHICAL ISSUES

According to Babbie (2007) and Babbie and Mouton (2008), researchers have a duty and obligation to abide by the code of conduct that governs most professions. Neuman (2003) argues that researchers have a moral and professional obligation to be ethical, even when research subjects are unaware of or unconcerned about ethics. When conducting research, social scientists enter into the private lives of their participants (Berg, 2001). Researchers therefore have to make sure that the privacy, the rights, and the welfare of their participants are guaranteed (Kumar, 1999).

In this study, informed consent from participants was requested after prior permission to conduct this research, as part of the Integrated School Development and Improvement (ISDI) project offered by the CERTI at NMMU, was granted by the Education, Research Technology and Innovation Committee (ERTIC) of the NMMU. After obtaining ethics clearance, the researcher approached the principals and teachers of the participating schools, where their roles as participants, right to choose to be participants and to participate or not in this study were explained to them. They were assured of confidentiality that participation was voluntary and were given a guarantee that they could withdraw from the study at any time and that no personal details would be disclosed. Confidentiality of information collected in the schools was also ensured and that no portion of the data collection would be used for any purpose other than this research.

9. SUMMARY

This chapter has outlined the research paradigms of this study, the qualitative, quantitative and mixed methods, the research design, the instruments and strategies of data gathering and the detailed research process as used in this study. The methods used are informed and guided by Creswell's (2009) explanation of concurrent mixed-methods design in addition to the research questions. The treatment of the data, issues pertaining to reliability and validity of this study, as well as ethical issues that guided this process were also described, discussed and explained. The next chapter focuses on the findings of the quantitative phase of the study, where the data analysis process will be demonstrated and discussed.

CHAPTER FOUR

RESULTS

1. INTRODUCTION

This chapter reports on the qualitative and quantitative data generated in this study using the methodology and research instruments described in chapter three. The qualitative data produced from classroom observations done in the experimental schools before, during, and after the implementation of intervention strategy, as well as the data generated from semi-structured teacher interviews and focus group of eight learners from each of the four experimental schools are presented. Quantitative data generated from pre- and post-tests administered in both experimental (n = 107) and comparison (69) groups are described. These data were analysed and subjected to analysis of variance (ANOVA) techniques to provide descriptive and inferential statistics.

As such, the study has made use of both qualitative and quantitative methods where data were analysed in this chapter, and triangulated and are discussed in chapter five within the theoretical framework provided by the literature review and methodology in prior chapters.

2. BASELINE OBSERVATIONS

Two classroom observations were carried out in each of the four experimental schools before the teachers were introduced to the intervention strategy. Through the use of the baseline observations the type of interactions that exist during classroom practice, the choice, and use of language and how learners solve mathematical problems in the classrooms were observed. The observations done revealed the following:

2.1. Kgabo Senior Secondary School

2.1.1. Teachers' use of language in the classroom

The teacher used English, the official language of learning and teaching (LoLT) for both teaching and assessment of concepts being taught during a lesson. The LoLT was broadly used for explanation of mathematical terms, clarification of mathematical language, to ask questions and provide feedback to the learners;

2.1.2. Learners' use of language in the classroom

Learners used their home language (isiXhosa) when they solved problems or tasks given in pairs or individually. Learners found it difficult to pose questions and build upon previous responses using the language that is not their home language. They were not given the opportunity to write in their books.

2.1.3. Classroom interactions

The teaching approaches and strategies did not promote discussion and argumentation in the classroom. The classroom atmosphere did not provide opportunities for learners to engage in dialogue, where they could agree to disagree in order to reach a common understanding. Forms of interactions in this classroom followed a narration and one-way question and answer approach.

2.1.4. Teaching methods and learning styles

Textbook and narration methods formed a fundamental approach to the teaching and learning of mathematics in this classroom. The teacher employed the chalk-and-talk method, with learners receiving top-down information. The lessons were dominated by teacher's talk and learners' roles were that of spectators in the learning process.

2.2. Kolobe Senior Secondary School

2.2.1. Teachers' use of language in the classroom

The teacher is not an isiXhosa speaker, but tried to use language as an invisible resource in her lessons. She used certain learners as participatory resources to their peers by allowing code-switching and translations between LoLT and their home language. The teacher's instruction was in English and she always encourages learners to use the LoLT supported by their home language.

2.2.2. Learners' use of language in the classroom

Most of the learners showed their preference for LoLT and not their mother tongue. They used English in the classroom for problem-solving of tasks in groups, and outside the classroom when they play. Learners switched between the two languages in their group discussions. The lesson on shapes and space experienced talk that was high in quantity but low in quality. Linguistic competence of these learners was a complex technical ability, because of the structure of power positions that was present, yet invisible, in the exchange between the teacher and learners.

2.2.3. Classroom interactions

Interactions in this classroom took the form of teacher initiated discussions, typified by teachers' frequent use of inauthentic initiating question turns. The follow-up turns by either the teacher or learners did not happen during classroom discourse. The teacher asked questions and learners responded mostly in chorus. The interactions that took place within this classroom were found to have highly ritualised components that are not explicitly taught, but are embedded within the classroom culture.

2.2.4. Teaching methods and learning styles

The teaching and learning was centred and planned within a question-and-answer approach. The teacher provided limited opportunities for observing learners and listening carefully to their ideas and alternative conceptions. More emphasis was put on procedural understanding, with low levels of comprehension of mathematical concepts and relations that were taught. The teacher did not show the ability to teach learners on how to reflect, explain, and justify own claims.

2.3. Tlou Senior Secondary School

2.3.1. Teachers' use of language in the classroom

The teacher was confident and competent in using dual-medium instruction in his lesson. He used both English and isiXhosa as a resource to explain mathematical terms used within the concepts being taught. The teacher's instructional practice suffered from a balance of linguistic and cognitive demands when assessing concepts being taught. He struggled to provide feedback that was adapted to the learner's level of language proficiency, lacking strong home-school connections.

2.3.2. Learners' use of language in the classroom

Learners used their home language to communicate mathematical ideas among themselves and with the teacher, when they seek clarification and explanations of concepts that were taught. isiXhosa appeared to be the language of choice for learners when they solved mathematical tasks in groups and pairs. They were also allowed to share their ideas with the entire classroom using their home language. Consequently, learners grappled primarily with acquisition of technical vocabulary in the LoLT and language of mathematics, development of comprehension skills to read and understand mathematical resources written in English, and the ability to solve mathematical problems in general.

2.3.3. Classroom interactions

This classroom was embedded with mathematical and social discourses that reflected both the culture of the learners' backgrounds and that of their classroom. The teacher's actions in the classroom showed a domain of discourse closely associated with learners' cultures having the same assumptions, values, and linguistic domain. The teacher's perspective on bilingual mathematics learners encouraged acquisition of vocabulary, and did not reflect high levels of construction of knowledge and meaning.

2.3.4. Teaching methods and learning styles

Lessons observed were learner-centred. The teacher's practice during the lesson reflected good organisational and communicational skills, but lacked substance in coordinating and managing mathematical discourses that took place. The teacher failed to employ necessary and relevant teaching strategies to coordinate the talk, which was good in quality, in the few identified groups during problem-solving.

2.4. Tholo Senior Secondary School

2.4.1. Teachers' use of language in the classroom

The teacher introduced the lesson in learners' home language and went on to explain some of the mathematical terms in both LoLT and learners' home language. She allowed learners to choose their own preferred language when they discussed during the lesson. The teacher did not have clear teaching strategies in her approaches. She used learners' home language to clarify and explain some key concepts that were taught, and as an invisible resource throughout her lessons.

2.4.2. Learners' use of language in the classroom

Learners' home languages took centre stage within the arguments that were attempted by the learners in their own groups. Over 95% of their utterances took place in their home language, but switched between the two languages when probed by their teacher during question-and-answer sessions. Their mathematical discourse was very low in quality and reflected poor comprehension of mathematical language and low levels of vocabulary. Learners were not free to express themselves in the LoLT and they successfully used code-switching as a learning strategy to solve mathematical problems.

2.4.3. Classroom interactions

Although the teacher occupied the largest percentage of talking time in her lesson, what she did was to enable the learners to engage in dialogue. This dialogue took place between the teacher and certain individual learners. Learners were not confident that they could argue a case and challenge the teachers. The teacher issued a lot of instructions about what the learners were to do and modelled what was to be done. She struggled to take firm comparison of the interactions during her lesson. The unsuccessful interactions in this classroom indicated scant understanding and agreement of the rules of engagement between the teacher and learners with a view to active and positive contributions to classroom discussions.

2.4.4. Teaching methods and learning styles

The teaching and learning in this classroom is guided and largely influenced by the teacher's quest to complete the syllabus on time. As such, the teacher is under pressure to teach according to a stipulated mathematics schedule designed by the provincial Department of Education. The teacher practised behaviourism in her approach to the teaching of mathematics in this classroom, which boasted learners of different academic achievements and social class. She could not strike a balance between teaching for inclusion and designing mathematical tasks that encouraged problem-solving in real world contexts. Although dialogue was promoted by the teacher, her pattern of utterances dominated the discussion and the lesson followed a teacher-centred approach.

3. PRE-TESTS: QUALITATIVE RESULTS

As noted earlier, learners (n=107) wrote the word problem test both in English and isiXhosa translations, following a particular order. Those who started with the English test are referred to as the English-isiXhosa (EI) [n=52] group, otherwise they are called isiXhosa-English (IE) [n=55] group. The tests were administered in four experimental schools and two comparison schools (n=67) respectively. In this section, both quantitative and qualitative pre- and post-test results gathered from the eight schools are presented. Apart from solving a task and providing a solution, learners were asked to describe their solution process and brief explanations for their problem-solving (PS) tasks. Their solutions to the three PS tasks were coded using a schema developed by Verschaffel, et al. (1994). In this study, three general categories were used, namely: *Realistic reaction (RR), No reaction (NR),* and *Other reaction (OR)*. As noted in chapter 3 of this study, learners' interviews after the pre-test were based on the interview protocol developed by Inoue (2005) as follows:

- If the same thing happens to you, would you respond in the same way in real life as you did in solving the problem? Why?
- Your solution may not work in real life because of (real factors). Why did you answer that way?

- Please think about on what condition your answer could become realistic. Could you come up with any assumptions or explanations that can make your answers justifiable?

- Do you think the contexts used in the content of tasks (or problems) that you solved in the pre-test are familiar and/or relevant to your everyday life experiences? Why?

3.1. Results of the problem solving task 1 (PS1)

Learners responses (or answers) to the problem-solving task 1 (PS1) were coded into three general categories: realistic reaction (RR), no reaction (NR), other reaction (OR), which were adapted from a schema developed by Verschaffel, et al. (1994). As noted earlier in chapter three, RR comprised all cases wherein a learner either gave the most accurate numerical response that also considered real-world aspects and context of the problem, or cases where there was an attempt to consider real-world situations without providing a numerically most correct response. On the other hand, OR were all those responses without real-world considerations, and situationally inaccurate responses with correct computations. NR were all the cases with no numerical responses and mathematically incorrect, without any further written responses that indicated that the learner was not aware of real-life aspects of the problem that made it impossible for him or her to solve the problem.

Table 4.1
Problem Solving task 1 (PS1)

100 children are being transported by minibuses to a summer camp at the sea-side. Each minibus can hold a maximum of 8 children. How many minibuses are needed?	Abantwana abali-100 bahamba ngebhasi encinane besiya konwaba ngaselwandle. Ibhasi nganye ithwala abantwana abasi -8. Kufuneka iibhasi ezingaphi zokubathwala bonke?

When asked about how they solved this problem in the follow-up interviews, one of the learners responded by saying:

> "*...when you divided children like that you will count that each minibus will get in 8 children, if you divided them in groups of 8, so that all 100 children can enter in all of the minibuses and you will know that you must have 12 mini buses*".

In solving the PS1 problem, learners' written and verbal responses were recorded. Table 4.2 shows examples of learners' responses to this problem with division with a remainder.

Table 4.2
Examples of learners' responses to PS1 task

	Answer	Realistic reactions (RR)	Other reactions (OR)
i.	100÷8=12.5	therefore 13 minibuses are needed (situationally most appropriate answer)	so 12.5 minibuses are needed (mathematically accurate, but numeric answer is situationally inappropriate)
ii.	100÷8=12; remainder 5	so 12 minibuses are needed (answer that does not consider problem context and situation)	so 12 minibuses are needed and a car for remaining 5 children (mathematically incorrect, other answer that considered problem situation)
iii.	100÷8=8.5	so 9 minibuses are needed (computational error, but situationally appropriate)	
iv.	100×8=180		so 180 minibuses are needed (incorrect operation used and calculation error, without situationally appropriate interpretation)

3.1.1. Problem solving and test order

Learners who answered the PS1 task in English first managed to complete the isiXhosa translation with much better understanding, which produced more mathematically correct answers in the isiXhosa translation, but generated most situationally appropriate numerical responses in the English translation. In other words, learners used their real-life knowledge and experiences to solve PS1 item in the English pre-test, but succeeded more in problem-solving of the same item in the isiXhosa translation of the pre-test.

3.1.2. Problem-solving and modelling

In this study, learners showed great difficulties in solving the division problem with a remainder realistically, consistent with results of studies conducted by Chen et al. (2005). The difficulty in realistic mathematical modelling of PS1 resulted in different responses and interpretation of a remainder, which could be argued that, as a consequence, performance on problem-solving was worse.

3.2. Results of PS2

The following word problem in Table 4.3, which is an example of a central part of mathematics learning, can be seen as attempts to connect mathematical reasoning to everyday life. In other words, the PS2 task can be viewed as a manifestation of the notion that mathematics is or should be part of mundane practices in everyday life. The results of this word problem illustrate that students acted in a complex situation when attempting to solve this problem below.

Table 4.3

Problem Solving task 2 (PS2)

Two boys, Sibusiso and Vukile, are going to help Sonwabo rake leaves on his plot of land. The plot is 1200 square meters. Sibusiso rakes 700 square meters during four hours and Vukile does 500 square meters during two hours. They get 180 rands (R) for their work. How are the boys going to divide the money so that it is fair?	Amakhwenkwe amabini, uSibusiso noVukile baya kuncedisa uSonwabo arhugule amagqabi entsimini yakhe. Ubukhulu bentsimi yakhe yi -1200 yee skwe mitha. Ngeeyure ezi-4, uSibusiso urhugule indawo ebukhulu bungama-700 ee skwe mitha, waza uVukile yena warhugula -500 skwe mitha ngeeyure ezimbini. Bebobabini bafumana imali eyi R180 ngalo msebenzi. Baza kwahlulelana kanjani ngale mali ukuze bangaqhathani?

Table 4.3 shows an example of word problems that needed to be solved by learners in an ambiguous reality. Learners responded to PS2 task by using different models (see Extract 4.1 below) that illustrated different interpretations and use of real world experiences in solving this problem. The following extract shows how learners interpreted and solved this problem, and their reactions after being prompted by the researcher.

Extract 4.1

L(earner)5:	Because they both worked, I will just give them the same equal amount.
R(esearcher):	Any other suggestion? How do you think they should divide the money fairly amongst themselves?
L5:	I will still share it equally because there's no need to take more money than her.
R:	OK...
L6:	To be fair I will give the one who raked 700 meters R100 and the other one R80.
R:	What do you think about he who raked for 2 hours?
L1:	It is not fair,... one did it in shorter time ..., and the one worked in 4 hours and did 700 square meters, so will first have to calculate the time and then divide up.

In responding to this problem, the majority of the learners from the English-isiXhosa (EI) group did better in the isiXhosa translation of the problem, after having seen the problem first in the English pre-test. At general levels, the results show that all groups suggested that the problem is very difficult to solve. The learners encountered problems of making sound and reasonable assumptions of what it means to ‘share or divide the money fairly’. From some of these learners’ socio-cultural perspectives, dividing the money fairly simply translates to sharing the money equally, as seen in the text of extract 1, when learner 5 said: “*Because they both worked, I will just give them the same equal amount*”. This statement provides another notion of multilingual classrooms, where learners enter these classrooms from a range of socio-cultural backgrounds, whereby learners whose socio-cultural background is congruent with that of the culture represented in and through the practices embedded within the mathematics classroom are more likely to be constructed as successful learners (Zevenbergen, 2000). Thus, the discussions are characterised by learners engaging in realistic considerations (Verschaffel et al., 2000), as a result of solving a problem in an ambiguous reality.

3.2.1. Mathematising as communicative work

The data show that learner discussions during the interviews moved back and forth between their problem-solving strategies that they employed. What appears to be evident from the texts in Extract 2 is that the culture and real-life knowledge of learners played a pivotal role in their mathematical reasoning and problem-solving of this task. Table 4.4 shows different models that were used and suggested by the learners in different groups, when attempting to solve the PS2 task in English pre-test.

Table 4.4

Models suggested for sharing money in Pre- and Post-tests

Models for sharing	**No. of learners (Pre-test)**		**No. of learners (Post-test)**	
	Experimental (n=107)	*Comparison* (n=69)	*Experimental*	*Comparison*
A. Divide equally (R180/2)	45	28	66	31
B. Amount of work done	32	21	21	29
C. Time taken to do work	11	7	2	5
D. Payment by performance	7	3	18	1
E. Other	12	10	0	3

The data in the table above depict that there was a high frequent response of sharing the money equally. It is very interesting to see that there were more suggestions beyond sharing or dividing the money equally, which can be taken as an indication that learners in the experimental group and the comparison group used both their classroom mathematical experiences and everyday-knowledge skills acquired through life-experiences. As noted earlier, the high responses suggesting sharing money equally seem to stem from multiple meaning of the word ‘fair’, influenced by learners’ socio-cultural backgrounds. In solving the PS2 task, the majority of the learners gave almost the same responses for both English pre-test and isiXhosa translation of the pre-test. As such, seeing this task in one language first and then the other, seemed to have no significant effect on the learners’ solutions, despite learners’ claims that writing the pre-test in English first increases the success rate of problem-solving on the isiXhosa translation of the pre-test.

3.2.2. Calculations using magnitude of work done

It is clear from the text in Extract 2 that most of the boys suggested a model of sharing the money by calculating the amount of work done, yet not considering the time as a proposition. Although the data could not explain the reason behind this, it is assumed that in African cultures, certain jobs are reserved only for boys, and as such, girls used their own real-life knowledge and cultural experiences in suggesting a model to solve this problem.

Extract 4.2

L6: To be fair I will give the one who raked 700 meters R100 and the other one R80.

L7: If we divide the piece of work done by the total ground that was raked, we have 700 divide by 1200, which gives 7/12. Then we multiply 7/12 by R180, the money to be shared, which gives R105. So one should have R105 and the other one gets R75.

The text in Extract 4.2 shows how two boys solved this problem. Both learners 6 and 7 considered the amount of work as a key factor of sharing the money fairly. It is clear that Learner 6 estimated the amount of money to be shared based on the magnitude of work done by each of the boys. In actual fact, his estimation is not far from learner 7's solution statement. Learner 7 used the concept of decimal fractions to solve this problem based on amount of area raked by each boy, and sharing the money according to the fraction equivalent to the work done. It also appeared that language had no effects in learners' interpretation of this problem statement.

Table 4.5

Comparison of PS2 results per country, and per experimental and comparison groups

Models for sharing	**No. of learners (Sweden)**	**No. of learners (This Study: Pre-tests)**	
	n=78	*Experimental* (n=107)	*Comparison* (n=69)
A. Divide equally (R180/2)	33 (42%)	45 (42%)	28 (41%)
B. Amount of work done	27 (35%)	32 (30%)	21 (30%)
C. Time taken to do work	18 (23%)	11 (10%)	7 (10%)
D. Payment by performance	0 (0%)	7 (7%)	3 (4%)
E. Other	0 (0%)	12 (11%)	10 (14%)

Similar to the situation in which Western students (e.g., Sweden and the US) have been challenged by the problematic word problems (Greer, 1997; Säljö, Riesbeck, & Wyndham, 2009; Verschaffel et al., 2009), the results in Table 4.5 shows that South African learners are not in the position to, as Freudenthal (1991) puts it, "mathematise" the world by means of elementary forms of mathematical modelling. The data in the table above show that majority (67%) of the South African learners in this study failed to argue and make counter-arguments beyond equating a "fair sharing" of the money with "dividing money equally". As such, only few (23%) of these learners engaged further in other models, compared to just over double this number (58%) of the Swedish students, who reportedly had multiple modelling approaches to problem-solving of the PS2 task.

The following extract reflects the recorded arguments made by the ninth grade learners when engaging in problem-solving of the PS2 task. The task was given to the learners after they were introduced to discussion and argumentation as a strategy to engage in problem-solving and connecting the mathematics classroom with the outside world.

Extract 4.3: Example of learners' group interactions when solving a PS2 task

Model			
Amount of work done	**Time**	**Pay by performance**	**Other**
L(earner)4: They both worked, I'll just give them same equal amount.			
	L1: …the other one did in shorter time…so we'll have to calculate the time and then divide up.		
L6: To be fair, I'll give the one who 700 square meters R100 and the other one R80			
	L5: ...one worked the smallest part in a short time, so the other one used much more time working in a bigger place...		
		L5: ...Vukile must have more than R90 because he did it in a very short space of time...	
L2: No...Vukile only did less work...			
		L5: I agree, but he did it faster than Sibusiso...	
			L3: Because they are friends, I will share it equally because there is no need to take more money....
	L2: But Sibusiso raked for four hours and Vukile for just two hours, how can you share money equally?		
L4: R180/2 is R90 for each of them, it's fair...			

The text in Extract 4.3 is an example of one of the episodes recorded during PS2 group discussions and interactions. During this activity, learners were encouraged to discuss in the language of their choice, and once more, they predominantly used English to solve the task, with rare occasions of code-switching. Although all the group members (eight learners in this group) participated in dialogue and talk, they could not arrive at a common solution to this problem. Rather, it was evident that the quality of arguments and nature of justifications improved over time, as they continued to engage in mathematical modelling of PS2.

3.3. The results of PS3

Word problems are often the only means of providing learners with a basic sense experience in problem-solving and mathematization (Reusser & Stebker, 1997). This word problem in Table 4.6 represents one of many questions that are used for assessments in mathematics classrooms, and elsewhere in the world (see Verschaffel et al., 2009). All the learners' solutions were classified into three main categories based on their written answers and verbal responses to the interview questions.

Table 4.6
Problem Solving task 3 (PS3)

John's best time to run 100 meters is 17 seconds. How long will it take him to run 1 kilometre?	UJohn ubaleka umgama ongama - 100 eemitha ngemizuzwana eli-17. Uya kuthatha ixesha elingakanani ukubaleka ikhilomitha enye?

The PS3 task has a mathematical structure that is related to real-life factors. In other words, the solution of this problem depends on the rate of progress influenced by factors such as physical strength, preparedness, weather, fatigue, etc.

3.3.1. The English-isiXhosa (EI) and isiXhosa-English (IE) groups

In solving this word problem, both groups failed to reflect common-sense understanding of reality in problem-solving. The majority of the learners answered "*170 seconds"* to this problem, consistent with findings of many studies conducted in Europe and Asia, for a wide variety of problems across different linguistic and cultural settings (see Schoenfeld, 1991; Verschaffel et al., 1994, 2000, 2009). In this case, learners simply read and converted the text into a mathematical operation in a fairly direct manner, without considering more carefully in what manner the text information is to be translated into a mathematical form in order to be successful. In responding to this problem, learners simply multiplied 17 seconds by 10 to find out how long it takes to run a kilometre. This runner problem, for instance, has been used in a number of studies in different parts of the world, and the results, consistent with the results of this study, are thought-provoking: "The percentage of students in the various countries who gave the unqualified answer 170 seconds ranged from 93% to 100%" (Verschaffel et al., 2000, p. 44).

3.3.2. The nature of justifications

The extract below demonstrates learners' responses to PS3 activity, and the nature of justifications made by learners before and after being prompted by the follow-up interviews.

<u>Extract 4.4</u>

L5: I multiplied 17 by 10 it gives me 170, and then I got my answer.

R: Your solution may not work, because of real life factors. Why did you solve the problem that way?

L1: I don't agree with **L5**, because it's a kilometre, when you run 100 meters you run with your full speed, but then at 17 you cannot run your full speed, you have to a bit sometimes jog because this is a kilometre it's not 100 meters...

R: Okay...

L1: Mathematically it's correct but in real life it's not going to be like that, it's going to be much longer, it's not going to be a 170 seconds.

The learners' responses to the researcher's question in Extract 4.4 demonstrated whether learners could justify their responses in terms of their own interpretations of the problem situation when confronted with, what Inoue (2009) refers to as, the "irrationality of their responses". The text illustrates example of justifications that learner 1 (see Extract 4.4) presented after she was prompted to do so in the interview question. Learner 1 suggests that although the solution is mathematically correct, "*in real life it's not going to be like that"*, as she reasons that in real life situation it will take John "*much longer*" to run one kilometre.

This learner acknowledges the disconnect that exists between what she learnt in classroom mathematics, and real-life problems that are not related to the mathematics discourse that she is exposed to. In so doing, her newly acquired argumentation and discussion skills assist her in affirming learner 5's mathematical solution, and in the process linking the mathematics to real knowledge by suggesting that "*When you run 100 meters, you run with your full speed, but then in this case you cannot run your full speed, you have to jog a bit sometimes, because this is a kilometre. It's not 100 meters"*. This reasoning is largely influenced by consideration of realistic factors that exist in real life situations. As can be seen in Table 4.7 below, there were different justifications of seemingly 'unrealistic' responses. These responses reflect a sample of justifications that were presented by the learners spontaneously (response from the second interview question) and as well as examples of justifications after being prompted explicitly.

Table 4.7
Learners' sample justifications of 'unrealistic' responses

Spontaneous justifications	**Justifications after being prompted explicitly**
John is a well trained runner. He can make this time.	I don't think that is possible, because if run too much you will get tired and your speed will decrease, so as the speed slows down the time goes bigger.
If he is fit as expected, John can maintain his best 100m time in a kilometre distance.	When you run 100 meters you run with your full speed, but then at 17 you cannot run your full speed, you have to a bit sometimes jog because this is a kilometre it's not 100 meters
	It's not true because in the first 100 meters you running your full speed, but when the time goes on you get tired
	If John is a super-fit athlete, who trains regularly with a coach, then he can make it on time

Similar to studies conducted by Inoue (2009) on introductory-level psychology classes in Southern California, most of the learners' justifications were based on the claim that common-sense real life factors do not necessarily apply to certain or particular real-life situation. In so doing, justification of computational answers were designed to make their responses reasonable and acceptable.

3.3.3. Connections between classroom activity and everyday life experience

The data showed that these learners are used to this kind of problem, particularly in natural science studies. Moreover, the text in Extract 4 shows that learners exposed to classroom settings were answering a structured problem and providing the answer is sufficient. This was clear when learner 5 answered: "*I multiplied 17 by 10 it gives me 170, and then I got my answer*", without providing justifications and checking whether the answer is reasonable. A prominent finding in most of the research of this kind is that learners' performance on word problems differs dramatically depending on how the problems are designed (see Verschaffel et al., 2000). PS3 task is formulated according to the standard expectations in mathematics teaching, and it can be solved through a straightforward operation such as division or multiplication.

3.4. Real-life mathematical word problem without real meaning (PWRM)

The situation in the Eastern Cape province of South Africa is similar to that in which many Western students have been challenged by the famous "*shepherd's age*" problem (e.g., '*There are 125 sheep and 5 dogs in a flock. How old is the shepherd?'*(Greer, 1997; Nesher, 1980). Most of these students would answer "130", as they normally do in the classroom. Similar studies on realistic problem-solving have been conducted in China (see Liu & Chen, 2003; Xin, Lin, Zhang, & Yan, 2007; Xin & Zhang, 2009; Xu, 2007), where students are often confronted with word problems such as: '*There were 5 birds on a tree. If one bird was shot down by a hunter, how many birds are left?'.* A more realistic answer to the problem would be "N*one, because all of the other birds would be frightened away by the sound of the shot"* (Xin, 2009), however, most of these students would give an answer as "4".

In this study, learners were given a real-life mathematical word problem without real meaning, similar to the problems discussed above as follow:

Table 4.8

Real-life Mathematical Word Problem Without Real Meaning (PWRM)

You have 10 red pencils in your left pocket and 10 blue pencils in your right pocket. How old are you?	Uneepensile ezilishumi ezibomvu kwipokotho yakho yasekhohlo, uphinde ubeneepensile eziluhlaza ezilishumi kwipokotho yakho yasekunene. Mingaphi iminyaka yakho?

The data of the pre-test results revealed that learners in both experimental and comparison schools had a string tendency to exclude real-world knowledge and realistic considerations from their solution processes to this task. The results of the English-isiXhosa (EI) and isiXhosa-English (IE) groups are discussed below. All the learners' responses were classified into four categories based on their written answers and their responses to the clinical interview questions. They are discussed in the next sub-sections.

3.4.1. The EI and IE groups

The data show that learners who wrote the English pre-test first had a stronger tendency to relegate and exclude realistic considerations and real world knowledge in their solution processes. The extracts below show learners' responses to and justifications of their "unrealistic" solutions after being probed.

Extract 4.5

Kgabo Secondary School:

R(esearcher):	How did you approach this question?
L(earner) 3:	My age is 20 years old, I added up 10 red pencils and 10 blue pencils and I got the answer 20.
R:	OK, what about you L5? How did you approach the question?
L5:	I added up 10 red pencils and 10 blue pencils then I got the answer 20.
R:	Any other different approach?
Ls:	None.
R:	Your solution may not work in real life because of real factors. Why did you answer that way?
L6:	The question said you have 10 pencils on this side and another 10 pencils on the other side, so I thought because of the question did not ask anything on personal details and then I thought when you add up the pencils from both sides, it bring up the total of your age or something.
L3:	It's because the question didn't ask how old you are in real life.

The text in Extract 5 shows that these learners failed to recognise everyday knowledge and their understanding of everyday practices described in the word problem. Cooper (1998) offers a different explanation for the reason behind the "unrealistic" solutions, suggesting that it originates from the socio-cultural norm of schooling that emphasises de-contextualised, calculation exercises. In actual fact, learner 3's argument that "*The question didn't ask how old you are in real life*" confirms Cooper's view, that the learners' "unrealistic" responses reflect the learners' relationship to school mathematics and their willingness to employ the approaches stressed in school.

3.4.2. Reality in problem-solving

In solving this problem, the grade 9 learners readily responded "*I am 20 years old*", as if their own age could be determined by the reasoning that "*I added up 10 red pencils and 10 blue pencils*". Schoenfeld (1991) characterised this type of problem-solving as "*suspension of sense-making*", referring to the disconnect between learners' understanding of reality and problem-solving. As such, both EI and IE learners' problem-solving was lessened and relegated to a procedural, mechanical task with little or no sense-making beyond the number procedures used in this problem.

3.4.3. Sense-making of problem statement

All the written responses that reflected the common-sense understanding of everyday practice were categorised as sense-making of problem statement. In extract 5, learner 6 argued that "*So I thought because of the question did not ask anything on personal details and then I thought when you add up the pencils from both sides, it bring up the total of your age or something"*, symbolises Lave's (1992) description of word problem-solving as stylised representation of hypothetical experiences separated from learners' experiences. According to Anoue (2005), students' minds could be torn between two types of knowledge systems that the word problem activates: one developed in the traditional mathematics classroom and the other developed in through real-world experiences. In this study, the learners who gave calculation answers appeared mindless and mechanical; however, pre-intervention observations into these classrooms revealed that what is really problematic seems to be the lack of the opportunity for the students to freely bridge the calculation answers and their everyday life knowledge.

3.4.4. Personal interpretation of problem situation

Most of the learners' responses were largely influenced by personal interpretation of the problem statement based on quantitative information that led to word problem-solving resulting in calculation exercises, and not a solution that makes sense in terms of their everyday knowledge and experiences. All the learners in the EI and IE groups interpreted the problem situation the same way, with justifications pointing the same direction of reasoning. Extract 5 shows that when the learners answered: "*20 years old*", it was not because they did not know their actual age, or they did not understand the relevant mathematical concept (Frankenstein, 2009). Rather, it was, as (Pulchaska & Semadini, 1987) suggest, because learners give illogical answers to problems with irrelevant questions or irrelevant data is that those learners believe mathematics does not make any sense.

3.5. Real-life mathematical word problem without real context (PWRC)

It was noted earlier in this study that learners in these classrooms are drawn from different socio- economical and cultural backgrounds, largely coming from single, low class and working families. The results below show how these learners responded to real-life mathematical word problem without real context (PWRC).

Table 4.9

Real-life Mathematical Word Problem Without Real Meaning (PWRM)

It costs R5.00 each way to ride the bus between home and work. A weekly ticket is R50.50. Which is the better deal, paying the daily fare or buying the weekly ticket?	Ibhasi ikuhlawulisa ama-R5.00 ukuya nokubuya emsebenzini usuka ekhaya. Itikiti leveki libiza ama-R50.50. Kokuphi okungcono, kukho ukuthenga itikiti losuku okanye itikiti leveki?

3.5.1. The English-isiXhosa (EI) and isiXhosa-English (IE) groups

It appeared that learners' responses to this problem were largely influenced by contexts of individual economic differences. As such, the appropriateness of the problem situation was relative, and jeopardised the accuracy of the problem solution. Moreover, these responses reflected, yet again, some of the classroom pedagogies that encourage and support mechanical way of solving real-world problems.

3.5.2. Real context in problem-solving

The results of the PWRM show that learners from different social classes interpreted the context of the problem statement differently. For example, learners coming from working class families "transformed the 'neutral' assumptions of the problem – *all people work five days a week and have one job* – into their own realities and perspectives" (Tate, 1995, p.440). On the other hand, learners coming from a low income families view the meaning of 'job', such as domestic or part-time work, in their experiences, as working more or less than five days a week and in the process making fewer or more bus trips in a week.

4. CLASSROOM OBSERVATIONS

Classroom observations were done during and after the intervention to reveal the ways in which language was used by both the teachers and learners to implement the intervention strategy used in this study. Teachers and learners were observed using a four point scale classroom observation.

4.1. Observations during implementation

Three classroom observations were carried out in each of the four experimental schools during the intervention of intervention strategy. One of the objectives of this study was to measure the effect of intervention strategy on the ninth grade learners' problem-solving skills and use of language in learning mathematics. In this study, the focus of the researcher and his assistant was also to observe how the teacher used the language during the implementation of this strategy, and whether opportunities were made available for learners to engage in discussion and argumentation during the process. The data that were gathered through observations attempted to respond to the following objectives of this study:

1. To identify the use of language by both the teacher and learners, when teaching and learning in multilingual mathematics classrooms (Components 1 – 3); and

2. To check whether the introduction of discussion and argumentation into classroom practice has an influence on learners' sense-making and problem-solving abilities. (Components 4 – 7).

4.1.1. Component 1: Use of language by the teacher when asking questions, teaching, giving feedback, explaining mathematical terms and concepts

The first component of the observation during the implementation of the intervention strategy was to understand and reveal the use of language(s) by the four teachers of the experimental schools, when teaching word problems and problem-solving in mathematics classrooms. The issues of language use included, amongst others, teachers' questioning techniques, giving feedback to the learners, explanation of mathematical terms and clarification of concepts being taught. The results obtained from this component also assisted on how learners reacted to the language that is used by their teachers and implications for their own learning.

Table 4.10 illustrates a summary of teachers' use of language while implementing the intervention strategy used in this study, and provides a numeric rating per teacher against component 1.

Table 4.10
Teachers' use of language while implementing the interventional strategy

Strategy	Teachers			
	A	B	C	D
Uses home language only				√
Discourage use of home language				
Use English and switch to home language			√	
Uses English only	√	√		

Table 4.10 shows that both teachers A and B used English only, whereas the other two teachers, C and D, switched between English and learners' home language. Teacher A used English to ask questions and elucidate concepts that were taught during the implementation of the intervention strategy. Although her lesson was learner centred and the instruction given in English, most learners on all observations did not engage successfully with the teacher, but with the context in content used during the lesson. Teacher A explained the problem-solving task, which was presented in the form of a concept cartoon, in English. Learners interpreted and solved the task amongst them using their home language, and the teacher also used learners' home language to clarify issues emerging from the task. Most of the learners seemed to be more actively engaged with both the content and mathematics discourse in their home language than when communication occurred in English. Only few learners in this

classroom managed to engage the teacher in English without fear of embarrassment before their own peers.

Teacher B, just like in Teacher A, used English only to teach, ask questions and give guidelines on the concepts that were taught in his classroom. Teacher B intentionally used, on several instances, re-voicing as a strategy to explain concepts that were learned in the classroom in learners' home language. In this classroom, isiXhosa was used as an invisible resource to interpret and solve problems in groups. Learners responded to teacher's questions in their preferred language, switching between the LoLT and their home language when necessary.

In all the observed lessons conducted by Teacher C during the implementation of the intervention strategy, a structured use of learners' home language and LoLT in different phases of the lesson was employed. Teacher C predominantly used English during the introduction and work phase. In other words, English was used to introduce new concepts to be taught and explain the application of these concepts when solving mathematical problems during the lesson. In so doing, it became very difficult for the learners to interact confidently with the teacher using the LoLT. Learners preferred to communicate in their home language, amongst themselves, during one-to-one and group discussions.

Teacher D approached her lessons differently compared to the other three observed teachers above. All the observations into her classroom revealed that she is a confident isiXhosa speaker and had higher vocabulary levels of mathematics terms compared to her peers. She used isiXhosa as a resource to improve and encourage maximum interactions and participation in the classroom. Her classroom talk was high in both quality and quantity. She used learners' home language to teach, ask questions, clarifying concepts were necessary and when solving problems. The use of learners' language resulted in dialogical interactions and utterances that made it possible for a complicit agreement between the teacher and learners to participate in classroom discourse.

4.1.2. Component 2: Uses of Language by the learners

The second component focused on learners' use of language to seek clarification, elaborate and solve mathematical problems, pose questions and build upon previous responses during the lessons. Some of the discussion on this category is given in the first component above. Table 4.11 depicts how learners used language during the observed lessons.

Table 4.11
Learners' use of language during implementation of the Intervention strategy

Strategy	Teachers classes of learners			
	A	B	C	D
Use home language to solve problems	√	√	√	√
Seldom use English				√
Use English but switch to home language	√	√	√	
Uses English only				

The choice of language uses by Teachers A, B and C, did not have any effect and/or influence whatsoever, in learners' use of language when solving problems during the lesson. Learners from the two classrooms switched from English to isiXhosa in order to understand what was required of them within a problem-solving activity. Although they used code-switching as a resource to interpret and solve problems, learners of Teachers A, B and C classrooms communicated mostly in their home languages. However, they were able to use English to present their written solutions to both the teacher and entire groups.

Although Teacher D and her learners used mostly home language in her classroom, learners' infrequent use of English was noticed. In this classroom, English was used by the learners to translate and re-voice activities to be solved. They used English sentence starters when presenting answers to the teacher and reading instructions given to them.

4.1.3. Component 3: Language use by learners in groups

This component revealed the use of language by the learners when working in groups to solve problems, discuss and share ideas, talk, argue and engage in dialogue during classroom interactions.

Table 4.12

Language strategies used by learners during implementation the Intervention strategy

Strategy	Teachers			
	A	B	C	D
Uses home language for group work	√	√	√	√
Seldom use English		√		√
Use English but switch to home language	√		√	
Uses English only				

Table 4.12 above illustrates that in all the four classrooms, isiXhosa was used as a preferred language for group work and group discussions. The quality of discussions in small groups was high amongst group members, whereas the whole-classroom discussions were very low in quantity, particularly discussions between the teacher and the learners during the lesson. In both Teacher A and B's classrooms, learners used English infrequently, compared to the other two classrooms, where learners used English first, and then immediately moved to their home language in order to have common and mutual understanding of concepts being learned.

Learners used home language to engage their peers in exploratory talk during group problem-solving of tasks. They participated fully in discussing and formulating arguments about different solution strategies. They used their home language, isiXhosa, to negotiate rules of engagement in their individual groups and during classroom interactions in general.

4.1.4. Component 4: Learners' use of writing

Component four focused on the general use of writing as a strategy to learn and solve real-world problems in mathematics. The ways in which some of the classrooms were structured seemed to support the development of learners' written explanations. These explanations were in most instances modelled by the teacher and developed gradually in a relatively consistent progression that reflected the use of sentence starters and/or writing frames in the learning of mathematical concepts, using the LoLT.

Table 4.13
Learners' use of writing to learn mathematics

Strategy	Teachers			
	A	B	C	D
Learners do not write at all				
Learners write ineffectively	√			
Learners write to record findings, but text quality does not enhance their problem-solving skills	√		√	
Learners write effectively to record findings and enhance their problem-solving skills		√	√	√

During implementation of the intervention strategy, observations on the management of students' writing revealed that three-quarters of the four teachers managed to use writing in mathematics as a learning and/or assessment tool for their learners, but struggled to analyse learners' writing for insight into student learning. Table 4.13, shows that learners of the two classrooms (teachers B and D) wrote effectively to record their findings. As such, most of the group tasks were solved successfully, which revealed that their problem-solving skills gradually improved over time. Although learners did not write arguably good mathematical explanations, they learned problem-solving within classrooms, in which writing about mathematics was an integral activity. Teacher A’s classroom pedagogy showed the fact that writing about mathematics can be used does not in itself justify its implementation as an important part of classroom instruction.

4.1.5. Component 5: Teacher promoting discussion

One of the key elements in the intervention strategy was the use of discussion and argumentation in the teaching and learning of mathematics. This component focused in the introduction of discussion by the teacher during the lesson. Table 4.14 below shows teachers’ ratings against this component.

Table 4.14

Teacher promoting discussion during implementation the Intervention strategy

Strategy	Teachers			
	A	B	C	D
No discussion, talk is irrelevant				√
Unclear expectations set about behaviour in group tasks, no exploratory talk	√			√
Prompts given to support talk and argumentation	√	√	√	√
Clear expectations set about behaviour in group tasks, and the purpose of their talk		√	√	

Teachers B and C illustrated what the intervention strategy can do in whole classroom situations. These teachers prioritised opportunities for discursive talk and avoided posing closed questions during classroom instruction. They successfully used sentence starters to support and promote cognitively orientated talk and argumentation. Learners of the two classrooms were free to engage in interactive discussions, contribute ideas and share their experiences. Teacher A, like Teacher B, could not use discussion effectively in the classroom. As such, learners from these classrooms were not given the opportunity to brainstorm ideas, discuss opinions, and debate controversial issues emerging from concepts that are being taught or learned. The two classrooms were places where teacher could not create a truly safe environment in which learners were willing to share and plan a good deal of structured conversation. The arrangement of furniture in these classrooms did not allow learners to freely engage in discussion and dialogue during the lessons.

4.1.6. Component 6: Learners' responses

This component focused on how learners responded to different interactions in the classroom. Learners' responses occurred between the teacher and learners, and among learners themselves. Table 4.15 below shows types of learner responses during classroom interactions.

Table 4.15

Learners' responses during implementation the Intervention strategy

Strategy	Teachers			
	A	B	C	D
Learners do not respond at all				
Learners struggled to initiate talk	√		√	
Teacher builds on responses, exploring ideas		√	√	√
Learners initiate talk and contribute to discussions		√		√

The lessons that were observed in classrooms of both Teacher A and C had very low participation in classroom discourse. Learners in these classrooms struggled to initiate talk, and the teachers could not understand the importance of an individual's negotiation of participation opportunities within classroom practice. Most of these teachers valued and acknowledged learners' responses and managed to build on these responses when exploring shared ideas. Teachers B and D had good open questioning techniques that probed learners' utterances which resulted in high discursive talk. Learners were encouraged to initiate talk, contribute to, and engage in authentic discussions. The teachers' talks were less discursive than that of learners.

4.1.7. Component 7: Learners work in groups

Different cooperative learning techniques and theories of learning were employed in the four experimental classrooms during the implementation of the intervention strategy. This component will only present group dynamics and the type of interactions that emerged during group work in these classrooms.

Table 4.16

Group work interactions during implementation the Intervention strategy

Strategy	Teachers			
	A	B	C	D
Learners sit in groups but work individually				
Only 2 or 3 learners in a large group interact	√	√		√
Groups of learners with limited interactions	√		√	
Groups of learners discuss problems by themselves		√		√

Table 4.16 depicts that although all the observed teachers practised group work techniques in order to promote and encourage learner participation, and allow learners to construct their own knowledge, only few instances of authentic discussion took place within groups. For example, three classrooms (Teachers A, B and D) experienced few learners in large groups dominating discussions and interacting amongst themselves in the process. Teacher D frequently engaged learners in whole-class conversations where he asked a question and then called on learners to participate and how they would participate. While she maintained rules for participation within certain groups, she would frequently allow the rules of discourse to disintegrate when the learners got excited about a topic and the learners were allowed to interrupt and speak over one another.

5. INTERVIEWS

The objectives of interviews include collecting concrete insight, understanding, meanings, constructions and perspective of the interviewee's own experiences or knowledge on various issues (Denzil & Lincoln, 2005). In this study, pre-observation interviews were conducted at both teacher and learner levels respectively. Semi-structured interviews were conducted with each of the four teachers and focus group interviews (n=6) took place immediately after baseline testing and were done with learners from each experimental schools. The outcomes of these interviews are presented in the next sub-sections below.

5.1. Learner interviews

The learner interviews were conducted to investigate which language they prefer to use during classroom interaction, to communicate, when they solve mathematical problems, and for assessment, and why? The results are presented below using a few selected extracts as examples from learners' responses. All questions were in English and asked in the same order for all the four experimental groups, consisting of eight learners per group. Learners were free to respond in their home languages, but all the learners chose to respond in English.

Most of the learners indicated, from their responses, that English was a preferred language for classroom communication, when they individually talk to the teacher and present their group work to the entire classroom. This explanation was given in response to the question regarding the language that they use for communication in the classroom. Extract 1 below represents texts from the two groups of learners in different schools.

<u>Extract 4.6</u>

Kgabo Secondary School learners:

Learners:	English
R(esearcher):	Why English?
L1:	Because when you are educated you *must* know how to speak English, because maybe you will be hired in a job by a white person not Xhosa speaking person and you will be required to speak English.
R:	OK
L2:	You *must* use English because when you write in mathematics book you will not write isiXhosa because it is not a Xhosa period or Xhosa class, you also provide written answers in English, so it's better for you to answer in English, and become used in speaking and answering in English.
L3:	And English is the most used language here in South Africa.
R:	Any other reason?
L5:	English helps you to communicate with people from other countries, for an example the visitors for 2010 soccer world cup, we will be able to communicate with them in English because they will not understand isiXhosa.

Of many things which the texts in Extract 4.6 may suggest, what comes to the forefront is the learners' reasons for the use and association of "*English*" with "*hired in a job*", "*the most used language here in South Africa*" and "*communicate with people from other countries*". All these learners, in exception of learner 2, provide reasons that are not necessarily related to their classroom interactions, but those that affect their everyday-life challenges. The frequent use of the word "*must*" emphasises the feeling of obligation that the learners expresses in using this language to "*write in mathematics book*" in order to "*provide written answers in English*", as stated in Extract 1 by learner 2.

Learners were also asked about the language(s) that they prefer to use when solving word problems, and why. The aim of this question was to understand mathematical discourses that occur when learners solve problems in groups and/or pairs. Data gathered from their responses to this question, and triangulated with the results of classroom observations, revealed that learners used isiXhosa to solve word problems in their groups. They primarily used their home language and then translated their solution statements into verbal and written English when they presented their solutions to the entire classroom, and in their notebooks respectively. For example, one of the learners stated that "*We discuss in isiXhosa, but in the answer book we write English and we give presentation to the teacher in English*". Although some of the few groups employed a parallel use of English and isiXhosa, the strategy of translating from learners' home language was consistently applied across all the experimental classrooms, with learners switching or moving from their home language to English.

Skiba (1997) suggests that in the circumstances where code-switching is used due to an inability of expression, it serves for continuity in speech instead of presenting interference in language. In these multilingual classrooms, code-switching stands to be a supporting element in communication of information and in social interaction, and therefore serves for communicative purposes in the way that it is used. The notion prevails that English second language learners in these classrooms are not able to express themselves entirely in English, and allowing them to switch to their home languages is seen to compensate for such deficiency.

The data gathered from the learner interviews in this study shows that there was an unconscious switch or movement between isiXhosa and English. This argument is supported by the following statements made by learners when responding to the question about the difficulties that they have experienced when solving word problems in isiXhosa and/or English test, accompanied by justifications in this regard:

Extract 4.7

L2:	Maybe someone wants to choose isiXhosa or English sometimes chooses to use both of them.
R:	Which one would you prefer?
L3:	Both
R:	Why?
L3:	Because.... in English there will be words that I will not be familiar with, but understand them in isiXhosa, that's why I will use both.
R:	Will you move between the two languages?
L2:	I will also use them both, because isiXhosa it's difficult for me but then again there are certain difficult areas in English, so that is why I choose to use them both.

Extract 4.7 demonstrates that learners' were granted the opportunity by their teacher to move freely between the two languages in their groups when they solve word problems. However, the switching discussed here appears to differ from the switching presented in chapter 2, where it was indicated that both teachers and learners in multilingual classrooms code-switch freely between their utterances (Setati, 2005b). In these classrooms, only learners switch freely between the languages; teachers use only LoLT for mathematics instructions.

5.2. Teacher-interviews

The purpose of the interviews was to probe why teachers preferred a certain language practice to support classroom discourse and which language (English or isiXhosa) they preferred to teach mathematics and to engage learners in classroom interactions. All four teachers were asked the same questions in the same order. Interview questions were in English, but interviewees were free to use language of their choice. These data gave insight into the use of language and strategies that are employed in the teaching of real wor(l)d problem-solving.

The following questions were asked to each teacher in the general categories written in italics:

- *Classroom discourse in general:* Which language(s) do you use to support communication in your classroom and why?
- *Language used for sense-making:* Which language do you prefer to use when clarifying concepts that are being taught in the classroom? Why?
- *Language used for word problem-solving:* Which language do learners use as a resource in order to understand word problem-solving? Why?
- *Language support in the classroom:* Do you provide learners with opportunities to talk, discuss, argue and engage in dialogue when you teach? How?
- *Language for teaching and learning:* Which language do you mostly use to teach word problem-solving? Why?
- *Language policy in the school:* Which language is actually the Language of Learning and Teaching (LoLT) in mathematics at your school? Why?

Few extracts are used as examples from teacher interviews, and are presented below. All the names of teachers and schools in these extracts are pseudonyms and transcriptions were not edited.

Transcript 1*:* Which language(s) do you use to support communication in your classroom and why?

Extract 4.8

Teacher A: Normally when I'm teaching mathematics *I*'m using English because *I* want my learners to get used in the questions for English, because maybe during the exam time they will not be asked by me, they will be asked by somebody else, so *I* want them to get used , using the language even if *I*'m teaching mathematics.... The problem that *I* am having is to translate the words from English to Xhosa [*meaning isiXhosa*], because usually we are using alphabets... so it will be difficult to teach in Xhosa.

Teacher A is a first isiXhosa speaker using English to support communication in his classroom. He prefers to use English because it is the language of assessment, and he portrays learners' home language as a 'difficult' subject to use for teaching in his classroom. The teacher's use of first personal pronoun "*I*" suggest his own identity and positioning as a mathematics teacher and the expected role he plays in his classroom. He did not mention the implication(s) of using English on his learners and their positions in this regard. The observations also revealed that Teacher A and the learners held different positions resulting in different identities. This became clear when he said, "*The problem is to translate words from English to isiXhosa*", without mentioning if his learners had the same problem of translating between the two languages. The following extract indicates that Teacher B exercised the same choice of language use but offered different reasons for her choice.

Extract 4.9

Teacher B: Basically *I* use English...*[pauses]*

R: Why?

Teacher B: Firstly *I*'m not isiXhosa speaking, so *I* rather refer to the language that *I* can speak fluently... *I* don't really face problems because at least I understand the language, so *I* don't have a problem; I even give *them* the liberty to speak in isiXhosa when *they* are in class, because the most important idea is for *them* to understand rather than to speak the language on its own.

The teacher's preferred language for conversation in her classroom is English because "*I am not isiXhosa speaker"* and can easily refer to the language that she can speak fluently. While explaining reasons for her preferred language of communication in her classroom, Teacher B used the first personal pronouns *"I", "them"* and then *"they"*. The use of these pronouns suggests the identities and positioning of both the teacher and the learners, and their expected and negotiated roles filled by each party according to their positions. In Extract 9, the way *"them"* is used identifies learners as the key element of her classroom, holding almost the same position within classroom discourse. This was also confirmed during observations of her classroom, where she frequently used learners' home language as an invisible resource through peer-to-peer translations of mathematical terms, and re-voicing as a strategy to re-phrase and re-word difficult mathematical concepts.

Extract 4.10

Teacher C: I use their mother tongue which is isiXhosa; because sometimes you could continue in English and you discover later that they really did not understand what you actual wanted to put through, so it's easier for them sometimes when you explain in their mother tongue.

Extract 4.11

Teacher D: I'm using isiXhosa and English, but if I want to emphasize I use isiXhosa... Mostly I use isiXhosa. I think my learners don't understand me, so I prefer to use isiXhosa, the language they are using at home...., but we are using English books.

R: OK

Teacher D: Using isiXhosa for teaching and English for assessment works just fine because I use factorization, expression, and monomial because I don't know these words in isiXhosa, so I use those terms.

Teachers C and D used the learners' home language for most of the classroom interactions, including teaching and learning activities. The teachers' choice of language seemed to be influenced by her learners' linguistic competences. Teacher D's belief that *"I think my learners don't understand me, so I prefer to use isiXhosa, the language they are using at home"* and Teacher C's notion that "*You could continue in English and you discover later that they really did not understand what you actually wanted to put through*" suggest that these teachers prefer isiXhosa to communicate in the classroom. Teacher D also uses code-switching as a strategy to engage learners in classroom discourse. In her classroom practice, she regards English as a language of assessment and for use in learner and teacher support materials, but not necessarily for teaching and learning.

Transcript 2: Which language do you prefer to use when clarifying concepts that are being taught in the classroom? Why?

<u>Extract 4.12</u>

Teacher A: Sometimes not most of the time, just for few seconds I translate when I want to emphasise something, I can translate the English word into Xhosa, so that they can be able to grasp what I'm teaching to them.

R: Do you switch between the two languages?

Teacher A: Yes, but in Xhosa I am just teaching it for few seconds, but mainly I use English. **S**ometimes if I am using too much English, I will find that, I can see my learners, you can see them that they do not understand this thing, let me use their language. You find that when I am using their language they understand me, but I like to teach mostly in English

Extract 4.13

Teacher B: I wish I could speak isiXhosa sometimes, because the things that you really want to explain but you can't really get to the point, so I wish I could speak isiXhosa then I would use both languages.... I use English and support it in isiXhosa, what I actually do is: when I teach a concept, obviously in every class there are learners that are fluent in English and who are fast learners, so they are sort of my assistants, because when I explain if they get the concept then I will ask them to teach or say it the way they understand and by so doing everyone gets it, but of course we've got the few that might remain behind.

Extracts 4.12 and 4.13, present two responses of teachers about their preferred language used for clarifying concepts in the classroom. Teachers A and B agree that using only one language is not sufficient when explaining concepts that are being taught and learned. For example, in Extract 4.13, Teacher B used the language of learners and learners themselves as *"my assistants"* to explain and translate English words to isiXhosa. She engaged learners in such a way that opportunities to negotiate rules of engagement during mathematical discourse in the classroom were created. Teacher A used mostly English to unpack and explain concepts during his lessons. However, he acknowledged that "*when I am using their language they understand me, but I like to teach mostly in English".* He preferred English over the language he claimed produced better understanding of concepts being taught. The frequent use of personal pronoun *"I"* suggested that Teacher A holds position of power and authority on how learners should learn mathematics.

Extract 4.14

Teacher C: It should be English, but as I have mentioned before, I prefer to use isiXhosa as these learners are very weak in English... so to put it across in isiXhosa makes things easy for them.

Extract 4.15

Teacher D: isiXhosa

On the other hand, Teacher C and D prefer using isiXhosa when clarifying mathematical concepts that are being taught in the classroom. In Extract 4.14, Teacher C acknowledges that although English is the LoLT in his school, "*I prefer to use isiXhosa*". He uses learners' home language as a strategy to simplify the mathematical content being learned, because "*to put it across in isiXhosa makes things easy for them*". The following transcript, Transcript 3, addresses teachers' views on the language used during word problem-solving.

Transcript 3: Which language do learners use as a resource in order to understand word problem solving? Why?

Extract 4.16

Teacher A: The learners are using Xhosa, sometimes I ask them in English but they will answer me in Xhosa, but what is happening is that I always encourage my learners to speak, even if you speak Xhosa I accept that because I'm encouraging my learners to participate that is the most important thing, so that if they are wrong I can correct them or if they are wrong I can guide them, that is what I normally preach to them, that is the way of encouraging them to participate. Because you won't know Mathematics if you just fold your hands, but if you are speaking it or writing something on the chalkboard or you are writing something on a piece of paper that is what I like from my learners.

R: Are they *[learners]* scared to use their home language (isiXhosa)?

Teacher A: No they are not afraid because I say to them as long you are speaking in my class you can use any language and then I will correct you if you are wrong, that is what I'm preaching with my learners.

Extract 4.17.

Teacher B: I think basically they are using isiXhosa and it's all because of their background, they are speaking isiXhosa all over except in class. They only speak English in class and I've noted that even in the English lessons they are having a problem because they sometimes refer things in isiXhosa, so I've noticed it's just me at the end of the day who is probably speak English. But my idea really since I'm teaching a content subject which is really requires them to understand the concept more than the language.

Extract 4.18

Teacher C: I think its English because word problem are the difficult part of the Mathematics to interpret words into an equation, I think English will be the better language to use because isiXhosa will be very much difficult to interpret these word problems.

From Extract 4.18, Teacher C thinks learners use English to solve word problems. The text from the above extract seems to contradict what he claimed earlier: "*These learners are very weak in English*". This contradiction seemed to be brought about by the dilemmas encountered in multilingual classrooms. The observations during his (Teacher C) lessons revealed that learners (Kgabo School) used isiXhosa to communicate and solve problems in their groups, but immediately switched to English when engaged by their teacher, in very brief and simple turns of utterances. The text in this extract also provides another pedagogical perspective about the expected roles of the teacher compared to those of his learners in classroom discourse.

Extract 4.19

Teacher D: isiXhosa

R: Why do you think learners choose isiXhosa?

Teacher D: Maybe they choose English because the text books are written in English, but when I'm teaching I'm using isiXhosa, whereas it is English in the text book, but the instructions are in English and I'm using English for instructions.

The teacher's voice in extract 4.19 provides a correct picture of how and when learners use language to solve word problems. According to Teacher D, learners use isiXhosa in most of their discussions, but would "*choose English because the text books are written in English*" every time they express their solutions in written form. Moreover, observations in this classroom revealed that both the teacher and learners used English to translate and re-voice contexts embedded in word problems. Teachers were asked about the strategies that they employ in the classroom to improve and encourage learner participation and discursive talk.

Transcript 4: Do you provide learners with opportunities to talk, discuss, argue, and engage in dialogue when you teach? How?

Extract 4.20

Teacher A: Yes that is what I normally do; I give them classwork... I encourage them that you can work in pairs, you can *discuss* it. ...I can say do it alone because we have done this last week or at the beginning of the year so you can do alone... I'm always encouraging them to work in pairs or I even encourage them to go to the board and do the feedback on the board.

Teacher A describes how he uses cooperative learning techniques to "*encourage them to work in pairs*" during his lessons. His strategy to engage learners in classroom discourse included allowing and encouraging learners to write their solution statements at the board for feedback purposes. In so doing, effective classroom interaction was not realised in this classroom. Only a few confident and brave learners benefited from this exercise by taking the most chances of standing in front of the others and explaining how a problem is solved. Teacher B, unlike Teacher A, had a strong belief in "*peer interaction and teacher to peer interaction"*, and a challenge that she faces is how to achieve whole classroom interaction, as seen in Extract 4.21below.

Extract 4.21

Teacher B: Very much. Mathematics requires that a lot, there's a need for interacting, there's a need for peer interaction, there's need for teacher to peer interaction, so we do involve them so much.

R: How do you go about doing that, what are those strategies that you employ usually in the classroom?

Teacher B: Sometimes it's guided discovery, there's a concept that I want them to discover, I just lead them to that concept for them to *discuss* it and discover it, so its peer interaction among them or it can be them and me

The text in the extract shows that the teacher knowledge that exists in multilingual classrooms cannot be easily translated and equated to productive and successful pedagogies that result in maximum classroom interactions. When asked about the strategies that she employs to engage learners in discussion in the classroom, Teacher B describes "*guided discovery*" as a strategy to guide and allow learners to co-construct their own knowledge. In the process, she believes that peer and teacher to learner interactions will occur.

In Extract 4.22 below, Teacher C has strong ideas about how to involve learners in the teaching and learning of mathematics. These include allowing social interaction and creating a conducive atmosphere in teaching.

Extract 4.22

Teacher C: I always try at all times to be friendly with these kids, you know when you teach Mathematics and if you always come to class being angry and so on with them you'll discover that it doesn't work, but although sometimes they will take advantage if you are too friendly, I just encourage even those who don't want to talk, just to *speak*... feel free to *voice out* your opinion, if its correct or incorrect its fine as long as you are able to stand up and say what you want, to say without fear.

Teacher C presents and portrays a mathematics teacher as someone who should be approachable to learners. The text in Extract 4.22 paints a picture of a teacher who "*always try at all times to be friendly with these kids*" when teaching, in order to draw them into active participation within classroom discourse. His strategy to involve these learners includes telling them to "*feel free to voice out your opinion"* and to say what is on their minds "*without fear*" of embarrassment before fellow peers.

Teachers were also asked about the language that they use the most for teaching mathematical word problems in the classroom. All the teachers' responses indicated that they use English for teaching word problem-solving. The transcript below presents a few selected extracts that are used as examples of teacher responses.

Transcript 5: Which language do you mostly use to teach word problem-solving? Why?

<u>Extract 4.23</u>

Teacher A: Ok I use English, but I know my learners they are having a problem in answering the word problems, to assist them I also use the Xhosa language because I think they understand better the word problems in Xhosa than in English.

Teacher B: I use English

Teacher C: I use English... sometimes it is difficult especially word problems, it is difficult for them to interpret it in isiXhosa, so what I always say to them, if you don't understand try to read it over and over and a meaning comes after a certain time, but I do try there and there to explain it in isiXhosa, but that's a difficult part in Mathematics to teach those word problems.

Teacher D: I teach in English but in some areas I use isiXhosa. Because they write in English, the tests are in English not in isiXhosa.

It is very clear in the texts of Extract 4.23 that the language of teaching word problem-solving is English in all the classrooms. From these texts, it can be argued that mathematics teachers in these schools, just as in other countries such as Burkina Faso, Ethiopia, Malawi, and Niger (Brock-Utne & Alidou, 2005; Chekaroua, 2004; Mekonnen, 2005; Chitera, 2009), are somehow familiar with the official LoLT required for the schools. However, these teachers have not received pedagogical support on how to implement the policy in multilingual contexts, where the LoLT is not the learners' home language. All teachers use English and then switch to isiXhosa when necessary. These teachers argue that teaching word problems in isiXhosa is very difficult because of the limited vocabulary of mathematics terms in isiXhosa. Teacher B uses English only, because the learners' home language is not her home language. As such, Teacher B uses learners as resources to re-voice and translate for peers during the lesson.

6. PRE- AND POST-TEST: QUANTITATIVE RESULTS

Descriptive statistics generated from pre- and post-test data are discussed below in light of research objectives of the study. The analysis done on PS items focuses on computational (or mathematical) correctness of learners' answers, together with situational accurateness of their responses. Comparative results of and differences between experimental and comparison groups are discussed before and after the intervention.

6.1. Results of the problem-solving (PS) tasks

6.1.1. The effect of language (home or LoLT) use in word problem-solving

Table 4.17 depicts data generated from learners' pre-tests on the problem-solving (PS) items in both English and isiXhosa translations. The overall percentages of RRs in the isiXhosa and English translation respectively were 15% and 12%, which indicate that learners' responses were more mathematically correct and situationally accurate in the isiXhosa test than the English translation. As such, a more detailed look at the responses revealed that these realistic reactions (RRs) in the isiXhosa translation produced more computationally correct other reactions (ORs) for PS1 and PS3, respectively, 37%, and 55%.

Table 4.17
Percentages (and absolute numbers) of realistic reactions (RRs), other reactions (ORs), and no reactions (NRs) on the three problem-solving (PS) English and isiXhosa items for the Experimental group

Item	**PS1**	**PS2**	**PS3**	**Total**	**PS1**	**PS2**	**PS3**	**Total**
	English Pre-test				**isiXhosa Pre-test**			
RR	27% (29)	5% (5)	4% (4)	12% (38)	10% (11)	29% (31)	6% (6)	15% (48)
OR	34% (36)	42% (45)	23% (25)	33% (106)	37% (39)	39% (42)	55% (59)	44% (140)
NR	39% (42)	53% (57)	73% (78)	55% (38)	53% (57)	32% (34)	39% (42)	40% (48)

Overall, the percentages of ORs on the three PS items for the isiXhosa and the English translation were 44% and 33%, respectively. In other words, the overall quantitative results suggest that more mathematically correct responses were produced in the isiXhosa translation of the pre-test compared to the English pre-tests, but these solutions were situationally inaccurate. PS3 item produced a high percentage (73%) of no reactions (NRs) than other PS items in both translations, which suggested learners' lack of awareness to succeed in realistic modelling of word problems.

6.1.2. The effect of test order on the problem solving and sense-making

The results of Table 4.18, which show the percentage of the isiXhosa-English (IE) group learners who wrote the isiXhosa translation first, indicate that seeing the paper in learners' home language had no effect on achievement scores of the English translation. However, 41% of the mathematically correct responses were obtained in the isiXhosa translation, with 60% of these responses generated on PS3 item compared to almost a third of the ORs produced on the same item of the English translation. So the percentage of RRs in

PS2 (of the isiXhosa translation) was somewhat more than that in PS1 and PS3, whereas the reverse was true for the other answers (ORs). The finding that PS2 yielded more RRs than PS1 is consistent with most previous studies showing lower percentages of realistic answers in a problem with division with a remainder (e.g., Verschaffel et al., 2000, 2009). This finding was not the case with responses in the English translation for the IE group.

Table 4.18

Percentages (and absolute numbers) of realistic reactions (RRs), other reactions (ORs), and no reactions (NRs) on the three problem-solving (PS) items for the isiXhosa-English (IE) Experimental group

Item	PS1	PS2	PS3	Total	PS1	PS2	PS3	Total
	isiXhosa Pre-test				**English Pre-test**			
RR	13% (7)	36% (20)	5% (3)	**18% (30)**	35% (19)	7% (4)	5% (3)	**16% (26)**
OR	33% (18)	31% (17)	60% (33)	**41% (68)**	30% (17)	49% (27)	25% (14)	**35% (58)**
NR	55% (30)	33% (18)	35% (19)	**41% (67)**	35% (19)	44% (24)	69% (38)	**49% (26)**

The results of English-isiXhosa for the same three items discussed are given in Table 4.19. The PS1, PS2, and PS3 item elicited 40%, 48% and 50% ORs respectively, and an average percentage of 46% in the isiXhosa translation. In fact, there was an increase of 15% ORs in the isiXhosa translation after already having seen the English. This finding indicates that learners' responses on the three items in the isiXhosa translation were mathematically correct after seeing the same items in the English translation. Only 8% of the learners produced realistic answers on the three items of the English translation, compared to an increase of 4% generated for the isiXhosa translation. The increase in percentage of the RRs revealed that not only more computationally correct responses were generated in the isiXhosa translation, but there was also a slight improvement in the percentage of learners who succeeded in producing situationally appropriate answers.

Table 4.19

Percentages (and absolute numbers) of realistic reactions (RRs), other reactions (ORs), and no reactions (NRs) on the three problem-solving (PS) English items for the English-isiXhosa (EI) Experimental group

Item	**PS1**	**PS2**	**PS3**	**Total**	**PS1**	**PS2**	**PS3**	**Total**
	English Pre-test				**isiXhosa Pre-test**			
RR	19% (10)	2% (1)	2% (1)	**8% (12)**	8% (4)	21% (11)	6% (3)	**12% (18)**
OR	37% (19)	35% (18)	21% (11)	**31% (58)**	40% (21)	48% (25)	50% (26)	**46% (72)**
NR	44% (23)	63% (33)	77% (40)	**61% (96)**	52% (27)	31% (16)	44% (23)	**42% (66)**

The pre-test results of Table 4.20, which depict the percentage (and absolute number) of learners who succeeded in producing three, two, one, and zero RRs to the PS tasks, illustrate that learners performed rather poorly on these items requiring not only computational skills, but realistic sense-making as well. Only 1% of learners in the experimental schools produced three situationally accurate answers or reacted three times in a way that shows attention to the realistic modelling complexity of the problems. A closer look at the post-test results for the experimental schools shows a 10% improvement in the production of 2RRs compared to a drop of 6% in the comparison schools.

Table 4.20

Percentages (and absolute numbers) of learners who produced three, two, one, and zero realistic reactions (RRs) on the problem-solving (PS) task for the Experimental and Comparison groups.

Category	3 RR	2 RR	1 RR	0 RR	Total	3 RR	2 RR	1 RR	0 RR	Total
	English Pre-test					**English Post-test**				
Experimental	1% (1)	3% (3)	27% (29)	69% (74)	100% (107)	2% (2)	13% (14)	27% (29)	58% (62)	100% (107)
Comparison	0% (0)	6% (4)	26% (18)	68% (47)	100% (69)	0% (0)	0% (0)	14% (10)	86% (59)	100% (69)

6.2. Results of word problem without real meaning (PWRM)

6.2.1. The effect of reality in word problem solving

Table 4.21 shows statistical comparison results of learners' responses to a problematic word problem without real meaning. At a general level, both English and isiXhosa translations produced high percentages, respectively, 86% and 75% situational inaccurate responses. On average, the pre-test results illustrate that 81% of the responses showed a strong tendency to exclude real world knowledge and lack of common-sense understanding. Similar findings have been replicated for a wide variety of problems, across different age levels and socio-cultural settings (see Verschaffel et al., 2000). In fact, learners solved the 'age' problem by a mere use of numbers given in a problem statement. As a result, only 2% and 5% of the responses considered realistic factors of the problem statement in both English and isiXhosa translations respectively, compared to 12% and 20% achievement of the same item after the intervention. As such, the results of the post-test for the PWRM revealed an improvement of just over 20% of the responses which succeeded in reflecting common-sense understanding of reality in problem-solving.

Table 4.21

Percentages (and absolute numbers) of word problem without real meaning for the Experimental group

Item	LA	20YRS	OA	LA	20YRS	OA
		Pre-test			Post-test	
English	2% (2)	86% (92)	12% (13)	29% (31)	57% (61)	14% (15)
isiXhosa	5% (5)	75% (80)	20% (22)	18% (19)	63% (68)	19% (20)
Total	3% (7)	81% (172)	16% (35)	24% (50)	60% (129)	16% (35)

6.2.2. Reality and context in word problem solving

Table 4.22 shows the results of word problem without real context (PWRC) for the items weekly (W), daily (D), and other answer (OA), which produced 45%, 32%, and 23% respectively, in the English pre-test, compared to 43%, 38%, and 19% generated for the same items in the isiXhosa translation. This finding suggests that learners interpreted and solved the problem almost the same way in both English and isiXhosa. 23% of the responses produced OAs that were both mathematically incorrect and situationally inappropriate, which may be attributed to failure by these learners to comprehend the problem statement successfully in both languages. It was also found that, similar to the studies conducted amongst inner-city African American students (Tate, 1995), learners transformed the neutral assumptions of the problem to *All people work 5 days a week* and *have one job* into their own real-life experiences and perspectives. As such, an average of 35% Ds was produced by these learners.

Table 4.22

Percentages (and absolute numbers) of word problem without real context for the Experimental group

Item	W	D	OA	W	D	OA
	Pre-test			Post-test		
English	45% (48)	32% (34)	23% (25)	36% (39)	28% (30)	36% (38)
isiXhosa	43% (46)	38% (41)	19% (20)	39% (42)	33% (35)	28% (30)
Total	42% (94)	35% (75)	21% (45)	38% (81)	31% (65)	32% (68)

7. STATISTICAL ANALYSES

The quantitative data generated by the pre- and post-tests for each of the five word problem items were treated via the analysis of variance model (ANOVA), to determine the statistical (non)significance of the results, based on mean difference between experimental and comparison groups before and after the intervention.

Cohen's d statistics were calculated to determine whether statistically significant ($p < .0005$) 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).

7.1. Effect of intervention and test language on problem solving

7.1.1. Problem solving before and after intervention (English test)

Analysis of pre-test results indicate a statistically significant difference between experimental and comparison groups, with the experimental group performing worse compared to the comparison group ($p < .0005$). After the intervention, the experimental group performed statistical significantly better ($p < .0005$) than the comparison group, with a mean difference ($\Delta\overline{\chi}$) of 29.14 (positive mean difference implies that the mean score of experimental group was more than that of comparison group – see Appendix I) on the English post-test.

7.1.2. Problem solving before and after the intervention (isiXhosa test)

The overall isiXhosa pre-test results show a statistically significant ($p < .0005$) difference between the experimental and the comparison groups, with the comparison group performing better than the experimental group ($\Delta\overline{\chi} = -12.37$) before the intervention. The researcher found that the experimental group performed statistical significantly ($p < .0005$) better in the translation of the isiXhosa post-test after the intervention. In other words, the problem-solving ability of the experimental group improved significantly after the intervention, even though it performed well below the comparison group on the pre-test (before the intervention).

7.1.3. Sense-making (or realistic considerations) of word problem solving

The mean difference ($\Delta\overline{\chi} = 0.47$) shows a statistically significant ($p < .0005$) difference between the experimental and the comparison groups for the English (RR) translation after the intervention. The positive mean score show that, although the comparison group had a tendency to consider reality and sense-making when solving the word problems before the intervention ($\Delta\overline{\chi} = -0.02$), it performed well below the experimental group after the intervention.

A statistically significant ($p < .0005$) difference, was also noted, between the experimental and the comparison groups on the overall isiXhosa (RR) translation, and the comparison group was better on the isiXhosa pre-test ($\Delta\overline{\chi} = -0.35$). In other words, the positive mean difference ($\Delta\overline{\chi} = 0.69$) shows that the experimental group's realistic considerations and/or sense-making of reality in word problem-solving improved significantly better than that of the comparison group after the intervention.

7.1.4. Practical significance of the differences (English and isiXhosa test results)

As $p < .0005$ in all cases, Cohen's d was calculated in order to gauge the effect size of the practical significance of the differences in the experimental and the comparison group. There was a large practical significance ($d = 1.56$) noted on the English translation, compared to a moderate practical significance ($d = 0.74$) on the isiXhosa translation. In comparing the effect sizes on the RR difference (English) between the experimental and the comparison groups, a moderate practical significance ($d = 0.57$) was calculated, compared to a large practical significance ($d = 0.86$) noted on the isiXhosa RR difference.

7.1.5. Matched-Pairs t-Tests (Post- Pre-test differences: Experimental vs. Comparison groups)

Table 4.23 shows the results of a matched-pairs t-test that were used to test whether there was a significant mean difference between English and isiXhosa before and after the intervention (or pre- and post-tests) in the experimental and comparison groups. In addition to this, Table 4.23 depicts mean scores of experimental and comparison groups in word problem solving and sense-making (RRs) of word problems in this study.

Table 4.23

A test of a significant mean difference between English and isiXhosa pre- and post-tests in the experimental and comparison groups using a matched-pairs t-test.

						Matched-Pair t-Test			
		Mean	**Std.Dv.**	**Diff.**	**Std.Dv**	**t**	**df**	**p**	**Cohen's d**
Experimental	Eng.a* Eng.b	40.64 57.72	21.33 24.92	17.08	31.76	-5.56	106	.000***	0.54
Comparison	Eng.a Eng.b	55.25 28.58	15.80 19.36	-26.67	20.79	10.65	68	.000	-1.28
Experimental	Xho.a Xho.b**	49.72 46.65	22.54 24.50	-3.07	29.17	1.09	106	.279	N.A
Comparison	Xho.a Xho.b	62.09 38.52	19.30 19.88	-23.57	24.98	7.83	68	.000	-0.94
Experimental	Eng.RRa Eng.RRb	0.36 0.59	0.59 0.79	0.23	0.89	-2.73	106	.007	0.26
Comparison	Eng.RRa Eng.RRb	0.38 0.14	0.60 0.35	-0.23	0.69	2.80	68	.007	-0.34
Experimental	Xho.RRa Xho.RRb	0.45 0.56	0.65 0.68	0.11	0.82	-1.42	106	.158	N.A
Comparison	Xho.RRa Xho.RRb	0.80 0.22	0.80 0.42	-0.58	0.79	6.07	68	.000	-0.73

**'a' denotes the pre-tests, and 'Eng.a' implies English pre-test*
*** 'b' denotes the post-tests, and 'Xho.b' implies isiXhosa translation of post-test.*
**** Note that reported p= .000 implies p< .0005*

At $p < .0005$ significance level, the study gives overwhelming evidence that problem solving scores of experimental group improved by 17.08 after the intervention., with a practical significance calculated for the experimental group (English) is moderate ($t = -5.56$, $df = 106$, $p < .0005$, $d = 0.54$). Although the comparison group's mean score was higher than that of experimental before the intervention (English pre-test), a negative mean difference ($\Delta\bar{\chi} = -26.67$) suggests that comparison group not only scored well below experimental group after the intervention, but performed significantly worse than the experimental group.

A practical non-significance (t = 10.65, df = 68, $p < .0005$, d = -1.28) was also calculated for the comparison group. Despite a small practical significance (t = -2.73, df = 106, $p < .007$, d = 0.26) found on the experimental groups' English RRs, the experimental group did significantly better than the comparison group with a marginal significant improvement in sense-making scores on the English and isiXhosa RRs, respectively $\Delta\overline{\chi} = 0.23$ and $\Delta\overline{\chi} = 0.11$ in the experimental group after the intervention.

7.2. Effect of test order

7.2.1. Problem solving and realistic considerations:

Statistical analysis of pre-test results indicates that problem-solving improved by 15% in the isiXhosa translation after having already responded to the English test in the experimental (EI) group. In addition, realistic considerations of word problem-solving improved marginally by 6% in the isiXhosa translation. In contrast, the IE group not only performed well below the EI group, but their problem-solving and sense-making of word problems decreased, by 4% and 10% respectively in the English pre-test. When comparing the overall English and isiXhosa results before the intervention, a negative mean ($\Delta\overline{\chi} = -2.24$) showed a better performance in the isiXhosa translation, and a positive mean difference score ($\Delta\overline{\chi} = 21.01$) suggests that learners' word problem-solving improved in English compared to the isiXhosa translation after the intervention. A statistically significant ($p < .005$) difference was also noted between the experimental and comparison groups in English-isiXhosa pre- and post-test order, with overall results showing significantly better performance in English.

8. QUANTITATIVE RESULTS SUMMARY

The following table, Table 4.23, shows the summary of quantitative results based on mean score differences before (pre-tests) and after (post-tests) the intervention, in the English and isiXhosa translation of the tests.

Table 4.23

Summary of results based on mean differences between the experimental and comparison groups (English and isiXhosa pre- and post-tests)

	English (pre- and post-tests)	isiXhosa (pre- and post-tests)
Problem-solving (mathematically correct answers)	• The comparison group scored statistically significantly ($p < .0005$) higher in problem-solving in the English pre-test but performed well below the experimental group after the intervention. • The experimental group's mean score for problem-solving improved statistically significantly more than the comparison group's did after the intervention (English post-test). A large practical significance ($d = 1.56$) was also noted. • The mean difference ($\Delta\overline{\chi}$) between English and isiXhosa problem-solving scores was statistically significantly different in favour of English after the intervention (post-tests).	• The comparison group performed statistically significantly better than the experimental group in isiXhosa pre-tests. However, the experimental group mean score was higher in the post-tests. • The experimental group's mean score (translation of isiXhosa post-test) improved statistically significantly better than that of comparison group, with a mean score difference of 20.50 after the intervention. There was also a moderate practical significance ($d = 0.74$) • The isiXhosa mean score was higher than that of English before the intervention (pre-tests), but the mean difference was not statistically significant after the intervention.
Sense-making (realistic considerations of problem statement)	• The comparison group scored slightly higher than the experimental group in sense-making of word problems in the English pre-tests, but the difference was not statistically significant. • The experimental group scored statistically significantly ($p < .0005$) higher than the comparison group in sense-making of word problems in English post-tests. A moderate practical significance ($d = 0.57$) was noted. • The $\Delta\overline{\chi}$ between English and isiXhosa sense-making scores was statistically significantly ($p < .015$) different in favour of English in the pre-tests.	• The comparison group performed statistically significantly ($p < .002$) slightly better than the experimental group in sense-making of isiXhosa translation of pre-tests. • There was a statistically significant ($p < .0005$) improvement in the experimental group in the sense-making in isiXhosa translation of the post-tests over the comparison group. A large practical significance was also noted after the intervention (isiXhosa post-tests) • There was a drop in $\Delta\overline{\chi}$ between English and isiXhosa sense making scores in favour of English post test, but there was no statistically significant difference noted.
Test order (English-isiXhosa [EI] and isiXhosa-English [IE] groups)	• Problem-solving and sense-making mean scores in English dropped, respectively, by 4% and 10% after seeing the paper in isiXhosa first. EI group performed better than the IE group.	• Problem-solving and sense-making mean scores in isiXhosa improved by 15% and 6% respectively, after seeing the paper in English first.

9. CHAPTER SUMMARY

Data analysis of all the research instruments used in this study indicate that although learners preferred both LoLT (English) and isiXhosa in word problem-solving, they performed better in English, which could be attributed to the fact that the intervention was done in English. However, learners' sense-making of word problems significantly improved in their home language. As a result, code-switching and re-voicing were found to be effective teaching and learning strategies during the implementation of the intervention strategy in the experimental schools.

Analysis of qualitative results at teacher level suggests that learners' home language(s) should be afforded a place in the teaching and learning of mathematics, particularly word problem-solving in multilingual classrooms. Analysis of variance (ANOVA) indicates that the difference between the experimental and the comparison groups was significant at the .0005 level. The effect size was derived from the overall mean scores and standard deviations to determine the magnitude of the quantitative results of this research, and an overall large (Cohen's $d > 0.8$) and moderate ($0.5 < d < 0.8$) practical significance for English and isiXhosa respectively. As such there is clear evidence from the data analysis that teachers' practice improved after the intervention.

In the next chapter, the results of this study are discussed by presenting an overview of both quantitative and qualitative data and responding to the research objectives and answering the research questions.

CHAPTER FIVE

DISCUSSION OF RESULTS

1. INTRODUCTION

This chapter critically examines the qualitative and quantitative data generated in this study. The results that emerged during data analysis of classroom observations before and during the intervention, and interviews of both learners and teachers, are discussed in terms of the general categories presented in chapter four. Thereafter the results of the quantitative data analysis of pre- and post-tests are presented. These data are interrogated within the context of the theoretical underpinnings noted in chapter two of this study in an attempt to provide answers to the research subsidiary questions.

2. QUALITATIVE RESULTS

As noted earlier, qualitative data were generated from classroom observations and interviews at both learner and teacher levels in the experimental schools during the intervention. Another set of data were gathered via four focus group discussions involving six to eight learners from each experimental school.

2.1. Classroom observations

Reports on classroom observations and teacher development suggest that classroom interactions and teachers' pedagogical practices predict learning and positive change (or improvement) as a function of specific and aligned support (e.g., intervention of this study) for teachers (Pianta & Hamre, 2009). As such, the classroom observations in this study were used to provide insight into and explanations of the use of language by both the teacher and the learners in multilingual mathematics classroom (first objective of this study). The classroom observations were also used to track the experimental teachers' progress and judge their ability to implement teaching strategies learned during the intervention workshops.

2.1.1. Baseline observations

The results of the classroom observations appear to substantiate that 'what teachers do' serves as a fundamental component to raising learner outcomes (Douglas, 2009). Overall, the pre-intervention classroom observations in the experimental group revealed four important findings:

- Very little discussion took place in the classrooms before the intervention, and in cases where discussion took place, it was characterised by, as identified and stated by Lemke (1990), talk and/or arguments that were high in quantity and low in quality;
- There were no opportunities created for learners in writing to learn mathematical word problems before the intervention and as such, very little evidence of writing was available; and
- Although experimental mathematics teachers struggled to promote the use of language, particularly learners' home language, as a visible and/or invisible resource in maximising learner participation in mathematics discourse, they seemed to improve over time during the intervention;
- After the intervention, lessons involved a set of group interactions and communication that occurred through some order of turn taking, where each party to the interaction made their talk comprehensible to all (Heap, 1990).

Data that were generated through classroom observations during the intervention responded to the two objectives of this study:

- To identify the use of language by both the teacher and learners, when teaching and learning in multilingual mathematics classrooms; and

- To check whether the introduction of discussion and argumentation into classroom practice has an influence on learners' sense-making and problem-solving abilities.

The data generated via the classroom observation schedule presents possible explanations to teachers' classroom practices and learners' behaviour during and after the intervention and are presented in the following sections.

2.1.2. Use of language in the classroom

Lerman (2001) reiterates the importance of accounting for alignment and power in analysing language in mathematics classroom, suggesting that the official language of the classroom can position certain groups with power and privilege. Although experimental learners were afforded opportunities to use the language they preferred for discussion and problem-solving in their small groups, the use of English by their teachers suggested the teachers as a figure of a powerful authority, which had an effect on the language used by the learners in the classrooms. Reports by researchers (Adler, 2001; Kaphesi, 2003; Moschkovich, 2002; Setati, 2005a) indicate that teaching and learning mathematics in a language that is not the learners nor teachers' home language is complex and can create dilemmas for teachers. As Setati and Adler (2001) argue, the movement from informal spoken language to formal written language is complicated by the fact that the learners' informal spoken language is typically not the LoLT. Mathematics teachers in multilingual classrooms are faced with yet another dilemma of encouraging learners to participate actively in mathematical discourse, and classroom talk in general. Baseline observations revealed that only a few learners in the experimental group participated in the discourse because they are not confident and competent in linguistic exchanges (Zevenbergen, 2000). The baseline observations suggest that most of the classroom talk was teacher dominated and in the process, learners' roles were relegated to that of a spectator in the teaching and learning of mathematics (Alexander, 2004). In so doing, teaching mathematics through problem-solving and understanding was not attempted and/or achieved in these classrooms.

In an analysis of lessons observed in the experimental schools, English emerged as the language of teaching, and thus the language of mathematics and of assessment (Setati, 2002). Data generated from observations revealed that, although most of the teachers in the experimental schools were found to be largely using English as the language of mathematics, authority and assessment (Setati, 2005), there were very few instances, contrary to findings by Setati, where the learners' home language, isiXhosa, functioned mainly as the language of consolidation. In fact, learners' home languages functioned mainly as the language to connect classroom mathematics activities with learners' everyday-life knowledge during small group discussions. As such, it appeared that the majority of the learners in the experimental schools preferred to use their home languages when discussing and solving problems in small groups. In rare cases where a teacher would use English throughout the lesson, communication and utterances were the domain of the teacher only. Only few learners responded to the teacher's questions in English, which possibly signalled their linguistic incompetence in this regard (Mayaba, 2009).

2.1.3. Classroom interactions

The baseline observations revealed that classroom interactions in the experimental schools took the form of teacher initiated talk (Mercer, 1995), characterised by teachers' regular use of inauthentic initiation turns. In cases where the teacher asked questions, learners responded in chorus (Mayaba, 2009). Moreover, these classrooms were embedded with social discourses that reflected learners' socio-cultural backgrounds (Lemke, 1990). There were only few occasions that resulted in learners' engagement in dialogue, which occurred between the teacher and a few individual learners. As such, there were no understanding and agreement of rules of engagement between the teacher and learners in these classrooms to actively engage with mathematical discourse in order to contribute positively in problem-solving initiatives. The tendency by learners to be passive may be attributed to the classroom linguistic structures that were restricted to English, characterised by teachers' inability to attend to gestures, representations, and everyday descriptions that second language learners draw on to create and communicate meaning in mathematics classrooms (Nasir, Hand, & Taylor, 2008). In doing so, teachers inadvertently missed the multiple, rich resources that learners bring to the classroom. However, data obtained from observations during and after the intervention illustrate that teachers demonstrated the abilities to allow learners to actively engage in mathematical discourses that paved way for the learners to effectively interact with the mathematics contexts in content via classroom discussion.

2.1.4. Code-switch and re-voice as teaching strategies in multilingual classrooms

Classroom observations showed that teachers used English to pose questions, teach and explain concepts that were taught in the experimental classrooms, whereas in other instances they moved between English and isiXhosa during the lessons. In most of the cases where English was predominantly used for teaching word problems, as mentioned before, learners would prefer to use their home language when solving word problems in small groups, but immediately switched back to English when giving feedback to both the teacher and entire classroom. This finding is consistent with the findings of a number of researchers such as Setati et al (2002); Rose & van Dulm, (2006); and Webb (2010), who reported that in classrooms where English second language speakers are taught in English, code switching practices are likely to happen. These researchers showed that switching between learners' home language and the language of instruction by both teachers and learners enhances the quality of mathematical interactions in the classroom. In so doing, these learners would then use isiXhosa as an invisible resource (Adler, 1998, 2001; Moschkovich, 2002; Ncedo, Peires, & Morar, 2002; Rakgokong, 1994; Setati &Adler, 2001; Setati et al., 2002) for learning and solving word problems.

It was also noted that in classrooms where English was frequently used for instruction, on several instances the teacher intentionally used Adler's (1998) re-voicing, as a strategy to clarify concepts that were deemed complex during the lesson. As such, learners would cross-check amongst themselves whether they fully understood the concepts; if not, the learners who seemed to understand better were then used as a resource to explain the same concepts, using the language of their choice, to the learners who did not understand the concepts being taught.

2.1.5. Implementation of the intervention strategy of this study

It was evident in all the experimental schools that teachers had begun to display signs of confidence in and understanding of key aspects of the intervention. They managed to incorporate the strategy learned from the workshops in their teaching approaches to mathematics word problems. In fact, they engaged learners in new innovative pedagogies that created an atmosphere conducive for the learners to participate actively in open discussion and allowed mutual respect for opinions from fellow peers. It appeared that learners understood and embraced the efforts of their teachers during the implementation of the strategy. However, what was equally clear was that learners were not able to maintain the good quality and effective discussions and/or arguments in their respective small groups. There were no coherent rules of engagement and joint negotiation of meaning that was constructed during classroom discourse, and those co-constructed specifically within individual group discussions.

During the implementation of the strategy in the experimental classrooms, instruction was characterised by learner centeredness, coupled with vivid positioning of the learner and their role in the learning processes. The learners' interactions in these classrooms were typified by what seemed to be effective discursive talk, emphasised by logical arguments that reflected reinforcement, re-voicing and free situational use of language of choice during problem-solving and sense-making of mathematical word problems. Learners' home language appeared to be a useful but yet invisible resource within group discussions, and during interactions between the teacher and learners, and between learners themselves. It was also noted, in few instances, that some of the teachers of experimental schools were unsuccessful in effectively managing high quantities of dialogue and discussions that emerged during the implementation of the strategy.

2.1.6. Discussion and argumentation in multilingual classrooms

For learners, discussion, debate and critique are all learned strategies. Sfard and Kieran (2001:70) emphasise that "the art of communicating has to be taught". As such, experimental learners were afforded appropriate time and space for exploring ideas and making connections (Stein, Grover, & Henningsen, 1996) between classroom mathematics and out-of-school mathematical knowledge and a sustained press for explanation, meaning, and understanding (Fraivillig et al., 1999), during the intervention. The overall results of the study support Carpenter et al. (2003) notion that the very nature of mathematics presupposes that students cannot learn mathematics with understanding without engaging in discussion and argumentation. It appears that in the experimental classrooms observed after the intervention, mathematical discussions and thinking were greatly enhanced by the pedagogical practices that allowed learners to engage in argumentation (Empson, 2003; Goos, 2004). In doing so, learners were not only in a position to discuss classroom activities and solve word problems, but they were involved in taking and defending a particular position against the claims of other learners (O'Connor & Michaels, 1996). They pointed out that this teaching process depends on the skillful orchestration of classroom discussion by the teacher. In particular, teachers in the experimental group showed signs of improvement over time, and had begun to understand how to promote discussion in mathematics multilingual classrooms, via the use of the concept cartoon as a stimulus. However, as Ball (1993) pointed out, highly articulate students displayed a tendency to dominate classroom discussions and, as such, the management of classroom discussion appeared to be vital if one is to promote conceptual understanding via this technique (Steinberg, Empson, & Carpenter, 2004).

Writing frames (or sentence starters) assisted learners to present their responses and findings in a structured and written form. Data also revealed that instruction that addressed aspects of learners' writing (such as writing frames) seemed also to address learners' understanding of word problem-solving. Learners' writing appeared to be beneficial to mathematics teachers as well (Drake & Amspaugh, 1994). In fact, written explanations of the learners' problem-solving process allow the teacher to understand and assess the learner's thinking and comprehension (Freitag, 2005). As such, the writing frames provided by the study served as an effective tool for word problem-solving and seemed to promote and improve writing in mathematics multilingual classrooms.

Before the intervention, the pattern of utterances and/or mathematical discourse in experimental classrooms imitated Mercer's (1995) Initiation-Response-Feedback (IRF) process, also known as triadic dialogue (Lemke, 1990). However, it was also evident that the quality of discussions and arguments in some of the experimental classrooms improved over time. Data generated from the observations during the intervention showed that teachers' attempts at initiating discussion, in the form of a question or task which predicts the learner response, were successful in most cases. In actual fact, a fair number of learner responses produced the information that made it possible for the teacher, in turn, to evaluate the response in terms of its closeness to the expected answer (Mehan, 1985; Mercer, 1995).

What was lacking in these classrooms was the ability for the teacher to realise more precise understanding of ways in which to follow up opportunities specifically for the learning of mathematical language and the language used in mathematics. This particular observation mirrors what Krashen (1982) and Long (1983) reported in their studies. These researchers observed that even though classroom discussions were used in their studies, the effectiveness of those classroom discussions was limited because it was the teacher who initiated what to be discussed, and decided who provides a response, after which the teacher either commends or condemns. In so doing, the teacher resolves when to put an end to the discussion, which was also evident in teachers' responses to the interview protocols used in this study.

2.2. Interviews

As pointed out earlier, both the teachers and the learners were interviewed. In this section the results of the semi-structured interviews conducted with the six purposefully selected sample of learner per classroom are discussed, followed by face-to-face semi-structured interviews held with the each teacher in the four experimental schools. Both predicted and emerged general categories that are related to the theoretical underpinnings presented in prior chapters of this study are used to present a discussion of the interview results. The purpose of or value for conducting these interviews was to interrogate objectives one and two respectively, viz.:

- To identify the use of language by both the teacher and learners, when teaching and learning in multilingual mathematics classrooms;
- To design and implement an intervention at teacher level to promote the introduction of discussion and argumentation as teaching strategies to improve effectiveness of classroom participation and discourse.

2.2.1. Learner interviews

Learner interviews were conducted to probe the experiences and perceptions of learners towards the use of language in the classroom when they interact and solve word problems. As noted earlier, English appeared to be learners' preferred language for classroom discourse, for example, when they communicate with the teacher and in cases where they had to present their feedback to the entire classroom.

Language of learning and teaching: English vs. isiXhosa

Learners' reasons for choosing English to support communication in the classroom centred around viewing English as the language of authority, power, status, prestige, and access to social goods, including jobs and international recognition, which is consistent with reports by various scholars (see Baldauf & Kaplan, 2005; Guitièrrez, 2002; Setati, 2005; Trewby & Fitchat, 2001). In fact, learners' use of English seemed to be aligned to these ideals, rather than as a resource to learn mathematics in the classroom. Learners' choice of LoLT is further influenced by what Adler (1999) refers to as the language of assessment.

Although all the learners seemed to be aware of the benefits of using English, some of the learners had a strong call for English to be used alongside and/or parallel to isiXhosa. This finding of the study is consistent with other reports (e.g., Setati et al., 2008) that called for pedagogical strategy that employs the use of learners' home languages deliberately and transparently (or invisibly) in order to solve real-world mathematics problems in South African classrooms. The learners who participated in this study claimed that problem-solving and connecting classroom mathematics activities to everyday-life situations is much easier to achieve, and stimulates their love for word problems when both languages are used. To some of these learners, as Hameso (2001) puts it, it seems that the use of foreign languages, such as English in education has partly made education irrelevant to the masses of their society.

Data obtained from the interviews in this study showed that learners preferred to use isiXhosa when they solve mathematical word problems in groups. This is supported by Setati and her colleagues (2008), who argue for the increased use of learners' home language, along with use of English, through dialogue and discussion in order for learners to acquire mathematical reasoning skills. It was also clear from learners' responses that learning through a medium of instruction other than the main (home) language is a challenge to both teachers and learners.

2.2.2. Teacher interviews

As described in chapter three, the interviews were semi-structured as this afforded the interviewer the flexibility to rephrase questions to ensure that the interviewees fully comprehended each question being asked and to probe why teachers preferred a certain language practice over the other to support classroom communication. The general categories that emerged from the semi-structured interview questions are discussed below, with reference to the research objectives in this section of interviews and framed by the theories presented in chapter two and three of this study.

Classroom discourse in general

Data from teacher interviews revealed that they preferred to use both English and isiXhosa at different times and stages of their lessons. The teachers' choice of language seemed to be influenced largely by learners' linguistic capabilities in English, which was also reported in other studies (see Adler, 2001; Bishop, 1998; Del Campo & Clements, 1987; Vorster, 2008; Webb & Webb, 2008b). The main reason for using English was because it is the official language of teaching and learning mathematics at school and they wanted learners to comprehend the texts in both learner support materials and assessments in order to do well in mathematics. These teachers also confirmed and acknowledged the important role that English plays in the business world as the universal language of power and economic discourse and to access social goods (Setati, 2005a). It was also acknowledged that learners have not yet reached a good command and understanding of English, consistent with reports by Webb and Webb (2008a). As a result, there is a need for them to employ teaching strategies such as code-switching and translation at various stages of their lessons.

Although learners' home language, isiXhosa, was predominantly used to support classroom communication and mathematical discourse when they solved problems in groups, some of the experimental teachers also believed that in so doing, learners would then be afforded the good chance of connecting classroom mathematics activities with learners' everyday-life knowledge and experiences (Inoue, 2009), and in the process improve classroom participation. However, this is very questionable because the classroom observation data before intervention of the strategy suggested that the teachers generally lacked pedagogies that encouraged and assisted learners with ways to make sense of the word problem-solving during the lessons.

Language used for sense-making

Although teachers in the experimental schools of this study seemed to understand the importance of construction of mathematical knowledge in the teaching and learning of word problems, interview responses revealed that they were not aware that this may not be achieved if there is little reasoning and argumentation between learner-and-learner and educator-and-learner (Alexander, 2004; Webb & Treagust, 2006). The use of learners' home language(s) has benefits for school progress particularly when it is used to explain concepts and for clarification (Cummins, 1981; Wong-Fillmore & Valadez, 1986). In her study of the use of English by standard six learners in Botswana, Arthur (1994) revealed that the absence of learners' home language (Setswana) diminished the opportunities for exploratory talk, and thus for meaning-making. In this study, the results of the teacher interviews also showed that using only one language of learning and teaching, which is not learners' home language, is not adequate for explaining and clarifying concepts that are taught and learned in the classroom. This reasoning could possibly be attributed to learners' lack of English competence and confidence in using the language as suggested by Setati and Barwell (2008).

Language used for word problem-solving

In this study, teachers' responses to the use of language for word problem-solving in the classroom, assumed that learners' incorrect situational interpretation and solutions to mathematical word problems was a result of lack of understanding of the language used for instruction and assessment. Although teachers also believed that the errors that learners made when solving problems arose from poor computing skills, Hater et al. (1974) and Newman

(1983) reported that often, these errors have been caused by an inadequate understanding of the language of mathematics.

In this study, teachers' responses indicated that both English and isiXhosa are used for word problem-solving. Furthermore, data suggest that learners' primary language is largely and actively used to solve problems within small groups in the classroom, whilst English is used to record group responses to the word problems and when reporting their solutions to the entire classroom. While in small group discussions, classroom observations suggest that the dual role and to greater extent, the dual usage of the language of mathematics and the language of common English appeared to be ineffective during word problem-solving. In fact, although the participating teachers in this study said they prefer to use English as the LoLT, they actually used their home language to consolidate concepts that were taught during the lesson. In so doing, as Ellerton and Clements (1991) puts it, the grammar, and syntax of mathematical language were far less flexible than is the case for English and isiXhosa usage. On the other hand, it was also observed that, as Alexander (2004) points out, learners sitting together in groups does not necessarily translate to making meaning together. Moreover, teachers' responses did not mirror Mercer and Littleton's (2007) notion of language as creative and meaning-making and the teacher's most pedagogic tool, a notion which presupposes that all users of the same language of learning and teaching should share a similar fluency.

Language for teaching and learning

English second language studies conducted amongst isiXhosa speakers in the Eastern Cape Province of South Africa (e.g., Mayaba, 2009; Webb, 2010) have reported that learners are not interested in learning to read or write in their home language. These researchers attributed this notion to the fact that isiXhosa have long since been marginalised and devalued. Contrary to these findings, data presented in this study suggest that isiXhosa does have a place alongside English, playing a dual role of language of teaching and learning mathematics in multilingual classrooms. Teachers' responses also highlighted the fact that it is difficult to persuade learners to speak English during a mathematics lessons, unlike in other studies conducted elsewhere on the African continent, where it was indicated that teachers use coercive measures to force learners to speak in the foreign languages used as LoLT in those classrooms (Alidou & Brock-Utne, 2005). As such, these researchers argued that the use of a foreign and/or unfamiliar language as the language of learning and teaching makes teachers use traditional and teacher-centred teaching methods. In this study, it was also acknowledged by the teachers that the use of both English and learners' home language may present unique problems, where a single word could have multiple meanings when translated. The use of language in the experimental classrooms were generously influenced in absentia by the LiEP that was introduced to schools for implementation prior to the curriculum reform in South Africa, which is not easily accessible and understood by the teachers.

Language policy in the school and the LiEP

Howie's (2003, 2004) studies provided corroborative evidence of the damaging effects of apartheid language-in-policy, which while not making English accessible to all learners, denied them an opportunity to use their home languages for learning and teaching. In particular, the LiEP in South Africa promotes multilingualism by allowing learners and teachers to use more than one language of learning and teaching (Department of Education, 2007; Setati et al., 2002). The new LiEP is acknowledged by few experimental school teachers as 'good but not accessible to them' and has already met significant on-the-ground constraints. Similar to the finding by Taylor and Vinjevold (1999), experimental schools do not opt for learners' home language(s). This situation was anticipated in this study because mother tongue instruction has a bad image among speakers of African languages (Setati, 2002).

Although all schools in this study chose English as the LoLT, it is widely reported that much code-switching takes place between English and isiXhosa (Peires, 1994, Mayaba, 2009; Webb, 2010; Webb & Webb, 2008b). Some researchers (e.g., Peires, 1994) found that speakers of African indigenous languages do not find it necessary to study their mother tongue at school because they feel that they are already fluent and competent in the language. This is contrary to the results of this study as it indicates that both English and isiXhosa are used together, and both learners and teachers lacked competence in their home language. As such, although both teachers and learners acknowledged the dilemma of using English as LoLT in the experimental schools, they preferred and continued to use English as the language of instruction (Barkhuizen, 2002, Brock-Utne, 2002).

Teachers' responses indicated that they are faced with the complex situation of using English and isiXhosa in a dual role when teaching mathematics in order to reap any benefits that come with such a pedagogical approach in the mathematics classroom. What is also questionable for the teachers is the effectiveness of such a strategy and its implications on mathematics teacher practices in multilingual classroom. Secada's (1992) studies in the US pointed to findings of a significant relationship between the development of language and achievement in mathematics. Secada reported that oral proficiency in English in the absence of teaching in learners' home language is negatively related to achievement in mathematics. However, the results of this study suggest that, similar to reports by Setati (2002), poor performance of bilingual learners thus cannot be attributed to the learners' language proficiencies in isolation from the wider social, cultural, and political factors that inspire schooling.

3. QUANTITATIVE RESULTS

The mean difference between the experimental and comparison groups for word problem-solving, sense-making, and realistic considerations of learners' responses to pre- and/or post-tests was calculated, and Analysis of Variance (ANOVA) techniques were applied. The interpretation of statistical and practical significant differences using p-value and Cohen's d respectively are examined and discussed below.

3.1. Pre- and post-tests

As mentioned before, a major argument for including word problems in the school mathematics curriculum has been the potential role to promote realistic mathematical modelling and problem-solving in mathematics classrooms. Word problems are important for the development in learners of the skills of when and how to apply classroom mathematical knowledge and everyday-life knowledge when solving problems (e.g., De Corte, Verschaffel & DeWin, 1985; Inoue, 2005; Verschaffel et al., 2000, 2009). In the light of this, the pre- and post-tests used in this study were administered in English (official LoLT) and isiXhosa (home language) to observe any possible changes or improvements to learners' abilities in problem-solving and sense making of mathematics word problems as a result of introduction of discussion and argumentation techniques and whether initially answering in English or isiXhosa had any effect on learners' performances.

3.1.1. Language use and word problem-solving

The results of the study echo a finding by Ellerton and Clements (1991) that a major source of difficulty with mathematical word problems can be attributed to the fact that the language of mathematics and the language of common English usage often differ in important ways. Although experimental teachers have often assumed that poor performances in word problems have arisen from lack of understanding of mathematical concepts or a deficiency in computing skills (Hate et al., 1974), the errors have been caused by an inadequate understanding of the language of mathematics. In fact, the pre-test results indicate that the solution errors on the problem-solving (PS) items seem to reflect deficiencies in logico-mathematical knowledge (De Corte et al., 1985), not akin to Cummins et al.'s (1988) reasoning fallacies.

3.1.2. Test order: English-isiXho0sa (EI) and isiXhosa-English (IE) groups

The English-isiXhosa (EI) group produced more mathematically correct answers in their home language, after responding to word problems in English first. The improvement in problem-solving abilities of the EI group in the isiXhosa translation may possibly be attributed to the fact that English, as LoLT, as a commonly used formal written mathematical language empowered learners with clearer understanding of problems in their home language, and as such, there was a successful move from formal written language to informal spoken mathematical language. However, answering the isiXhosa translation first resulted in the isiXhosa-English (IE) group showing a tendency to relegate reality or common-sense when solving word problems in English. This finding suggests that a decline in learners' problem-solving appeared to stem from their inability to comprehend word problems in isiXhosa translation. In other words, it appeared that having seen the pre- or post-test in English first made it easier for the experimental learners to comprehend and make sense of the word problems in the isiXhosa translation. This finding may have implications for teacher practice in multilingual mathematics classrooms of the Eastern Cape Province.

3.1.3. Reality, sense-making, and context in word problem-solving

A report by Julie and Mbekwa (2005) raises concerns with the way in which the notion of what constitutes a 'relevant context' might not be in the same for curriculum developers, teachers, and learners. In other words, the overall results of the study suggest that mathematics word problems used in school curricula are not relevant to and do not address the socio-cultural situations faced by and known to the learners from poor socio-economic backgrounds. Sethole (2004) suggests that foregrounding of context may lead to a loss of focus on the development of conceptual mathematics knowledge and render the mathematics invisible or inaccessible. Contrary to this, the results of this study suggest that with well-planned and effective teacher development interventions, the issue of context in mathematics teaching may play a pivotal role in the development of learners' problem-solving abilities. The pre-test results indicated that current school instruction given for mathematical word problems is likely to develop in students a tendency to exclude real-world knowledge and/or reality in their solution processes (Cooper & Harries, 2005; Greer, 1997; Verschaffel, De Corte, Lasure, Vaerenbergh, Bogaerts, & Ratinckx, 1999; Yoshida et al., 1997).

According to a socio-cultural perspective, modelling implies engaging in inter-semiotic work, that is, one has to decide about the appropriate and productive manners of coordinating linguistic categories and mathematical expressions and operations in order to come to a solution of a problem (Säljö et al., 2009). Learners' pre-tests responses indicate that strategies employed by the experimental group teachers, when teaching word problems, put more emphasis on syntax and mathematics rules rather than, what Xin (2009) refers to as, a description of some real-world situation to be modelled mathematically. As a result, it could be argued that a significant number of learners who produced the no reactions (NRs) for PS items might have made realistic considerations during the solution process of the PS items, but finally have decided to neglect these realistic considerations in their final answers. Learners may have simply anticipated that such 'unusual answers' would not be appreciated by the researcher and/or the mathematics teacher (Verschaffel et al., 2000). However, analysis of the effects of promoting discussion and use of out-of-school mathematics revealed that the ability to take into account real-world considerations properly when solving word problems increased, as expected, with sense making.

The data generated via word problems without real contexts (PWRC) in this study revealed that an inappropriate use of contexts, particularly when learners are invited to engage in the real world, but then penalised for doing so, results in classroom inequalities (Boaler, 2009). As learners learn to answer nonsensical questions about ‘number of blue and red pencils in your pocket’ (see Appendix B), they come to believe that mathematics classrooms are strange places in which common sense cannot be used. In doing so, learners realise that when you enter *Mathslands,* you leave your common sense at the door (Verschaffel et al., 2000).

The finding that unrealistic solutions may not simply stem from mindless or procedural problem-solving, but could originate in students’ diverse effort to make sense of the problem situation and the nature of the problem-solving activity in socio-cultural contexts, is consistent to the reports by Inoue (2009) and Verschaffel et al. (2009). For example, both the experimental and the comparison group’s pre-test responses to the ‘bus problem’ (see PWRC in Appendix B) indicated that their everyday socio-economic life experiences and knowledge influenced the way they interpreted the problem situation (or context). In particular and as noted before, they produced different definitions of a ‘week’ in their problem solutions. The study has also shown that, in addition to social and cultural class inequalities that result when certain contexts are used, one group is prompted more than the other, to engage with real-world variables, thus compromising their performance (Boaler, 1994). In other words, learners who come from households of professionals, will interpret a week as having five days in cases of school teachers, or less than five days in instances where a parent is employed as a domestic worker, or any other job that requires them to report six or seven days in a calendar week. In fact, Zevenbergen's (2000) studies have shown that learners of a particular linguistic or cultural background are similarly disadvantaged or advantaged.

3.1.4 Connection between classroom mathematics and real-life knowledge

The connection between classroom mathematics and learners' everyday experiences is a complex issue because the two contexts differ significantly (Cooper & Harries, 2005). While there may be some inherent differences between the two contexts, these can be reduced by creating classroom situations that promote learning processes closer to those arising from out-of-school mathematics practices. The results of this study reflect the notion that in normal teaching practice, establishing connections between classroom mathematics activities and everyday-life experiences still regards mainly word problems (De Corte et al., 1985). As such, word problems are often the only means of providing learners with a basic sense experience in mathematisation, especially mathematical modelling (Reusser, 1995). In other words, the intervention of my study has demonstrated the need for effective pedagogies that empower mathematics teachers to teach mathematics word problems with understanding through connecting classroom mathematics with out-of-school mathematics. Improvement in the ability of the learners in this study to connect and bring reality into mathematics over time may possibly be attributed to the intervention strategy that emphasised starting from learners' everyday-life experience and using *cultural artefacts* to analyse *mathematical facts*. It has been noted that, in particular, cultural artefacts embody theories that users accept, even when they are unaware of them (Saxe, Dawson, Fall, & Howard, 1996).

Everyday-life experience and classroom mathematics, despite their specific differences, should not be seen as two disjunctive and independent entities. Instead, a process of gradual growth is aimed for, in which classroom mathematics comes to the fore as a natural extension of the learners' experiential reality. The idea is not only to motivate students with everyday-life contexts but also, as Gravemeijer (1999, p.158) points out, "to look for contexts that are experientially real for the students and can be used as starting points for progressive mathematisation". Studies conducted on word problem-solving (e.g., Säljö et al., 2009; Verschaffel et al., 2000, 2009) reveal that as learners are acting in a complex situation, they have to consider what discursive practices are relevant and acceptable when solving problems and when arguing in a particular setting.

The complexity of moving between discourses is illustrated in this study by analysis of concept of a 'week', which was discussed earlier in this chapter and summurised in chapter four. Similar to findings by Säljö and his colleagues (2009), only a few high achieving learners in the study managed to move between discursive boundaries without any problem. These students realised that a week can be either seven days (calender week) or five days (South African school week) depending on what discursive practice is relevant. On the other hand, low achieving learners appeared to reason within one discursive practice and kept a rule that 'a week has seven days'. This observation illustrates that moving between discourses requires complex and subtle skills about how to make meaning of the world in an abstract situation (Oslon, 1994).

3.2. Language survey

The language survey revealed that all learners (experimental and comparison groups) and teachers who participated in this study are first language speakers of isiXhosa, and English is their second language, and sometimes foreign. Learners are taught in their primary or home language during the first four years of primary schooling, thereafter English is introduced formally from grade five as second language. As stated before, the LiEP of South Africa affords all schools in South Africa the right to choose the language of learning and teaching (Department of Education, 2007). The schools in this study use English as the official LoLT and learners' home language is frequently and informally used by both teachers and learners for various reasons, as noted in chapter four. In addition, isiXhosa is used as an informal spoken mathematics language, whereas English is used as a formal written mathematical language and as the language of assessment in these schools.

4. OVERVIEW OF QUANTITATIVE AND QUALITATIVE RESULTS

The role of language in teaching and learning mathematics has been recognised locally (Adler, 2001; Mayaba, 2009; Setati, 2005a; Setati and Barwell, 2008; Webb & Webb, 2008b; Webb, 2010), and elsewhere around the world (Bishop, 1998; Chitera, 2009; Clements & Del Campo, 1987; Lemke, 1990; Moschkovich, 2000; Vorster, 2008). As such, the sections below examine these aspects of the quantitative and qualititative results of the study in the light of the above.

4.1. Formal and informal mathematics language

The teaching strategies used during the intervention of the study acknowledge the role of language in promoting discussion and arguing in the mathematics classroom. The overall results of the study illustrate that word problem-solving and sense making is facilitated by informal mathematics language (Setati, 2002), in either writing or spoken form, particularly when solving problems in small groups. According to Setati's (2002) report, informal language is the kind that learners use in their everyday life to express their mathematical understanding. In particular, in answering the second problem-solving (PS2) item learners' everyday life interpretation of 'sharing the money fairly' simply translated to 'dividing the money equally', because learners who participated ignored the problem situations such as 'the amount or magnitude of work done', and 'the time taken by each boy to do the tasks'. As such, they divided the money equally amongst themselves. On the other hand, formal mathematics language refers to the standard use of terminology that is developed within formal school's settings. Whilst Setati and Adler (2001) agree that the cherished goal in school mathematics classrooms is formal written mathematical language, the study shows that informal spoken mathematical language appeared to be of equal value in word problem meaning making.

4.2. Use of language (home and/or LoLT)

Although the quantitative data revealed an overall statistically significant improvement in the experimental groups' English test scores compared to isiXhosa translation (particularly the computational correctness of learners' responses), qualitative data suggested that the learners in the experimental group used their home language during word problem-solving. The statistically significant difference in English test scores between the experimental and comparison groups may be attributed to the fact that the intervention was done in English. However, learners' sense making or realistic considerations of word problems improved in the isiXhosa translation. In fact, the experimental group generated more situationally appropriate (or accurate) responses in the isiXhosa translation. Moreover, overall results of this study suggest that the experimental group performed statistically significantly better than the comparison group when writing the post-tests in isiXhosa. It appeared that learners in the experimental group moved successfully from informal spoken language to formal written mathematical language, because both informal spoken and formal written languages took place in their home language. This finding supports Setati and Adler's (2001) claim that the movement between formal spoken language and written mathematical language is complicated by the fact that the learners' informal spoken language is not the LoLT. This finding led the researcher to question the seemingly strong ties between mathematics classrooms and the mathematics community, which are discussed in the next section, suggesting that, as Moschkovich (2002) puts it, the two fundamentally differ in purpose and character.

4.3. Mathematics classroom and the mathematics community

Drawing on the work of Bakhtin (1986), I argue that the *speech genre* of mathematics community seem to predominate school mathematics and as such has significant sway over the look and feel of legitimate and/or illegitimate mathematical activity. This is affirmed in the case of the 'age problem' in the pre-test, where learners calculated their own age by adding the number of pencils given in the word problem statement (Verschaffel et al., 2000, 2009). This finding suggests a strong emphasis on pedagogies that promotes procedural understanding rather than conceptual understanding of word problem-solving in mathematics classrooms. However, experimental learners, as Nasir and Hand (2008) point out, did fit with the culture of the mathematics classroom after the intervention. In solving 'a runner problem' (see PS3 item in Appendix B), learners appeared not to consider alternative explanations that lead to new and/or existing understanding. However, the study shows that when learners are further probed to justify their solution statements, they tend to display good command and understanding of mathematics community. As such, the study echoes Nasir et al.'s (2008) notion that mathematics practices should support teachers in eliciting and building on learners' ideas, thus opening up the possibility for dialogic learning experiences (Webb, 2010) in mathematics classrooms with learners from diverse linguistic and cultural backgrounds. The pre-test results of this study illustrated that, as Moschkovich (2002) argues, learners' mathematical sense making is grounded in their everyday discourse practices, which originate in the home and local communities. However, the post-test results suggest that learners moved succesfully between multiple modelling of word problem situations and their mathematical meaning making (discussed in the next section) improved over time.

4.4. Improving learners' performance: Intervention of the study

To a larger extent, the study sought to explore effective methods to improve learners' performance on word problems that require mathematical modelling of the problem situation(s). As a result, it appeared that promoting the introduction of discussion and argumentation techniques had a positive impact on learners' word problem-solving and sense making in the experimental group. As mentioned earlier, pre-test results suggested that learners in the experimental group demonstrated a strong tendency to exclude real-world knowledge and realistic considerations from their solution processes when solving PS items of this study (Verschaffel et al., 2000; Xin, 2009). The quantitative data of the study demonstrate that, consistent to findings of other studies elsewhere (see Reusser & Stebler, 1997; Yoshida et al., 1997), pre-test written or verbal warning (or instruction) aimed at improving the disposition towards more realistic mathematical word problem-solving did not produce the expected positive effect. In other words, despite the fact that the instructions were explained to the learners before they wrote the pre-tests, realistic considerations on the solution statements did not improve. However, during the intervention, Xin et al.'s (2007) instructional intervention, termed "process-oriented instruction" intervention, was proposed in the experimental group, which aimed at helping learners not only identify problem situations that are problamatic from realistic point of view, but also consider the (in)appropriateness of applying a straightforward mathematics operation in their answers.

As noted earlier, the results (English post-test) of the study showed that the difference in mean scores of the realistic considerations between the experimental and comparison groups were statistically significant and there was a moderate practical significance ($\Delta\overline{\chi} = 0.47$, $p < .0005$, $d = 0.57$). Even though the intervention was done in English (LoLT), the learners in the experimental group performed significantly better when answering the isiXhosa translation post-test compared to the English post-test ($\Delta\overline{\chi} = 0.69$ vs. $\Delta\overline{\chi} = 0.47$, d = 0.86, *large*). This finding could be attributed to, as pointed out earlier, successful movement from informal spoken mathematical language to a formal written language. However, the overall results of the study illustrate that experimental learners improved significantly better in English in the post-test, as they appeared to produce more computationally correct responses in the English post-test after the intervention in word problem-solving.

5. ANSWERING THE RESEARCH QUESTIONS

As mentioned before, the study aimed to answer the following research question:

What issues of language (home and LoLT) play a role in grade 9 second language learners' mathematical problem-solving abilities in township schools and can these issues be ameliorated by promoting discussion and argumentation techniques in mathematics classrooms?

In responding to the research question above, the sub-questions, which emanate from the objectives of the study, and the research question are answered in the next sections.

5.1. Do the learners solve word problems better in their first language or the LoLT?

The qualitative results of the study illustrate that, although learners preferred English as the language of learning and teaching, they used isiXhosa to solve word problems in small groups. In doing so, learners translated their solution statements into verbal and written English when presenting their solutions to the entire classroom. Statistical results of the study revealed that there was a statistically significant difference ($p < .0005$) between English and isiXhosa ($\Delta\overline{\chi} = 21.01$). In other words, a positive mean suggests a significantly better performance in the English post-test. Moreover, a large practical significant difference (d = 0.91) was also noted between the two languages after the intervention (overall post-test results). In particular, pre-test results of descriptive statistics show that experimental learners solved word problems better in isiXhosa ($\overline{\chi} = 49.72$) compared to English ($\overline{\chi} = 40.64$). However, post-test results indicated that experimental learners improved significantly better in English ($\overline{\chi} = 57.72$) than in isiXhosa ($\overline{\chi} = 46.65$). As such, it appeared that learners solved word problems better in English, the official language of learning and teaching in South African schools, after the intervention.

5.2. Are the number (algebraic) skills and errors that the learner's exhibit related to the language used or are they generic?

The analyses of classroom observations and learner interviews illustrated that the word problems whose solutions require and involve interpretation of meaning of numbers focus on using different kinds and arrangements of numbers. As a result, understanding the algebraic rules and acquisition of number skills appeared to be necessary to understand the meaning of contexts or situations that illuminate the manner in which the reality of the world is structured. On the other hand, quantitative data suggest that mathematical errors that learners make, particularly the number skills, seem to stem from the inability to use language, home (isiXhosa) and/or LoLT (English) effectively in order to solve problems. In fact, formal written mathematical language appeared to take precedence over the informal spoken mathematical language that learners exhibit during word problem-solving and meaning making. In particular, this finding could possibly be attributed to the disconnection between classroom mathematics activities and learners' everyday life knowledge and experiences, and/or out-of-school mathematics.

5.3. Does the introduction of discussion and argumentation into classroom practice influence learner's sense-making and/or the problem-solving abilities?

As mentioned before, the intervention of the study in experimental schools was aimed at improving learners' problem-solving skills, and sense making (or realistic considerations) of word problems in multilingual mathematics classrooms. The effect(s) of introducing discussion and argumentation techniques in the teaching of word problems is gauged against change in learners' problem-solving and sense making abilities as discussed below.

5.3.1. Problem-solving

Analysis of the data generated as triangulation of the data obtained from pre- and post-tests, interviews and classroom observation schedule, revealed that learners' problem-solving abilities in both English and isiXhosa post-tests improved over time (in favour of English as noted before) after the intervention. In fact, statistical results illustrate that there was a statistically significant difference ($p < .0005$) between the experimental and comparison groups before the intervention (pre-tests), with comparison group performing significantly better in English and isiXhosa, respectively ($\Delta\overline{\chi} = -14.61$ vs. $\Delta\overline{\chi} = -12.37$). However, after the intervention the experimental group performed statistical significantly ($p < .0005$) better in English compared to comparison group ($\Delta\overline{\chi} = 29.14$ vs. $\Delta\overline{\chi} = 8.13$), with a marginal statistically significant ($p < .05$) difference between the two groups in isiXhosa translation after the intervention. In other words, it appeared that the intervention strategy in this study (discussion and argumentation techniques) positively influenced learners' word problem-solving abilities. As a result, a large practical significance ($d = 1.56$) and a medium practical significance ($d = 0.74$) were also noted on the English and isiXhosa mean score differences respectively.

5.3.2. Sense-making

The overall results of this study's word problems without real meaning and real context illustrate that learners' performance on word problems differs dramatically depending on how the problems are designed (Verschaffel et al., 2000, 2009). In addition, such word problems require more extensive consideration of how the situation (or context) should be modelled, and if the information provided is relevant and sufficient for solving the problem (Säljö et.al., 2009). The quantitative results of this study, before the intervention (pre-test), show that learners have a tendency to respond to the problems even if the information given is irrelevant to answering the question given. In fact, it is interesting to see that intercultural comparison studies show similar findings (Säljö et.al., 2009; Verschaffel et al., 2000; Xin, 2009; Xin et al., 2007).

The statistical results revealed a statistically significant difference ($p < .0005$) between the experimental group and comparison group. The experimental group appeared to show a tendency to consider reality marginally better than the comparison group. In particular, learners seemed to make realistic considerations better in the isiXhosa translation post-test compared to the English post-test ($\Delta\overline{\chi} = 0.69$ vs. $\Delta\overline{\chi} = 0.47$). A large practical significant ($d = 0.86$) difference between the experimental group and the comparison group was also noted in the isiXhosa translation, compared to a moderate practical significance ($d = 0.57$) noted in the English test after the intervention. As such, the results of the study demonstrate that the introduction of discussion and argumentation techniques in the teaching and learning of mathematics word problems had a positive effect on learners' ability to consider reality during word problem-solving.

6. CHAPTER SUMMARY

The discussion of results in this chapter focused on both the qualitative and quantitative data generated from the study. Both descriptive and inferential statistical analysis of pre- and post-tests, together with interview responses, and classroom observations were examined within the theoretical underpinnings presented in chapters two and three.

Qualitative data indicate that English, the official language of learning and teaching in South African public schools, is the preferred language in the teaching and learning of mathematics in multilingual classrooms of the experimental schools. However, analysis of learners' interviews suggests that, although English is the preferred LoLT, they proposed a dual-use and/or parallel-use of English and isiXhosa for teaching and learning. Triangulation analysis of learners' interviews and classroom observations during the intervention demonstrated a use of both isiXhosa and English during word problem-solving and meaning-making of problem situation. Learners appeared to be successful problem-solvers in cases where the dual-use of LoLT and learners' home language was evident. Overall results suggest that English is used during whole-class discussion, problem-solving and assessments, whereas isiXhosa is used during word problem-solving and sense-making of problems in small groups.

Classroom observations data revealed an improvement of teachers in their general teaching practice over time during and after the intervention. In particular, teachers had begun to display signs of confidence in managing and maintaining mathematical discourses in multilingual classrooms. Consequently, learners had a clear understanding of the magnitude and effectiveness of discussion during word problem-solving and meaning making. There was also evidence of the benefits of code-switching throughout most of the lessons observed, coupled with instances of peer translation, and/or re-voicing.

Results of the survey indicated English as the language of choice in the teaching and learning of mathematics in both experimental and comparison schools. The choice of English as language of learning and teaching from grade five appeared to be influenced and guided by the LiEP. All the schools in this study attract learners from isiXhosa home language households, and English is regarded as a second language in the community.

Statistical analysis of variance showed statistically significant and large practically significant evidence that the introduction of discussion and argumentation techniques in the teaching and learning of mathematics word problems increases problem-solving and sense-making abilities of English second language learners. The study's level at which the threshold of p was set is 0.05, which means that there was a 5 percent chance that the results was accidental. The large practical significance noted in the study implies a research result that should be viewed as important for teaching practice in mathematics classrooms. Although the study's aim is not to generalise the results, this finding has implications for the teaching of mathematics in multilingual classrooms of the Eastern Cape Province of South Africa.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

1. INTRODUCTION

For many decades, mathematics teachers have been calling for more relevance and meaning in terms of learners' classroom mathematical activities (Verschaffel et al, 2000, 2009; Brownell, 1945; Fruedenthal, 1991), while researchers have been reporting on the role of language in the teaching and learning of mathematics, in particular, the effects of second language teaching and learning in multilingual classrooms (e.g., Adler, 2001; Arthur, 1994; Chitera, 2009; Freitag, 2005; Setati, 2005a). This study combines issues of rendering mathematics, mathematical problem-solving, and meaning-making more relevant to learners' everyday life and language by observing how second language learners treat real wor(l)d problems in multilingual classrooms exploring the effects of an intervention which aimed at promoting discussion around mathematical meaning making and problem-solving.

In this final chapter the rationale and design of the study is reflected upon and thereafter conclusions drawn and inferences made as to the extent to which the intervention of this study has impacted both teachers' and learners' problem-solving abilities, as well as their ability to make realistic considerations of word problems. The limitations of the study are discussed and implications for teacher practice and development is outlined. Finally, suggestions for are made further research.

2. RATIONALE AND DESIGN

As noted in chapter two, mathematics teaching and learning in many multilingual mathematics classrooms are characterised in what appears to be a 'disconnect' between classroom mathematics activities and out-of-school mathematics. The assumptions at the outset of this study was that mathematics teachers in the Eastern Cape, the region in which the researcher lives and works as a mathematics education educator, have difficulties when attempting to teach mathematics through problem-solving in a way that connects classroom mathematics and learners' everyday life knowledge and experiences. The literature suggests, and initial observations appeared to confirm, that these difficulties are related to both language use (Adler & Setati, 2005; Setati, 2008) and effective pedagogical strategies that advance problem-based and whole-class discussion approaches to the teaching and learning of mathematics word problems (Verschaffel et al., 2000, 2009). A major issue contributing to these difficulties is the fact that in South Africa many teachers and learners use English for teaching and learning, which is not their home language. As such, the study was designed to investigate issues of language and mathematics when English second language learners solve mathematics word problems, and whether a strategy for teachers, which is aimed at training teachers to effectively promote and introduce discussion and argumentation in both learners' home language and LoLT, would advance problem-solving and meaning making in their learners. Before designing the intervention, it was however, necessary to ascertain teachers and learners' perceptions about language practices in their classrooms, the strategies they used for teaching and learning word problems, and how they used language (home or LoLT) as a resource in the classrooms.

A pre-test – intervention – post-test design was used in the study. The pre-tests investigated what the situation was in terms of language practices and problem-solving abilities of grade 9 second language mathematics learners, after which follow-up interviews were conducted to clarify what problems they encountered, and why they solved the problems the way in which they did. Teachers were then introduced to appropriate discussion and argumentation techniques in the teaching and learning of word problems. An observation schedule was used to track learners' attempts at discussion and argumentation in the classroom, and post-tests investigated any changes and possible reasons for them. The intervention took place over a six month period.

3. MAIN FINDINGS

As discussed in the previous chapter the main finding of this study is that, in classrooms of experimental schools in which discussion and argumentation techniques were successfully implemented, there was a statistically significant improvement in the learners' word problem-solving competences. The practical significance (Cohen's d) of these data was high, suggesting that this approach could have significant implications for, and relevance to, mathematics teacher development interventions, as well as for the development of teacher and learner support materials which are targeted at multilingual settings.

The quantitative and qualitative data suggest that there was also an improvement in terms of the experimental group of learners' ability to consider reality and common-sense when solving word problems, as well as an improvement in their sense-making/meaning-making abilities after the intervention. The findings suggest that better connections between classroom mathematics and out-of-school mathematics were made and that there was better integration between the learners' formal written mathematical language and their informal spoken mathematical language. In fact, learners did not only generate more computationally correct responses, but also produced more situationally accurate and appropriate solutions to real-wor(l)d problems in the post-test.

The finding that learners performed significantly better in English test (official LoLT) may be attributed to the fact that the intervention took place in English, and the teacher learner support materials were designed and presented in English. Although the study did not specifically investigate effects of writing, it was observed that the learner' writing skills improved, something which can probably be attributed to the use of writing frames during the problem-solving intervention activities. The data also revealed that the social and economic benefits that are associated with learning English are key factors in terms of learners' devaluing isiXhosa (their home language) and, as noted in the literature (Mayaba, 2009; Webb, 2010) home language literacy competence suffers.

The data generated in this study also suggests that whole-class discussion and problem-based approaches to the teaching of word problems can be applied appropriately and successfully (to certain degree) in second language teaching and learning settings, and can assist both mathematics teachers and learners improve their knowledge of mathematics real wor(l)d problems. The degree to which experimental teachers demonstrated an acceptable level of content knowledge and pedagogical content knowledge seems to be directly connected to the content (topics) addressed during the intervention workshops. While this confirmed that the pedagogic- and content-based training aspect of the workshop strengthened and improved teachers' problem-solving abilities in general, it was evident that they still require additional and continuous support on the ways in which learners' dual use of both English and isiXhosa influence word problem-solving and meaning making. As such, it is suggested that strategies to promote the use of learners' home language, alongside LoLT, should be considered by curriculum planners and teacher development institutions and agencies.

The findings of this study suggest that the objectives of the research were achieved, namely, the language use by both the teachers and learners for teaching and learning in multilingual mathematics classrooms was identified; and an intervention that has the potential to promote the introduction of discussion and argumentation techniques successfully in the teaching and learning of word problems was implemented, investigated and reported. The problem-solving and sense-making abilities of teachers and learners in the classroom were tracked (before, during and after the intervention), and the introduction of discussion and argumentation measured (resulting in statistically significant improvements in the experimental group of learners' problem-solving and sense making of word problems).

Code-switching was observed throughout the study, which suggests that the language realities of second language mathematics classrooms require teaching strategies that recognise the learners' home language(s) as well as language of learning and teaching and that more emphasis should be placed on developing teachers' code-switching skills. In addition, the use of metaphors, translation and/or re-voicing between informal spoken mathematical language (or the learners' home language) and formal written mathematical language (LoLT) need to be formalised to give clarity and avoid confusion (Setati & Adler, 2000; Barwell & Setati, 2005).

Another finding of the study was that computational errors made by the learners, in particular number skills, appear to stem from the inability to use language(s) (home and/or LoLT) effectively in order to solve problems in a realistic situation. This finding suggests that mathematics practitioners (i.e., teachers, teacher educators, textbook authors, etc.) should generate mathematics activities that take into consideration the reality of the situations that are related to learners' out-of-school mathematics. Learners should be afforded opportunities to use their everyday life experiences and knowledge when making sense of problems. In doing so, there should be a smoother movement between learners' informal language and formal written mathematical language.

As such, recognition of the role of common sense and out-of-school knowledge in learning mathematics word problems, coupled with considerations of the complementary roles of learners' home language and the language of learning and teaching in multilingual classrooms, appear to be potentially fruitful approaches to teacher development in the multilingual contexts found in the Eastern Cape Province of South Africa.

4. LIMITATIONS OF THE STUDY

The findings of the study should be viewed in light of following limitations. The selection of learners for focus group discussions was made on the basis of convenience sampling, rather than on statistical considerations. In addition, only a limited number of teachers participated in the study and as such, both learners and teachers of this study do not represent the population of schools in the Eastern Cape, or even of the Port Elizabeth district. Secondly, there were concerns from some learners about the isiXhosa translations. In particular, these learners were critical of the dialect used in the translation when used in different parts of Port Elizabeth, which could have led to different interpretation of the situation(s) used. However, the researcher and research assistant reached an agreement on key issues involving transcriptions to be used and consistent interpretation of learners' responses and, as such, these issues did not significantly threaten the validity of the study.

5. IMPLICATIONS FOR TEACHER PRACTICE AND DEVELOPMENT

Although the intervention of the study targeted only a limited number of teachers and schools in Port Elizabeth townships, and although the conclusions drawn from the study cannot be generalised, the findings provide sufficient insights and understandings from which tentative recommendations for mathematics teacher development can be drawn. Analysis of quantitative data suggests that promoting the introduction of discussion and argumentation techniques in mathematics classrooms had benefits and in all probability promoted the participating learners' problem-solving abilities and significantly increased the likelihood of realistic considerations of word problem-solving. However, to successfully implement such a strategy, teachers need appropriate fundamental skills and the necessary knowledge of managing and maintaining classroom discourses that allow development of cognitive formal written mathematical language and the skills necessary for negotiation of meaning within informal spoken mathematical language.

A key implication of this study in terms of teacher development in teaching mathematics with meaning and understanding via the use of Chapman's (2009) contextual (or situational) problems is the explicit consideration of teachers' conceptions of contextual problems in multilingual classrooms. The findings of this study suggest that if teacher development programmes are designed and structured in a way that empower mathematics teachers with knowledge and skills that promote understanding of the contextual role of problem situation in (word) problem-solving, while at the same time maximising the effective use of language (both the LoLT and home language), they would be better placed to bridge the gap between school and everyday mathematics, as well as gaps between, home, school and mathematical language, whether using mother tongue or English.

6. SUGGESTIONS FOR FUTURE RESEARCH

This study showed that issues of connection (or relationship) between mathematics word problems and real life contexts is important for both the mathematics teachers and their learners. As such, the reflection about the importance of the way word problems are solved in the classroom reinforces the need to further probe issues that teachers in multilingual classrooms face in designing (or selecting) and organising tasks for instruction to bridge the gap between classroom mathematics activities and everyday mathematics.

Also, the intervention in this study was done in the official language of teaching and learning (English) and targeted isiXhosa home language learners. A variation on the theme that might provide further insights could be to implement the intervention with other language groups. An example of this could be to compare how English second language learners who are Afrikaans first language speakers solve word problems, and explore how they handle different contexts used in word problems in second language context. Implementing the strategy in both the LoLT and learners' home language(s) has the potential to illuminate deeper issues of language and learning when solving real-wor(l)d problems, as well as broadening and deepening understandings issues of sense making and problem-solving in both first- and second language teaching contexts.

Other questions that have the potential to improve our understanding of the problems of mathematical context and language include: What has the greatest influence in terms of improving learners' problem-solving abilities?; Is it mostly the result of improved formal written mathematical language, or is it mainly because of improved informal spoken mathematical language?; How do these two issues influence one another?; What aspect of the intervention impacted most positively on learners' abilities to consider reality in word problem-solving?; and What is the impact of problem-solving and meaning making in overall academic achievement of second language learners in multilingual mathematics classrooms?'

7. CONCLUSION

In this study the effects of promoting the introduction of discussion and argumentation techniques as a strategy to improve second language learners' word problem-solving and sense-making abilities were explored. The ideas generated should contribute to national and international academic debates on issues such as the realities of teaching and learning mathematics through a problem-based approach in multilingual mathematics settings. The findings should provide insights for individuals and groups who strive to empower mathematics teachers with innovative and effective pedagogies, particularly those who attempt to assist second language learners to use their everyday life knowledge, experiences, and common-sense understanding freely when solving mathematics word problems.

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APPENDIX A

Description of terms used in this study

Adapted from Adler (2001) and Chitera (2009)

Bilingual/Multilingual: Refers to an individual who is proficient in two or more languages respectively.

Bilingual/Multilingual classroom: Refers to a situation where learners bring into a class a range of home languages. This does not imply that all learners and/or teachers in the class are themselves necessarily multilingual.

Code-switching: Means shifting from one code (i.e. language, dialect or language variety) to another between utterances or for a section of an utterance that is at least of sentence length. All forms of code-switching presuppose a speaker's sensitivity to different social contexts and conventions.

Colonial language: Is used in this thesis to refer to languages that came with the colonizers of the country. For example, South Africa was colonised by Britain, and as such, English became and still is the *official language*. Thus, English in South Africa is a colonial language.

Discourse: This term refers to ways of using words, including the purpose to which the language is put.

Discourse practice: This term in this thesis, refers to the whole process of social interaction which includes language forms (written and spoken), patterns of interaction among the participants, as well as the values embedded in the use of language and the power relations and attitudes to knowledge.

First language: Refers to a language that a child acquires from birth and in which he or she is most proficient. In some books terms such as *mother tongue* and *home language* are used instead of *first language.* In this thesis, I use the terms interchangeably.

Foreign language: Refers to any language which learners are likely to hear or read outside the classroom in which they are learning it because it is not in use in the wider community.

Home language: See *first language* above.

Language of Learning and Teaching: Is the term that refers to language(s) used for both learning and teaching across the curriculum and gives equal importance to both learning and teaching. These terms can also be referred as "language of instruction" or "medium of instruction". Thus, in this thesis, these two terms are used interchangeably.

Learner: In this study, learner refers to a school pupil. Note that, in this study, this term is used interchangeably with the word student (*see student below*)

Local language: See *first language* above.

Main language: Refers to the language most often used by an individual, in which he or she becomes proficient. Some people who are fully bilingual or multilingual (see above) may use two or more languages on an approximately equal basis and thus have more than one main language. In some books, they use *primary language* to mean the *main language*. In this thesis, I use these terms interchangeably.

Medium of instruction: See *language of learning and teaching* above.

Mother tongue: See *first language* above.

Multilingual: Refers to the speakers' proficiency in more than two languages.

Multilingual mathematics classroom: Refers to a mathematics classroom where students bring a range of home languages. It does not imply that all students are multilingual. The meaning in this thesis is that there are more than two languages in the classroom.

National language: This is a language that represents the national identity of a nation and in most cases it is used for political and legal discourse. In South Africa, English is the national language and is used officially as a medium of instruction.

Official language: Is a language that is given a unique legal status in a country. It is typically the language that is used in national legislative bodies. The official language is sometimes not the same as the language of learning and teaching and so the two are not interchangeable. In South Africa, the official language is English.

Student: Is a *learner*, or someone who attends an educational institution. In some nations, the English term (or its cognate in another language) is reserved for those who attend university, while a schoolchild under the age of eighteen is called a *pupil*.

Texts: Refers to the written or spoken language produced in a discursive event.

APPENDIX B

English pre-test

Grade 9 Mathematics pre-test: Solving word problems

Date: ____________________

(Please provide the following information about you by completing spaces below)

Name of Leaner: ______________________________________

Name of School: ______________________________________

Grade: ______________________________________

Age of Learner: ______________________________________

Home Language: ______________________________________

Gender: ______________________________________

Ethnicity: ______________________________________

Instructions:

Answer ALL questions given below using a pen in the answer sheets given to you. Show ALL your working and explain in written words where necessary.

SECTION A

1. *Solve the following three problems and write down how you arrived at the answer:*

1.1. 100 children are being transported by minibuses to a summer camp at the sea-side. Each minibus can hold a maximum of 8 children. How many minibuses are needed?

Solution:	How I arrived at the answer:

1.2. Two boys, Sibusiso and Vukile, are going to help Sonwabo rake leaves on his plot of land. The plot is 1200 square meters. Sibusiso rakes 700 square meters during four hours and Vukile does 500 square meters during two hours. They get 180 rands (R) for their work. How are the boys going to divide the money so that it is fair?

Solution:	How I arrived at the answer:

1.3. John's best time to run 100 meters is 17 seconds. How long will it take him to run 1 kilometre?

Solution:	How I arrived at the answer:

SECTION B

2. You have 10 red pencils in your left pocket and 10 blue pencils in your right pocket. How old are you?

Solution:	How I arrived at the answer:

3. It costs R5.00 each way to ride the bus between home and work. A weekly ticket is R50.50. Which is the better deal, paying the daily fare or buying the weekly ticket?

Solution:	How I arrived at the answer:

END

APPENDIX C

isiXhosa translation of the pre-test

Ibakala 9 uvavanyo lwemathematiki: ukusombulula iingxaki zamagama

Umhla:____________

(Nceda unike ulwazi ngawe ngokuthi uzalise ezi zikhewu zingezantsi apha)

Igama lomfundi: ______________________________

Igama lesikolo: ______________________________

Ibakala: ______________________________

Ubudala: ______________________________

Ulwimi oluthethwa ekhaya: ______________________________

Isini: ______________________________

Ubuhlanga: ______________________________

Imiyalelo:

Phendula yonke imibuzo elandelayo usebenzisa usiba kula maphepha uwanikiweyo. Bonisa indlela osebenze ngayo, uchaze ngamazwi apho kuyimfuneko.

ICANDELO A

1. *Sombulula ezi ngxaki zintathu zilandelayo, uze ubhale phantsi ukuba uyifumene njani na impendulo.*

1.1. Abantwana abali-100 bahamba ngebhasi encinane besiya konwaba ngaselwandle. Ibhasi nganye ithwala abantwana abasi -8. Kufuneka iibhasi ezingaphi zokubathwala bonke?

Isisombulo (impendulo):	Ndiyifumene njani impendolo:

1.2. Amakhwenkwe amabini, uSibusiso noVukile baya kuncedisa uSonwabo arhugule amagqabi entsimini yakhe. Ubukhulu bentsimi yakhe yi -1200 yee skwe mitha. Ngeeyure ezi-4, uSibusiso urhugule indawo ebukhulu bungama-700 ee skwe mitha, waza uVukile yena warhugula -500 skwe mitha ngeeyure ezimbini. Bebobabini bafumana imali eyi R180 ngalo msebenzi. Baza kwahlulelana kanjani ngale mali ukuze bangaqhathani?

Isisombulo (impendulo):	Ndiyifumene njani impendolo:

1.3. UJohn ubaleka umgama ongama - 100 eemitha ngemizuzwana eli-17. Uya kuthatha ixesha elingakanani ukubaleka ikhilomitha enye?

Isisombulo (impendulo):	Ndiyifumene njani impendolo:

ICANDELO B

2. Uneepensile ezilishumi ezibomvu kwipokotho yakho yasekhohlo, uphinde ubeneepensile eziluhlaza ezilishumi kwipokotho yakho yasekunene. Mingaphi iminyaka yakho?

Isisombulo (impendulo):	Ndiyifumene njani impendolo:

3. Ibhasi ikuhlawulisa ama-R5.00 ukuya nokubuya emsebenzini usuka ekhaya. Itikiti leveki libiza ama-R50.50. Kokuphi okungcono, kukho ukuthenga itikiti losuku okanye itikiti leveki?

Isisombulo (impendulo):	Ndiyifumene njani impendolo:

APPENDIX D

Classroom Observation Schedule

CLASSROOM OBSERVATION SCHEDULE

School Name: ....Topic: ....

Teacher Name:...: .... Gender: ....Qualifications: ....

Grade Level: ....…… Number of learners: ....

Observer Name:...………….. Date of observation:……………………………………..

Component 1: Use of Language by the teacher (asking questions, teaching, giving feedback, explanation of terms and concepts)			
4 Teacher uses English only	3 Teacher uses English and switches to home language when necessary.	2 Teacher discourages the use of home language even when learners do not seem to understand	1 Teacher uses home language only
Description:			
Component 2: Uses of Language by learners in general classroom discussion (seek clarification, elaborate and solve problems, pose questions, build upon a previous response, etc.)			
4 Learners use English fluently.	3 Learners use English but switch to home language.	2 Learners seldom use English	1 Learners use home language only.
Description:			
Component 3: Learners' use of language with individual and/or group peers (problem-solving, talk, argue, dialogue, etc.)			
4 Learners use English only.	3 Learners use English but switch to home language.	2 Learners seldom use English	1 Learners use home language only.
Description:			

Component 4: Learner Writing (use of Writing Frames, writing comprehension, etc.)			
4 Learners write effectively to record	3 Learners write to record their	2 Learners write ineffectively –	1 Learners do not write al all
Description:			

Component 5: Teacher Promoting discussion (collaborative tasks – paired activities, group presentation, arguments, etc.)			
4 Clear expectations set about behaviour	3 Prompts/sentence starters	2 Unclear expectations set about	1 No discussion, talk is irrelevant,
Description:			

Component 6: Learner Responses (individual, group, paired, hands-up, at the board, verbal, in writing, negotiation of meaning, etc.)			
4 Responses are valued,	3 Some responses are valued;	2 Learners struggle to initiate	1 Learners do not respond at all,
Description:			

Component 7: Learner Work in Groups			
4 Groups of learners discuss problems, questions and activities by themselves	3 Only two or three learners in a large group interact	4 Groups of learners with limited interaction/interact when teacher motivates	4 Learners sit in groups but work as individuals.
Description:			

APPENDIX E

LANGUAGE SURVEY FORM

Conduct a survey at your school in order to find out the information needed to complete the tables below:

Total number of learners at the school	
Total number of languages spoken at the school	
Languages of learning in the school	
Languages used most frequently in the classroom	
Grade at which other languages are introduced	
Grade at which other languages are introduced as languages of learning	
Languages used for assessment in the school	

Home languages of educators and learners:

LANGUAGE	NUMBER OF EDUCATORS THAT SPEAK THE LANGUAGE	NUMBER OF LEARNERS THAT SPEAK THE LANGUAGE

APPENDIX F

Learner Interview Questions (Immediately after pre-testing)

1. If the same thing happens to you, would you respond in the same way in real life as you did in solving the problem? Why?

2. Your solution may not work in real life because of (real factors). Why did you answer that way?

3. Please think about on what condition your answer could become realistic. Could you come up with any assumptions or explanations that can make your answers justifiable?

4. Do you think the contexts used in the content of tasks (or problems) that you solved in the pre-test are familiar and/or relevant to your everyday life experiences? Why?

APPENDIX G

Interview (Teachers and Learners)

Teacher Level

1. Which language(s) do you use to support communication in your classroom and why?
2. Which language do you prefer to use when clarifying concepts that are being taught in the classroom? Why?
3. Which language do learners use as a resource in order to understand word problem solving? Why?
4. Do you provide learners with opportunities to talk, discuss, argue and engage in dialogue when you teach? How?
5. Which language do you mostly use to teach word problem-solving and word probem-posing? Why?

Learner Level

1. Which language do you use to communicate in your classroom? Why?
2. Which language do you prefer to use when you solve word problems? Why?
3. What problems do you usually have when understanding and solving word problems?
4. Which language do you prefer to be taught mathematics with? Why?
5. What difficulties did you experience when solving word problems in isiXhosa test? What about English test? Why?
6. Which language will you choose for your assessments? Why?

APPENDIX H

Examples of teacher interviews

Interview with Teacher A

Researcher: Ok its 13h45; it's a Friday the 7th of May 2010. We are here at Sakhisizwe Senior Secondary School and we are with Teacher A, a Grade 9 Mathematics teacher whom we are working with and then Teacher A has agreed to do this interview with us, and then we do have a voice recording instrument. And then the questions I'm going to ask are only general questions that revolve around the language of teaching and learning and then maybe the home languages of the children or the learners. And here with me we have Assistant Researcher my assistant researcher. The questions I will ask Teacher A will be in English and then if Teacher A wants to mix English and isiXhosa that will be acceptable as well. The first question is:

Researcher: Which language or languages do you use to support communication in a classroom?

Teacher A: Normally when I'm teaching mathematics I'm using English because I want my learners to get used in the questions for English, because maybe during the exam time they will not be asked by me, they will be asked by somebody else, so I want them to get used , using the language even if I'm teaching mathematics.

Researcher: So why do you think maybe it will not be advisable maybe to teach them in their own languages which is in this case isiXhosa?

Teacher A: The problem that I'm having is to translate the words from English to Xhosa, because usually we are using alphabets, so it will be difficult, for an example if I'm using the alphabet "**B"** it means I will be using the word like **"Bi"** and when I'm using **"X"** lets say I'm saying to them you need to solve for "**X"** so I will say you need to……. It will be really difficult to teach in Xhosa Mathematics.

Researcher: The second question that I want to ask is, which language do you prefer to use when clarifying concepts that are being thought in a classroom?

Teacher A: Sometimes not most of the time, just for few seconds I translate when I want to emphasise something, I can translate the English word into Xhosa, so that they can be able to grasp what I'm teaching to them.

Researcher: So meaning you co switching moving between two languages?

Teacher A: Yes I can teach, but in Xhosa I'm just teaching it for few seconds, but mainly I'm using English.

Researcher: So do you maybe have another reason to just using those few seconds for isiXhosa in favour of English.

Teacher A: Sometimes if I'm using too much English, I will find that, I can see my learners, you can see them they don't understand this thing, let me use their language. You find that when I'm using their language they understand me, but I don't like to teach mostly English.

Researcher: And then if maybe I were to take this question further and talk about the language and education policy of the school, do you have a language policy in the school to say you need to teach this language or this other language?

Teacher A: At school we are using English and Xhosa; we are using both of them, because here in our school we are having Xhosa learners, so we don't have other learners who are colours or who are English speaking people, we only have Xhosa learners at our school, so it is acceptable to speak both English and Xhosa, even in our Assemble we usually speak Xhosa but we can use English sometimes, it is acceptable.

Assistant Researcher: Is there an official language policy, is there a policy that you must teach in a particular language, is there an existing policy from the department, and is there a declared policy?

Teacher A: Let me put it this way, I'm new in this school, I started in July last year, but I'm not sure about whether it is included there in the policy for the school.

Researcher: The third question will be Teacher A, which language do learners use as resource in order to understand word problem solving?

Teacher A: The learners are using Xhosa, sometimes I ask them in English but they will answer me in Xhosa, but what is happening I always encourage my learners to speak, even if you speak Xhosa I accept that because I'm encouraging my learners to participate that is the most important thing, so that if they are wrong I can correct them or if they are wrong I can guide them, that is what I normally preach to them, that is the way of encouraging them to participate. Because you won't know Mathematics if you just fold your hands, but if you are speaking it or writing something on the chalkboard or you are writing something on a piece of paper that is what I like from my learners.

Assistant Researcher: So they are not afraid to use Xhosa?

Teacher A: No they are not afraid because I say to them as long you are speaking in my class you can use any language and then I will correct you if you are wrong, that is what I'm preaching with my learners.

Researcher: The fourth question will be: Do you provide learners with opportunities to talk, to discuss, to argue and engaging in dialogue when you teach?

Teacher A: Yes that is what I normally do; I give them class works, normally when I'm giving them the class works, so if I think this class work is slightly difficult to my learners I encourage them that you can work in pairs, you can discuss it. If we are doing that, if I'm giving them the class work for the first time in that particular section, I'm encouraging them to work in pairs. Lets say if I'm repeating the same thing that I've done last week, but lets say now I'm using different numbers I can say do it alone because we have done this last week or at the beginning of the year so you can do alone, but if I'm giving them the class work for the first time in that particular section I encourage them to work in pairs. Because for an example, what I normally noticed from my learners they have got a problem with Algebra. Algebra is where they are having the problem mostly, that is why I'm always encouraging them to work in pairs or I even encourage them to go to, lets say when I want the answer I encourage them to go to the board and do the feedback on the board, while I'm doing the corrections, I don't write the corrections me. I first say go to the board, they will write all the answers, then at the end I will say, I will ask the class first is that right? If they say no it's wrong, I will call another learner to come and help that particular learner in that particular question. If I can see that particular learner is still having a problem, it is when now I do my own, I do that particular question myself. Do you understand?

Researcher: Okay thank you very much for that, I think you gave a very good account of the question, and then the next question, which is the fifth one on my list: Which language do you mostly use to teach word problem solving and word problem posing and why?

Teacher A: Ok I use English, but I know my learners they are having a problem in answering the word problems, to assist them I also use the Xhosa language because I think it is, they understand better the word problems in Xhosa than in English. You understand me?

Researcher: Yes

Teacher A: Because they've got the problem in using, they don't know, let's say because when you are using the word problem, normally we supposed to use the unknowns, so when we are want to get the unknown, it means that you have to use the alphabet to represent the unknown, it means that you have to put "X' or to put "A" that is where they are having a problem, because when you are working with the word problem you must use the alphabet as an unknown or as what is needed by the question. You understand?

Researcher: Okay now the next question will be: what language do you encourage them to use when they solve the word problems in their individual groups or in pairs?

Teacher A: When they are working alone as individuals?

Researcher: No in groups, what language do you usually encourage them to use?

Teacher A: So when they are working in groups I usually encourage hem to speak their own language. You understand? They cannot use, because they understand them better when they are using their language other than using the English. Because it is funny for them to use English, for they must use their own language when they are discussing.

Researcher: Do you think maybe you have vibrant learners in your classroom, do you think they initiate talk, do you think they initiate discussion within the classroom?

Teacher A: In the classroom no, they do not initiate their discussion, it is me who initiate the discussion with them. Sometimes I say no man do you understand this? They will keep quite and then I will repeat again, no man you can't keep quite if you don't understand something, you have to ask me, I usually say that to them.

Researcher: So meaning, if maybe I were to ask you, how do you usually make them talk, how do you stimulate their discussion, what strategies do you usually use to make them comfortable in maybe talking or discussing in the classroom?

Teacher A: I've go no other strategy rather than encouraging them to ask a question when they don't understand, I don't have other strategy, I do the problem myself and then I ask them, do you understand that? If they say no we don't understand Sir, can you repeat that step, I will repeat it and then after that if I've seen that they understand now, it is where now I will give them the problem to do themselves as a group or as individuals that is what I usually do.

Researcher: Tata do you want to ask something?

Assistant Researcher: No

Researcher: I think we done unless if you maybe have questions maybe to ask us, to ask me or Assistant Researcher, this will be an opportunity for you to do that, but if you don't have any question, then its also ok.

Teacher A: No I don't have a problem, no questions, because you see when I'm teaching sometimes I work according to the work schedule. So I usually push my learners to do what I'm supposed to do at that particular time, so I don't think I will have the other strategy because I want to finish that thing at that particular time, to move to the other thing, because I'm working with time. That is where I'm having a problem, so I don't have any questions.

Assistant Researcher: When you in classroom do you feel comfortable teaching in our presence, don't you feel we going to be criticising you, how do you feel in our presence, do you get comfortable and normally like me?

Teacher A: I'm comfortable with the teaching, the learning area in Mathematics, but you see what is normally disturbing me with my learners, its when they are making noise, they are not concentrating on what they are supposed to be doing, you'll find that when I'm teaching Maths, sometimes they are doing home works for other learning areas like Life Orientation or Xhosa, that is when I become so stressful because I want my learners to concentrate on what I'm doing. I don't like the learners who are unroll in my class; I try by all means them to concentrate on what I'm teaching.

Assistant Researcher: Do they talk in class while you are teaching?

Teacher A: They talk, but find out they are not talking about mathematics, they talk about something else, that is where I become angry.

Researcher: Thanks very much Sir, we really appreciate your time and then we really appreciate your inputs and I think you gave a very good account of the questions and we really excited about that.

Interview with Teacher B

Researcher: This is the morning of the twelve May 2010, so we are here with Teacher B the Mathematics teacher grade 9 at a school, and we feel very honored and privileged to have you Mam and then I'm just going to ask you semi structured interviewed questions and then if you have questions maybe you need clarity on the question, maybe read or rephrase the question again. The first question that I want to ask you centers around the use of language in the classroom, when you teach Mathematics on isiXhosa learners and then it should be noted that Mam is fluent in English but then she can also speak isiXhosa, but she's not that competent in isiXhosa because she just learned the language here in Eastern Cape. Mam the first question is: which language do you use to communicate in the classroom.

Teacher B: Basically I use English.

Researcher: Why?

Teacher B: Firstly I'm not isiXhosa speaking, so I rather refer to the language that I can speak fluently.

Researcher: So if I can follow up, do you have a problem or do you encounter problems especially when isiXhosa learners would maybe express themselves in isiXhosa when they discuss with other ones or when they give feedback to other ones.

Teacher B: I don't really face problems because at least I understand the language, so I don't have a problem; I even give them the liberty to speak in isiXhosa when they are in class, because the most important Idea is for them to understand rather than to speak the language on its own.

Researcher: Now we moved to the second question, which language do you prefer when you solve word problems to the learners?

Teacher B: I wish I could speak isiXhosa sometimes, because the things that you really want to explain but you can't really get to the point, so I wish I could speak isiXhosa then I would use both languages.

Researcher: Does the question has to do when you clarifying concepts that are being taught in the classroom, you always use English and support that in isiXhosa.

Teacher B: Yes I do support it in isiXhosa, what I actually do is: when I teach a concept, obviously in every class there are learners that are fluent in English and who are fast learners, so they are sort of my assistance, because when I explain if they get the concept then I will ask them to teach or say it the way they understand and by so doing everyone gets it, but of course we've got the few that might remain behind.

Researcher; the third question is: which language do learners use as a resource in order to understand word problem solving, and why do you think that is the case?

Teacher B: I think basically they are using isiXhosa and it's all because of their background, they are speaking isiXhosa all over except in class. They only speak English in class and I've noted that even in the English lessons they are having a problem because they sometimes refer things in isiXhosa, so I've noticed it's just me at the end of the day who is probably speak English. But my idea really since I'm teaching a content subject which is really requires them to understand the concept more than the language.

Researcher: Now the next question is: Do you provide learners with opportunities to talk, to discuss, to argue and maybe engage in a dialogue when you teach?

Teacher B: Very much Mathematics requires that a lot, there's a need for interacting, there's a need for peer interaction, there's need for teacher to peer interaction, so we do involve them so much.

Researcher: And then if maybe I were to ask you, how do you go about doing that, what are those strategies that you employ usually in the classroom?

Teacher B: Sometimes it's guided discovery, there's a concept that I want them to discover, I just lead them to that concept for them to discuss it and discover it, so it's peer interaction among them or it can be them and me

Researcher: Do you usually have a problem in terms of maybe learners being channeled to talk in English or to speak in English because them knowing that you not that competent in their own language.

Researcher: I used to face the problem, but now not anymore, because in my first year in this school it was really quite difficult to teach because back then I didn't know the quality of the learners very well, so it was a little bit difficult for me, but for now I sort of adjusted and now I can fit in very well and I know what pace to go on and what language do you use where and when.

Researcher: Now last but not list: which language do you mostly use to teach word problem solving?

Teacher B: I use English

Researcher: And that will be the same reason that you gave?

Teacher B: Yes

Researcher: I think Mam this will be enough for now or for today, unless if you have some questions to ask us about anything, then this will be your opportunity to do it.

Teacher B: No I don't have anything maybe next time.

Researcher: Thank you very much for allowing us this brief interview, we really appreciate you giving us your time and space.

Interview with Teacher A

Researcher: Today is Monday the 17th May 2010 we are with Teacher C our grade 9 Mathematics teacher at Tyhilulwazi Senior Secondary School. Now what we going to do sir, before we start thank you very much for the time that you sacrificed to wait for us here, we have about five questions and the questions are based on your experiences through out your teaching career, especially now in the new curriculum to say what are those issues of language that you have experienced in the school when you teach Mathematics and maybe your experience when you interacted with learners. Now I'm going to start with the first question, and the first question says: **Which language or languages do you use to support communication in your classroom and why?**

Teacher C: I use their mother tongue which is isiXhosa, because sometimes you could continue in English and you discover later that they really did not understand what you actual wanted to put through, so its easier for them sometimes when you explain in their mother tongue, you'll just actual to relate again every day use of isiXhosa because sometimes if you go deep in isiXhosa they will also not understand, so if you use actual day to day language which is isiXhosa and you will discover that at the end of the day you have actual been successful to put across the message.

Researcher: The second question will be: **Which language do you prefer when clarifying concepts that are being taught in the classroom and why?**

Teacher C: It should be English, but as I have mentioned before, I prefer to use isiXhosa as these learners are very weak in English especially the little ones from grade 8 and grade 9, their English is very weak and you can also go up to grade 10 you will discover that they don't understand a thing, so to put it across in isiXhosa makes things easy for them.

Assistant Researcher: Do they understand isiXhosa, and which isiXhosa do you use, is it a deep or simple Xhosa?

Teacher C: You know if you can take a boy here from P.E. and take a boy from Transkei, you will discover that the one from Transkei is speaking deep isiXhosa and sometimes you wont understand, so these learners here don't speak deep isiXhosa, they the township isiXhosa. You also have to interact with them using that township language and you will discover that they understand better, I also discovered that in you test again there were deep isiXhosa words, so also one must gather against the deep isiXhosa.

Assistant Researcher: I also thought about that here in P.E.

Researcher: So maybe you will say that is isiXhosa that is being used in the rural area?

Assistant Researcher: Yes and my wife comes from the rural area in Transkei, from a proper isiXhosa speaking area, but here in Port Elizabeth I find it very difficult.

Researcher: Now I remember asking those kids what type of other kids there because you talking about this isiXhosa slang and then I asked them what isiXhosa are you doing in the isiXhosa period, isiXhosa learning area and they say no we are doing the correct isiXhosa, but when we speak and when we play we switch to this isiXhosa slang. And then moving to the third question: **Which language do learners use as a resource in order to understand word problem solving and why do you think that is the case?**

Teacher C: I think its English because word problem are the difficult part of the Mathematics to interpret words into an equation, I think English will be the better language to use because isiXhosa will be very much difficult to interpret these word problems.

Assistant Researcher: You don't find problems in translating English words into isiXhosa, for an example words like multiply and kilometres?

Teacher C: I know other English words are better left as they are sometimes.

Assistant Researcher: It's useless to translate every word.

Teacher C: To translate each and every word it becomes confusing and writing words like kilometres or square metres it's very difficult.

Researcher: If I were to ask in terms of changing policy, because the examination papers like the common ones you will find there's English and Afrikaans and learners who are fluent in both languages they have the liberty to switch between the two, so do you think maybe if you that opportunity to change policy making or policy design, you suggest maybe you have another life for isiXhosa speaking kids, maybe you have English and isiXhosa, where those who don't understand English can switch to isiXhosa maybe that can work?

Teacher C: I think it can work, because those learners there that can understand both Afrikaans and English they have an advantage, why not for our kids because sometimes they do understand the problem it self, but the English that is being used makes it difficult for them to understand what is being said, not that they don't understand the content, it does happen sometimes.

Researcher; The fourth question will be: **Do you provide learners with opportunities to discuss in the classroom, to talk, to argue and maybe to engage in dialogue when you teach them?**

Teacher C: Yes I do, but then I discovered that they always want to communicate in isiXhosa.

Researcher: I don't mean in English, in either of the languages.

Assistant Researcher: You encourage them in interaction.

Teacher C: It does help; you know those groups of 6 although you'll find that some kids are so shy even to speak to their friends.

Researcher: Because my follow up question will be: **How do you go about making that possible in the classroom, given such difficulties of other learners being shy, not that spoken?**

Teacher C: I always try at all times to be friendly with these kids, you know when you teach Mathematics and if you always come to class being angry and so on with them you'll discover that it doesn't work, but although sometimes they will take advantage if you are too friendly, I just encourage even those who don't want to talk, just to speak. For home work I always say write what you think its correct, a correct answer or incorrect answer that's not important, just express yourself, feel free to voice out your opinion, if its correct or incorrect its fine as long as you are able to stand up and say what you want, to say without fear.

Researcher: Question number five: **Which language do you mostly use to teach word problem solving and word problem posing?**

Teacher C: I use English and as I have said in the previous question that sometimes its difficult especially word problems, its difficult for them to interpret it in isiXhosa, so what I always say to them, if you don't understand try to read it over and over and a meaning comes after a certain time, but I do try there and there to explain it in isiXhosa, but that's a difficult part in Mathematics to teach those word problems. You know one other thing is that our schools don't have language policies, that's another area to encourage learners to communicate in a language that is not their mother tongue, it doesn't happen in our schools, you can go around there is no school that has got a language policy, you can ask them if they do have a language policy. I only know the whites schools that do have a language policy where a learner is forced according to the policy of the school that must communicate in a particular language. Offcourse it will be difficult in the beginning and kids turned to become used to it and then they enjoy it, which can also help in building their vocabulary in English.

Researcher: So you are isiXhosa speaking?

Teacher C: Yes

Researcher: And then if now you were requested to teach in isiXhosa and allowed to prepare a lesson in isiXhosa and not to use any English word, do you feel comfortable in doing that?

Teacher C: I don't think I will be comfortable; I will not be able to teach in isiXhosa through out the whole period, because I don't speak isiXhosa all the time even at home or with my friends.

Assistant Researcher: You struggle explaining in isiXhosa questions like "x to the power 3"

Teacher C: There's also that part, which is difficult to explain or translate in isiXhosa the questions like "2 to the power 3 and 2 multiply by 3"

Assistant Researcher: Do they understand?

Teacher C: Yes they do understand

Researcher: I think they should because in the lower grade I think they are taught in their mother tongue.

Assistant Researcher: From grade R to grade 6

Researcher: The policy says they must be taught in their mother tongue, but I'm not sure which grade is it where they switch off to English, but maybe you wouldn't know because you not in foundation phase.

Teacher C: No I'm not familiar with that.

Assistant Researcher: I didn't know they can do that, teaching them in their mother tongue.

Researcher: So you don't have anything you want to ask us? I think we asked you some questions of which you excelled.

Assistant Researcher: You have done very well.

Teacher C: Not really, but I think you do want to observe a lesson, but I don't know when can we arrange that?

Interview with Teacher D

Researcher: Today is the tenth of May 2010i'm at Gqebera Senior Secondary School and this is an interview a very brief interview, one on one interview with Teacher D, a grade 9 Mathematics teacher. We going to discuss about the issues of language and Mathematics in your classroom and how do you deal with issues of language when teaching Mathematics in your classroom at grade 9, I have structured questions that I'm going to ask you, under this teacher level which are not that different from the learner level. The first question I want to ask you: which language or languages do you use to support communication in your classroom?

Teacher D: I'm using isiXhosa and English, but if I want emphasize I use isiXhosa

Researcher: Do you have any preferences of which language to use in the classroom when you teach them?

Teacher D: Mostly it's isiXhosa

Researcher: If I would ask why do you prefer teaching them and emphasize in isiXhosa rather than English?

Teacher D: I think my learners don't understand me, so I prefer to use isiXhosa the language they are using.

Researcher: At home?

Teacher D: Yes

Researcher: If maybe I was to follow up in this question: Do you think they like talking in isiXhosa in the classroom, do they like explaining in isiXhosa?

Teacher D: Yes, but we are using English books.

Researcher: So do you maybe sometimes find a conflict between you using isiXhosa and them especially when they write exams or it works just fine for you?

Teacher D: It works just fine because I use factorization, expression, and monomial because I don't know these words in isiXhosa, so I use those terms.

Researcher: You borrow other languages, Maths words into isiXhosa. Ok which language do you prefer to use when clarifying concepts that are being taught in the classroom?

Teacher D: isiXhosa

Researcher: And you answered why.

Researcher: The third question will be: which language do learners use as a resource in order to understand word problem s in the classrooms?

Teacher D: isiXhosa

Researcher: Why do you think learners choose isiXhosa?

Teacher D: Maybe they choose English because the text books are written in English, but when I'm teaching I'm using isiXhosa, whereas its English in the text book, but the instructions are in English and I'm using English for instructions.

Researcher: So do you think maybe switching between the two languages also assist you as a resource to make them understand.

Teacher D: Yes

Researcher: I'm going to ask you about your interactions in the classrooms with your learners, do you usually provide learners with opportunities to talk, to discuss, to argue and then engage in a dialogue when you teach? If I may ask how do you go about doing that, in other words what are those strategies that you use maybe to make learners free to talk, to discuss in the classroom to talk to each other and then talk to you?

Teacher D: When I'm starting a topic to a new chapter and ask them before I explain to them, so they talk what he or she thinking about.

Researcher: About the theme?

Teacher D: Yes

Researcher: So they don't have problems, maybe in terms of asking you questions.

Teacher D: No I told them I'm not the Lion, if she wants to ask something, she can do it

Researcher: Do you only use English and maybe why English?

Teacher D: Because they write in English, the tests are in English not in isiXhosa.

Researcher: So if I understand well, when you teach any other topic in Mathematics you teach them in isiXhosa or you mix?

Teacher D: I mix

Researcher: When you come in maybe problem solving activities like word problems you prefer teaching them in English and not in isiXhosa.

Teacher D: In English but in some areas I use isiXhosa.

Researcher: What are other issues of language that you think maybe learners might have and then what would you suggest maybe in terms of the policy of the school in terms of language policy or the policy of the department. Do you think maybe it can be necessary for the department to also maybe ask questions, because usually they ask questions in English and Afrikaans, so do you think it can help for the department to ask questions in the language that learners use at home?

Teacher D: Maybe English or isiXhosa, if you don't understand English and check to isiXhosa.

Researcher: Have you ever tried this here, the strategy of maybe using both languages parallel, like giving them a test in English and in isiXhosa, have you tried that before?

Teacher D: No we are using English.

Researcher: Thanks very much Mam for the interview, I really appreciate it, unless if you maybe have a question and then you can ask me.

Teacher D: No question

Researcher: OK

Examples of focus group discussions with learners

Kgabo Secondary School learners

PS1:100 children are being transported by minibuses to a summer camp at the sea-side. Each minibus can hold a maximum of 8 children. How many minibuses are needed?

Learner 1 (L1) wrote an answer as 12 minibuses do you want to explain to us, how did you arrive at 12? You can say it even in isiXhosa its fine.

L1: The question said, there were 100 school children and buses can only take 8 children and then I took 100 and divided by 8 and I didn't use a calculator, I counted with my mind then I got that answer, 12.

Researcher: If the same thing happens to you, would you respond in the same way in real life as you did in solving the problem? Why?

L1: No

Researcher: How will you do it?

L1: I don't know, I guess I don't know.

Researcher: What about others, if that was a problem how would you solve it? Will you also use the same method that she used?

L 2: I will do it like that, when you divided children like that you will count that each minibus will get in 8 children, if you divided them in groups of 8, so that all 100 children can enter in all of the mini-buses and you will know that you must have 12 minibuses.

Researcher: In other words you will divide them into groups of 8 and then after that you count them.

L2: Yes

You have ten red pencils in your left pocket and then ten blue pencils in your right pocket. How old are you? How did you approach the question? L 3?

L3: My age is 20 years old, I added up 10 red pens and 10 blue pens and I got the answer 20

Researcher: OK, what about you **L5**? How did you approach the question?

L5: I added up 10 red pencils and 10 blue pencils then I got the answer 20.

Researcher: Any other different approach?

ALs: Yes

Your solution may not work in real life because of (real factors). Why did you answer that way? If I ask, how old are you? What will you say?

L2: I'm going to tell you him my age

Researcher: And what age would that be?

L2: Maybe its 14 or 15

Researcher: Your actual age, your real age?

L: Yes

Researcher: **L7**, you said 20 years old. Can you please explain your answer?

L7: The question said you have 10 pencils on this side and another 10 pencils on the other side, so I thought because of the question did not ask anything on personal details and then I thought when you add up the pencils from both sides, it bring up the total of your age or something.

L3: It's because the question didn't ask how old you are in real life.

Researcher: Now this is the second and the last part of the interview, I know you want to go home now and what I'm going to do, I'm going to try to be a bit quicker on this one, and I'm going to take the questions as they are. The first question says: Which language do you use to communicate in your classroom.

Learners: English

Researcher: All of you?

Researcher: Why English?

Learner 1: Because when you are educated you must know how to speak English, because maybe you will be hired in a job by a white person not Xhosa speaking person and you will be required to speak English.

Researcher: So in other words you using English because you want to access things like jobs?

Learners: Yes

Learner 3: You must use English because when you write in mathematics book you will not write isiXhosa because it is not a Xhosa period or Xhosa class, you also provide written answers in English, so it's better for you to answer in English and become used in speaking and answering in English.

Learner 4: And English is the most used language here in South Africa.

Researcher: Any other reason?

Learner 2: English helps you to communicate with people from other countries, for an example the visitors for 2010 soccer world cup, we will be able to communicate with them in English because they will not understand isiXhosa.

Learner 1: Here in our class we are all blacks, but there is one of the learners who is not Xhosa and he does not understand isiXhosa clearly and that is why when the teacher ask a question you must answer in English so that the other learner who does not speak isiXhosa can also understand what you are saying.

Researcher: Which language do you prefer to use when you solve problems in Maths?

Learners: English

Researcher: Do you prefer English?

Learners: Yes

Researcher: Are you sure?

Learners: Yes

Researcher: Why do you prefer English rather than isiXhosa?

Learner 4: Because not all the time you speak isiXhosa and in English class you are told to speak English, but maybe some times you will speak isiXhosa, but most of the time you must speak English.

Lerner 3: Mathematics period it's not a period for isiXhosa and if you are in Mathematics class you must use English not isiXhosa.

Researcher: But somebody may argue saying we have isiXhosa class and we have English class or we have English lesson.

Assistant Researcher: Why don't you use English in English class and then also use isiXhosa in isiXhosa period?

Learners: Because there is no language called Mathematics, Life Orientation or Arts and Culture.

Assistant Researcher: No the argument is that English and isiXhosa have their own classes, so why again you must use English in Mathematics?

Learner 1: Because Maths it's not a language it's just a subject.

Learner 3: If maybe a teacher was not Xhosa but a white person, we would have to speak English and even in text books are written in English not in isiXhosa.

Researcher: Thank you all.

Kolobe Secondary School

Researcher: Today is the twelve of May 2010 and then we are with the learners of Newell Senior Secondary School. And then we just going to ask them questions about their experiences about the use of language of learning and teaching which is English and the language of Mathematics and again the language that they use when they play, when they talk to each other and even at home, which mostly is isiXhosa. And then what I want to ask you is, remember there was a question that says you have ten red pencils on your left pocket and ten blue pencils on your right pocket, and the question said how old are you, how did you find the question? Remember before you speak just say learner 1 or learner 2 and then say your responses.

Learner 5: Will you please repeat the question.

Researcher: The question said *you had ten red pencils in your left pocket and ten blue pencils in your right pocket, how old are you?*

Learner 5: On my paper I wrote 20 because there is 10 in both sides, so I added them together and get 20.

Researcher: So you added the pencils, the red ones and the blue ones, so ten plus ten was twenty.

Learner 5: When time goes I thought I should have wrote my age, because the question is asking about age, how old are you.

Researcher: So after the test you thought?

Learner 5: That I should have written my age which is fifteen.

Researcher: Why did you think like that?

Learner 5: Because it says how old are you, and you have ten red pencils and ten blue pencils and it says how old are you and I thought it meant my age.

Learner 1: It was a bit tricky, but then since there were different and they were not the same, I said its ten red pencils and ten blue pencils I added them together and got twenty and they ask how old was I, and I thought I should maybe take it as it is, and I thought I should put myself as a ten or twelve year old because sometimes they don't know how to pronounce but they can count, so I took ten and added with another ten and that's how I got my twenty.

Researcher: So you answered the question as somebody in pre - school.

Leaner 1: Yes because it sounded much better that way and that's how I got my twenty.

Researcher: Remember we are not saying how you solved the problem or the question is wrong, and we are not saying its right, I just want to know how you went about solving the problem.

Leaner 3: Since it was one of the same number but different color I thought to add them up and I got twenty.

Learner 4: I've got twenty

Researcher: Why twenty?

Learner 4: Because the question said you have ten blue pencils and ten red pencils and I added that and I got my answer.

Researcher: If I were maybe to ask: if I met you somewhere maybe at Spar or just along the road and then perhaps ask you how many coins do you have in your pocket and say perhaps you've got five coins in both pockets and maybe your friends asks you how old are you, what are you going to say?

Leaner 6: Fifteen

Researcher: How did you get fifteen?

Learner 6: He is asking my age, so I'm telling him my age

Researcher: You will be saying your really age.

Leaner 5: I think I will say I've got ten coins in my pocket and there's five from each pocket and my age is fifteen.

Researcher: So you will say your really age?

Learner 5: Yes

Researcher: And what is the difference in that question outside the classroom and inside the classroom?

Leaner 1: Can you please repeat the question.

Researcher: Isn't it that you saying if someone ask you outside the classroom you'll tell them your really age, so why in the classroom you don't say your really age? I just want to know.

Learner 5: Because it was tricky, I couldn't actual get it, but as someone speaks to me I get it.

Researcher: Now we will go back to the test, but we just mixing up these things, I've got very simple questions for you about the language. And the first question says: Which language do you use to communicate in the classroom?

Learner 3: Mostly is isiXhosa but partly English, when the teachers are teaching they use English, but partly isiXhosa for us to understand it easier.

Researcher: So why do you think that is the case leaner 3?

Leaner 1: They want us to understand it better so they use isiXhosa.

Leaner 5: Me and leaner 1 all the time we speak English, in the class or outside even at home and everywhere although we do sometimes speak isiXhosa and here in class we use English.

Researcher: So why do you choose English when you play, when you at home, when you in the classroom?

Leaner 5: I actual use both of them, in isiXhosa you know things , but then in English you get to discover words that you didn't know.

Learner 1: I would like to elaborate on that, well myself I'm used to speaking English because practice makes perfect and I'm also practicing other words, so in class other learners maybe they feel that since we are in blacks school we should be speaking isiXhosa or maybe they are afraid of being teased by others and calling them names such as "coconuts" but they don't realize that practicing speaking English it's going to do good for them because English is South Africa's main language, so if you don't know English you will struggle to get a job and if you want to be a receptionist you must know English, so that you can be able to answer the phone and communicate with other people who does not understand isiXhosa but speaks English.

Researcher: Now remember you don't have to agree with learner 1 and learner 5. The question says what language do you use to communicate in a classroom?

Learner: Mostly is isiXhosa.

Researcher: Why do you use isiXhosa?

Learner 1: I've always in black schools, and it's just the fact that I'm used to it and I also like English, I love talking in English, but some of my friends mostly are isiXhosa speaking so we have to keep up to each other.

Learner 5: Last year I wasn't speaking English the way I speak it with learner 1, but with others I talk isiXhosa and maybe if he doesn't understand English that much then I do talk isiXhosa. In English there are words that are nice to play around with.

Researcher: It's cool?

Learner 5: Yes it's exciting

Researcher: And isiXhosa?

Learner 1: Yes it is cool, because we as learners we put a slang and then it becomes not a proper isiXhosa, but the one we write is proper, so that is why everyone here thinks isiXhosa is much better, because you can hear it slang, it's like we colored speaking, because colored don't speak like Boers, because Boers speak proper Afrikaans, but colored mix it to make it slang.

Researcher: Any other comment?

Researcher: The second question: *Which language do you prefer to use when solving word problems and why?* Problems in Mathematics, remember word problems are like the problems that you had in the test. Now the question is, which language do you prefer to use when you solve word problems?

Learner 6: It's English because it's easy to understand, I have not been in black schools before this is my first time in the black schools, so I don't understand isiXhosa.

Learner 5: I also prefer English because isiXhosa it's hard, because right now I don't know what is multiplication in isiXhosa we say it in our own way which is "phinda phinda" that means again and again, which is not a right way of saying it, so English is better.

Learner 3: I will prefer English because isiXhosa is much hard there are even words that we say everyday which we don't know what they mean; isiXhosa is much harder that is why I prefer English.

Learner 1: I will prefer English as well, even though sometimes it is tricky, but then it's much more understandable more than isiXhosa, because isiXhosa it's a first language when it is written, it's not third language and third language it's much more easier it's for grade 3's, doing Maths in isiXhosa it's a bit harder because they using other words that you not familiar with, but when they translate it in English you then see the question it's easy.

Researcher: Learner 2 you have not yet spoken today. Which language do you prefer to use?

Learner 2: It's English, when you speak English you quickly understand what the teacher is talking about, when you speaking isiXhosa it's hard to understand.

Researcher: But now I want to ask you something, when you play outside which language do you use?

Learner 4: I use isiXhosa.

Researcher: Why do you use isiXhosa?

Learner 4: Because I understand isiXhosa very well.

Researcher: Better than English?

Learner 4: Yes

Learner 5: I mix them together

Researcher: So you switch between the two languages?

Learner 5: Yes and my friends think that I'm making myself a righteous or a brighter person.

Learner 6: I mix because I have different friends that comes from different schools , so when I'm with the learners from model c schools I speak English and when I'm with my friends here at school I speak isiXhosa.

Researcher: Any other comment?

Assistant Researcher: What reaction do you get from your parents when you speak English?

Learner 5: My mother is used in English.

Learner 1: Here at school the seniors from grade 10 to grade 12they like the way I speak English because it's good, but when you get to grade 9 they say that this girl is fool of herself, so here there are fears of speaking English because people will say you trying to be someone else that you not.

Assistant Researcher: What do you say in examination paper, a final examination paper, do you want the questions to be in English or mix both English and isiXhosa?

Learner 5: English

Assistant Researcher: All of you?

Learners: Yes

Learner 4: isiXhosa

Researcher: Why isiXhosa?

Learner 4: Because isiXhosa explains too much.

Researcher: Better than English?

Learner 4: Yes

Researcher: Question number 3: *What problems do you usually have when understanding and solving word problems*, like in the test what kind of problems did you encounter when you solve these word problems here? Whether it's language problem, whether it's Mathematics, skills problem, anything you encountered.

Learner 5: It's the language because it's tricky and there were isiXhosa words but not the actual isiXhosa that we speak and we ended up getting it.

Learner 1: I would like to elaborate, but then I'm not going to make an example about those, I like to make an example about equations and algebra, like now we are doing by nomial squares, we did multiplication by nomial and it was easy, but then when you get to squares, sometimes there is no additional sign on the brackets then it get a bit trick when you have to add it up to get the solution.

Researcher: So can you say it's the language or Mathematics rules?

Learner 1: It's the language, the way it's being used it's tricky.

Researcher: Question number 4: *which language do you prefer to be taught Mathematics with and why?*

Learner 5: English or mix it, but mostly it should be English because it's an easy language, because you get into a word that you already know and then you pass the question quickly, but in isiXhosa you will have to wait and think about the word trying to know what it means and that is going to take a lot of time, so I prefer English.

Learner 6: I prefer English because we are used to English and it's easy to understand.

Researcher: So you agree with learner 5

Learner 1: I also agree with them because there is this expression or saying in isiXhosa that there is no interpretation of isiXhosa, so if we had to be taught in isiXhosa then when the teacher had explained it's going to be a bit trickier when she tries to explain in other language, because it's already tricky for us.

Learner 2: English because it is easy and quick to understand, when you speak isiXhosa it is hard to understand other words.

Learner 3: I agree with learner 5, it's English and learner 1 has said it all and on the saying that there is no interpretation of isiXhosa, but there are words in isiXhosa that needs to be interpreted in English so that you can understand.

Learner 5: isiXhosa has got difficult words which you don't know and when you answering the question you will find words that you don't know and get stuck and you end up living without answering the question and then you will lose marks, but in English you will understand the question and if you answered right you will be right and sometimes in isiXhosa you don't even know the question and you will skip it.

Researcher: And I'm going to take this further and say, do you usually enjoy your isiXhosa language period? IsiXhosa as a learning area.

Learner 3: Yes I enjoy it and I guess it's because I know isiXhosa and I understand what we being taught and Mathematics is different from isiXhosa, because in Mathematics we mostly use numbers.

Leaner 1: I enjoy it because it's my first time doing it and the teacher is teaching in the way that I could understand and when the teacher explains, he explains more clear so that it's easy for you to understand. And the environment is so comfortable because we help each other in understanding and learning.

Learner 5: I enjoy it because when the teacher say a word and you don't understand the word, he then sometimes makes a joke about that word and then explains it further till you understand the exact meaning of the word.

Assistant Researcher: *So when you speak isiXhosa you don't feel sometimes that's a lower status, and when you speak isiXhosa don't you have that perception of you have a low status than the one who speaks English?*

Learner 1: Sometimes there is , when you get other kids from multiracial schools there is that fear of no more isiXhosa, you must speak English, but it's our choice to speak English or to speak isiXhosa, because when we are together we just speak isiXhosa because we from black school and we good at it.

Learner 5: IsiXhosa is our language and you will never forget it, so if you take me at this age and teach me another language, I will know that language, but I won't forget isiXhosa.

Researcher: It's in the blood?

Learner 5: Yes it's in the blood.

Learner 1: I'll like to disagree some how because I have cousins that can understand when you speak isiXhosa, but can only reply in English, so it's better when your parents speaks to you in isiXhosa and you speak English when you grow up, but at home you should be speaking isiXhosa if you are a young kid that goes to whites schools or else you will grow up not knowing your own language.

Researcher: Now I will quickly move to question number 5: *what difficulties did you experience when solving word problems in isiXhosa test?*

Learner 5: The test was easy and the words were not difficult although there is a question that I didn't understand, and everyone didn't understand the question of blue and red pencils they kept on asking each other about what they wrote.

Researcher: What about the language that was used in the test, the isiXhosa language, was it easy to comprehend and understand?

Learner 1: Well the way you handed out the papers made it easy for us, because you first handed out English, so when you handed out English and since the questions where the same it became easy, but then if you had isiXhosa papers with different subject it was going to be a bit hard.

Researcher: So who wrote the isiXhosa paper first?

Learner 3: It was easy doing the Mathematical stage, but it was a bit hard to explain, because you said we must explain how we got the answer, so it was a bit hard.

Learner 5: It was easy because that's the isiXhosa that we understand, it's the Xhosa that we speak and I don't think it is the really isiXhosa, but I don't know if it is or not, but it was understandable.

Researcher: And what about the English test?

Learner 6: It was easy because the first paper was English, so the difficult part was to explain how you got your answer.

Researcher: So meaning you agree with me if I understand you well, that seeing a paper in one language has an effect when you have seen the paper in another language. Will that be? And preferable those who saw the test or wrote the test in English first find the isiXhosa test much easier.

Learner 5: I found it easy because of I understand the question and then took the English paper and I saw that I also understand it.

Learner 1: I think it was going to be easy if I started with isiXhosa, it was going to be easy writing the Mathematical form and then it was going to be hard in explaining in words how I got my answer because we speak the isiXhosa slang we don't speak the really isiXhosa, so writing down isiXhosa it's so difficult.

Learner 5: If you take the word Binomial and put it in isiXhosa you completely won't understand even the word algebra.

Researcher: What if I say iAlgebra, iBinomial?

Learner 5: Still that's not correct because you slang.

Researcher: What about the English test?

Learners: It was easy.

Researcher: Talking about easy, I have an English test here with me. Now I'm going to ask you to discuss one question again, the one that you wrote before. Now remember there was this question, it says: *Two boys Sbusiso and Vukile are going to help Sonwabo rake leaves on his plot of land, the plot is 1200 square meters the surface area, Sbusiso rake 700 square meters of the 1200 square meters, so how many square meters are left? If Sbusiso rakes 700 there will be 500 left. Vukile rakes 500 square meters, so both of them did the whole area which is 1200 square meters. Now Sbusiso raked 700 square meters during four hours and then Vukile does 500 square meters in two hours, those are the times they took to complete their square meters or their area and they get R180 for their work, that's their pay and the question said: how are the boys going to divide their money, so that it is fair, they have to share the R180 that they got. How will you go about sharing the money, given the amount of work that they did?*

Learner 5: Because of they both worked I will just give them the sane equal amount

Researcher: So you will take R180 and divide it by two. Any other suggestions, learner 4 you seem not to agree.

Learner 4: I will take that money and add it together.

Researcher: Remember there's one R180 that they need to share.

Learner 5: how much will you give them?

Researcher: I will answer this later on

Assistant Researcher: Tell me if this was written in isiXhosa alone would you understand it?

Learners: No

Researcher: But now I want to ask some question in really life, suppose you and your friend were raking leaves at my place you have about 10 square meters, you only do 3 and he does seven and I give you guys R200, where you going to take R100 each?

Learner 5: Because it's my friend there's no need to take more money than him because we both worked.

Researcher: Ok maybe its Sweetness and she is not your friend.

Learner 5: I will still share it equally because there's no need to take more money than her.

Researcher: But now the question is: is it fair?

Learner 1: it is not fair, let me make an example about colleagues, you get the President, you get the Prime Minister and the Prime Minister doesn't get paid as the President because the President rules the whole country, so they do different job, but now doing the same jobs it's just the time, the other one did it in shorter time and not 700 but 300 meters and the one worked in 5 hours and did 700 meters, so will first have to calculate the time and then divide up.

Researcher: Because now I'm not looking for the accurate answers, but then the reasoning behind doing it that way. Because sometimes fair doesn't have to do with friends, family or brother.

Learner 6: T o be fair I will give the one who raked 700 meters R100 and the other one R80

Researcher: But now the other one did 700square meters in 4 hours the other one did 500 square meters in 2 hours, so who worked hard between these two? Do we check the amount of work done or the time taken to do the amount of work?

Learner 5: Both of them because the other one worked the biggest part and the other one worked the smallest part in a short time, so the other one used much more time working in a bigger place, so to me it's the same that's why I say its fair.

Researcher: Now I will move to another question, question number three: 1.3 it says John 's best time to run 100 meters is 17 seconds, then how long will it take him to run a kilometer? How did you solve this question? I'm not looking for the actual answer, but then how you went about answering this question?

Learner 5: I said 1700

Learner 1: Since I kilometer is 1000 meters we multiplied it by 17 seconds, I think that's how I did the question.

Learner 5: I multiplied 17 by 100 it gives me 1700 and then there are 60 minutes in one hour, I divided the 1700 by the minutes in an hour which is 60minutes and then I got my answer.

Researcher: So now what I wanted to ask you, because I understand he way you did the question, you made it into you Mathematics and then you assumed that the answer for each and every 100 meters it will take John 17 seconds, 17 seconds ten times because there are ten hundred meters in a kilometer. How many hundreds are there in a thousand?

Learners: 10

Researcher: Meaning there are ten hundred meters in that race.

Learner 1: So it means 17 multiply by 100

Researcher: 17 multiply by 10, that's the way you did it.

Researcher: Now I have something like this and from here to there that's your thousand meters or kilometers and I divided this into 10, but each interval it's 100, but ten hundreds makes a thousand meters, now for this hundred it's 17 seconds plus 17 plus 17 plus 17 that's how you did it, so in other words you multiplied 17 by ten then you got 170 seconds, it's ok. This is Mathematical correct according to what we are taught, but now do you thing this is a realistic situation in really life, if you were to run a kilometer and run 100 meters would you maintain the same time to complete each 100 as the distance becomes longer and longer?

Learner 5: No I don't think so

Researcher: What would happen?

Learner 5: Because one kilometer it takes 17 seconds

Researcher: No for 100 meters he takes 17 seconds

Learner 1: No because it's a kilometer, when you run 100 meters you run with your full speed, but then at 17 you can not run your full speed, you have to a bit sometimes jog because this is a kilometer it's not 100 meters because 100 meters it's like a quarter track

Researcher: Now if I ask you learner 1this answer is it correct mathematically?

Learner 1: Mathematically it's correct but in really life it's not going to be like that it's going to be much longer, it's not going to be a 170 seconds.

Researcher: So do you think what we teach you in the class, the Maths that we teach you it's not related to what you experiences in really life, would you agree with me saying that.

Learner 6: I would say no, it's not true because in the first 100 meters you running your full speed, but when the time goes on you get tired.

Researcher: But then when you wrote the test you were convinced that this is the way we should answer it?

Learner 5: I will talk about the Maths in the classroom; I think sometimes it's really.

Researcher: Sometimes it's really sometimes it's not really?

Learners: Yes

Researcher: I'm not agreeing and I'm not disagreeing, I'm just listening to what you are saying. The last question was the question on the bus pass the bus ticket, it says it cost R5 each way to ride the bus between home and work, let's say between home and work. A weekly ticket it's R50.50 which is the better deal, paying the daily fare or buying the weekly ticket, paying R5 each day or paying R50.50 per week?

Learner 4: I will buy a weekly ticket.

Researcher: Why

Learner 4: Because I don’t use money too much

Researcher: Oh you don’t use money too much everyday?

Learner 4: Yes

Learner 1: I would say the R5 option because it’s R5 when you go to work and come back, so when you multiply R5 by 7 days of the week you get R30, but then if you buy a weekly ticket you get R50.50, so paying R5 a day is cheaper than to pay a R50.50 for a weekly ticket.

Researcher: Ok I’m going to ring the question again. The question says it cost R5 each way to ride the bus between home and work.

Learner 5: It’s R70

Researcher: Ok let’s do this, did you calculate it before you decide which one is best

Learner 5: Actual I calculated 5 multiply by 7, I didn’t think about every way, I thought going and coming back it’s R5.

Researcher: So is it the issue of language?

Learner 1: No it’s the way we read it.

Learner 3: I considered it as 5 multiply by 5 because mostly people go to work Monday to Friday, so I did like 10 multiply by 5 is 50, so it wasn’t much difference, only 50 cents

Assistant Researcher: So when the question said each, what did you understand?

Learner 1: It’s R5 to go and R5 to come back.

Assistant Researcher: Is that how you understood or is it now you understand it?

Learners; It’s now that we understand.

Learner 1: It’s the each that we took out from the sentence and then we got it wrong.

Learner 5: It’s the understanding we had, we didn’t actually get through reading it thoroughly we looked at it the way that it’s easy.

Researcher: Now that you understand the problem of the question, which one will be the better deal?

Learner 3: I would say it’s buying the bus ticket a weekly ticket.

Researcher: You don’t have to agree with them remember you said the difference was 50 cent and you find that when you multiply that by 5.

Learner 3: I counted in 5 days not 7 days because most people go to work 5 days in a week.

Learner 5: Also the weekly ticket because the daily fare a week it’s going to cost me R70

Researcher: Let’s go back to really life again, I love really life situations; my mother was a domestic worker when I grew up, she was working at the suburbs, but she was not working everyday, she would go there on a Monday, Wednesday and Friday sometimes maybe they would even call her on a Saturday, but usually she will only go there for 3 days or 4 days a week. My father was a security guard he used to work 3 days in 3 days out, 3 days in 3 days off. My friend’s father was a lecture and he worked from Monday to Friday and then his mother worked at Pick n` Pay and at Pick `n Pay its like Monday to Saturday sometimes Monday to Sunday. So when you answered this you didn’t take this into consideration these other factors.

Assistant Researcher; the question was talking about a week, what do you understand about a week?

Learners: its seven days.

Assistant Researcher: All of you seven days?

Learners: Yes

Assistant Researcher: If someone works from Monday to Friday?

Learner 1: It's still a week

Learner 5: You wait until she calls you

Researcher: No you have an agreement, you know that in a week you have three days, but sometimes they will call you on a Saturday if they have visitors, you will come in to cook for the visitors, you must clean wash the dishes and so on.

Leaner 1: The question says the mother of the boys works 3 days a week, it's not saying the whole week.

Researcher: Now the last question, very last one: which language would you choose for you assessment? Which language would you choose for your test, your assignments, class work and your home work, which language and why?

Learner 3: I would say it's English because questions like these and some other Mathematical questions. I'll just be blank, I understand English mostly, especially in Mathematics.

Learner 1: I will says English in a perspective of assignment, because I will be the one who will be presenting it as in writing or typing so if I had to choose isiXhosa, I will have to use the really isiXhosa not the slang, so English is very easy.

Learner 5: English because in isiXhosa you will get stuck in writing an assignment but English is very easy.

Learner 6: I would say English because it is to understand, but sometimes you have to read it twice and make sure about your answer

Learner 4: It's English because you can understand it.

Learner 1: I would like to elaborate on that, when you do an assignment, if you have to research, you can't take the whole information, so you'll have to take parts of it and if it's a comprehension that you must summaries, so doing that in isiXhosa it's going to be a bit hard, so English is much better.

Learner 5: It's English because in our days for assignments we use computers and you cannot type isiXhosa, because the computer doe not understand isiXhosa.

Assistant Researcher: So when you read a text in isiXhosa and a text in English, is it faster to read a text in isiXhosa book or is it faster to read in English?

Learner 1: When I read English I read faster than isiXhosa.

Assistant Researcher: Why

Learner 1: Because there are hard words in isiXhosa that you will struggle to understand

Researcher: In closing, unless if Tata you have something to ask or you guys have something to ask.

Learner 5: What language would you prefer to teach Maths with?

Researcher: In Setswana in my own mother tongue, because I understand my own language better.

Researcher: Thank you very much for coming and giving us your space, your time, sacrificing your time to talk to us and it was brilliant and then we enjoyed your responses and then I think we should be very honored to have you because you are really brilliant kids and we wish you all the best in your examination.

Tlou Secondary School

Researcher: This interview is the follow up of the interview because we wanted to find out about the answers that you gave in the Pre – Test because previously you wrote a Maths pre – test and then what we going to discuss with them, it's just to find out how they went about solving different questions, but before we ask question on the pre –test I want to maybe ask about the use of language, how they communicate with the teacher in the classroom and how they communicate or talk to each other I the classroom. I'm not sure if maybe you all understand why we are here today. Remember you are going to say learner 1, learner 2 or learner 3 when you answer the question. The first question that I wanted to ask you is: *Which language do you use to support communication in your classroom?*

Learner 4: English

Learner 3: isiXhosa

Learner 5: isiXhosa

Researcher: So basically it's isiXhosa and English. Learner 3 if I were maybe to ask you why you use isiXhosa as the language to support talk and discussion in the classroom?

Learner 3: Because I understand isiXhosa better than English.

Learner 4: Because some of us we understand English very well

Learner 5: Because isiXhosa it's my home language

Researcher: That is why you want to talk in isiXhosa.

Learner 2: Some words in English we don't understand, but in isiXhosa we understand them very well, so that is why we like to use isiXhosa.

Researcher: Tata do you want to ask something?

Assistant Researcher: When you are among yourselves, when you are together which language do you use to communicate?

Learners: isiXhosa

Assistant Researcher: Those who said English, they were talking to whom?

Learners: We use English when we are talking to the teacher.

Assistant Researcher: You all use English when you talking to the teacher?

Learners: Yes

Assistant Researcher: Oh ok me needed clarity on that.

Researcher: I think learner 2 does not agree, she wants to explain

Assistant Researcher: let her explain

Learner 2: Sometimes we use isiXhosa when we talk to the teacher, when there are words that we don't understand we then use isiXhosa and then the teacher we'll make us understand in isiXhosa those English words that we don't understand.

Researcher: Now the second question: Which language do you prefer to use when solve word problems or when you solve problems in Mathematics in the classroom?

Learner 4: isiXhosa

Researcher: Why isiXhosa?

Learner 4: Because sometimes we don't understand the activity in English.

Researcher: So you use isiXhosa when you solve problems in a group or with your partner?

Learner 4: Yes

Researcher: Now learner 4 when you talk to the teacher or when you report back on behalf of your group to the rest of the class do you also talks in isiXhosa?

Learner 4: isiXhosa or English.

Researcher: Oh you just choose.

Learner 1: We use isiXhosa when we talk.

Researcher: Learner 6 which language do you prefer to use when you solve Mathematical problems?

Learner 6: In some classes we must speak English, but in others they say we must speak isiXhosa because of we don't understand English that much.

Researcher: And then in Maths classroom?

Learner 6: We use English maybe if we understand the words if we don't understand them we use isiXhosa.

Assistant Researcher: So if I give you a test in isiXhosa or English which one would you understand more when you write examination?

Learner 6: I would understand English better

Learner 1: I agree with learner 6

Learner 2: It's sometimes in English, but I can understand them both.

Researcher: Now moving to question number 3: What problems do you usually have when understanding and solving word problems? Word problems are those problems that I give you in the test; those are Maths problems expressed in words, like a story problem.

Assistant Researcher: What problems do you encounter when you reading questions in your question paper, do you understand the words that are being used in the question paper?

Learner 6: Some words we do understand them, but some we don't understand.

Assistant Researcher: What are the problems?

Learner 6: When we are reading there are some words that we don't understand what they mean.

Researcher: I'm going to ask you something on the test that you wrote; I'm doing this because this question is related to what you did in the test. Now there was a question that says you have ten red pencils in your left pocket and then ten blue pencils on your right pocket. Do you still remember the question?

Learners: Yes

Researcher: And then the question said how old are you? Learner 2 what did you say, how did you solve the question?

Learner 2: It was very difficult I didn't know how to solve it, but I tried and I can't remember the answer that I wrote.

Learner 1: I added the pencils and then my answer was twenty.

Researcher: You added the two sets of pencils and then your answer was twenty?

Learner 1: Yes

Assistant Researcher: Twenty what?

Learner 1: Twenty years

Learner 6: I agree with learner 1 because I also added the two sets of pencils.

Researcher: So why did you do that? Why did you solve the problem that way?

Learner 1: because we talking about the pencils not our age.

Assistant Researcher: But the question asked how old are you?

Researcher: Let's say if you met somebody in the street and then somebody ask you how many coins so you have in you left pocket, maybe say the answer it's four and he ask you again how many coins do you have in your left pocket, then maybe you have two coins and the person continues and ask you how old are you, what are you going to say to your friend in the street?

Learner 6: I'm going to say I'm fifteen years old.

Assistant Researcher: Your age?

Learner 6: Yes

Researcher: So learner 6 you going to say you are fifteen years your age?

Learner 6: Yes

Researcher: And what about you learner 2

Learner 2: I was going to say the same thing

Researcher; You going to say your really age?

Learner 2: Yes

Researcher: So now why when you solve word problems in the classroom, why do you make use of the numbers that are given and not you really age?

Learner 6: Because there were no ages given, so that we can select or choose our right age, so that is why we did it like that.

Researcher: So that is why you just used those numbers that gave you?

Learner 6: Yes

Researcher: Remember we not only talk in English because Tata understands isiXhosa, so if you feel like talking in English or isiXhosa it's up to you. And later on he is going to help to translate. Now there was this question that says; 100 children are being transported by mini buses to a summer camp at sea side and the question said each mini bus can hold the maximum of eight children and the question was how many mini buses are needed?

Learner 6: its twelve buses

Researcher: How did you solve that?

Learner 6: I calculated it

Researcher: How did you calculate it?

Learner 6: I subtract 8

Researcher: Remember there are 100 kids that need's to go somewhere for a trip and then they need to hire many buses and then each mini bus can only take eight kids for the trip, so how do solve such a problem?

Learner 1: I divide them in groups of eight, so that they can fit in the buses.

Researcher: So meaning you need eight mini buses.

Learner 1: I divide them in groups of eight so that I can see how many buses I will need.

Researcher: Oh so you divide the children in the groups of eight?

Learner 1: Yes

Researcher: So how many groups did you find?

Learner 1: Twelve groups

Researcher: Now if you find twelve groups then you concluded that there were twelve mini buses?

Learner 1: Yes

Researcher: And then when you counted the total did it accommodate all the number of all the kids?

Assistant Researcher: If you have twelve buses and each bus takes only eight children, how many will go?

Researcher: its 8 multiply by 12, so there are 4 left.

Assistant Researcher: Do you want to be left behind?

Researcher: So how many buses do we need now?

Learners: 13 Buses

Researcher: There are others who took hundred children and divided that by eight and the answer it's 12.5 it's twelve and a half. You can do that quickly I have a calculator. Now when you solve this Mathematical most they say 12.5 most of you said 12.5. So what will be the number of mini buses if get an answer like this?

Learner 6: It will be a mini bus and a small car

Learner 2: I agree with him

Researcher: Any other different answer?

Researcher: Now I'm going to move to the next question: which language do you prefer to be taught Mathematics with?

Learner 6: English

Researcher: Why English?

Learner 6: Because some of do understand English, but some they don't understand it and if we don't understand English we will not find work.

Assistant Researcher: You will not find what?

Researcher: So will I be correct if I say learner 6, you simple suggest that you want to make use of English in order to find job opportunities in the future

Learner 6: Yes

Researcher: What about others?

Learner 4: I think we can use isiXhosa because it is part of our study and we can understand English when we mix these languages together.

Learner 2: I agree with learner 4 we must mix both of them; we can use both of them so that we can understand.

Learner 5: I agree with learner 4 and learner 2 because we understand both English and isiXhosa, but we understand isiXhosa better than English.

Researcher: Learner 1 seems not to agree, so learner 1 what do you think?

Learner 1: I think we can use isiXhosa so that we can ask our teacher to explain for us, because there are some activities that we don't understand them in English so we can ask our teacher to explain for us in isiXhosa.

Researcher: What difficulties did you experienced when you were solving word problems in isiXhosa test?

Assistant Researcher: Did you find any problems in the test, maybe the words that were used or the way it was asked?

Learner 6: I didn't have a problem because I understand isiXhosa very well.

Assistant Researcher: So you understood all of those questions?

Learner 6: Yes

Learner 5: I understand isiXhosa because it is very easy, it's not difficult.

Learner 4: I understand English because in isiXhosa there were words that I didn't understand

Learner 6: I agree with learner 4 because I understand English better.

Assistant Researcher: So you understand the questions better in English?

Learner 6: Yes

Researcher: Why do you think that is the case, not understanding the home language? Is it maybe because you are taught in English from a lower grades or is it because you not competent or confident in isiXhosa?

Learner 6: Most subjects are taught in English.

Learner 2: I agree with learner 5, the better test was the one in isiXhosa; it was easy because it's our home language.

Researcher: But then learner 4 said English, so you disagree with learner 4

Learner 2: Yes

Learner 3: I agree with learner 5 because isiXhosa it's easy.

Researcher: Learner 1 also agrees with learner5. Now the last questions from my part; which language will you choose for your assessment, for your tests, for your assignments and for your exam?

Learner 5: isiXhosa

Researcher: Why isiXhosa?

Learner 5: Because isiXhosa is very easy to me

Learner 4: I will choose English because I don't find any difficulties in English, but in isiXhosa I find some difficult words.

Learner 1: I will choose English because many assessments we do them in English that is why I will choose English.

Learner 2: I agree with learner 4 and learner 1 it's better in English because there are words in isiXhosa that we don't understand, but you can understand them in English.

Assistant Researcher: So when you write your final exam which language will you enjoy in answering the question paper?

Learners: English

Assistant Researcher: Who said isiXhosa?

Learners: its learner 3 and learner 5

Researcher: Ok back to our question paper under section A number 1.3 there was a question that said John's best time to run 100 meters is 17 seconds, in other words it takes John to complete 100 meters 17 seconds and the question was how long will it take him to run 1 kilometre? How did you approach this question? And then maybe just to simplify the question, remember 1 kilometre is equal to 1000 metres and then if we divide 1000 metres by 100 metres we only get ten, it goes ten times. So if he can run 100 meters in 17 seconds what do you think will be his time to run a kilometre a 1000 metres? How will you solve the problem? Ok let me change this question, but it will be similar, suppose maybe from here to the other side of the class to the other wall, it takes me 5 seconds not running but walking from here to the other end of the class to the other wall it takes me 5 seconds walking, now if we have ten classes joined in together, how long will it take me to complete ten classes walking, if it only takes 5 seconds for one class?

Learner 1: It will take 50 seconds

Researcher: How did you solve that?

Learner 1: Because I multiplied those 5seconds by ten.

Researcher; You multiplied 5 seconds by ten?

Learner 1: Yes

Researcher: So if it's 1000 metres how long will it take him, if he takes 17 second to run 100 metres? Are you going to do the same way, can we multiply 17 by 10? Its fine you don't have to panic, I know the question it's not easy, I'm not looking for answers I'm looking for reasons behind the answer. Remember I'm going to say from there to there, I'm going to call this A B, I'm going to say this distance here it's 1 kilometre which is a 1000 metres. What we know from A to C we that this one it's 100 metres, but we'll have 100 metre 100 metres, so each interval will be 100 metres, can we all see this one, so it will be 100 metres all the way to make on kilometre. But what the question tells us is that for this distance he can run 17 seconds for this part. The question says for the whole part how long will it take him to run from here to there, if it takes him 17 seconds to run from there to there? And remember there are ten of these distances. I'm not looking for the answer now, but how will you get it and I know we don't have calculators now so we won't be able to give me the accurate or correct answer, you can just explain how you are going to solve it.

Assistant Researcher: How did you solve it?

Learner 1: I multiplied 5 seconds by ten.

Assistant Researcher: Why did you do that or why did you do it that way?

Learner 1: I said from here to there it's 5 seconds by ten then I got 50

Assistant Researcher: So can how will you do this one, will you also do it the same way that you did in the previous question

Learner 1: Yes because I will multiply 17 by ten

Researcher: Now if maybe you were really running, just forget about Maths now. You are running during athletics, there are people who run short distances like 100 metres others run 15000 metres and other maybe they will run 1 kilometre, so if you were in a real situation running a 100 metres in 17 seconds do you think you will keep running each and every 100 metres with the time or you will do it in a lesser time or even with a longer time as you go around? Let's say you running twelve rounds in soccer field now the first part of the field is 100 metres, you run 17 seconds, the second 100 do you think you can run it the same time?

Learner 6: No you can't run it the same time maybe it will take a longer time.

Researcher: Why do you think so?

Learner 6: Because you are not only running 100 metres maybe you are running ten rounds, so if you take 100 metres in time scene like ten maybe you will find it bigger.

Teacher: This does not depend on the field it depends on you.

Researcher: Because we in terms of your stamina are you fit enough to maintain the same speed, remember the speed that you are running in its related to distance and time. I f we do this we assume that you are running at the same speed until you complete ten rounds or kilometre, so do you think in real life is that possible?

Learner 6: I don't think that is possible, because if run too much you will get tired and your speed will decrease, so as the speed slows down the time goes bigger.

Researcher: Now my last question is: when we solve Maths in the classroom and when we do things outside the classroom, do we solve problems the same from this example that you give and the other examples that we talked about? What is the difference when we solve Maths and when we solve real life problems outside the classroom? Is it because you were taught to solve Maths problems because of the number that are there or is it because the question the say in a real life situation?

Teacher: Can we solve problems outside the same way that we use inside the classroom?

Learners: No sir

Learner 3: No we don't solve them the same way.

Teacher: So if we are outside and you have ten red pencils in your left pocket and ten blue pencils in your right pocket and then I ask you how old are you what will be your answer?

Learner 2: I will say its fifteen years

Teacher: And then when you inside the classroom?

Learner 2: I will say it's twenty

Learner 6: Because in the question we were not told about the age of a person, we were just told about the pencils.

Assistant Researcher: The question is asking you about your age not someone else. When you are outside you give an answer that is different from the one you gave inside, why is that?

Researcher: Let's say I'm home in rural areas and we have cows and goats, so if somebody come and say you have twenty cows and five goats how old are you, what are you going to say?

Learner 6: I'm going to tell him my real age that I'm fifteen years old.

Researcher: So when you come back to the classroom you going to add the cows and the goats?

Learners: Yes

Assistant Researcher: And say that's your age?

Learner 6: No perhaps we didn't understand that question

Researcher: I think we have arrived to the end, and we really enjoyed, we appreciate you sacrificing your time for you to go home and then stay here with us and also thanks again to the teacher. I think you are fortunate because you have a lovely teacher, you have a brilliant teacher because I worked with too many schools and there are very few teachers like him out there, so you must proceed being brilliant as you are and you still going to see me at school, I'm still going to do other things with you and good luck for your exams and not only you even the other ones, but we couldn't interview all of you and they must also know that it's not because you are too clever than them, but it's because you are representing them.

APPENDIX I: Experimental Minus Comparison Scores (Mean Differences)

Statistics	Age	Eng.a	Xho.a	Eng.b	Eng.RRa	Xho.RRa	Eng.RRb	Xho.RRb	Eng.d	Eng.RRd	Xho.d	Xho.RRd	Eng-Xho.ad	Eng-Xho.RRad	Eng-Xho.bd	Eng-Xho.RRbd
n	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Mean	**0.42**	**-14.61**	**-12.37**	**29.14**	**-0.02**	**-0.35**	**0.44**	**0.34**	**43.75**	**0.47**	**20.50**	**0.69**	**-2.24**	**0.33**	**21.01**	**0.10**
SD	0.18	5.53	3.24	5.56	-0.01	-0.15	0.43	0.26	10.98	0.20	4.18	0.02	4.85	0.00	2.87	0.32
Statistical Significance based on Mean Difference																
t-Statistic	2.27	-4.89	-3.76	8.24	-0.24	-3.18	4.39	3.78	10.12	3.70	4.81	5.55	-0.48	2.45	5.89	1.06
d.f.	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174
p-value	**.025**	**<.0005**	**<.0005**	**<.0005**	.812	**.002**	**<.0005**	**<.0005**	**<.0005**	**<.0005**	**<.0005**	**<.0005**	.632	**.015**	**<.0005**	.290
Practical Significance based on Mean Difference																
Cohen's d	**0.35**	**0.75**	**0.58**	**1.27**	n.a.	**0.49**	**0.68**	**0.58**	**1.56**	**0.57**	**0.74**	**0.86**	n.a.	**0.38**	**0.91**	n.a.
df	**2**	**2**	**2**	**2**	2	**2**	**2**		**2**	**2**	**2**	**2**	2	**2**	**2**	2
Statistical Significance based on Frequency Distribution																
Chi2-stat	**18.02**	**25.11**	**43.19**	**0.41**	9.28	**17.96**	**13.58**		**54.89**	**14.76**	**16.99**	**25.16**	0.95	**10.45**	**26.89**	10.65
p-value	**<.0005**	**<.0005**	**<.0005**	**.813**	.010	**<.0005**	**.001**		**<.0005**	**.001**	**<.0005**	**<.0005**	.621	**.005**	**<.0005**	.005
Practical Significance based on Frequency Distribution																
df*	**1**	**1**	**1**	**1**	1	**1**	**1**		**1**	**1**	**1**	**1**	1	**1**	**1**	1
Cramér's V	**0.32**	**0.38**	**0.50**	**n.a.**	0.23	**0.32**	**0.28**		**0.56**	**0.29**	**0.31**	**0.38**	n.a.	**0.24**	**0.39**	0.25

APPENDIX J: Analysis of Varience

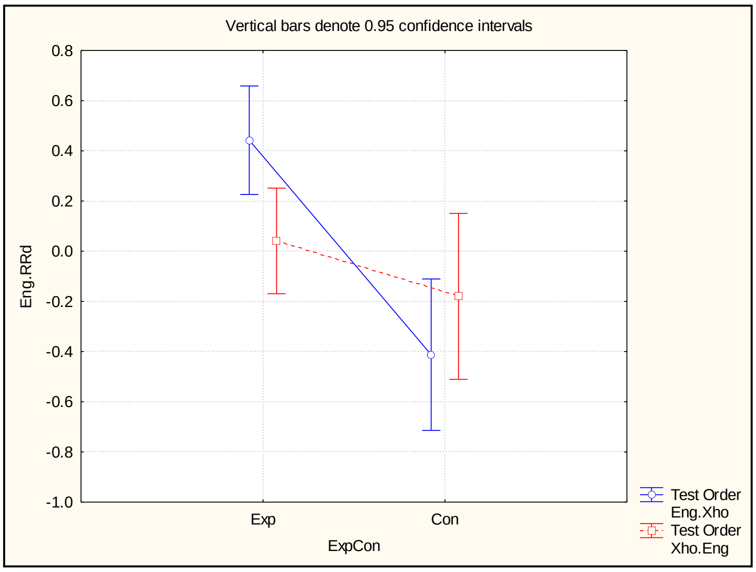
English Difference

	SS	d.f.	MS	F	p
Intercept	2876.27	1	2876.27	3.79	.053
ExpCon	63863.23	1	63863.23	84.13	**.000**
Test Order	571.78	1	571.78	0.75	.387
Gender	2044.78	1	2044.78	2.69	.103
ExpCon*Test Order	1459.05	1	1459.05	1.92	.167
ExpCon*Gender	343.70	1	343.70	0.45	.502
Test Order*Gender	1149.81	1	1149.81	1.51	.220
ExpCon*Test Order*Gender	1176.12	1	1176.12	1.55	.215
Error	127534.00	168	759.13		

English.RRd

	SS	d.f.	MS	F	p
Intercept	0.10	1	0.10	0.16	.691
ExpCon	9.66	1	9.66	15.48	**.000**
Test Order	0.24	1	0.24	0.38	.538
Gender	1.52	1	1.52	2.44	.120
ExpCon*Test Order	3.35	1	3.35	5.37	**.022**
ExpCon*Gender	1.04	1	1.04	1.66	.199
Test Order*Gender	0.14	1	0.14	0.22	.639
ExpCon*Test Order*Gender	1.14	1	1.14	1.83	.178
Error	104.85	168	0.62		

Exp.Con	Lang1.2	n	Mean	Std.Dev
Exp	Eng.Xho	52	0.4423	0.7518
Exp	Xho.Eng	55	0.0364	0.9616
Con	Eng.Xho	35	-0.3429	0.7648
Con	Xho.Eng	34	-0.1176	0.5911



isiXhosa Difference

	SS	d.f.	MS	F	p
Intercept	22435.85	1	22435.85	30.01	**.000**
ExpCon	12961.11	1	12961.11	17.34	**.000**
Test Order	342.49	1	342.49	0.46	.499
Gender	406.65	1	406.65	0.54	.462
ExpCon*Test Order	2558.11	1	2558.11	3.42	.066
ExpCon*Gender	2298.54	1	2298.54	3.07	.081
Test Order*Gender	9.59	1	9.59	0.01	.910
ExpCon*Test Order*Gender	551.10	1	551.10	0.74	.392
Error	125581.55	168	747.51		

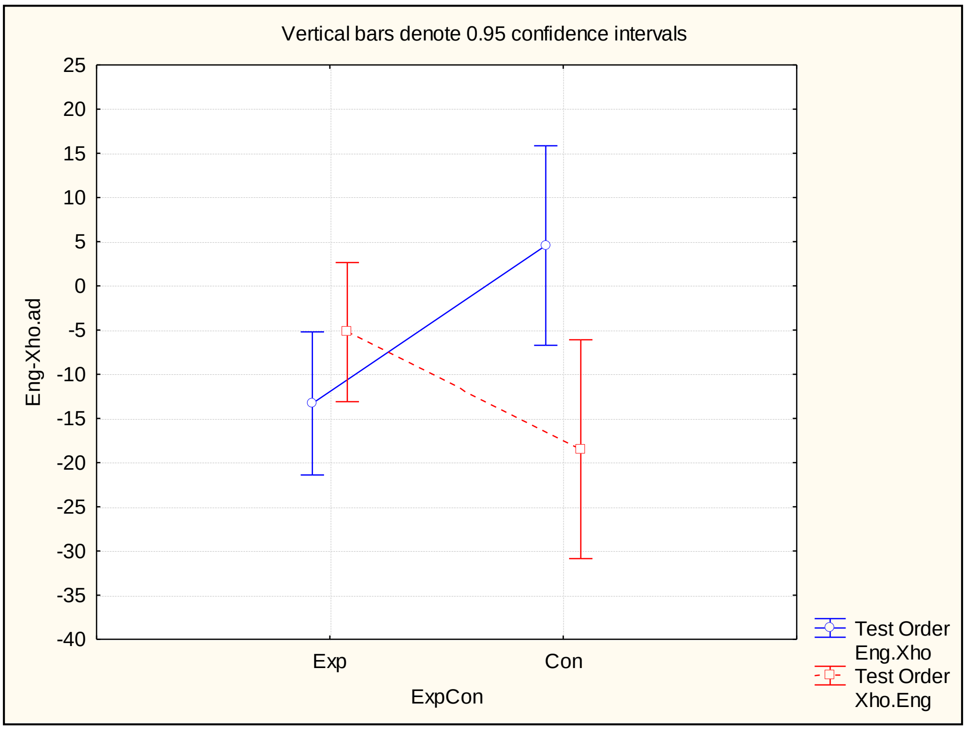
isiXhosa.RRd

	SS	d.f.	MS	F	p
Intercept	8.92	1	8.92	13.76	**.000**
ExpCon	18.12	1	18.12	27.95	**.000**
Test Order	0.03	1	0.03	0.04	.844
Gender	0.00	1	0.00	0.01	.943
ExpCon*Test Order	0.58	1	0.58	0.90	.345
ExpCon*Gender	0.77	1	0.77	1.19	.276
Test Order*Gender	2.06	1	2.06	3.19	.076
ExpCon*Test Order*Gender	0.27	1	0.27	0.41	.522
Error	108.89	168	0.65		

English – isiXhosa Pre-test Difference

	SS	d.f.	MS	F	p
Intercept	8797.33	1	8797.33	10.06	**.002**
ExpCon	178.10	1	178.10	0.20	.652
Test Order	1869.96	1	1869.96	2.14	.146
Gender	1555.88	1	1555.88	1.78	.184
ExpCon*Test Order	8082.94	1	8082.94	9.24	**.003**
ExpCon*Gender	34.86	1	34.86	0.04	.842
Test Order*Gender	675.26	1	675.26	0.77	.381
ExpCon*Test Order*Gender	940.63	1	940.63	1.08	.301
Error	146911.36	168	874.47		

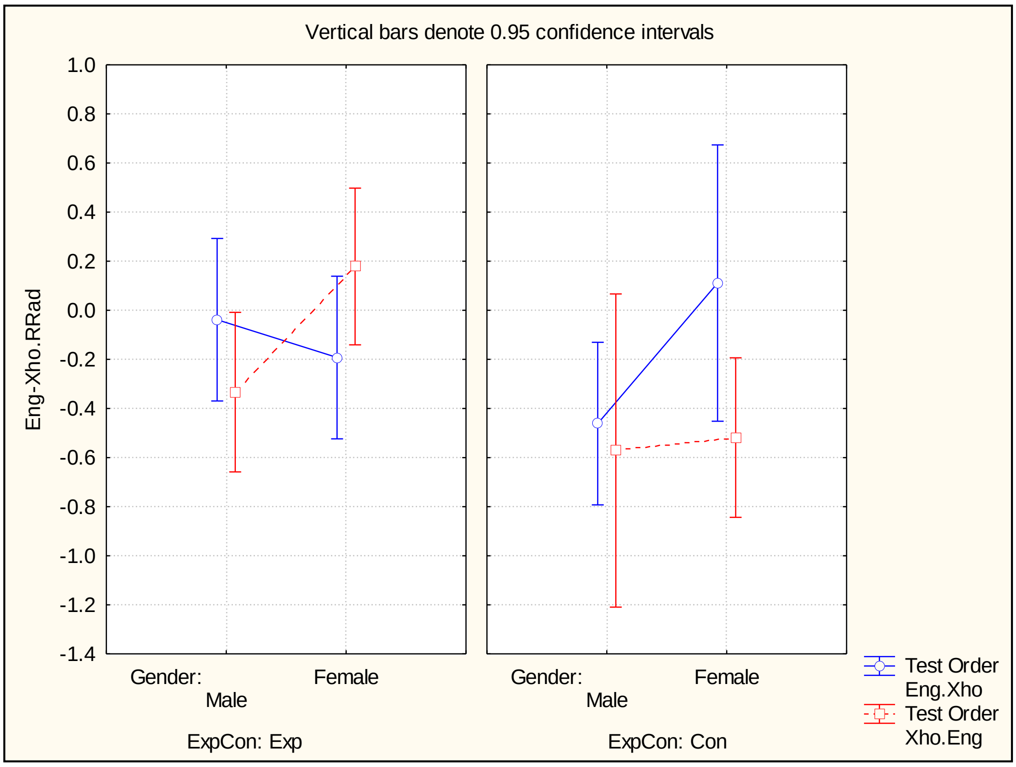
Exp.Con	Lang1.2	n	Mean	Std.Dev
Exp	Eng.Xho	52	-13.3077	31.30842
Exp	Xho.Eng	55	-5.0909	32.5162
Con	Eng.Xho	35	2.4571	30.1958
Con	Xho.Eng	34	-16.4118	19.9683



English – isiXhosa (RR) Pre-test Difference

	SS	d.f.	MS	F	p
Intercept	6.96	1	6.96	9.51	**.002**
ExpCon	2.32	1	2.32	3.17	.077
Test Order	0.92	1	0.92	1.26	.264
Gender	2.02	1	2.02	2.76	.099
ExpCon*Test Order	1.39	1	1.39	1.90	.170
ExpCon*Gender	0.15	1	0.15	0.20	.652
Test Order*Gender	0.04	1	0.04	0.06	.806
ExpCon*Test Order*Gender	2.93	1	2.93	4.01	**.047**
Error	122.91	168	0.73		

Exp.Con	Lang1.2	Gender	n	Mean	Std.Dev
Exp	Eng.Xho	Male	26	-0.038462	0.527695
Exp	Eng.Xho	Female	26	-0.192308	0.693930
Exp	Xho.Eng	Male	27	-0.333333	0.832050
Exp	Xho.Eng	Female	28	0.178571	1.188013
Con	Eng.Xho	Male	26	-0.461538	0.760567
Con	Eng.Xho	Female	9	0.111111	1.054093
Con	Xho.Eng	Male	7	-0.571429	0.975900
Con	Xho.Eng	Female	27	-0.518519	0.848998



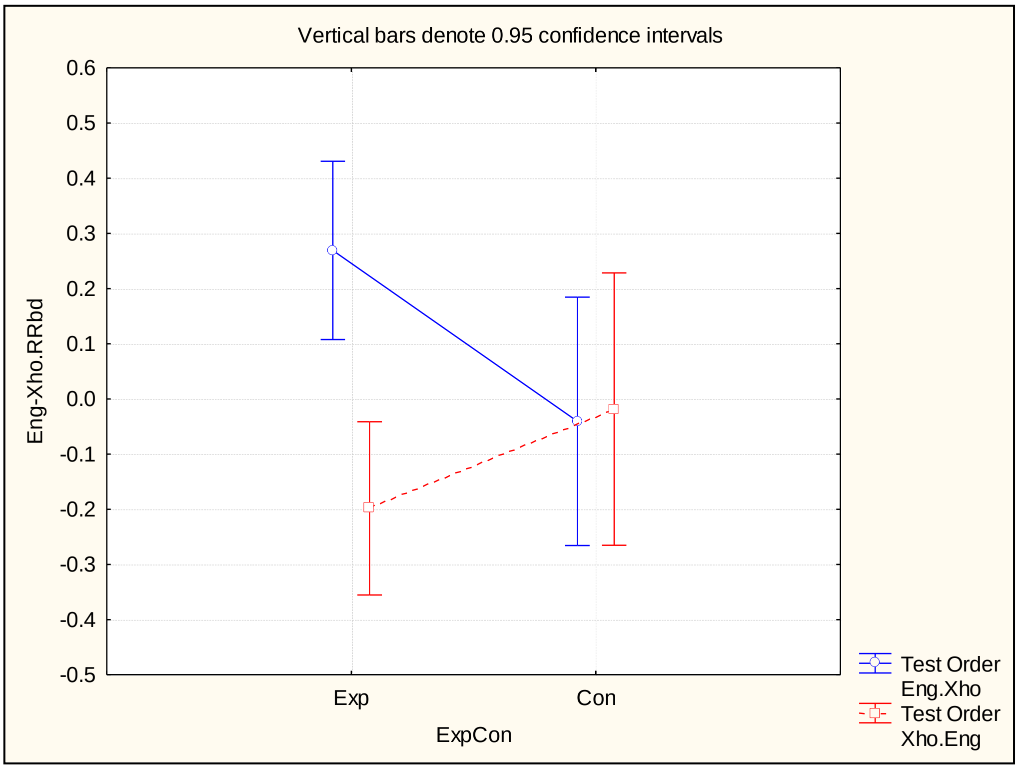
English – isiXhosa Post-test Difference

	SS	d.f.	MS	F	p
Intercept	5.57	1	5.57	0.01	.919
ExpCon	15755.14	1	15755.14	29.24	**.000**
Test Order	0.68	1	0.68	0.00	.972
Gender	207.10	1	207.10	0.38	.536
ExpCon*Test Order	1.28	1	1.28	0.00	.961
ExpCon*Gender	552.26	1	552.26	1.02	.313
Test Order*Gender	121.45	1	121.45	0.23	.636
ExpCon*Test Order*Gender	734.43	1	734.43	1.36	.245
Error	90535.06	168	538.90		

English – isiXhosa (RR) Post-test Difference

	SS	d.f.	MS	F	p
Intercept	0.00	1	0.00	0.00	.954
ExpCon	0.14	1	0.14	0.41	.525
Test Order	1.66	1	1.66	4.77	**.030**
Gender	0.06	1	0.06	0.17	.680
ExpCon*Test Order	2.00	1	2.00	5.76	**.018**
ExpCon*Gender	0.28	1	0.28	0.80	.374
Test Order*Gender	0.73	1	0.73	2.10	.149
ExpCon*Test Order*Gender	0.02	1	0.02	0.05	.828

Exp.Con	Lang1.2	n	Mean	Std.Dev
Exp	Eng.Xho	52	0.27	0.72
Exp	Xho.Eng	55	-0.20	0.65
Con	Eng.Xho	35	-0.11	0.47
Con	Xho.Eng	34	-0.03	0.30



APPENDIX K: Matched Pairs T-Tests (Experimental Group)

Post - Pre Differences - Experimental (n = 107)

					Matched-Pair t-Test			
	Mean	**Std.Dv.**	**Diff.**	**Std.Dv.**	**t**	**df**	**p**	**Cohen's d**
Eng.a	40.64	21.33	17.08	31.76	-5.56	106	.000	0.54
Eng.b	57.72	24.92						
Xho.a	49.72	22.54	-3.07	29.17	1.09	106	.279	n.a.
Xho.b	46.65	24.50						
Eng.RRa	0.36	0.59	0.23	0.89	-2.73	106	.007	0.26
Eng.RRb	0.59	0.79						
Xho.RRa	0.45	0.65	0.11	0.82	-1.42	106	.158	n.a.
Xho.RRb	0.56	0.68						

APPENDIX L: Matched Pairs t-Tests (Comparison Group)

Post - Pre Differences - Control (n = 69)

					Matched-Pair t-Test			
	Mean	**Std.Dv.**	**Diff.**	**Std.Dv.**	**t**	**df**	**p**	**Cohen's d**
Eng.a	55.25	15.80	-26.67	20.79	10.65	68	.000	-1.28
Eng.b	28.58	19.36						
Xho.a	62.09	19.30	-23.57	24.98	7.83	68	.000	-0.94
Xho.b	38.52	19.88						
Eng.RRa	0.38	0.60	-0.23	0.69	2.80	68	.007	-0.34
Eng.RRb	0.14	0.35						
Xho.RRa	0.80	0.80	-0.58	0.79	6.07	68	.000	-0.73
Xho.RRb	0.22	0.42						