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THE POSSIBLE IMPACT OF A LANGUAGE RICH FORMAT ON THE MATHEMATICS PERFORMANCE SCORES OF GRADE 8 LEARNERS

by

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ABRMAR019

A minor dissertation submitted in partial fulfilment of the requirements
for the award of the degree of Master of Education
specializing in Applied Language Studies

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December 2006

DECLARATION

I, Mark Abrahams, declare that this work has not been previously submitted in whole, or in part, for the award of any degree at any other institution. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work or works of other people has been attributed, and has been cited and documented in the references.

Signature: signature removed ... . Date:..16/12/06

ACKNOWLEDGEMENTS

I hereby acknowledge CALLSSA (the Center for Applied Language and Literacy Studies and Services in Africa) for providing funding for the coursework year of this degree.

I wish to thank my supervisors, Professor D Young and Professor K Rochford, for their invaluable expertise and guidance throughout this process. A special thank you to Professor Rochford for the infinite patience, enthusiasm and encouragement that you have displayed towards this work which will always be remembered. It has truly been an honour and a privilege to have you as a mentor.

I would also like to thank the learners and teachers who participated in this study. Without them, it would not have been possible.

A very special word of thanks to my daughter Nina and to my wife and friend Joy, for her inspiration and encouragement throughout this process. Thank you for your unselfish support and motivation.

Finally, I wish to thank my parents, Ronald and June, for providing me with the confidence needed to succeed. Thank you for making me believe in myself.

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ABSTRACT

This study reports on the changes which occurred in the performance scores of 89 Grade 8 English first language speakers when they attempted two sets of counter-balanced mathematics tests, each comprising of 17 items. After a preliminary pilot study, the main investigation proceeded through three phases, first two being quantitative and the third phase being qualitative.

The research engaged a counter-balanced methodology advocated by Adentula (1990), coined as a "flip-flop" strategic design in two phases, with repeat testing formats being introduced consecutively over a period of two months. The first achievement test was presented in a Notational Format (mathematics expressed using traditional signs and symbols); and one week later the same learners answered the same 17 mathematical content items (the second achievement test) presented linguistically in a Language Rich Format instead. This comprised Phase I of the investigation.

In order to corroborate the effect of assessment format as an independent variable, a month later a second phase of testing was conducted with the same sample. This utilized the same number of mathematical test items with a different but similar content base. In this second phase the order of the testing was now reversed: the Language Rich Format was administered first, followed by the Notational Format, with mathematical content once again held constant, thus engaging the counter-balance with the second pair of achievement tests.

In the third phase, supplementary interviews were conducted with a selection of eight learners and with the one educator who was responsible for teaching the 89 Grade 8 learners mathematics.

The study highlights the findings and presents the results that occurred when learners were tested in Language Rich Format by comparison with that of Notational Format presentation which used the traditional signs and symbols. It concludes that, irrespective of sequence of presentation, the 89 learners repeatedly and significantly under-performed on the same content by an average of 18% to 22% when tested with the Language Rich Format by comparison with the Notational Format.

The study's implications for the recently Revised National Curriculum Statement (Mathematics) are that language is of key importance if we want to foster competence in mathematics and if we wish to develop mathematical concepts in learners in such a way that they can distinguish how and when they should be used and where they can be used effectively from the printed texts.

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LIST OF ABBREVIATIONS

AILA	Association Internationale de Linguistique Appliquee
AS	Assessment Standard
CA	California
CALLSSA	Centre of Applied Language and Literacy Studies and Services in Africa
CASS	Continuous Assessment
C2005	Curriculum 2005
CD	compact disc
cf	compare
CSE	College School Education
CT	Connecticut
CTA	Common Tasks for Assessment
DoE	Department of Education
ed	Edition
Ed.	Editor
Eds.	Editors
e.g.	example
et al.	et alii (Latin: and others)
ESL	English Second Language
FET	Further Education and Training
GET	General Education and Training
HG	Higher Grade
HSRC	Human Sciences Research Council
kl	kilolitres
km	kilometers
LOLT	Language of Learning and Teaching
LRF	Language Rich Format
LSSA	Linguistics Society of South Africa
l	litres
m	meters
ME	Mathematical English

M.Ed.	Master of Education
n	number
NEPI	National Education Policy Investigation
NF	Notational Format
OBE	Outcomes-based Education
OBET	Outcomes-based Education Training
OE	Ordinary English
pg	page
R	rand
RSA	Republic of South Africa
RNCS	Revised National Curriculum Statement
SA	South Africa
SAALA	South African Applied Linguistics Association
Std 5	Standard five (Grade 7)
Std 6	Standard six (Grade 8)
Std Dev	standard deviation
SG	Standard Grade
TIMSS	Third International Mathematics and Science Survey
TIMSS-R	Third International Mathematics and Science Survey-Repeat
UCT	University of Cape Town
UK	United Kingdom
UNESCO	United Nations Educational, Scientific, and Cultural Organisation
USA	United States of America
WCED	Western Cape Education Department
%	percentage
°	degrees
$\sqrt[3]{27}$	cube root
$\sqrt{121}$	square root

CHAPTER 1: INTRODUCTION

1.1 Origin and importance of the study

Mathematics is widely regarded as one of the most important subjects taught in any school curriculum. This is apparent in the new system of Outcomes-based Education (OBE), commonly known as Curriculum 2005, currently being implemented in all South African Schools, where 18% of all teaching time for grades 1 to 9 is allocated the learning of mathematics. Mathematics has been accorded the status of a 'core' subject in the Revised National Curriculum and, consequently, occupies an appreciable amount of the learners' classroom time. The Department of Education's National Curriculum Statement (NCS) Grades 10 – 12 (2002), which will be implemented in 2006 mathematics as a 'core' subject, requires all learners in grades 10 to 12 to study either mathematics or mathematical literacy.

The expectation that many learners should be able to demonstrate a high level of competence in school mathematics seems to becoming a norm in South Africa and over many parts of the world. A reason for this is that mathematics underpins science and technology and, with the present emphasis on the technological advancement and globalisation of the planet, curricula will have to take cognizance of this fact. The latest document of the Revised National Curriculum Statement for Grades R to 9 (2002) embodies a vision of the kind of learner required by our society. Its definition of the learning area of mathematics states that

> Mathematics is a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. Through this process, new mathematical ideas and insights are developed. Mathematics has its own specialised language that uses symbols and notations for describing numerical, geometric and graphical relations. Mathematical ideas and concepts build on one another towards creating a coherent structure. Mathematics is a product of investigation by different cultures – a purposeful activity in the context of social, political and economic goals and constraints.
> (Department of Education, Revised National Curriculum Statement 2002:4)

The relevance and instrumentality of mathematics are further emphasised when employment considerations deem competence in mathematics to be an important criterion. It is commonly seen that parents want their children to succeed in the subject, largely in the hope that their job prospects will be improved. Furthermore, mathematics is used as a 'filter' or 'hurdle' possibly more often than any other subject, in that an examination pass at an appropriate level is often demanded before entry to a particular profession or occupation can even be considered - whether any mathematics is required in the performance of the job or not (Ortin & Frobisher, 1996:1). One reason cited why mathematics is used as a filter is that it is often claimed to be equated with clear logical thinking and the general ability to solve problems, even though no substantial evidence actually proves this point of view. However, the various language presentation formats used in schools to introduce mathematics problems to learners for solution might constitute performance barriers to understanding. The importance of this investigation is underpinned by the need for better teaching and learning methods. It is a world-wide phenomenon that drives the need for constant research; for example, how learners learn and *understand* mathematical concepts, and how learners' grasp of language possibly influences their mathematics achievement results.

1.2 Background to the study

The Third International Mathematics and Science Study (TIMSS, 1995, cited in Jaworski & Phillips, 1999:40) rated South Africa as a country having one of the lowest national average mathematics achievement scores. This TIMSS report, in which 15 000 South African primary and high school learners participated, corroborated the known overall under-performance in mathematics in many Western Cape schools.

In November 2004, in the Southern Metropole there were 62 schools providing 3934 grade 12 full-time learners who wrote the Western Cape Education Department's matriculation mathematics examination. Of the 3934 candidates, 3239 wrote mathematics on the Standard Grade and only 695 wrote it on the Higher Grade. Furthermore of the 62 schools only 48 entered learners for the Higher Grade examination, of these 21 out of the

62 Standard Grade schools had a mean achievement standard of less than 20% and four out of the 48 Higher Grade schools had a mean achievement level of less than 20% (Western Cape Education Department, 2005).

Similar results had also been noticed in the school at which my research was conducted, since the pass rates in mathematics for the grade 12 classes in recent years had been as follows:

2002: Number of candidates: 81
Number of passes: 35, giving the school a pass rate of merely 43.2 %
Average mathematics achievement percentage total 43.6%

2003: Number of candidates: 72
Number of passes: 36, giving the school a pass rate of 50%
Average mathematics achievement percentage total 45.6%

2004: Number of candidates: 64
Number of passes: 40, giving the school a pass rate of 62.5%
Average mathematics achievement percentage total 52.7%

2005: Number of candidates: 63
Number of passes: 33, giving the school a pass rate of 52.38%
Average mathematics achievement percentage total 53.53%

Furthermore, at my school it was reported with concern that there had been a marked decline in the number of learners opting for mathematics as a grade 12 subject.

The school has had an average enrolment of 350 to 360 grade 8 learners for the past five years. This is a basic indicator of the total of new grade 8 learners enrolled every year who are compelled to study mathematics; yet the number of grade 12 learners enrolled in mathematics in 2005 was a mere 63. A total of 61 learners wrote it on the Standard

Grade, but only two learners studied it on the Higher Grade. Only 21 learners took mathematics through the medium of Afrikaans and the other 42 had English as medium of instruction.

In the past there has been a widespread failure of mathematics education to provide the majority of South African learners with the knowledge and qualifications necessary to enter scientific and technological careers (National Education Policy Investigation (NEPI), 1993:4) and to prepare school leaving learners adequately for the formal sector. If we as South Africans want to succeed in the global arena in a dynamic competitive world, it is necessary for schools to prioritise the place of science and technology. In support of this, Howie (1998:77) stated seven years ago that programme changes, initiatives and reforms must be implemented in science and mathematics education as soon as possible.

The former Minister of Education, Kader Asmal, stated in 2000 that all mathematics teachers should be retrained and that all the good science and mathematics teachers who had voluntarily left the profession should be re-employed in an attempt to improve the existing low academic results (Cape Times, 2000:5). This statement by the former Minister and the poor performance in TIMSS constituted a clear signal that the state of mathematics education in South Africa was not as it should be.

Wedepohl's summary (in Howie, 1997: 52-61) of various earlier studies undertaken pin-pointed a number of problems that existed in South African schools, especially in the former disadvantaged schools, that could possibly be the root of why our performance was not on par with that of the rest of the world:-

- **Home environment**: the majority of learners came from poor socio-economic backgrounds. Their parents themselves had a low literacy rate, which often meant that they were unable to assist their children with homework. Often malnutrition and under-nutrition also affected a large sector of school-goers, which contributed to poor concentration levels in class.

- **General school environment**: many schools had inadequate facilities and a lack of basic needs such as running water, reading and writing material, seating accommodation and electricity. Classrooms were overcrowded which often resulted in poor attendance by both teachers and learners.
- **Peer environment**: learners who often did well at school were not encouraged to study harder and further, and they succumbed to peer pressure.
- **Gender**: there was little encouragement for girls to enter the traditional male domains. Furthermore, in some cultures the burden of housework was the sole responsibility of that of the young women.
- **Homework**: less time was spent on homework by South African learners than by their international counterparts.
- **Curricula were heavily content-based**. More recently the Revised National Curriculum (RNCS) is trying to address this so that teacher assessment and teaching methods will also have to change to meet the demands of the new curriculum.
- **Students' lack of self-motivation**: science and mathematics were perceived as subjects which were difficult to pass.
- **Lack of quality teachers and proper in-service training**: many skilled mathematics and science teacher were lost to the profession when teachers in general were offered voluntary severance packages, leaving voids that were filled by unqualified teachers often taking over these departing teachers' classes. Poor content knowledge and the teachers' lack of motivation often had a detrimental effect on the learning process.
- **Language of instruction**: most learners continued to be instructed in a second or even in a third language. This made the communication, the learning and the teaching of concepts extremely difficult, especially in subjects such as science and mathematics.

According to the Department of Education's (DoE) more recent Grade 3 systemic Evaluation report (2002a:3), the objectives of the systemic evaluation were to:

- Determine the context in which teaching and learning was taking place;
- Obtain information on learner achievement;

- Identify factors that were affecting learners' achievement; and
- Make conclusions about appropriate education interventions.

As early as 1998 the DoE had begun to identify and select appropriate indicators that could be used to measure the condition of the South African education system. Through broad consultation with many organizations, a set of 26 indicators was developed and agreed upon. They were classified into the following four subsections:

- Context indicators, which supply information on the socio-economic context of learners;
- Input indicators, which supply information on the resources and infrastructure of the system;
- Process indicators, which supply information on aspects related to the teaching and learning process; and
- Output indicators, which supply information on the outcomes of the system, one of which is learner performance in numeracy and literacy.

1.3 Purpose of the study

The purpose of this study was linked to the process indicators and output indicators mentioned above and they especially focused on the final point mentioned above by Wedepohl (in Howie,1997:52-61) because I considered the poor results in mathematics to be symptomatic of a wider language problem. I found that the Languages of Learning and Teaching (LOTL) were not the same languages for many of our schools' intake of grade 8 learners. Many learners were being obliged by their schools or instructed by their parents to change from Afrikaans as LOTL to English as LOTL, as English was seen as the language of access, power and upward mobility. Hence I intend investigating if and how language presentation format might influence learners' performances in school mathematics.

1.4 Statement of the problem

Post-1994, after the relaxation of the apartheid laws, the ethnic composition of many South African classrooms changed radically. The diverse nature of South African people in general was now being manifested in classrooms as they became multicultural which, in essence, meant that they had also become multilingual. Although learners in the same class might be of the same age, they now displayed a variety of different skills, abilities and languages based on their individual experiences. Furthermore, many South African parents viewed English as the language of access to employment, further education and upward mobility. Thus they choose English to be the medium of instruction for their children, even though it was not their mother tongue.

The language problem was exacerbated further by the fact that the available learning material was mostly in English; yet many concepts which the learners were expected to know had completely different meanings in their mother tongue.

As part of the taught component of our Masters programme in Applied Language studies in the Centre of Applied Language and Literacy Studies and Services in Africa (CALLSSA), three colleagues and I conducted a pilot study in March 2001 in which eleven basic science concepts were written down and then translated into Xhosa as part of a glossary for a sample unit of a English as Additional Language (EAL) science textbook dealing with concept formation. Learners were then invited to respond after being given a short explanation in both languages. The findings showed that, in many of the cases, the particular concept would have a completely different meaning when translated directly from English to Xhosa. In some cases there was no one word or term that could describe the concept in Xhosa, and a couple of sentences were required to explain the one word concept.

Confusion also arose with homonyms and homophones. An example of one word that was used in both mathematics and science was *power*. In mathematics the term *power* was used when dealing with exponents. Here the translation to Afrikaans was a single word "*mag*" but in Xhosa their was no single word which when translated would give one a full meaning of the word *power*. The closest phrase which explained *power* was "*Amandla-kuziphinda-phinda*". When viewing the term *power* in terms of science, the Afrikaans translation was "*drywing*". Here once again the Xhosa dictionary could not supply one word to describe *power* in terms of science but offered the following phrase - "*iqondo lokusebenza*". Arising from this study in 2001 was the realization that it may have been easier if there existed one symbol which could encompass the meaning of the concept *powe*r in both mathematics and science as this might help to eliminate any confusion or ambiguity. If there were, it might help to improve the learners' understanding of the concept and help to improve the learners' results if they were to be tested.

Therefore, the problem investigated in the follow-up study from 2002 - 2004, as reported herein, led me to the research questions outlined below.

1.5 Research questions

- Is the performance of a convenient sample of 89 grade 8 learners on a linguistically formatted (language rich) mathematics test different from the performance of the same grade 8 learners on a symbolically presented (notational) mathematics test of similar content?
- Does the performance differential remain the same two months later with a new mathematics content test?
- Is their a statistically significant difference in learners' mathematics achievements when the same test content is presented in two different formats: symbolically and linguistically?
- Does the performance difference depend on the sequence or order in which the two different formats are presented?

1.6 Hypothesis

It was hypothesised that, for the sample of 89 grade 8 learners, there would be no significant difference between the achievement scores obtained by learners when the same test content was given using two different formats of testing (a Notational Format and a Language Rich Format), irrespective of sequence of presentation of the two pairs of parallel formats.

1.7 Aims and objectives of the research

The first aim of this study was to investigate 89 learners' levels of language competencies in selected aspects of mathematics and their equivalent symbolic mathematical language abilities over a period of two weeks by recording the disparity between their performance on notationally (symbolically) represented mathematics textbook sums and the same sums represented in a language rich format.

Extending the study to two months, by utilizing a second, different topic in mathematics with the same sample of 89 learners in a counter-balanced research design (which I have coined as a "flip-flop") sequence advocated by Adentula (1990), the second aim of the study was to:

- establish how the format of presentation of language might influence the learning of selected topics in high school mathematics;
- establish how the format and sequence of presentation of language might influence the achievement scores obtained in a grade 8 mathematics test;
- elicit possible explanations for different tests producing different scores; and
- find out if there were any particular words which caused special problems.

If there was a discrepancy in achievement, a third aim of the research was to see how this difference in language format and presentation related to the learners' varying mathematical performance scores.

1.8 Definitions and clarification of terms

Notational Format (NF): was defined as mathematics performed by use of the normal symbols and signs e.g. the use of -, $+$, $\sqrt{\ }$, $\div$, $=$

***Language Rich Format (LRF)**:* was defined as using words to replace mathematical signs and symbols
e.g. "subtract" instead of "-"; "add" instead of "+"; "square root" instead of "$\sqrt{\ }$"; "divide" or "find the quotient" instead of "÷"; etc.

1.9 Limitations of the study

The main study was located in only one high school in Cape Town. Consequently the findings cannot be considered representative of the language-in-mathematics problems widely experienced in the region, province or whole country. However, they might be indicative of some trends in education at present.

1.10 The research plan

The research design consisted of three parts, i.e. quantitative, qualitative and a cross-validation part, and is depicted in Figure 1.1.

In Part One the sample of 89 English First Language Grade 8 learners from two classes undertook a series of quantitative tests under examination conditions. The quantitative part consisted of four "flip-flop" diagnostic achievement tests where the same mathematics content was presented sequentially in Notational Format and Language Rich Formats. The formats were switched around or reversed, to balance the possible effect of order (sequence) which provided us with phases I and II. Phases I and II were conducted over a period of three months.

Part Two involved eight selected learners and the mathematics teacher in an interview process and tackled the research with a qualitative approach. The learners were purposefully selected on the basis of their results obtained in the quantitative part and the teacher was the one who taught the whole sample of 89 learners.

Part Three was a cross-validation of both the quantitative and qualitative parts of the investigation, and was carried out by means of triangulation.

Figure 1.1 A summary of the plan of the research.

MAIN A RESE	**RESEARCH QUESTIONS**	**NULL HYPOTHESIS**
I QL	1)How might the format of presentation of language influence the learning performance of selected topics in high school mathematics? 2) How might the format of presentation of language influence the learning performance of mathematical concepts? 3)How might the format of presentation of language influence the achievement scores obtained in a grade 8 mathematics test?	For the sample of grade 8 learners, there will be no significant differences between the achievement scores obtained by the learners when the same test content is given using two different but parallel formats of testing, irrespective of the sequences of presentation of the two forms of parallel formats.
PART TW	How might language format have impacted on the results of the test conducted?	
P, Cr(	Is their consistency between the interview responses and the learners' responses in Phase I and Phase II?	

1.11 Summary of the chapter

This chapter has provided some background on the position that mathematics holds in the new South African curriculum. It looked at how South Africa compares with the rest of the world by examining the results reflected in an international standardised test; how these were symptomatic of its national results; and some of the challenges it is presently facing. The main purpose of the study was described as an investigation into the possible impact of language presentation format on mathematics performance scores of grade 8 learners in one selected under-achieving high school in Cape Town. The research questions, hypothesis, research design and research methods have been introduced.

1.12 Organisation of the remainder of the dissertation

Chapter 2 presents a brief review of the literature that is relevant to the current study. Particular attention is paid to the use of language in mathematics, and to the formation of mathematical concepts by exploring the nature of concepts and looking critically at issues in the teaching of word sums.

Chapter 3 introduces the research design in more detail and justifies its selection. It sets out the many aspects of the methodology chosen for the study to add further insight into the research questions and their possible answers. The selection of the site, sample and the data instruments are described and justified. It also explains how the research question is being addressed in the study, and it concludes by briefly considering some of the possible limitations of the research design and methodologies adopted in this study.

Chapter 4 reports on the findings obtained from the tests, and from the interviews. It focuses on explaining how the two types of testing formats used produce certain patterns when compared. The results are presented in two sections, i.e. qualitative and quantitative. It also provides the analysis of the likely impact that language presentation format has on the learning of mathematics, by closely examining the results and assessing it. It concludes by cross-linking the qualitative and quantitative findings.

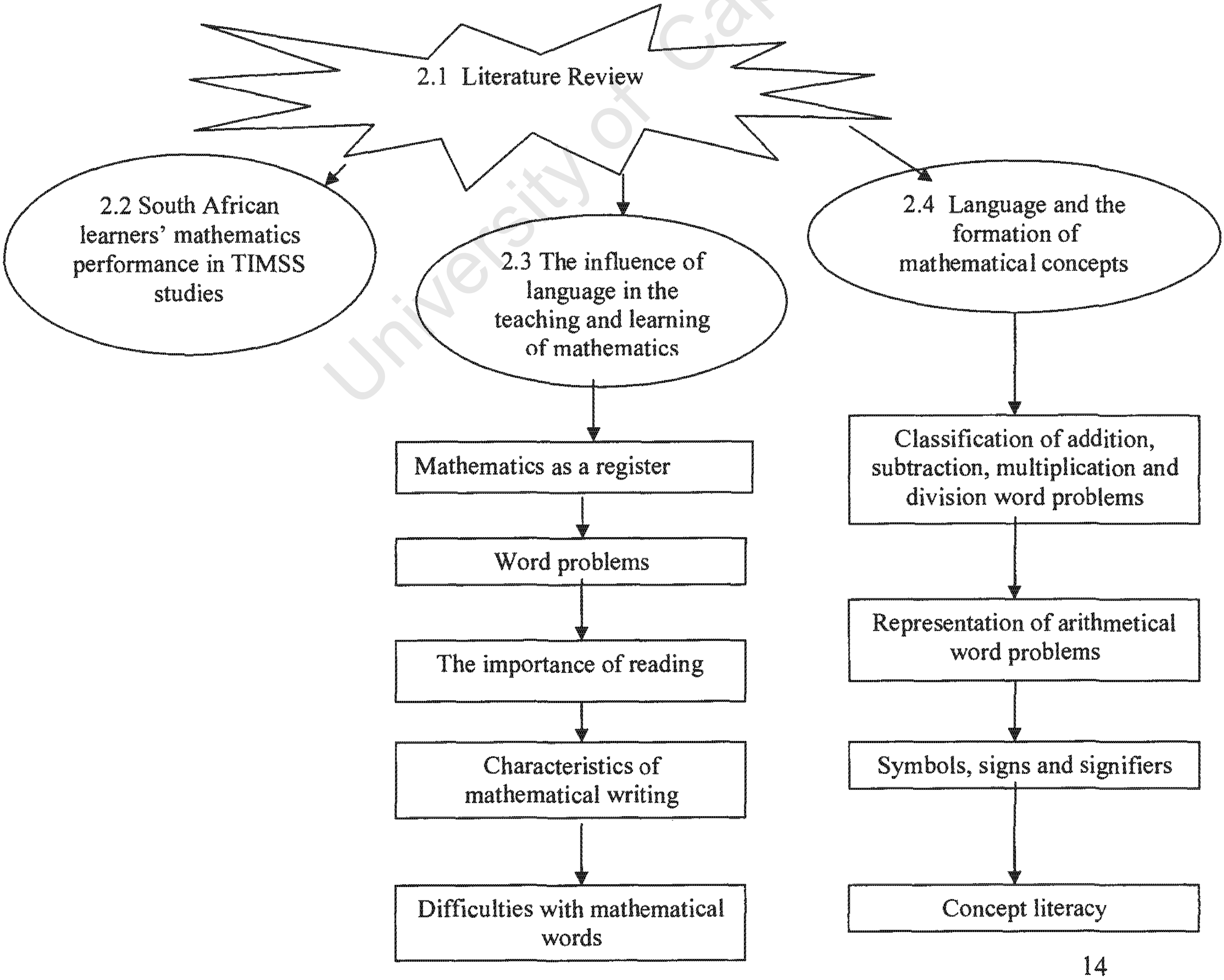
Chapter 5 reviews the outcomes of the research proposal that was investigated in my study. Based on the results obtained, implications and recommendations are made for the school, suggestions are also indicated for future larger research. In offering recommendations I once again reflect on the Revised National Curriculum Statement (2002 and 2003), revisit the TIMSS tests (1995 and 1999) and look at the role of textbooks. Finally I provide a conclusion.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter reviews the evidence in the literature for the existence of possible relationships between modes of presentation of language and the formation of mathematical concepts. It provides an overall perspective on the role of language, that is presented to learners specifically in text form, in the formation of concepts in mathematics. Within the extensive educational research area of language and mathematics I have limited my survey of how learners engage with text to papers and journals that have focused on language, word sums and concept formation in mathematics. Figure 2.1 presents a summary of the structure of Chapter 2 and its inter-related components.

Figure 2.1 A summary of the structure of Chapter 2 and its inter-related components.



The chapter has three major components. The first main section 2.2 reviews the mathematics performance results generated by the TIMSS studies conducted in 1997, and repeated as TIMSS-R in 1999 (Howie, 2001) and again in 2003, to see how the TIMSS study ranked South African learners compared to their international counterparts. Linked to the results generated by TIMSS, section 2.3 ascertains the main thrust of reported educational research findings on the influence of language in the teaching and learning of mathematics. Finally, section 2.4 documents the role of language in learners' understanding of mathematical concepts, reviewing how the presentation and use of language subsequently constructs teachers' and learners' perceptions of mathematics, and how such factors appear to impact on formal assessment.

2.2 South African learners' mathematics performance results in TIMSS studies

The Third International Mathematics and Science Study (TIMSS 1995, cited in Jaworski & Phillips, 1999) rated South Africa as a country with one of the lowest mean scores in mathematics achievement nationally when compared to the performances of 500 000 learners in 44 other countries including Singapore, the Czech Republic, Japan, Korea, England, Russia, Canada, Iran, Australia, Colombia, Germany, Denmark, Thailand, Kuwait and the USA. This TIMSS survey, in which 15 000 South African learners from more than 400 primary and high school learners participated, tested the learners in mathematics and science at five different grade levels.

Howie (2002) reported the results obtained by the participating learners from South African schools compared with those from the other countries. Listed below are some of the findings from a preliminary questionnaire given to gather information about the South African learners' attributes and backgrounds:

- Only 21% percent of the learners wrote the achievement tests in their home language.
- The amount of completed homework reported by learners for both science and mathematics was much lower than the international average.
- The number of books reported in the home was, on average, far fewer than the international average. Sixty percent of the school learners reported that they had fewer than 26 books at home.

- The majority of learners had parents with primary school as their highest attained educational level.
- The average age of South African learners in standard 5 (grade 7) was 13.9 years and in standard 6 (grade 8) was 15.5 years. The South African learners' average age was the second highest and only Colombia had older learners participating in TIMSS.
- The international results indicated that there was a strong link between the quality of the home environment and achievement by the learners.
- South African learners had less learning time in classrooms than the learners in the top performing countries in TIMSS.

In the same report, Howie (2002) drew a number of conclusions detailing the findings of the achievement tests scores for standard 5 (grade7) and standard 6 (grade 8). I have listed some of these conclusions that are pertinent to my study.

- South Africa's scores were very low in comparison with those of students from other countries.
- South Africa's results did not reveal any area of science and mathematics in which students performed well.
- South Africa's results indicated the lowest overall improvement from standard 5 (grade7) and standard 6 (grade 8).
- There was evidence of language problems and the vast majority of the South African learners wrote the TIMSS tests in a language that was not their mother tongue. Of the 8146 learners that took part in the TIMSS-R test, 24% never spoke the language in which they were tested, 53% sometimes spoke the language in which they were tested, and only 23% always or almost always spoke the language in which they were tested (Howie, 2002:107). The students with English and/or Afrikaans as their mother tongues performed significantly better than those with other mother tongues.
- The study indicated the South African mathematics curricula were in line with those of the other countries, with 50% to 79% of the TIMSS questions being included in the mathematics curricula respectively.
- It appeared that South African learners generally had difficulty in constructing their own answers in the language required by the TIMSS tests.

In the chapter on '*Possible factors affecting the performances of South African students'* Howie (1997) commented on the problems in the South African school education system. The one factor which stood out, and which relates to my own study, was the learner's language of instruction. She stated that, for many learners (especially African language learners), the language of instruction in standards 5 and 6 (grades 7 and 8) was not the same as their home language. This often leads to communication problems, particularly where unfamiliar new concepts in science and mathematics are involved. For this reason it is also important to phrase test questions in a language that is as clear and direct as possible.

In the preliminary remarks on the relation of the above problem to the TIMSS findings for South Africa, the comment about language stated that all students wrote the achievement test in the language in which they received formal instruction. However, for a large majority of learners this was different from the home language. Howie (2002:121) recorded that 5496 participants spoke African languages, 1281 spoke Afrikaans, 533 spoke English and 24 spoke other languages. This discrepancy between the test language and the home language may have put the learners at an appreciable disadvantage.

In 1999 the TIMSS study was repeated and was known as the Third International Mathematics and Science Study-Repeat (TIMSS-R), with tests and questionnaires administered in 38 countries. In South Africa a total of 8146 Grade 8 learners from 194 schools were tested. In the executive summary, Howie (2002) gave the South African mean score as 275 out of the possible 800 points, which was well below the international mean of 487 out of 800. Once again, on average, the South African learners were the oldest in the TIMSS-R as they were 15.5 years of age - significantly above the international average age of 14.4 years.

Furthermore, in her conclusions and recommendations on TIMSS 1994/1995 and on TIMSS-R 1998/1999, Howie (2002: 227) observed that, even though the importance of all eleven official languages had been stressed in policy papers, the reality was that in many schools the language of instruction used and the mother tongue of the teachers and/or learners were different. To illustrate this, when she looked at how different language groups performed in the mathematics test, it was found that learners who spoke either English or Afrikaans at home achieved higher scores than those who did not speak these languages as home languages, and they achieved 100 points above the national average. Another interesting finding was that children who spoke other languages at home (for example, Greek, Portuguese, or Tamil), and who therefore also learned in a second language, on average scored only 20 points less than first language speakers. However, children speaking African languages at home attained 100 points less than the other groups of second language speakers.

The following results presented by Howie (2001) are central to this study:

- South Africa's overall 1999 score decreased by three scale points compared with the 1995 scores, which is not statistically significant. In other words, there was no real difference between the performances of the learners in 1999 and in 1995.
- South African learners' performances were relatively low in the content areas of mathematics (ranging from 37% for algebra to 45% for data representation, analysis and probability).
- Difficulties were noted when the learners were required to comprehend word problems and to articulate their answers and solve problems in writing.
- On the whole, learners were unable to communicate their answers in the language of the test and they lacked the basic mathematical knowledge expected at the grade 8 level.
- Only 26% of learners spoke the language of the test as their first language, but these performed better in both mathematics and science. More than 70% of learners from South Africa did not always speak the language of the test at home.
- Most of the learners participating in TIMSS-R came from a low socio-economic background with few books in the home and few, if any educational aids. These factors were known to be related to achievement.
- Learners were not fluent in the language of testing, whether English or Afrikaans, and they struggled to communicate. Although other countries had similar problems of learners having to learn in languages other than the one

> they spoke at home, their learners did not appear to have been disadvantaged by this.

As seen above, generally South African learners scored significantly lower than their international counterparts. Howie (2001:40) stated that the language issue contributed to the poor subject knowledge of both teacher and learner in South Africa and, if there is to be a commitment to improving the levels of learners' performance in these core subjects in the future, then solving the language issue will be a critical part of the solution. As seen in chapter 1, my research question endeavours to ascertain whether there is a difference in the achievement scores obtained when a convenient sample of grade 8 learners are tested in two different formats (Notational Format and Language Rich Format). Once again this would investigate whether the language issue in Howie (2001:40) is still contributing to poor subject knowledge. Furthermore, my form of testing could possibly corroborate the difficulties noted by the TIMSS when the learners were required to comprehend word problems, thus seeing if this trend was still the norm six years after the initial tests.

In 2004 the Human Sciences Research Council (HSRC) reported on the latest Trends in International Mathematics and Science Study (TIMSS 2003). Fifty countries, including South Africa (SA) participated. TIMSS 2003 was the third in a four-year cycle of international mathematics and science assessments project of the International Association for the Evaluation of Educational Achievement.

The HSRC had conducted these studies in SA in 1999 and 2003 and tested about 9000 learners in mathematics and science at the Grade 8 level in 254 schools in all the provinces. Six African countries (Egypt, Tunisia, Morocco, Botswana, Ghana and South Africa) participated in TIMSS 2003 and SA had scored the lowest score in science and mathematics. Dr Vijay Reddy of the HSRC, who co-ordinated the study in SA, said that the South African scores reflected the largest distribution of scores in mathematics and science of all the countries that participated in the study, and that this meant that there were very low scores included, as well as a few high scores. Analysis showed that the large distribution was a reflection of the continued inequalities in education in the South African society.

In comparison with TIMSS 1999 there was no significant difference in mathematics and science scores. Table 2.1 gives a comparison of the overall mathematics and science results of TIMSS 1999 and TIMSS 2003. It also compares the SA average scores with that of the international average scores.

Table 2.1 Shows a comparison of the mathematics and science results of TIMSS 1999 and TIMSS 2003. It also compares the South African (SA) average scores with that of the international average scores.

	Mathematics scores	**Science scores**
TIMMS 1999		
SA average score	275	243
International average	487	488
TIMMS 2003		
SA average score	264	244
International average	467	474

Reddy stated that there was no single cause of South Africa's poor and diverse performance but preliminary explanations were linked to multiple, complex and connected sets of issues, which included the following:

- The administration of the study (in November 2002) was in the midst of the curriculum change to the Outcomes Based Curriculum 2005, thus the lack of content specification and low overlap with international curriculum contributed to the low score.
- Issues of poverty, resources and infrastructure of schools.
- The low teacher qualification and the poor learning cultures in schools.
- Language proficiency[1] was also seen as a contributory factor but the issues of conceptual and cognitive demands placed on the learners in classrooms were the most significant.

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[1] Where it is ones second language and refers to the ones skill in the language.

2.3 The influence of language in the teaching and learning of mathematics

Language competence[2] is often revealed through daily exchanges. Even more so, this can be revealed in the mathematics classroom if competence is tested through written and oral (spoken) text or both.

Bourdieu & Wacquant (1992:146) argued that:

> Linguistic competence is not a simple technical ability, but a statutory ability... what goes on in verbal communication, even the content of the message itself, remains unintelligible as long as one does not take into account the totality of the structure of the power positions that is present, yet invisible, in the exchange.

Consequently, learners who have a better understanding of the language are more likely to be in a better position to decode and deconstruct texts. Zevenbergen (1998) reiterated that the linguistic habitus of learners will have substantial impact on their capacity to make sense of the discursive practices of the mathematics classroom, and hence their subsequent capacity to gain access to legitimate mathematical knowledge, along with the power and status associated with that knowledge.

2.3.1 Mathematics as a register

When looking at mathematics as a register I will consider three aspects:

a) How mathematics has a specialised vocabulary;
b) the specialised nature of the vocabulary used in mathematics; and
c) the role of lexical structure in mathematics

Specialised vocabulary

Learners have to grasp the specialised vocabulary of mathematics if they want to become effective learners in the subject. The words and terms used are sometimes subject-specific and border on ambiguous when they have very different meanings in the non-school context compared to the formal mathematics context.

Here the words that come to mind are words such as **prime**, **odd**, **mean**, **right** and **root**

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[2] Where it is ones First Language and refers to ones ability. I use both proficiency and competence as the sample consisted of learners who had English their first and second Language.

(as in square root or cube root), which have completely different meanings, depending on which context they are being used.

Zevenbergen (1998) emphasised that learning mathematics is, in part, learning the unique correspondence between the signifiers (words) and the signified (concepts) within a mathematical context, with some words having different meanings - depending on which section it is being used in the mathematics curriculum. For example, **base** and **square** have totally different meanings when used in the contexts of space/shape and of number. Another difficulty is posed to students when the words are similar in their soundings, which include homophones such as **straight/strait, sum/some** and **hole/whole,** just to mention three examples. Those learners who have difficulty deciphering the mathematics signifier are at risk of giving a discourse that is completely different from the one intended by the teacher. Zevenbergen (1998) related an example when viewing a lesson pertaining to fractions. A teacher was using doughnuts to talk about two halves and how the two halves, when combined, made a whole. Unfortunately, the doughnuts used were ones with a hole in the middle so many learners were extremely confused as to how two halves could make a whole (rather than a hole!). Some learners' experiences in mathematics positioned them to accept the teacher's comments as the truth. For this group, the relationship of signification became a source of confusion, particularly for those who did not understand the concept or language to begin with.

Another variation on the theme of specialised vocabulary is that of the technical vocabulary used in mathematics. These words are purely specific to mathematics and are sometimes unfamiliar to students who have not been given the background to begin with. Words that come to mind here are **tessellations**, **numerator** and **denominator**. In dealing with fractions we often state that the numerator is the top number and the denominator is the bottom number. However this simple translation of the two words does not hold ground when the teacher deals with the subtraction of equations where the bottom number can be subtracted from the top number.

Specialised vocabulary also considers the use of the preposition in mathematics. McGregor (1991:7) noted that the prepositions used in mathematics often caused difficulty in understanding the tasks. She noted the use of prepositions in various examples: The temperature fell *to* 10 degrees….*by* 10 degrees …*from* 10 degrees; and the effect of omitting the preposition completely: the temperature fell 10 degrees. In all of the above instances, if the intended preposition was not explained clearly to the learner, he/she would not be able to understand what operation was required.

Lastly, we look at trigger words. Sometimes these are embedded in the expression of word sums or word problems, so they ought to be unpacked and interpreted correctly if learners are expected to perform the specific task given in the problem. For example, in many word problems, trigger words such as **more**, **less**, **got**, or **took away** provide cues for the learners as to what operation ought to be performed (Schoenfeld, 1988). In part this is due to the way in which mathematics is most frequently taught to the students.

Semantic structure

In mathematics lessons word problems are typically classified or identified as **change**, **combine** and **compare** problems (De Corte & Verschaffel, 1991). It is recognised that the problems are simple insofar as the basic arithmetic is concerned, but are semantically complex. Depending on the word order of the problem, and what operations need to be undertaken in the sequence, the complexity of the task increases.

The example quoted by them was the following. It concerns an additive change problem in which the unknown is the solution and the form of the equation is given as $3 + 2 = x$. The task is relatively easy for the learner. A word sum question of this form may be: “Ron has 3 cars, June gave him 2 more. How many does he have altogether?” Another way in which it could be asked is with the unknown as the first variable. For example, with the form of the equation as $x + 2 = 5$, the question could be: “Ron had some cars. June gave him 2 more so he has 5 cars. How many did Ron start off with?” In this case the complexity is much greater for the learners and fewer are able to respond (De Corte & Verschaffel, 1991). Research focussed on changing the semantic structures so that the word sum was presented more in line with the language used by learners rather than the more formal expression of the problem. This increased the learners’ capacity to solve tasks (De Corte & Verschaffel, 1991).

It is concluded that, while changing the semantic structure of a word sum question may make the question more accessible and help the learners to find answers, nevertheless it does not help them to "crack the code" of the mathematics register.

Lexical structure

Halliday (1975) pointed out that the lexical structure found in mathematical and scientific registers is somewhat more dense than that found in spoken or written language. He defined lexical density as "the number of lexical items as a ratio of the number of clauses" Halliday (1988:67). Halliday suggested that somehow lexical density contributes to the complexity of written problems in mathematics and may be a further barrier to learning. Mathematical tasks are often characterised as being concise and very precise. There are very few redundant words and the words used are highly specific, relating to the task at hand. In most cases, to translate the tasks into a more accessible form would require a lengthy description which would result in a high level of complexity in the translation of the problem.

Dawe & Mulligan (1997:9-10) cited the example of a task where students had to estimate the volume of a telephone box with the accompanying text reading: "The volume of the phone box is about 0.1 cubic meters, 2 cubic meters, 5 cubic meters, 10 cubic meters." Then they contrasted it with the following question: "Trish's model boat is 8cm long. It is 50 times shorter than the real boat. How long is the real boat? 4m, 6.2m, 40m, or 50m." Clearly there are substantial differences in the mathematical demands of the two tasks, but the complexity of the task is compounded by the lexical density.

2.3.2 Comparison word problems

Zevenbergen (1998:208) stated that the syntax of the mathematics register often found in 'comparison' word problems can be difficult for students to decipher. He gave the following example:

Two friends walk to school. Anna travels 0,3 km. Maria travels 760m.
Which statement is correct?

a) Anna walks further by 300m	b) Maria walks further by 460m
c) Anna walks further by 1.06 km	d) Maria walks further by 0.73km

In the task a comparison is made between two data sets, namely for Anna and Maria. Furthermore, it requires a subtractive operation followed by a conversion of length to a single form. All these steps have to be identified by the learners. It is a complex task because the learners must be able to identify the different units being used. This in itself requires them to recognise the different symbols used (km = kilometers and m = meters) and also the conversion between the two units supplied. The learners then have to recognise that the term "further" refers to a comparison between the distances the two walkers travel rather than some additional distance. In its own right the term "further" suggests an increase or growth. Hence it is associated with addition, but the learners must undertake the operation of subtraction to determine the distance travelled by Anna in comparison to the distance travelled by Maria. Finally, the learners must also consider the different units of measurement supplied in order to determine which unit would be appropriate for making a comparison between the distances travelled by Anna and Maria respectively. Various aspects of the above information given to the students could easily be misconstrued, thus not getting to the answer that is wanted.

Furthermore, looking at word problems, Ernest (1998) and Vile (1998) discussed the role of semiotics where they relate to the role of semiotics in mathematics education. Vile (1998) stated that learners' interests in language and in other general socio-cultural issues had been considered to be a part of this budding interest, even though they could be regarded as part of semiotics. Earlier Rotman (1988) also emphasised that mathematics is about having the ability to count, and is thus the study of natural numbers; whereas semiotics is concerned with the study of numbers and the sign activity associated with numerals. Thus there is a relationship between the signs and the symbols, he said. Furthermore he argued that reading a written text is the first step in decoding what mathematicians say (i.e. what is being said) and is followed by the second step, which is recognising what had been written.

Rotman's view aptly addressed one of the major concerns of my study, which is why learners fail to decode and recognise both the mathematics content and the mathematical processes embedded in a word sum activity. My concern is that language presentation restricts the mathematical process and dictates the extent of the mathematics with which the learners can engage. Ernest, on the other hand, focused more on the text and sign relations in mathematics.

Adler (2001:2) sketched three dilemmas which she saw lying at the heart of teaching and learning secondary level mathematics in multilingual classrooms in a changing South Africa. They were coined *the dilemmas of code switching, mediation* and *transparency.*

In *the dilemma* of *code switching* - which is when an individual generally alternates between two or more languages - bilingual teachers are faced with a continual *dilemma of whether or not to code-switch languages* in their day-to-day teaching. If they sustain the English language, some learners might not be able to understand, or, if they revert to Setswana, the learners might be denied access to English and being able to improve.

The *dilemma of mediation* involves a tension between validating diverse learners' meanings and, at the same time, intervening with learners to develop their mathematical communicative competence (language used to communication).

The *dilemma of transparency* is embedded in having an *implicit or explicit language practice* as a classroom practice. The problem in explicit language teaching is that one focuses too much on of what is said, and how it is said, yet it appears to be a primary condition for access to mathematics, particularly for those learners with primary languages other than English.

Adler promoted a shared interest in communicating with practicing mathematics teachers. She found that teachers did not distinguish between (1) the difficulties of access to mathematics as a specific discourse, and (2) access to mathematics in English.

Their stories revealed contradictory assumptions, including:

- Mathematics is difficult for everyone, irrespective of the learner's main language;
- Learning mathematics in English is necessary at the secondary level;
- Language is learnt through use, so learners should be encouraged to use English in the mathematics class; and
- Learners should be able to use their primary language in mathematics lessons – they cannot understand certain concepts when they are explained only in English.

Even though, in my study, I did not observe the learners' interactions in their day to day mathematics lessons, I wondered whether any code-switching took place because many learners in the sample indicated that Afrikaans was their home language.

2.3.3 The importance of reading in mathematics

Written communication is a major component of the methods of teaching mathematics used in many schools today. Worksheets, textbooks, flashcards, the overhead projector and writing on the chalkboard form an integral part of the resources used by teachers of mathematics. A printed page of mathematical text may communicate comparatively easily with the learners, or it may also fail to communicate what the teacher intends. Thus it is important for teachers of mathematics to recognise whether children are likely to be able to read easily the written text presented to them. For the purposes of this study the term 'reading' is used in a very wide sense. In this case reading refers to 'getting the meaning from the page'.

The process of reading is influenced by the style of writing, the graphic images used and the presentation on the page. The style of writing in mathematics is vastly different from that of styles normally found in non-mathematical subjects and text. The reading of mathematical text requires special reading skills from the reader. The Bullock Report (1975:188) stated:

> We must convince the teacher of history and science, for example, that he has to understand the process by which his pupils take possession of the historical

> or scientific information that is offered to them; and such an understand involves his paying particular attention to the part language plays in learning.

After the publication of the Bullock report, all teachers were urged to think of themselves as teachers of reading, and mathematics teachers were encouraged to appreciate that language factors affect mathematics performances.

2.3.4 Readability

A factor that affects the learners' engagement with text is called readability. It refers to all the factors that affect the success in reading and understanding a text, such as motivation, interest, legibility of print and complexity of words and sentences in relation to the reading ability of the reader (Johnson, 1979, cited in Wegerhoff, 1981). Very little research in readability has been undertaken in South Africa and the international research conducted has been done in the area of science due to the level of difficulty of its vocabulary.

Despite the problem of using readability formulae with Mathematical English (ME), nevertheless it remains important to assess whether a particular piece of ME material is 'easy' or 'difficult' or about right' for a particular learner. To arrive at an informed judgement, it is necessary to look at the styles of writing used in ME. Here readability refers to the factors that affect the successes in reading and understanding a text, such as the interest and motivation of the reader, the legibility of print and the complexity of words and sentences in relation to the reading ability of the reader.

2.3.5 Characteristics of mathematical writing

The main difference between mathematical text and text used in other subjects lies in the variety of purposes and types of writing which are found in mathematical text. In many cases the piece of text is clear in the author's mind, but that purpose might not be explicit enough in the text, and in the reading of the text. Thus the learner needs to work out for himself/herself what the author intends by it. When designing a particular text the author or teacher must have a defined intended purpose for the passage. The teacher /author must be able to distinguish whether the intended piece is testing or teaching concepts, principles, skills and problem-solving strategies; or whether is it aimed to give practice in the use of concepts, principles, skills and problem-solving; or whether is it testing the acquisition of concepts, principles, skills and problem-solving strategies and, in addition, developing mathematical language. The role of the mathematics teacher/author was aptly put by Setati, Adler, Reed & Bapoo (2002:79) when they stated that the mathematics teacher faces the major demands of continuously needing to teach both mathematics and English at the same time.

Classification of types of text

Several different types of text are used in order to carry out specific purposes intended by the author, and each type has its own characteristics. The various types of text may be classified under the following headings:

- exposition of concepts and methods, including explanations of vocabulary;
- notation and rules, instructions to the reader to write, draw or do;
- examples and exercises for the reader;
- peripheral writing, such as introductory remarks; and
- signals, e.g. headings, letters, numbers, etc.

2.3.6 Difficulties with mathematical words

Otterburn & Nicholson (1976) investigated 300 learners' understanding of mathematical words used in College School Education (CSE) mathematics courses. They classified the pupils' responses to each word given as:

correct, which demonstrated a clear knowledge of what the word means;

blank if the pupil did not give any indication that he knew what the word meant, although he may have recognised the word; or

confused if the pupil generally had muddled comprehension.

The learners were given a list of words used in mathematics.

In column (1) they were told to put *Yes* if they understood what the word meant, *No* if not.

In column (2) they were told to put the symbol for the word, if the word had one.

In column (3) they were asked to draw a diagram or use symbols or numbers to show what the word meant.

In column (4) they had to *describe* in words what the word meant, using an example if they wanted.

An example is given below: -

Word	yes/no	Symbol	Draw a diagram	Describe in words
Plus	yes	+	oo + oo = oooo 2 + 2 = 4	Add, e.g. two plus two equals four.

The results of some of the words and the results of the testing were as follows: -

WORD	% CORRECT	% BLANK	% CONFUSED
Minus	99.7	0.3	0
Multiply	99.7	0.3	0
Square	94	3	3
Square root	40	44	16
Product	21	59	20
Multiple	20	45	35

It is possible to question the importance of using these words in understanding mathematics in the classroom. Nevertheless, inevitably they form part of the language used in examination papers, where understanding of their meaning is presumably taken for granted.

Such research makes it clear that there is a serious problem. Many ME words - which teachers, authors and examiners take for granted, and expect to be understood - seem to be absent from the vocabulary of a large proportion of learners or, at best, they have only a vague or confused idea of what the word actually means.

Nicholson (1977) followed up with a second investigation in which he gave clear contextual clues for specific words. The words were given in a sentence or a group of sentences rather than in isolation as the first test. Although the two investigations were not comparable, the learners again had problems with some common ME words. However responses to some words 'improved' in the second investigation. This might have been due to the different backgrounds of the learners, or it may have been that some words were more susceptible to contextual clues than others. Is it thus possible that learners would be able to define more words by using clues of context from the textbook, and this could be improved by using additional contextual clues in all textbooks?

2.4 Language and the formation of mathematical concepts

Learning mathematics requires a learner to understand certain concepts. However, the difficulty that arises is that many concepts cannot be learned without intellectual effort over a long period of time. Orton & Frobisher (1996) understood concepts as abstract ideas such as ‘equality’, ‘work’ and ‘quality of life’. In mathematics some examples of concepts are ‘real number’, ‘similarity’ and ‘function’. Thus mathematics incorporates a multitude of concepts where some might be deemed to be more abstract than other. Hence concepts express generalisations rather than particulars. Cohen & Manion (1992:17) listed the following words as examples of concepts - *anger, achievement, velocity*. They stated that, when examining these words, it could be seen that each word represents an idea, which brought them to the conclusion that a concept is the relationship between the word or symbol and an idea or conception. Every day we make use of concepts as they are shared and used by all groups of people within the same culture.

On the other hand, a concept can be subject-specific, having restrictions, and thus be used only by certain groups of individuals, specialists, or members of a particular profession.

> Concepts enable us to impose some sort of meaning on the world: through concepts reality is given some sense, order and coherence. They are the means by which we are able to come to terms with our experience. How we perceive the world, then, is highly dependent on the repertoire of concepts we can command. The more we have, the more sense data we can pick up and the surer will be our perceptual and cognitive grasp of whatever is ‘out there’ (Cohen & Manion, 1992:18).

If this is so, then it means that things we perceive around us are determined by what concepts we have been exposed to, showing that individuals with different sets of concepts might view the same objective reality differently.

Piaget (1926) distinguished between 'ego-centric' and 'socialized' talk in his earliest study of intellectual development. In ego-centric talk, the child does not bother whether it is being listened to, nor to whom it is speaking. It is suggested that this type of speech begins to disappear at about the age of seven. Later Piaget gives a more general view of the relationship between language and thinking, stating that language and thought are linked, where each necessarily leans on the other but both depend on the intelligence of the individual.

Thus language plays an essential role in the development of higher order concepts. Both Piaget (1926) and Vygotsky (1962) provided some evidence that the development of linguistic structure in some cases precedes the appreciation of the corresponding logical relationships. For example Piaget's experiments suggested that children use the subordinate clauses with logical connectors introduced by '*because*', '*unless*', etc., long before they grasp the logical relationship corresponding to these forms: the statement 'grammar precedes logic' was used by both Piaget and Vygotsky.

In his experimental study of concept formation, Vygotsky (1962) probed more deeply into the dependence of the understanding of concepts on the language which described them. His simple experiments showed that children explained the names of objects by their attributes. Vygotsky's conclusion was not simply that concept and language are inextricably linked, but that concept formation depends on linguistic development:

> That is why certain thoughts cannot be communicated to children even if they are familiar with the necessary words. The adequately generalized concept that alone ensures full understanding may still be lacking. Vygotsky (1962:7)

The notion that concept formation arises through verbal discussion also appears to have a fairly general acceptance. Cummins (2000:162) stated that concepts are expressed through language, and linguistic communication in both oral and written modes is the primary means through which we come to understand these concepts. Thus language supplies verbal symbols which can represent concepts and be used as stimuli for the internalized manipulation of these concepts. Hence, as educators, we should not neglect the oral verbalization of mathematical ideas and the chosen words we use should not be used loosely or ambiguously.

It is commonly stated that mathematics itself is a language. Furthermore, it seems as though language can interfere with, and even obscure or obstruct, the learning of mathematics simply because mathematicians have decided to adopt a particular word or combination of words, whether familiar or unfamiliar to the learner.

Otterburn & Nicholson (1976) investigated the difficulties pupils had with mathematical words used in College School Education (CSE) mathematics courses. They classified the learners' responses to each one of a given set of words as: correct, blank or confused. 'Hard' words, as they termed them, may often cause problems for the reader. Generally 'hard' words are those that are unfamiliar to the reader, perhaps because they are not used frequently. In other school subjects the unfamiliar words are often softened by the context, and the surrounding sentences may give valuable clues to the meanings of the hard word. (In mathematics the word sums consist of text and concepts that are also used in ordinary English).

Mathematics text is more complex than ordinary English text, partly because mathematics uses a technical vocabulary which overlaps with the vocabulary of ordinary English (Shuard & Rothery, 1984:24). Some of the comparisons between Ordinary English (OE) and Mathematical English (ME) are the following:

- Words which have the same meaning in ME and OE;
- Words which have a meaning only in ME;
- Words which occur in both OE and ME, but which have a different meaning in ME from that of their meaning in OE.

One of the difficulties of learning to use ME is that in its spoken form (and generally also in its written form) it is blended with OE, and the distinction between the two languages is often blurred (Setati, 2005:79). One feature that distinguishes ME from OE is the extensive use of symbols in mathematical writing where mathematical ideas are often conveyed using specialised, highly condensed symbol systems (Setati, 2005:80). Setati goes on to state that mathematics learners are required to learn the different mathematical symbols, how they are read and the different meanings they take in different mathematical contexts.

Pirie (1998) found that learners experienced problems with the subtraction symbol '-' when it is used to represent the words 'minus', 'subtract', 'take away', 'difference', and 'negative' interchangeably. Two examples are given to illustrate the subtraction problem of '15 – 4 = 11' and they are represented in the following problems:

> Thembi had 15 marbles and gave 4 of them to John. How many marbles does Thembi have now?
>
> Thembi is 15 years old and her brother Sipho is 4 years old. What is the difference between their ages?

Another example that I would add is one that is commonly used in mathematics lessons where the learner is asked to find the difference between 15 and 4.

Learners who do not have a good grounding in the language used in mathematics could misconstrue the word 'difference' due to the fact that it has a different meaning in OE to that of ME. Very often the context provided by a mathematical question or passage is also less rich or informative than the context of an OE question or passage.

Most mathematics classes are conducted in a mixture of OE and ME (Setati, 2005:81) and, according to Pimm (1987: 88), the learners' failure to distinguish between the two can result in breakdowns in communication. This is apparent in the school at which my research was conducted where learners found themselves in an English first language medium class in which many of them did not speak English as a first language. With the learners not being able to speak English as a first language, the learning of mathematical concepts may be expected to be further hampered because both the OE and ME are new phenomena to the learners.

Another aspect of the language problem occurs when learners who do not have English as their home language / mother tongue are tested in English (in tests such as TIMSS and, more recently, the one conducted in South Africa by the University of New South Wales Educational Testing Centre). The outcomes of such testing were reflected in Howie (2002:258) in Key Finding 3 when she stated that *"Pupils who spoke either English or Afrikaans at home achieved higher scores than those who did not"*. The diverse nature of South Africa has led to our eleven official languages. With the perception that English is the language of access and opportunity, we as researchers will have to come up with innovative solutions to improve the achievement scores in tests such as TIMSS which is conducted in a language other than that of the home language/mother tongue of learners.

2.4.1 Classification of word problems

Before 1980, research on solving word problems concentrated heavily on the effects of superficial or mathematical task variables on problem solving capacity. It concentrated on aspects such as the number of words in the problem and the structure of the number sentence hidden in the problem (Verschaffel, 1984). In the late 1970s, the focus of the research on word problem solving shifted from superficial and mathematical task variables towards a new kind of task characteristic which had received hardly any attention before, namely, the type of problem situation.

Classifying addition and subtraction word problems

Carpenter, Fennema, Peterson, Chiang & Loef (1988) classified verbal problem types into different classes according to their semantic characteristics. The classification schema for addition and subtraction problems distinguished between three basic categories of problem situation that involve change, combining and comparing problems.

Change problems refer to active or dynamic situations in which some events change the value of the initial quantity. **Combine** problems relate to static situations involving two quantities that are considered either separately or in combination. **Compare** problems involve two amounts that are compared and the differences between them. Each of these three basic categories of problem situation could be subdivided further into different problem types, depending on the identity of the unknown quantity. For **Change** and **Compare** problems, further distinctions can be made - depending on the direction of the change (increase versus decrease) or on the comparative relationship (more or less). Combining these three task characteristics, Carpenter et al. (1988) distinguished 11 types of addition and subtraction problems. The overall conclusion was that the **type** of problem situation had a strong impact on the difficulty of elementary addition and subtraction word problems. They suggested that, besides the task variable, the relative difficulty of a particular problem was also seriously affected by a number of factors such as the exact phrasing of the problem, the particular numbers used, the testing procedure, the age, the instructional background of the learners, etc.

Classifying multiplication and division word problems

Although it was suggested in the late 1970s that a similar classification task could be undertaken for word problems involving multiplication and division, systematic attempts emerged somewhat later. Examples of classification have been provided by Greer (1992). According to Greer, the extension of the concepts of multiplication and division can be continued almost indefinitely to encompass more complex numbers, e.g. decimals, fractions, negative numbers, etc. Contrary to analysis in the field of addition and subtraction, the conceptual analyses of multiplication and division situations were not accompanied to the same degree with systematic research on the difficulty of the distinct problem types. Instead the focus was on the difficulty of the types of numbers used. Moreover, the scarce results were difficult to interpret because of dissimilarities in the classification schemata used by different researchers. However there was one clear finding, namely, that problems involving "Equal groups" and "Equal measures" were systematically found to be easy, while those involving "Cartesian product" and "Measure conversion" appeared to be very difficult.

2.4.2 Representing arithmetical word problems

The problems associated with language used in mathematics become apparent in questions where the protocol for representation is embedded in the task. Learners must be able to decode not only the linguistic form of the question but also the symbolism used in mathematical practices (Zevenbergen 2002:209). When dealing with word problems, learners will have to construct a network of the basic semantic relationships between the words and the quantities in the problem. This representation of words and numbers results in a complex interaction of bottom-up and top-down processing. Throughout this constructive process of problem representation, different kinds of knowledge play an important role. In an illustration that comes from a study by De Corte and Verschaffel (1985), three knowledge types can be highlighted - schemata of problem situations; linguistic knowledge; and knowledge about school word problems and their role. This may be illustrated using the following Combine 2 problem:

> Pete has 3 apples, Ann also has some apples, Pete and Ann have 9 apples altogether. How many apples does Ann have?

This is an example of a set of elementary addition and subtraction word problems that were administered to a group of 30 first graders individually three times during the school year. With respect to each problem, the learners were given a series of tasks. Two of these were aimed especially at obtaining information about the problem representation, namely, retelling the problem and building a material representation using puppets and blocks. It was found that, when pupils failed to master the generic knowledge about **Combine** relations, they were unable to infer the part-whole relation between the nine apples that Pete and Ann had altogether, and the apples that each of them had on his/her own. In the given example the part-whole relation was not explicitly stated in the problem and so, without the corresponding schematic knowledge, learners had no way to infer the relation between the distinct given quantities, and therefore may have interpreted each problem sentence separately.

Capps & Pickreign (1993) examined some aspects of language connections in the learning of mathematics. Basic to learning any language are four steps: listen, speak, write and read. Essentially one acquires spoken language first by hearing it (listening) and then by reproducing it (speaking). Then follows learning the printed symbolic form, which involves recording what is heard and spoken (writing) and interpreting the written form (reading). Reading and writing are closely associated.

In mathematics instruction several parallels to reading instruction are seen in the way the language is taught, but unique differences are also evident. A key difference is in the amount of reinforcement of mathematical language that occurs outside the mathematics lesson. Although "everyday" language is used constantly in the classroom, at home and in social interaction throughout the day, mathematical language is not. Exacerbating this lack of reinforcement in daily use is a lack of attention to direct instruction of the language and symbolism of the mathematics lesson. This is evident in some mathematics classrooms if teachers do not write the words or symbols on the chalkboard and discuss their meaning and pronunciation.

The following ideas were suggested as partial actions that can be taken to offer adequate practice with mathematical language and symbolism. In the initial stage of instruction, whenever possible, the use of concrete models is critical. Learners should verbalise and discuss ideas as they work with models. By listening to and speaking with one another, learners will connect their prior language learning to the new concept and language being taught. As learners touch, see and verbalise, teachers can guide the development of the appropriate mathematical language and symbolism. The use of manipulatives and verbal discourse during instruction afford the teacher an opportunity to assess the learners' understanding. Diagnosis and corrective action can almost be simultaneous.

Emphasis on context is a second area in which language connection requires attention. Here prior learning also plays a major contextual role in making the language connection.

In a counter-balanced study, 48 Nigerian children were asked to solve arithmetical word problems by Adetula (1990). The word problems involved "more" or "less" as the cue words and they were presented in English and in their native language.

The sample was drawn from primary grade 4 pupils in private and public schools (24 from each) from the Yoruba and Hausa ethnic groups. The children were asked to solve 10 addition and subtraction word problems presented in English, and 10 parallel problems presented in their native language (Yoruba or Hausa). The 10 problems included six **Compare** questions and four **Pure Number Compare** questions. Each of the 10 problems was made up with "less" or "more" as either a distractor or a valid cue. Half of the children in each ethnic group were given the problems in English before their native language. This process was reversed for the other half. This process guaranteed that the order of presentation of the problems in languages would be counter-balanced, that is the process checked the order effect.

Retrospective interviews were conducted with each child to find out how they analysed the meaning of each problem, deciding which operation to use to solve it. These responses were audio-taped and coded into three strategies which were, in order of efficiency:

Strategy 1: Based on attending to the two given numbers in the problem.

Strategy 2: Based on rote translation of key words.

Strategy 3: Based on the analysis of comprehending the meaning of the problem statement.

A preliminary study conducted by means of observation by Adetula revealed that most of the children (especially the Yoruba children) could not count effectively using their native language numeracy; therefore English language was used in the native language parallel problems. This study investigated the issue of language in mathematics education. The findings indicated that performance was better in both skills and strategies when mathematics word problems were presented in children's native language than when presented in English. Both public and private school children performed better in both skills and strategies when problems were presented in their native language than when presented in English, but only public schools had the result of significance ($p< 0.025$). Also, data obtained from the interviews were in a accord with psycholinguistic theories concerning the polarized comparative pair of "less" and "more". This conclusion was in accord with the findings in other research studies (Clements, 1982; Cuevas, 1984; Mathews, 1984).

The data collected from the interviews enabled the researcher to probe the thoughts of each of the children on the problems. Their thought processes were exemplified by the strategies used. These strategies were analysed and then summarised. The data revealed that wrong solutions to distractor problems presented in English were based predominantly on strategy 2 for private school children, and/or both strategies 1 and 2 for public school children. Wrong solutions of problems both in English and in the children's native language due to strategy 3 were usually produced by inappropriate mental representation of problems. The findings also indicated that the private school children used more efficient strategies (strategy 3) across all the problems presented in English and also in the children's mother tongue.

In attempting to understand this finding, the author Adentula was led to Newman's hypothesis. According to Newman (1983), a person confronted with a written verbal problem has to:

(1) read it,

(2) comprehend what he has read,

(3) carry out the transformation from the words to the selection of an appropriate mathematical model,
(4) apply the necessary process skill and, finally,
(5) encode the answer.

From this hypothesis it was clear that the stumbling block created by the language of the problem presentation often led to faulty problem transformation, and consequently led pupils to use inappropriate process skills in an attempt to find a solution.

One weakness of this study was that the sample was drawn from a Hausa locality only. This definitely had an effect on the Yoruba children's native linguistic skills and, in turn, affected their performances in the problems presented in Yoruba language. A future study can consider drawing samples either from its locality or from the ethnic groups outside their localities.

One of the positive features of this study concerned the efficacy of the interviewing technique for unravelling the weak level of understanding of the wording of the problems (or of the English language).

Zevenbergen (1998) pointed out that the role of language in the teaching and learning of mathematics and mathematical concepts had been given increasing recognition. This was due to the fact that constructivist epistemologies had placed aspects of language central to the learning process. Learners' interaction with language - whether hearing it or actually using it - possibly allows for the language to encompass the learners and, in so doing, they may develop a linguistic habit. Thus, when entering the mathematics classroom, they carry with them this linguistic habit which, in some cases, differs from the formal school language. Where there is greater continuity between the home and school, there is a greater chance of success in school mathematics (Bourdieu, Passerson & de Saint Martin, 1994).

2.4.3 Symbols, signs and signifiers

The Collins English Dictionary (1992:1472) defines 'symbol' as follows:

- A formal authoritative statement or summary of the religious belief of the Christian church;
- A written character or mark used to represent something;
- Something that stands for, represents, or denotes something else (not by exact resemblance, but by vague suggestion, or by accidental or conventional relation).

The third definition is most apt when applied to mathematics, because a symbol often 'stands for, represents or denotes something else', and the symbol is material whereas the 'something else' is immaterial or abstract.

Learners must be able to unpack and decode not only the linguistic forms of a question but also the symbolism that is used in mathematical practices. Consider, for example, geometry and the language used when working with angles. Words such as **congruent**, **obtuse**, **reflex**, **supplement**, **complement**, **acute**, **alternate**, etc. demonstrate the complexity of the language as these words signify certain entities.

Learners who do not have access to the symbolism and specific signifiers will not be able to understand the task at hand, nor answer the question effectively. Zevenbergen (1998) looked at terms such as **pentagon, prism,** and **vertices**. He stated that their complexities must be accessible for the learners to "crack the code" of any question that contains these terms. Being able to read and comprehend the question is critical to the capacity to answer it. To do this, the student must have access to the specific language embedded in the question as well as to the formal symbolism of the diagrammatic representation.

Consider a simple equation, similar to that used by Zevenbergen (1998: 210). If a learner is given the equation $100 \text{ x } 5 > 50 \text{ x } \boxed{\quad}$, the learner must know what is meant by these terms and, concerning symbolic signifiers, the learner must be able to make sense of the symbols in the equation. If not, the ability to give the correct answer will be curtailed. Another level to consider is the complexity of the sentence structure. Is the learner able to make sense of the question mathematically and thus link the elements into something coherent, so as to deduce the correct answer?

2.4.4 Concept literacy

The idea of concept literacy is explored in the context of the teaching and learning of mathematics and the sciences in grades 5–9 in Western Cape schooling. The interplay between language, literacy, concept formation and the textbook as a source of concept induction is examined (Young, Mbatha, Abrahams, Deyi, van der Vlugt & Farragher 2002). In Young et al (2002), the AILA paper 'Towards concept literacy' outlines this project which is presently in progress and spearheaded by the Centre for Applied Language and Literacy Studies and Services in Africa (CALLSSA) at the University of Cape Town (UCT). The AILA paper identifies key specialised mathematics and science concepts as they appear in English as language of instruction textbooks used by Xhosa- and Afrikaans-speaking learners. Mother tongue Xhosa terms are sought and placed in a communicative context as annotations to the existing textbooks, to establish concept literacy in English Second Language (ESL) learners, particularly where speakers of Xhosa claim that no such barrier to concept literacy and concept formation is explored.

Abrahams' research findings in a case study of grade 9 ESL learners who were attempting mathematics using words sums in comparison with their attempts to solve "mathematics minus the word sums" - revealed that when the words were removed from the sums the learning and problem solving in mathematics was enhanced (Young & Abrahams 2002). Young (2002) also stated that learning and problem solving in mathematics improves when the words are removed from word sums and when the more traditional symbolic mathematics notation is used.

2.4.5 The Concept Literacy Project (CLP)

It is accepted that an understanding of key concepts in mathematics and science is fundamental to the teaching and learning of these disciplines. Research confirms that one of the key dimensions to understanding concepts is language (Schafer 2005: Abstract). To address the relationship between language and the understanding of concepts, Schaffer (2005) refered to a multilingual learning and teaching resource and support book (grade 9 – 10 levels) developed by CALLSSA. He went on to explain how the book provides detailed meanings and explanations for key mathematics and science concepts in Zulu, Xhosa, Afrikaans and English. He argued that when learners and educators have access to these concepts in their own languages, they can transfer such understanding to their dealings with English as the LOLT (Schafer 2005).

The problem of inadequate language proficiency as a hindrance to the learning of mathematics and science in the South African context is well documented (Adler 2001; Howie 2002; Setati 2005). Young, van der Vlugt & Qanya. (2004) suggested that this obstacle can be addressed at two inter-related levels, namely, (a) concept understanding and use, and (b) language/discourse context and forms in which these concepts are embedded (Schafer 2005). The notion of concept literacy that frames the CLP can be described as 'understanding, through reading, writing and appropriate use, basic learning-area specific terms and concepts in their language contexts' (Young et al., 2004). Schafer (2005) alluded to Kilpatrick, Swafford and Findell, cited in Mwakapenda (2005), who described conceptual understanding as a critical component of mathematical proficiency that is necessary for anyone to learn mathematics successfully. Here conceptual understanding implies an understanding of knowledge that not only revolves around isolated facts but also includes an understanding of the different contexts that frame and inform these facts (Schafer, 2005).

Kilpatrick et al. (cited in Mwakapenda, 2005) intimated that 'learners with sound conceptual understanding … have organised their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to the knowledge they already posses and know'. Schafer (2005) saw a concept as controversial and difficult to define as it ranges from a personal idea or construct to a statement that could be universal or generic. The RNCS (2003a: 23) states that 'for most part mathematical concepts are abstract and if the learners are to develop rich mathematical understanding then they need to be able to 'see' mathematical concepts as objects themselves.

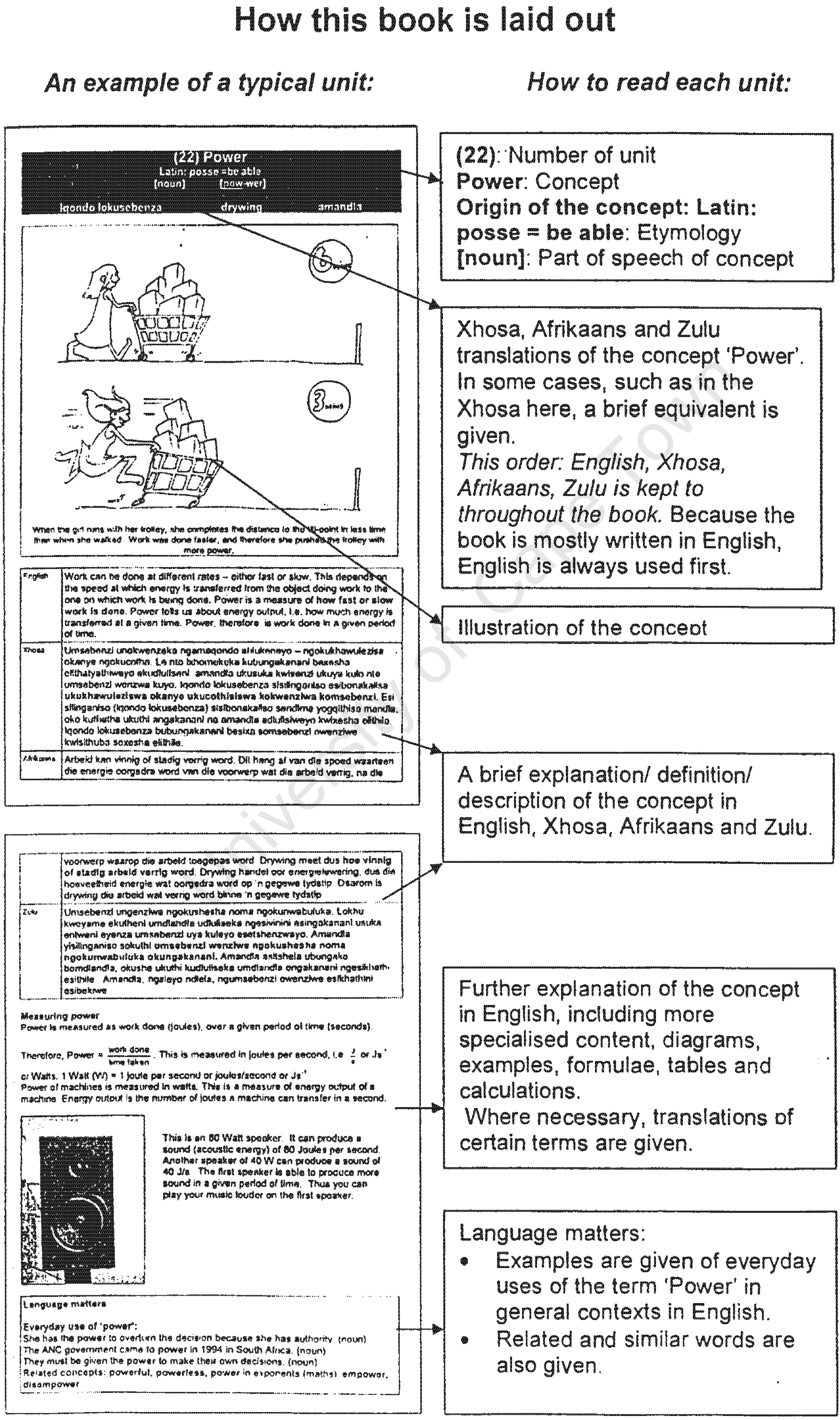
On the other hand, Young et al. (2004) state that the definition that underpins the CLP suggests that a concept is a 'mental picture which has a standard and universally accepted meaning'. Similarly Schafer (2005) indicated that a comprehensive definition of literacy is difficult to pin down as it no longer simply refers to the ability to read and write. Young et al. (2004) argued that literacy implies a capacity to recognise, reproduce and manipulate the conventions of text, spoken and written, shared by a given community. In summing up, Schafer (2005) stated that concept literacy emphasises the interaction between context and content – it is a dynamic process that changes over time as the concept is internalised and understood. Schafer (2005) went on to validate the claim of Young et al. (2004) that modifying one's prior knowledge if one is learning in an additional language (a language other than one's first language) can be problematic, particularly if one is not proficient in that additional language.

2.4.6 Why is there a need for CLP?

When Young et al. (2002:17-24) reviewed the mathematics and science curriculum, concepts and textbooks they found that the textbooks had deficiencies in explicating subject-specific concepts. They proposed modifications to the mathematics and science textbooks to illustrate how they believed that concept literacy might be enhanced.

Textbooks are both the text and pretext for most classroom teaching, classroom tasks and activities. Thus there is a heavy dependence on such textbooks for the induction and development of subject understanding, especially by under-qualified teachers who form the bulk of the teaching force in mathematics and science (Young et al., 2002). To further illustrate how concept literacy might assist with the development of understanding key concepts in mathematics and science, so that teaching and learning of these disciplines could be enhanced, Figure 2.2 illustrates an example of how a typical unit in the CLP book is laid out, and how it might assist both learners and educators.

Figure 2.2 An example of how a typical unit in the CLP book is laid out and how it could assist both learners and educators (Young, van der Vlugt & Qanya, 2004: 91-92).



How this book is laid out

An example of a typical unit:

How to read each unit:

(22) Power
Latin: posse =be able
[noun] [pow-wer]

Iqondo lokusebenza drywing amandla

When the girl runs with her trolley, she completes the distance to the till-point in less time than when she walked Work was done faster, and therefore she pushed the trolley with more power.

English	Work can be done at different rates – either fast or slow. This depends on the speed at which energy is transferred from the object doing work to the one on which work is being done. Power is a measure of how fast or slow work is done. Power tells us about energy output, i.e. how much energy is transferred at a given time. Power, therefore is work done in a given period of time.
Xhosa	Umsebenzi unokwenzeka ngamaqondo ahlukeneyo – ngokukhawulezisa okanye ngokucotha. Le nto ixhomekeke kubungakanani bexesha elithatyathiweyo ekudluliseni amandla ukusuka kwisenzi ukuya kulo nto umsebenzi wenzwa kuyo. Iqondo lokusebenza sisilinganiso esibonakalisa ukukhawuleziswa okanye ukucothisiswa kokwenziwa komsebenzi. Esi silinganiso (Iqondo lokusebenza) sisibonakaliso sendima yogqithiso mandla, oko kuthetha ukuthi angakanani na amandla adluliswayo kwixesha elithilo. Iqondo lokusebenza bubungakanani besixa somsebenzi owenziwe kwisithuba soxesha elithile.
Afrikaans	Arbeid kan vinnig of stadig verrig word. Dit hang af van die spoed waarteen die energie oorgedra word van die voorwerp wat die arbeid verrig, na die voorwerp waarop die arbeid toegepas word Drywing meet dus hoe vinnig of stadig arbeid verrig word. Drywing handel oor energielewering, dus die hoeveelheid energie wat oorgedra word op 'n gegewe tydstip Daarom is drywing die arbeid wat verrig word binne 'n gegewe tydstip
Zulu	Umsebenzi ungenziwa ngokushesha noma ngokunwabuluka. Lokhu kweyame ekutheni umdlandla udluliseka ngesivinini esingakanani usuka entweni eyenza umsebenzi uya kuleyo esetshenzwayo. Amandla yisilinganiso sokuthi umsebenzi wenziwe ngokushesha noma ngokunwabuluka okungakanani. Amandla asitshela ubungako bomdlandla, okusho ukuthi kudluliseka umdlandla ongakanani ngesikhathi esithile Amandla, ngaleyo ndlela, ngumsebenzi owenziwe esikhathini esibekiwe

Measuring *power*
Power is measured as work done (joules), over a given period of time (seconds).

Therefore, Power = $\frac{\text{work done}}{\text{time taken}}$. This is measured in joules per second, i.e $\frac{J}{s}$ or Js^{-1} or Watts. 1 Watt (W) = 1 joule per second or joules/second or Js^{-1}
Power of machines is measured in watts. This is a measure of energy output of a machine Energy output is the number of joules a machine can transfer in a second.

This is an 80 Watt speaker. It can produce a sound (acoustic energy) of 80 Joules per second. Another speaker of 40 W can produce a sound of 40 J/s The first speaker is able to produce more sound in a given period of time. Thus you can play your music louder on the first speaker.

Language matters

Everyday use of 'power':
She has the power to overturn the decision because she has authority (noun)
The ANC government came to power in 1994 in South Africa. (noun)
They must be given the power to make their own decisions. (noun)
Related concepts: powerful, powerless, power in exponents (maths) empower, disempower

(22): Number of unit
Power: Concept
Origin of the concept: Latin: posse = be able: Etymology
[noun]: Part of speech of concept

Xhosa, Afrikaans and Zulu translations of the concept 'Power'. In some cases, such as in the Xhosa here, a brief equivalent is given. *This order: English, Xhosa, Afrikaans, Zulu is kept to throughout the book.* Because the book is mostly written in English, English is always used first.

Illustration of the concept

A brief explanation/ definition/ description of the concept in English, Xhosa, Afrikaans and Zulu.

Further explanation of the concept in English, including more specialised content, diagrams, examples, formulae, tables and calculations.
Where necessary, translations of certain terms are given.

Language matters:
- Examples are given of everyday uses of the term 'Power' in general contexts in English.
- Related and similar words are also given.

2.5 Summary

The aims of this chapter were:

a) To review mathematics performance results generated by the TIMSS studies conducted in 1997, repeated as TIMSS-R in 1999 and in 2004, to see how the TIMSS study placed South African learners compared to their international counterparts.

b) To ascertain the main thrust of the reported educational research findings on the influence of various modes of presentation of language in the teaching and learning of mathematics.

c) To document the role of language in learners' understanding of mathematical concepts; for example, looking at concept literacy, seeing how language presentation and usage constructs teachers' and learners' perceptions of mathematics, and its possible impact on formal assessment.

Some aspects of this literature review have been concerned with how mathematical knowledge is influenced by language, be it written or symbolic. Research has suggested that the way in which students learn mathematics is directly influenced by their language competence. Thus it would appear that mathematical competence and the ability to respond to questions and produce correct responses are underpinned by the way in which language is used to develop an individual's mathematical understanding.

The role of language in the development of mathematical understanding is significant and the following reasons were evident:

- Language is the basis for formalising intuitive mathematical understanding.
- Language shapes the way in which learners are able to express themselves and, in turn, their mathematical thoughts.
- Language used is an indicator of one's social upbringing, one's socialization and one's thoughts.

My task is to try to explain why learners have this inability to engage with mathematical sums containing words from topics in the mathematics syllabus that they have been taught.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter has two major components. The first main section 3.2 introduces the overall research **design** and justifies its selection. The second main section 3.3 presents the finer details of the research **methodology** that were applied to the conduct of the study and explains their selection and inclusion. Smaller sections 3.4 and 3.5 complete the chapter.

Section 3.2 commences by setting out the over-arching (or focus) research questions, and explains how and why they were chosen. A consideration of the research questions then leads to the generation of the research **design**, which is explained and connected to the focus questions. The adoption of a mixed method research design is accounted for in terms of Mode 1 and Mode 2 research methodologies, grounded theory and triangulation, resulting in a decision to combine both quantitative and qualitative types of research methodologies. These encompass a counter-balanced or "flip-flop" research strategy in phases I and II, followed by the generation of more substantial and rich data through selected interviews in phase III. The adoption of this approach is justified through a discussion of general issues of validity and reliability. Section 3.2 also introduces the time line for the research study.

Section 3.3, in two parts, elucidates the research **methodology**. Part 1 tackles the research questions from a quantitative point of view whilst Part 2 tackles the same research questions from a qualitative perspective.

Section 3.3 part 1 commences by stating the research questions and hypothesis. It explains how the quantitative research methodology was applied using a "flip-flop" or counter-balanced research strategy. It explains and justifies the selection and content of the initial data collection instruments in the form of four mathematics achievement tests, alternating in parallel pairs, for grade 8 learners, and presents their specification frameworks. It also explains how the tests were piloted, refined and validated in terms of content, constructs and expert opinion, and how their reliabilities were established in terms of standard procedures.

A rationale is presented for the selection of the test items in terms of the requirements of the current grade 8 mathematics curriculum, explaining why they were appropriate for the samples of learners tested. Details of the refined tests are given and justified, e.g. their final length, their scaling, their time restrictions, the difficulty of the test items and the cognitive processes which the items were purported to be assessing in terms of the specifications frameworks given for each of the four tests.

It describes the site and samples of learners and justifies their selection in terms of specific criteria related to the research questions. Section 3.3 part 1 also presents the criteria used for the selection of the site and the sample; it describes the administrative procedures engaged to produce the quantitative data; and it describes the implementation of the relevant research ethics.

Section 3.3 part 2 of the research methodology tackles the research questions with a qualitative approach. It introduces the main data generating instruments: the interview schedules. It justifies the inclusion of each question in the schedules and explains the selection criteria in each instance. It justifies the selection and validation of the interview items in terms of criteria specifically linked to the main research questions; and it describes the samples of interviewees. The data collection procedures are described, together with the relevant ethical considerations. Then follows the discussion and explanation of the procedures adopted for systematizing and treating the interview data produced. Issues of reliability and consistency are also considered.

Section 3.4 of this chapter briefly considers some of the possible limitations of the research design and methodologies adopted in this study.

Section 3.5 supplies a summary or overview of Chapter 3.

3.2 Research design

The research design was shaped by the core research questions that were formulated in Chapter 1 investigating:-

- Whether the performance of a convenient sample of 89 grade 8 learners on a linguistically formatted mathematics test was different from the performance of the same grade 8 learners on a symbolically presented mathematics test of similar content;
- Whether the performance differential remained the same two months later with a new mathematics content test;
- Whether there was a statistically significant difference in the learners' mathematics achievements when the same test content was presented in two different formats: symbolically and linguistically; and
- Whether the performance difference depended on the sequence in which the two different formats were presented.

Adopting the 26 indicators developed by the DoE (Chapter 1: page 5), three of the four pedagogical dimensions considered in this study were:

- input indicators, providing information on the resources and infrastructure of the system;
- process indicators, providing information on aspects related to the teaching and learning process; and
- output indicators, providing information on the outcomes of the system, one of which is learner performance in numeracy and literacy

In order to look at these three aspects comprehensively, I decided to engage a mixed methods approach for this study, as explained on the following pages.

3.2.1 The adoption of a mixed methods research design

In the production of new knowledge, universities have been moving from a Mode 1 epistemology of learning (i.e. one that is: factual, systematic, explicit, objective, codified, fragmenting into more and more specializations, reductionist, orderly, empirical, establishment-minded, context-independent, theory-bound, authoritarian, empirical, universal and transcultural) to a Mode 2 epistemology (one that is: holistic, context-driven, mission-orientated, multi-authored, heterogeneous, divergent, reflexive, personalized, insecure, entrepreneurial and workable) - Hills & Tedford (2003:17-28).

After conducting a pilot trial, the nature and design of the main study allowed me to use both qualitative and quantitative research methods, which encompassed both Mode 1 and Mode 2 epistemologies of research. Firstly, a series of alternatively formatted mathematics achievement tests was administered to a sample of Grade 8 learners; and then this manner of data generation was followed up by personal interviews with selected participants drawn from the learners, plus the educator who taught the sample group, with the intention of interpreting, corroborating and explaining the outcomes of the primary data collection.

Much discussion has occurred about the differences between qualitative and quantitative research. Bauer and Gasell (2000:7) summed it up as follows. Quantitative research deals with numbers, uses statistical models to explain the data, and is considered 'hard' research. By contrast, qualitative research tends to avoid numbers, it deals with 'interpreting' social realities and it is considered 'soft' research. Table 3.1 broadly summarises some differences between the two strategies.

Table 3.1 A summary of several main differences between quantitative and qualitative research approaches to the generation of data (Bauer and Gasell 2000:7).

	Strategy	
	Quantitative	**Qualitative**
Data	Numbers	Texts
Analysis	Statistics	Interpretation
Prototype or example	Opinion polling	Depth interviewing
Quality	Hard	Soft

Struwig and Stead (2001:4) view quantitative research as a form of conclusive research involving large representative samples and a fairly structured data collection procedure, with the primary role being to test a hypothesis. They define a hypothesis as a proposition (or statement) regarding the relationship between two or more variables (phenomena) that can be tested. Quantitative research requires that the data collected be expressed in numbers (i.e. they can be quantified). It is the type of research format that may be influenced by many factors, and the most common methods used to conduct quantitative research are described as either exploratory, descriptive, experimental or quasi-experimental.

On the other hand, the term 'qualitative research' does not describe a single research method and, although its not easily defined, it has certain characteristics that distinguish it from quantitative research. It concerns itself partly with approaches such as phenomenology, ecological psychology, ethnography, symbolic interactionism and postmodernism (Bryman, in Struwig and Stead 2001:4). It employs research methods such as participant observation, archival source analysis, interviews, focus groups and content analysis. Therefore, qualitative research can be viewed as interdisciplinary, multi-paradigmatic and multi-method (c/f Denzin and Lincoln, in Struwig and Stead, 2001:11).

Furthermore, a qualitative approach locates the researcher firmly within the research process and acknowledges the role of researcher subjectivity. Fundamentally, such an approach strives to gain a deep understanding of a phenomenon from an insider perspective; and it proposes to describe and understand rather than explain and predict human behaviour (Babbie, Mouton, Payze, Vorster, Boshoff, & Prozesky, 2001:53). Key within such an approach is acquiring an understanding of individual perspectives and experiences, and understanding the phenomenon in natural settings (Fraenkel & Wallen, 1993 and Maykut & Morehouse, 1994). This implies an all-embracing approach which includes a sensitivity to context and process, an inductive approach to analysis, flexibility in research and design and a commitment to understanding, rather than to prove or to promote (Green, 1998).

3.2.2 Justification for the choice of both qualitative and quantitative methods

Layder (1988), cited in Brannen (1995:3), stated that traditionally a gulf had been perceived between qualitative and quantitative research, with each belonging to distinctly different paradigms. The distinctions between the paradigms relate to a number of levels concerning the production of knowledge and the research process. Many researchers see themselves as belonging to either one or other paradigm, whereas others are able to combine the two methods. Flick (2002:257) also supports this view. He sees the combination of both qualitative and quantitative research approaches crystalised as a perspective and also being compatible opposites which may be combined. He sees qualitative research as comprising a specific understanding of the relationships between issues and methods, whilst the traditional version of quantitative research starts with the building of a model from which an hypotheses is derived and tested against empirical conditions. However I had decided to use both the qualitative and quantitative methods because the results from the quantitative tests might turn out to be supported by the interviews which would be conducted subsequently in the qualitative phase. In the following section I review both methods of research and I will show how both relate to this type of study conducted.

How does the qualitative approach relate to my study?

The reason for my choosing qualitative research to supplement or complement the quantitative findings may be aptly summed up by Bogdan and Biklen (1992:29-32) when they presented several characteristics of qualitative research:

- It takes place in the **natural** setting and is fundamentally concerned with **context**.
- It is descriptive, with emphasis on **detail** rather than on generalities.
- It is concerned with the **process** rather than the outcomes of the test.
- The data is analysed inductively with its aim being to develop **grounded theory**.
- The **meanings** that the research subjects/participants attribute to the events and actions being studied are of central concern.

My research was partly classroom-based and, through interviews, it attempted to elicit the influence that different aspects of language might have had on the learning of mathematical calculations and on mathematical concepts. Studies have shown the existence of differences in learners' responses to various tasks when studies were conducted in both a controlled laboratory setting and a classroom setting.

My qualitative analysis was descriptive and it concentrated on how the ten learners selected for the interviews interpreted their own disclosed test results and how they commented on why they obtained the scores they did in the series of tests.

My main concern was to discover how language as both an input and process variable possibly influenced the learning of mathematics and mathematical concepts. Nevertheless, the results obtained were important for both the learners and teacher, as part of the school's programme of continuous assessment and accountability. For this reason the series of tests were conducted in two phases to try to reduce external factors that might have influenced the results obtained.

As the researcher I had initial prior perceptions and conceptions of how language usage theory might be influencing the learners' classroom mathematics performance results.

This small-scale research study sought to evaluate to what extent my preconceived ideas were supported by the emergent data. In my analysis of the data I also attempted to give an account of results obtained by the learners in the series of tests, taking their points of view into consideration. Their meanings and explanations have also been presented and discussed in my analysis and interpretation of the results in later chapters of the dissertation.

How does quantitative research relate to my study?

Quantitative research is grounded in the numerical measurement of the data under investigation and thus it explores traits and situations from which numerical data can be obtained. It makes heavy use of measurement and statistics (Charles, 1995:21). This view was supported by Brannen (1995:5) who defined quantitative research as being typically associated with the process of enumerative induction, with its main purpose being to discover a relationship between variables or aims to infer a characteristic. Quantitative research does not always test hypotheses, even though its goal is often descriptive, and those who work with this method frequently neglect to include theoretical and statistical inferences.

My study measured how many individuals had the same pattern or characteristic. Because the measurable data for the research was collected from a primary source, i.e. the learners, it was collated and diagnosed statistically. In total, a series of four tests was administered sequentially to the participant sample. This numerical data was then analysed and interpreted statistically so as to support or refute the hypothesis.

3.2.3 Triangulation

Punch (1998: 247) refers to triangulation as "how the findings from one type of study can be checked against the findings deriving from the other type. For example, the results of a qualitative investigation might be checked against a quantitative study. The aim is generally to enhance the validity of findings". Thus it refers to the extent to which independent measures confirm or contradict the findings. Various methods can be used to analyse the data such as observation, quantitative measures, interviews or documents. Some researchers complement their qualitative findings with data from quantitative measures to determine if similar patterns in the data emerge from both analyses. Furthermore, if the data from the various sources are in conflict with one another this should not be ignored. As conflicting as they may be, such contradictions may be used to broaden the interpretation of the data collected and may enable the researcher to view the research from a new perspective.

In the current study I used the technique of triangulation by combining the qualitative and quantitative methods, as the two different methodological perspectives complemented each other. In his original formulation of triangulation Denzin, in Brannen (1995:11), saw the combining of research strategies as a means to examine the same research problem from different perspectives and so to enhance claims concerning the validity of the conclusions that could be reached about the data. In Denzin's view, the assumption was that the data generated by the two approaches, which were assumed to focus on the same research problem, were consistent with - and were to be integrated with - one another. I tried to link both the qualitative and quantitative research to confirm and corroborate the results obtained. It also helped me to develop the analysis procedure. In the future it may assist me and others to develop new ways of thinking how aspects of language may influence the learning of mathematical word sums for grade eight learners.

3.2.4 The research strategy: Phases I and II

The tests were administered in two phases, following a counter-balanced or "flip-flop" research methodology design, as depicted in Figure 3.1. The term "flip-flop" was coined after Adentula's (1990) counter-balanced study as it was somewhat similar in design. I emulated this method of testing when I tried to explain how the two parallel tests comprising a Notational Format test and a Language Rich Format test were administered. It merely means that the testing was done in two phases where Phase I Test 1 was a Notational Format test followed by a Language Rich Format test (Test 2) and in Phase II the sequence of testing was switched around where the Language Rich Format test (Test 3) was administered first then followed by the Notational Format (Test 4) - in other words it implemented a “vice versa” or “alternating” research approach. The switching around of the two formats in the testing phases was done so not to favour the one format test over the other format test and thus they were interchanged in Phase II.

A comparable analogy to the “flip-flop” design occurs in the game of tennis when players reverse ends regularly as the match progresses, or in soccer during extra time when the sides reverse ends half way through. This influence of extraneous factors such as sunlight in the eyes of one team, the presence of a headwind down the ground benefiting one team, etc. would thus affect both teams as they both would be exposed to the same factors equally.

In figure 3.1 which follows the "flip-flop" research design is depicted diagrammatically. In the pilot study the design consisted of 20 items which were later reduced, after refinement, to 17 items in the final version of the tests.

Figure 3.1 Diagram depicting the "flip-flop" research design. The 20 items were reduced, after refinement, to 17 items in the final version of the tests.

PHASES	MATHEMATICS CONTENT DESIGNATION	TEST CONTENT	TEST FORMAT
PHASE I of flip-flop procedure	Summative Test 1 Mathematics content X (Week 1)	20 original arithmetical calculations by numbers	Notational Format NF (numerical)
	Summative Test 2 Same mathematics content X (Week 3)	20 original identical arithmetical calculations by words	Language Rich Format LRF (words/verbal)
PHASE II of flip-flop procedure	Summative Test 3 Mathematics content Y (Week 12)	20 new arithmetic calculations by words	Language Rich Format LRF (words/verbal)
	Summative Test 4 Same mathematics content Y (Week 14)	20 identical new arithmetical calculations by numbers	Notational Format NF (numerical)

3.2.5 The interviews (data collection in Phase III)

To contextualize or moderate the quantitative results obtained in Phases I and II, the interviews were designed. This formed Phase III, comprising individual interviews with a selected group of learners and the educator.

Bless and Higson-Smith (2000:105) stated that interviews involve direct personal contact with a participant who is asked to respond to a set of questions. Those interviewed are free to expand on the topic as they see fit, to focus on particular aspects and relate their own experiences. The interviewer may intervene to ask for clarification or further explanation, but not to give directives or to confront the interviewee with probing questions.

There are three common types of interviews, namely, the structured interview, the focused or semi-structured interview, and the unstructured interview (Minichiello, Aroni, Timewell, & Alexander, 1990: 89). The interviews I conducted with a selected sample of learners were structured, where I asked each interviewee a series of pre-determined questions, in the same order, yet also it was informally conducted.

3.2.6 Issues of reliability and validity in quantitative and qualitative research

Reliability and types of reliability in quantitative research

Reliability may be defined as the extent to which test scores are accurate, consistent or stable (Struwig & Stead 2001: 130). A test score's validity is dependent on the score's reliability since, if the reliability is inadequate, the validity will be poor. Therefore it is important to determine a score's reliability before examining its validity. Nevertheless, a test score can be highly reliable yet still be invalid (e.g. the time on the clock that is consistently five minutes slow). A reliability coefficient, which generally has a value between 0 to 1.00, reflects an estimate of the extent to which 'true' variance, rather than 'error' variance, comprises the observed score variance (Struwig & Stead 2001: 131).

Error variance can occur for the following reasons (Kline, 1987:121-122):

- Subjective marking, as it allows for differences between markers and between the same marker on different occasions.
- Guessing by the testees; however it affects mainly true-false items.
- The items may reflect different meanings to the testees (i.e. the items are ambiguous).
- The test items may be subjectively or inaccurately scored.
- The test may not be administered correctly.
- Test length: the longer the test, the more reliable it will be.

- Test instructions should be unambiguous and clear.
- The testing environment may distract participants.
- The participants may not be motivated to complete the test.

There are various ways to determine the reliability of test scores, namely: test-retest reliability, parallel-forms reliability, split-half reliability and internal consistency reliability (Struwig & Stead 2001: 131).

In the case of this study, pairs of equivalent or parallel or similar tests were administered twice to the same (intact group of) individuals over a period of time. The time interval was a gap of two weeks between the equivalent Tests 1 and 2, with an interval of two months between the first phase and the second phase of testing with the new but equivalent Tests 3 and 4. The time period and interval were neither too short, lest the participants remember the questions; nor too long lest the participants matured so much that their responses were affected. Furthermore, the test-retest reliability was determined by pairing the scores from the first phase of testing and second phase of testing and then I calculated an appropriate correlation coefficient on the scores received.

Phase I, which consisted of administering two methods of testing, and Phase II which also scheduled two methods of testing, involved both parallel-forms or equivalent forms, even though they were interchanged, so that the value of the reliability coefficient might be increased. Lastly, the internal consistency reliability index was determined by means of the Cronbach alpha (α) calculation. The Cronbach coefficient alpha is appropriate when individuals respond to items on multiple levels (Struwig & Stead 2001: 133).

Reliability and types of reliability in qualitative research

In qualitative research, reliability is also viewed as being synonymous with consistency (Struwig and Stead, 2001: 133). Types of qualitative reliability are quixotic reliability, diachronic reliability and synchronic reliability (Kirk and Miller, 1986:41). They refer to quixotic reliability as any observational method that continually provides you with the same findings. Diachronic is similar to test-retest reliability used in quantitative research in that your observations are stable over time. Synchronic reliability refers to the extent to which observations from different sources are similar within a specified time period. The only way in which this study addressed qualitative reliability was by means of the interviews that were conducted. The study had only one person conducting the interviews and the interviewer was a person who had some training in interview techniques. To eliminate ambiguity the same set questions, asked consistently by the same interviewer, was given to the candidates who were selected to participate in the interview process.

Validity in quantitative research

Validity in quantitative research refers to the extent to which a research design is scientifically sound or appropriately conducted, and it comprises external and internal validity. External validity is the question of generalizability. How far are the findings of the study generalisable (Punch, 1998: 260)? It addresses the extent to which you can generalize the results of a single, small-scale study to another population or to a different group. It is intimately linked to the sampling procedures, time, place and conditions in which the research was conducted. Internal validity addresses the issue of whether the pre-selected independent variables, and not other extraneous variables, were responsible for the variations in the dependent variables (Struwig & Stead 2001: 136).

To safeguard the validity the same learners were used for all four tests, and they were taught by the same educator in the same venue. They were even tested at the same time of day, in the same period on the timetable, and on the same day of the week for all the tests. Even the invigilator was the same in each phase of the tests. Thus I tried to control the extraneous variables as far as possible so that I could be more confident about whether the changes in the dependent variable were due to the independent variable and not to the extraneous variables.

Validity in qualitative research

Validity in qualitative research is also referred to as trustworthiness or credibility. According to Mishler (1990:419), validation is the 'degree to which we can rely on the concepts, methods, and inferences of a study, or tradition of inquiry, as the basis for our own theorizing and empirical research'.

Struwig & Stead (2001: 146) offer some general considerations when using reliability and validity in both qualitative and quantitative research, as follows: -

When using qualitative research, and when reporting the reliability and validity of the data, attention should be focused on:

- the background of the researchers;
- taking the data back to the participants for their comments on its accuracy;
- the use of terminology and interpretation of the data;
- checking the data coding on different occasions, or asking other raters independently to provide their categories, and then comparing the coding schemas. The use of triangulation can also contribute to the validity of the findings.

When using established quantitative measures it is important to report parameters such as the reliability and evidence for the validity of test scores obtained in previous studies (e.g. the mean with its standard deviation and the frequency). It is essential to report the nature of the sample tested.

Using Struwig & Stead (2001: 146) as my guidelines I ensured that my tests met acceptable levels of reliability and validity by conforming to the general considerations stated above, as reported in more detail in Chapter 4 which records the values obtained for the four Cronbach alpha reliability coefficients, etc.

3.2.7 Time–line

For the various types of data production, the time-line was as follows.

January:	Pilot study and refinement of the test items.
Mid-February:	Administration of Phase I Test 1 i.e. the Notational Format (NF), content X presented in traditional mathematics textbook format sums.
End of February:	Administration of Phase I Test 2 i.e. the Language Rich Format (LRF), the same mathematics content X sums presented in sentence format.
Mid- April:	Administration of Phase II Test 3 i.e. the Language Rich Format (LRF), content Y sums presented in sentence format.
End of April:	Administration of Phase II Test 4 i.e. the Notational Format (NF), the same mathematics content Y sums presented in traditional mathematics textbook format.
May:	Follow-up consultations and interviews were conducted with selected samples of learners and with educator K.

3.3 Part 1- the quantitative research methodology

3.3.1 Hypotheses/ research questions

The following research questions and hypotheses were addressed:

(1) Is the performance of grade 8 learners on a linguistically formatted mathematics test significantly different from the performance of the same grade 8 learners on a symbolically presented mathematics test of similar content?

(2) Does the performance differential remain the same two months later with a new mathematics content test?

(3) Is there a statistically significant difference in learners' mathematics achievements when the same test content is presented in two different formats: using symbols and using words that replace the symbols?

(4) If so, does the performance difference depend on the sequence in which the two different formats are presented?

The Null Hypothesis

That, for the constant sample of grade 8 learners, there will be no significant differences between the achievement score means obtained by the learners when fixed mathematics test content is examined using two different formats of testing, irrespective of the sequence of presentation of the two pairs of equivalent formats of two extracts of mathematics content.

3.3.2 Methodology using the "flip-flop" research strategy

In Phase I, Test 1 measured the basic mathematical content X of the learner in traditional notational textbook format, hence known as the Notational Format (NF).

Test 2 measured the same learners' performance content X by means of the same sums that were used in Test 1 but, in this instance, the Language Rich Format (LRF) replaced the simple mathematical signs and symbols.

In the second phase (Phase II), Test 3 with mathematical content Y was presented to the same sample in Language Rich Format first, i.e. the sequence of presentation was now reversed.

Finally Test 4, measuring performance on the same mathematical content Y was presented in Notational Format (NF) to the same sample of learners.

The instruments and data collection techniques in Phase I and Phase II

After conducting a feasibility study with sets of 20 mathematical items on trial, reported below in section 3.3.3, I developed two sets of parallel tests each containing 17 items or questions. Each set comprised of a Notational Format test and a Language Rich Format test. I had adapted some examples in Macmillan Mathematics edited by Thorburn (1987) and these were similar to the Year 8 Mathematics Assessment from the University of

New South Wales Educational Testing Centre (2004) a test which was undertaken by the Western Cape Education Department(WCED). A copy this WCED test and the results of the test are included in Appendix 6. Copies of the tests 1 to 4 which I designed and that was used are reproduced below.

Figure 3.2 Phase I Tests 1 and 2, followed by Phase II Tests 3 and 4

PHASE I Mathematics Test 1 administered in mid-February.

NAME:…………………………………………………… AGE:……………

HOME LANGUAGE:………………… GENDER: Male/ Female
(circle the correct one)

Starting Time:……….

1. 127 + 17 =
2. 1725 – 1274 =
3. 7 x 5 =
4. 872 – 427 =
5. 8276 – 984 =
6. 8721 - 4720 =
7. $90^0 - 82^0$ =
8. 6 x 5 =
9. 197 – 87 =
10. 105 ÷ 5 =
11. 3878 – 3052 =
12. $\sqrt{121}$ =
13. 54 ÷ 6 =
14. $^3\sqrt{27}$ =
15. 360 ÷ 4 =
16. 72 ÷ 2 =
17. R3.75 + R2.75 + R15.78 =

PHASE I

Mathematics Test 2 administered at the end of February.

NAME:.. AGE:...............

HOME LANGUAGE:..................... GENDER: Male/ Female

(circle the correct one)

Starting Time:..........

1. Find the sum of 17 and 127.
2. Subtract 1274 from 1725.
3. Find the product of 5 and 7.
4. If point A equals 427 and point B equals 872. Find the distance between point A and B.
5. Decrease 8276 by 984.
6. From 8721 subtract 4720.
7. Give the complement of 82 degrees.
8. Karen bought 6 CD's. There were 5 songs on each CD. How many songs did she buy in total?
9. Find the difference between 87 and 197.
10. Prove by means of division that 5 is a factor of 105.
11. A plane flies non-stop from New York to London. The distance covered is 3052 kilometers. A second plane flies non-stop on the exact route but lands in Athens. The distance now covered is 3878 kilometers. How far apart is Athens and London?
12. Give the square root of 121.
13. Sid has 54 nails. He wants to put 6 nails in each row. How many rows could he fill?
14. Give the cube root of 27?
15. A revolution is divided into 4 equal parts. How many degrees will each part consist of?
16. A angle of 72 degrees is bisected. Give the answer you would have after the angle is bisected.
17. Jacki goes to the shop and purchases a bread for R3.75, a piece of cheese for R2.75 and R15.78 worth of meat. What is the total cost of her shopping spree?

PHASE II

Mathematics Test 3 administered in mid-April.

NAME:………………………………………………… AGE:……………

HOME LANGUAGE:………………… GENDER: Male/ Female
(circle the correct one)

Starting Time:……….

1. Find the answer when 296 is decreased by 18.

2. Find the sum of 517;142 and 785.

3. What is the square of 11?

4. What would it cost to purchase 8 liters of cooldrink if 1 liter costs R5.26.

5. Find the square root of 81.

6. What is the product of 728 and 8271?

7. Find the difference between 64 and 624.

8. What is the complement of 28 degrees?

9. What is the cube of 3?

10. What is the supplement of 72 degrees?

11. If point X equals 547 and point Y equals 876.

    Find the distance between point X and Y.

12. Find the answer when an angle of 82 degrees is bisected.

13. Increase 529 by 872.

14. From 8921 subtract 8704.

15. Find the cube root of 27.

16. A revolution is divided into 3 equal parts. How many degrees does each part consist of.

17. Find the quotient of 5 and 625.

PHASE II

Mathematics Test 4 administered at the end of April.

NAME:…………………………………………………… AGE:……………

HOME LANGUAGE:………………… GENDER: Male/ Female
(circle the correct one)

Starting Time:……….

1. 296 -18=
2. 517+142+785=
3. 11 x 11=
4. R5.26 x 8=
5. $\sqrt{81}=$
6. 728 + 8271=
7. 624 - 64=
8. $90^\circ - 28^\circ =$
9. $3^3 =$
10. $180^\circ - 72^\circ =$
11. 876 - 547=
12. $82^\circ \div 2^\circ =$
13. 529 + 872=
14. 8921 - 8704=
15. $\sqrt[3]{27} =$
16. $360^\circ \div 3 =$
17. $625 \div 5 =$

3.3.3 Pilot study conducted prior to Phase I and Phase II

A pilot study with a mathematics test comprising 20 items was conducted prior to the main study. This feasibility study used auxiliary grade 8 learners from a school in a neighbouring metropole and also two grade 9 classes at the school chosen as the site for the study. The reason for the pilot study was to test whether any of the 20 items asked were ambiguous, and also to see what time duration would be sufficient for the tests. The pilot study revealed that three of the questions (items 6, 9 and 12) caused some ambiguity in the responses. After consultation with Teacher K and other mathematics educators at various schools the questionable items were subsequently omitted from the tests given to my two sample classes in the main study. The problem with the questions was that they were easily understood in Test 1 which was in Notational Format (NF) but the problems arose during Test 2 when the same sum was tested in Language Rich Format (LRF). It was found that the sum was somewhat clumsy when I tried to put it in Language Rich Format. In Figure 3.4 the questions that caused problems are highlighted and I decided to leave them out of the final set of tests and that was how I arrived at 17 test items.

Also included on the sheet of pilot study items was a space where the learners wrote down their starting time and finishing time. From the recorded data of the pilot study I found that 30 minutes would be ample time for the completion of each of the individual tests. A copy of the unrefined pilot study test is reproduced below in Figure 3.3.

After the pilot study was conducted, in the main study Tests 1 to 4 comprising of 17 items each were administered during the learners' timetabled mathematics periods, inside their usual mathematics classroom during normal mathematics lessons, for the maximum duration of 30 minutes on each occasion. The respondents were guided on how to answer the questions, if there were any queries about how or where to supply their attempted answers.

Figure 3.3 The unrefined Notational Format mathematics test consisting of 20 items used in the pilot study with auxiliary learners.

Pilot study Mathematics Test 1

NAME:…………………………………………………… AGE:…………….

HOME LANGUAGE:………………… GENDER: Male/ Female (circle the correct one) Starting Time:……….

1. 127 + 17 =
2. 1725 – 1274 =
3. 7 x 5 =
4. 872 – 427 =
5. 8276 – 984 =
6. 247 + (82 x 64)
7. 8721 - 4720 =
8. 247 + (82 x 64) =
9. $90^0 - 82^0 = 794 - (248 + 126) =$
10. 6 x 5 =
11. 197 – 87 =
12. $720^0 \div 6 =$
13. $105 \div 5 =$
14. 3878 – 3052 =
15. $\sqrt{121}$ =
16. $54 \div 6 =$
17. $^3\sqrt{27}$ =
18. $360 \div 4 =$
19. $72 \div 2 =$
20. R3.25 + R2.75 + R15.78 =

Finishing time: ……………………

Figure 3.4 The unrefined Language Rich Format mathematics test consisting of 20 items used in the pilot study with auxiliary learners.

Pilot Study Mathematics Test 2, with the three troublesome items highlighted.

NAME:.. AGE:...............

HOME LANGUAGE:..................... GENDER: Male/ Female (circle the correct one) Starting Time:..........

1. Find the sum of 17 and 127.
2. Subtract 1274 from 1725.
3. Find the product of 5 and 7.
4. If point A equals 427 and point B equals 872. Find the distance between point A and B.
5. Decrease 8276 by 984.
6. Increase 247 by the product of 82 and 64.
7. From 8721 subtract 4720.
8. Give the complement of 82 degrees.
9. Find the difference between 794 and the sum of 248 and 126.
10. Karen bought 6 CDs. There were 5 songs on each CD. How many songs did she buy in total?
11. Find the difference between 87 and 197.
12. The size of two revolutions are divided into six equal parts. How many degrees does each part consist of?
13. Prove by means of division that 5 is a factor of 105.
14. A plane flies non-stop from New York to London. The distance covered is 3062 kilometers. A second plane flies non-stop on the exact route but lands in Athens. The distance now covered is 3878 kilometers. How far apart are Athens and London?
15. Give the square root of 27.
16. Sid has 54 nails. He wants to put 6 nails in each row. How many rows could he fill?
17. Give the cube root of 27?
18. A revolution is divided into 4 equal parts. How many degrees will each part consist of?
19. A angle of 72 degrees is bisected. Give the answer you would have after the angle is bisected.
20. Jacki goes to the shop and purchases a bread for R3.25, a piece of cheese for R2.75 and R15.78 worth of meat. What is the total cost of her shopping spree?

Finishing time: ....

3.3.4 The specifications framework for the four tests

The selection of the test items that were included in the four tests had to adhere to the RNCS Grades R - 9 (Schools) Policy as specified out for mathematics by the Department of Education (DoE). The table below is compiled from the RNCS Assessment Standards of the DoE (2002b:69-87). It indicates how the four tests reflected the Assessment Standards (AS) as prescribed by the DoE concerning what the learners should know and which they should be tested.

Table 3.2 Indicates how the four tests reflected the Assessment Standards (AS) as prescribed by the DoE concerning what the learners should know and on which they should be tested.

Assessment Standard	AS Found in which Test	Item Number in the Test reflecting the AS
Recognises, classifies and represents numbers in order to describe and compare.	Test 1 Test 2 Test 3 Test 4	12,14,17 10,12,13,14,17 5,9,15 5,9,15
Recognises and uses equivalent forms of rational numbers.	Test 1 Test 2 Test 3 Test 4	12,14 12,14,15,16 3,5,9,15 5,9,15
Solves problems in context, e.g. financial.	Test 1 Test 2 Test 3 Test 4	17 17 4
Estimates and calculates by selecting and using multiple operations.	Test 1 Test 2 Test 3 Test 4	 11,13 16 9,12,16,17
Uses a range of techniques to perform calculations.	Test 1 Test 2 Test 3 Test 4	1-16 1-16 1-16 1-16

Investigates and extends numeric and geometric patterns.	Test 1	
	Test 2	4,8,10,13
	Test 3	11
	Test 4	
Determines analyses and interprets the equivalence of different descriptions.	Test 1	12,14
	Test 2	12,14
	Test 3	5,9,15
	Test 4	5,9,15
Uses conventions of algebraic notation and the commutative, associative and distributive laws.	Test 1	12,14
	Test 2	12,14
	Test 3	5,9,15
	Test 4	5,9,15
Interprets and use basic algebraic vocabulary.	Test 1	14,
	Test 2	1,2,3,5,6,14
	Test 3	9
	Test 4	
Recognises, visualises and names geometric figures.	Test 1	7
	Test 2	7,15
	Test 3	16,
	Test 4	10,16,
Solves problems involving time, distance and speed.	Test 1	
	Test 2	11
	Test 3	11
	Test 4	
Uses a range of strategies to check solutions.	Test 1	1-16
	Test 2	1-16
	Test 3	1-16
	Test 4	1-16

3.3.5 Site and sample

The study was confined to grade 8 learners at one school in the former Department of Education and Culture [formally known as the House of Representatives] in Cape Town. The school had a population of more than 1200 learners and a staff of 35 educators. The learners varied in their socio-economic background due to the physical situation of the school, which lay between a sub-economic housing estate and an upper middle class suburb. The school was both co-educational and dual medium but, for the purposes of this study, I decided to make use of the learners who had English as their Language of Learning and Teaching (LOLT). Another reason for selecting the school as the site for the study was that part of the entrance requirements to grade 8 required the learners to be subjected to a diagnostic test in English, Afrikaans and Mathematics. Being one of the mathematics educators at the school I found that the results of the mathematics tests were remarkably low. A main concern was the nature of the sums that the learners were required to read before answering. I noticed that the learners scored better in the plain algebra sums which did not contain any words. This was deemed to be a problem at the school and my investigation was motivated by my curiosity to see if this was a once off occurrence or the trend at the school.

The learners were drawn from two grade 8 classes, both of which had the same mathematics educator, teacher K (not the writer). Having both classes being taught by the same educator in the same venue eliminated the influence of two possible extraneous variables.

The mathematics teacher K was well qualified, having a degree and nine years of teaching experience. She viewed mathematics as a dynamic activity that was interesting, fun and important in the broader educational process. She tried to convey these facets to her learners, within the constraints of teaching classes that had an excess of 50 learners each. She also had to complete the syllabus with some time constraints and also had to prepare her learners for examinations. She also encouraged her learners to talk and verbalise their ideas to develop their competence and confidence in using English to express their opinions.

Data was gathered from a sample of 105 Grade 8 English first language speaking learners at the school. The majority of the learners in both classes had in-depth prior exposure to mathematics since all had experienced mathematics classes from grade 1 to grade 7, with all of them having passed the grade 7 level of mathematics. The school had two grade 8 English-speaking (Language of teaching and learning) classes consisting of 53 learners and 52 learners respectively. These were the two classes that were used as my sample. Of the 105 learners who participated in the mathematical exercises, 48 were girls and 57 were boys. Their ages varied from 13 years to 15 years.

3.3.6 Treatment and presentation of the data from Phase I and Phase II

After the tests were administered they were marked with a memorandum (see Appendix 4). All the raw scores from Tests 1 to 4 were collated and those learners who had not completed all four tests in Phases I and II were omitted. The total sample at the start of the investigation was 105, as stated above, but if any of the learners were absent or if any learners missed one of the four tests given, the final sample was reduced. After the tests were marked, the scores were totaled and the means were calculated. An internal consistency reliability coefficient was then to be calculated by means of the Cronbach alpha (α) formula as the Cronbach coefficient alpha is appropriate when individuals respond to items on multiple levels.

3.4 Part 2- the qualitative research methodology

Eight learners were purposely selected for interviews, depending on their results obtained in the notational and language formats tests. The interviewees were chosen directly and purposefully on the basis of the scores they obtained in their series of tests. They were selected using the following criteria:

1. If their scores remained the same in the *Language Rich Format test* and *Notational Format test* in either of the two phases; or
2. If their scores reflected an appreciable increase from *Language Rich Format test* to the *Notational Format test* in either of the two phases; or
3. If their scores reflected any statistically significant decrease from *Language Rich Format test* to the *Notational Format test* in either of the two phases.

The teacher who was the mathematics educator for all the learners that participated in the investigation was also interviewed about her role as facilitator in the learning of mathematics.

The interviews focused on how language presentation format may have impacted on the results or scores on the tests conducted. While conducting the interviews I had access to the test answers that the learners had written for me, as well as the results they obtained for the tests, and the memorandum used to mark the test. The scored tests were handed back to them during the interviews and these scores assisted me in the modification of the schedule of questions drawn up in outline prior to the interviews.

The interviews were conducted privately and individually with learners so that they did not feel intimidated by the presence of the rest of their peers, and thus they could express themselves more freely.

Each interview was conducted during school time in the school's Learner Representative Council room, where few or no interruptions took place. A twenty-minute period was scheduled to limit the amount of time spent interviewing. The interview with the teacher K took place after school in the staff workroom when all the other educators have left. This prevented interruptions.

The interviews with the school learners took place two months after the initial tests had been administered, as I thought that the tests were still relatively fresh in their memories but would not impact on the work that still had to be done in the new term. Follow-up interviewing was carried out if I considered that insufficient data had been gathered.

The interviews were tape-recorded and transcribed later. Some field notes were also taken but these were limited so as not to break the flow of the conversation between interviewer and interviewee. All the interviews were structured around the framework of how language appears to influence their mathematics performance.

The interview data was collected over a period of two days. Subsequently the dialogue was transcribed but minor aspects of the discussion such as voice tone, and other phonetic characteristics were not transcribed, as they were unnecessary for the purposes of this study and my analysis. It was anticipated that each interview would last approximately twenty minutes but this was only a guideline as some interviews took longer than others. I did not set myself a cut-off time for each interview. I allowed myself the leisure of not being dictated by time but rather by the process of the interview. Thus no fixed time limit was set to constitute the time allocation for face-to-face discussion for the purpose of the data text. The data was then analysed to substantiate, contextualise or moderate the results obtained from analyzing the raw test scores. Figure 3.5 presents a copy of the interview schedule of questions used with eight learners and, separately, Figure 3.6 gives the questions that were used with the educator.

Figure 3.5 The schedule of interview questions used to engage the responses of eight learners to elicit some responses to why they scored the results they did.

1. You scored ......*(specific result of the individual given)* out of 17 for Test 1 and ....*(specific result of the individual given)* out of 17 for Test 2. You then scored ......*(specific result of the individual given)* out of 17 for Test 3 and ....*(specific result of the individual given)* out of 17 for Test 4. How do you interpret the two results that you obtained?
2. Which test was more difficult in Phase I, Test 1 or 2?
3. Which test was more difficult in Phase II, Test 3 or 4?
4. Which one of the two test formats was easier?
5. Why do you say that the ....*(depending on which format they stated was easier)* test / format was easier?
6. Why did you improve / do worst / perform the same in the second phase of the test series(Phase II)?
7. Which test layout are you more accustomed too in mathematics and mathematics tests? (Notational or Language Rich Format).
8. Were there any words that caused problems in the test that was given if so would you tell me which words they were?
9. What do you say is teacher K's role in the mathematics classroom?
10. How do you rate yourself in mathematics? Do you rate yourself as average, good, bad, or as above average?
11. Do you enjoy mathematics and why /why not?

Figure 3.6 The schedule of interview questions used to engage the responses of the Educator teacher K.

1. How do the learners view their results of the test which they do?
2. Do they do any word sums in the grade 8 syllabus?
3. Do you think that these types of test provide information to us as mathematics educators?
4. What do you see as the objective for the series of test that was presented to the learners?
5. In your opinion which part of the grade 8 syllabus do the learners enjoy the most?
6. How do you see your role as educator so as to facilitate the learning process?
7. Do you think your learners you teach enjoy mathematics and why?

3.5 Research ethics and confidentiality

Prior to starting my study I explained to both classes the purposes and procedures of the research, and I had already obtained their permission. To the learners who were chosen later for the interview, I again explained the procedure and purposes of the interviews and stressed that the interviews would be confidential and be heard only by myself, their teacher and, where necessary, possibly a translator. I recorded the interview process and none of the learners asked to do the interview expressed any objections to being recorded.

The school's name was withheld to ensure that it is not stigmatised in any way. The participants in the tests remained anonymous. The results of the participants in the two phases, although matched, were recorded, but the participants remained anonymous.

The learners, who are also the respondents in the tests, were informed about the purpose and confidentiality of the research. The respondents were also informed that participation in the tests was voluntary and that at any time they could exclude themselves from the test. They were assured that their names and that of the school would be kept confidential and that fictitious names would be fabricated and allocated, if names were needed for any part of the reporting back or writing up of the study, even though they were asked to include their actual names on the test sheets.

Those chosen for the interviews remained anonymous and were assured that the research was to help advance the educational process. As teachers and researchers, we sought to learn where the mathematics shortcomings were, and thus the study would not in any way harm the learners' schooling and the results would not be used against them in any way. The research was one of investigation and not looking to blame any of the participants for the academic scores and results they obtained. The subsequent disclosures of achievement performances was not aimed to find fault with any of the participants but rather help analyse how the educational process itself might be improved. Also, the data collected by the researcher would in no way be manipulated, altered or changed to suit the researcher; instead, the presentation of all data would be truthful, open and transparent.

3.6 The data collection phases: an overview

The data collection in this study occurred in three phases. All the phases took place during one calendar year and lasted for a total of four months. The first phase was conducted in February where Test 1 and Test 2 were given to the learners and the data produced. The initial sample was 105 participants who were tested during their mathematics period (Phase I). Two months later in April (Phase II), the second round of tests were administered under the same conditions as that of the first phase except that the order or sequence of the tests that were reversed (switched around). In Phase I, Test 1 presented to the learners with a set of 17 sums (mathematics content X) in Notational Format (traditional mathematics textbook format). In Test 2 the same mathematics content X was presented but with the 17 sums in Language Rich Format (sentence format), one week later. In Phase II, a different Test 3 with mathematics content Y, was presented to the learners in Language Rich Format (sentence format), followed by a similar Test 4 but with mathematics content Y presented in Notational Format (traditional textbook format). Figure 3.2 earlier in the chapter presented the four tests that were administered during Phase I and Phase II.

In May the final number of participant learners was reviewed and where any of the learners missed one of the four tests they were excluded.

Phase III of the data collection process comprised interviews with some of the learners. This took place during May. The interviews were conducted with some of the respondents to elicit possible explanations for different test producing different scores; and to find out if there were any particular words which caused problems.

3.7 Limitations of the study

The study was confined to grade 8 learners at one school. In future, if any other study is conducted to see whether language influences the results obtained in mathematics achievement test scores, then the school sample should possibly be more representative of the diverse culture and language groups that exist in the post-apartheid South Africa.

In the present study the test content was limited to arithmetic and geometry. Each achievement test was limited to one language medium (English) and had only 17 items. The school was co-educational and dual medium, the learners varied in their socio-economic background but I decided to make use of only the sample of learners that were taught by the same educator (teacher) in one single language of instruction in the same classroom. The learners were drawn from only two classes out of six possible grade 8 classes. However both classes were taught mathematics by the same teacher.

I found myself as both insider and outsider in this research project. As a teacher of mathematics, and seeing the problems we have with language - or rather the lack thereof at school - I would thus classify myself as an insider and at the same time an outsider conducting research on a problem at hand at a school.

The structured interviews were conducted with only a few of the learners who were tested.

No observations were conducted to study how the learners actually engaged with teacher K and with other teachers in the classroom situation. (Possibly I might have gathered other information that could have assisted my discussion from such observations).

Overall, there are many limitations with testing in general even though I tried to eliminate these as far as possible.

3.8 Chapter summary

In this chapter the research design, the site and the sample in this investigation have been described, and the instruments used in the study have been explained. The hypotheses to be tested, the data collection procedures and the methods selected used have been described. The results and findings and their interpretation follow in Chapter 4.

CHAPTER 4: RESULTS, ANALYSIS, INTERPRETATION AND DISCUSSION

4.1. Introduction

The main objective of this study was to investigate how several aspects of language presentation format might influence grade 8 learners' levels of performance in selected mathematics tests.

As previously stated, my performance study thus investigated the relationship between language and mathematical knowledge with special reference to **Notational Format** and **Language Rich Format** equivalents presented in alternating sequences. It was carried out in two grade 8 classes in which the medium of instruction was English. The total sample at the start of the investigation was 105 but - due to learners' absences, or learners missing one of the four tests given - the final intact sample was reduced to 89. The performance testing took place in the learners' mathematics classrooms during normal mathematics lessons. With traditional mathematical content held constant, the learners completed four individual tests presented in a counter-balanced pedagogical strategy which I have coined as a "flip-flop" research design sequence. The investigation monitored how the learners interacted with two parallel forms of tasks formatted at their level, and how they responded a month later when similar tasks were presented a second time but in reverse order. In Phase I, Test 1 presented to the learners comprised a set of 17 sums in **Notational Format (traditional mathematical textbook format)**. This was followed by Test 2 in which the equivalent 17 sums were presented in a **Language Rich Format (sentence format)** one week later. Then four weeks later, in Phase II, Test 3 containing different mathematical content was presented to the learners in **Language Rich Format**, followed by similar Test 4 but which was in **Notational Format**. In other words, the presentation format was reversed, with mathematical content held constant again.

It was hypothesised that, for the sample of grade 8 learners, there would be no significant differences between the achievement scores obtained by learners when the same test content was presented repeatedly using two different formats of testing, irrespective of sequence of presentation of the two pairs of parallel formats.

The null hypothesis was rejected, and the assertion that a language presentation format did appear to influence the levels of achievement scored in a mathematics test was supported; as will be explained in this chapter in due course.

In this chapter I report on the findings obtained from not only the tests, but also from the interviews which subsequently followed. I focus on explaining how the two types of test formats produced different sets of mathematics achievement scores, yielding a clear difference between the patterns obtained when the results generated by the two test formats were compared.

In terms of my research design and methodology outlined in Chapter 3, I present my results in two sections, i.e. qualitative and quantitative.

In Part One of this chapter I report on the analysis of results obtained after Tests 1, 2, 3 and 4 were administered. I present the quantitative findings, which either support or refute the hypotheses, and the results are analysed and displayed through various statistical tables and graphs.

In Part Two of this chapter I report the qualitative analysis of the responses obtained from a selection of learners who were interviewed at the end of the test process. I seek to explain the common patterns arising from the responses obtained during the interviews which I conducted - not only with the learners, but also with an educator who was responsible for teaching the learners.

In Part Three I conclude by cross-linking the findings of Part One and Part Two that consistently reinforce each other by synthesizing the learners' views on how their scores might be improved.

4.2 Part One: Quantitative analysis

4.2.1 Presentation of data

In Phase I of the study, the learners completed Test 1, i.e. they attempted the 17 Notational Format items on mathematics content X; and then 15 days later they attempted the equivalent corresponding 17 Language Rich Format items comprising Test 2 on the identical mathematics content X.

In Phase II of the study, using different mathematics content Y two months later, the same learners completed the "flip-flop" reverse sequence, i.e. they attempted 17 new Language Rich Format items, comprising Test 3, first. Finally they attempted the equivalent corresponding 17 Notational Format items, comprising Test 4 on mathematics content Y, fifteen days later. The tests were marked using a memorandum where the maximum score allocated for a correct answer was one mark, and a zero mark was allocated for an incorrect answer. All the raw scores were collated and any learner not having completed all four tests was omitted. The number of learners that completed both Phase I and Phase II intact (i.e. all four tests in total) diminished to 89 after initially having 105 learners participating in the tests. This reduced number (now 84.8% of the original sample) was due to learners' absence or learners missing one of the four tests given (i.e. one of the two tests in Phase I or one of the two tests in Phase II).

Tables 4.1 to 4.4 present the questions given, the mean scores and the standard deviations obtained for all 68 items (where the maximum score for a correct answer was one mark) in time sequence by the combined sample of 89 test participants in Phase I and II of the investigation, when the learners were tested in both Notational and Language Rich Formats.

Table 4.1 Mean scores obtained by the 89 learners on mathematics content X when tested in Notational Format (Test 1), in Phase I of the investigation.

Test Item Number	Question	Mean	Std Dev	Maximum score	Minimum score
1	127+17=	0.91	0.29	1	0
2	1725 – 1274=	0.67	0.47	1	0
3	7x 5=	0.80	0.40	1	0
4	872 – 427=	0.72	0.45	1	0
5	8276 – 984=	0.63	0.49	1	0
6	8721 – 4729	0.85	0.36	1	0
7	90° – 82° =	0.78	0.42	1	0
8	6 x 5=	0.96	0.21	1	0
9	197 – 87=	0.90	0.30	1	0
10	105 ÷ 5=	0.75	0.43	1	0
11	3878 – 3052=	0.87	0.34	1	0
12	$\sqrt{121}$ =	0.73	0.45	1	0
13	54 ÷ 6=	0.65	0.48	1	0
14	$\sqrt[3]{27}$ =	0.69	0.47	1	0
15	360 ÷ 4 =	0.61	0.49	1	0
16	72 ÷ 2 =	0.71	0.46	1	0
17	R3.25+R2.75+R15.78=	0.66	0.48	1	0
	Total Score	12.89	6.99	17	0
Cronbach alpha reliability coefficient α = 0.81 (n = 89)					

Table 4.2 Mean scores obtained by the 89 learners on mathematics content X when tested in Language Rich Format (Test 2), in Phase I of the investigation.

Test Item Number	Question	Mean	Std Dev	Maximum score	Minimum score
1	Find the sum of 17 and 127.	0.66	0.48	1	0
2	Subtract 1274 from 1725.	0.55	0.50	1	0
3	Find the product of 5 and 7.	0.48	0.50	1	0
4	Point A equals 427 and point B equals 872. Find the distance between point A and B.	0.56	0.50	1	0
5	Decrease 8276 by 984.	0.49	0.50	1	0
6	From 8721 subtract 4729.	0.55	0.50	1	0
7	Give the complement of 82.	0.19	0.40	1	0
8	Karen bought 6 CD's. There were 5 songs on each CD. How many songs did she buy?	0.85	0.36	1	0
9	Find the difference between 87 and 197.	0.69	0.47	1	0
10	Prove 5 is a factor of 105.	0.60	0.49	1	0
11	A plane flies non-stop from New York to London. The distance covered is 3062km. A second plane flies non-stop on the exact route but lands in Athens. The distance now covered is 3878 km How far apart is Athens and London?	0.67	0.47	1	0
12	Give the square root of 121.	0.72	0.45	1	0
13	Sid has 54 nails. He wants to put 6 nails in each row. How many rows could he fill?	0.66	0.48	1	0
14	Give the cube root of 27.	0.63	0.49	1	0
15	A revolution is divided into 4 equal parts. How many degrees will each part consist of?	0.56	0.50	1	0
16	72 degrees is bisected. Give the answer after the angle is bisected.	0.27	0.45	1	0
17	Jacki purchases bread for R3.25, cheese for R2.75 and meat for R15.78. What is the total cost of her shopping when adding the following?	0.71	0.46	1	0
Total Score		9.84	8.00	17	0
Cronbach alpha reliability coefficient $\alpha = 0.83$ (n = 89)					

When perusing Tests 1 and 2 the questions which recorded the greatest mean differences were items 3, 5, 7 and 16. Under closer inspection it was seen that the words used in these questions in Test 2 were **product, decrease, complement** and **bisected**. Already there was an indication that the use of these words could be causing some problems to the learners that was tested.

Table 4.3 Mean scores obtained by the 89 learners when tested on mathematics content Y in Language Rich Format (Test 3), in Phase II of the investigation.

Item No.	Question	Mean	Std Dev	Maximum score	Minimum score
1	Find the answer when 296 is decreased by 18.	0.66	0.48	1	0
2	Find the sum of 517,142 & 785.	0.57	0.50	1	0
3	Find the square of 11.	0.29	0.46	1	0
4	What would it cost to purchase 8l at R5.26?	0.54	0.50	1	0
5	Find the square root of 81.	0.64	0.48	1	0
6	What is the product of 728 and 8271?	0.29	0.46	1	0
7	Find the difference between 64 and 624.	0.53	0.50	1	0
8	What is the complement of 28 degrees?	0.29	0.46	1	0
9	What is the cube of 3?	0.29	0.46	1	0
10	What is the supplement of 72 degrees?	0.39	0.49	1	0
11	If point X equals 547 and point Y equals 878. Find the distance between point X and Y.	0.54	0.50	1	0
12	Find the answer when an angle of 82 degrees is bisected.	0.18	0.39	1	0
13	Increase 529 by 872.	0.60	0.49	1	0
14	From 8921 subtract 8704.	0.64	0.48	1	0
15	Find the cube root of 27.	0.62	0.49	1	0
16	A revolution is divided into 3 equal parts. How many degrees does each part consist of?	0.44	0.50	1	0
17	Find the quotient of 5 and 625.	0.34	0.48	1	0
	Total Score	7.85	8.12	17	0
	Cronbach alpha reliability coefficient α = 0.77 (n = 89)				

Table 4.4 Mean scores obtained by the 89 learners when tested again on mathematics content Y but in Notational Format (Test 4), in Phase II of the investigation.

Item No.	Question	Mean	Std Dev	Maximum score	Minimum score
1	296 – 18=	0.83	0.38	1	0
2	517 + 142 + 785 =	0.78	0.42	1	0
3	11x11 =	0.63	0.49	1	0
4	5.26 x 8 =	0.48	0.50	1	0
5	$\sqrt{81}$ =	0.74	0.44	1	0
6	728 + 8271 =	0.87	0.34	1	0
7	624 – 64 =	0.67	0.47	1	0
8	$90^\circ - 28^\circ$ =	0.73	0.45	1	0
9	3^3 =	0.53	0.50	1	0
10	$180^\circ - 72^\circ$ =	0.73	0.45	1	0
11	876 – 547 =	0.65	0.48	1	0
12	$82^\circ \div 2^\circ$ =	0.79	0.41	1	0
13	529 + 872 =	0.80	0.40	1	0
14	8921 – 8704 =	0.67	0.47	1	0
15	$\sqrt[3]{27}$ =	0.55	0.50	1	0
16	$360^\circ \div 3$ =	0.61	0.49	1	0
17	625 ÷ 5 =	0.60	0.49	1	0
Total Score		11.66	7.68	17	0
Cronbach alpha reliability coefficient $\alpha = 0.86$ (n = 89)					

Once again, when perusing Tests 3 and 4 the questions which showed the greatest mean differences were items 3, 6, 8 and 12. Under closer inspection it was seen that the words used in these items in Test 3 were **square, product, complement** and **bisected**. This showed clear signs that some of the same words used were possibly causing problems to the same 89 learners who was tested. When merely looking at the mean scores that were found in the two phases the findings were as follows:

In Phase I the mean score of the 89 learners, when tested in Notational Format (Test 1) was 12.89. With the identical mathematics content X presented in Language Rich Format seven days later (Test 2), the mean score for the same sample of learners declined to 9.84. The learners' decrease in performance was statistically significant (Table 4.5).

Table 4.5 Analysis of Phase I scores (n = 89) for significant difference.

Mathematics content	Test	Mean ± Std. Dev.	Z	p
X	1	12.89 ± 3.49		
X	2	9.84 ± 4.11	6.2469	< 0.000003

In Phase II the mean score of the same 89 learners, when tested on mathematics content Y in Language Rich Format (Test 3) was 7.85. With the identical mathematics sums (content Y) presented in a Notational Format seven days later (Test 4), the mean score for the same sample of learners was 11.66. Once again there was a significant difference in performance between the Notational Format of testing and the Language Rich Format, and the learners' change in performance was statistically significant (Table 4.6).

Table 4.6 Analysis of Phase II scores (n = 89) for significant difference.

Mathematics content	Test	Mean ± Std. Dev.	Z	p
Y	3	7.85 ± 3.81		
Y	4	11.66 ± 4.30	4.685	< 0.000001

Figures 4.1 to 4.4 depict the distributions of mathematics scores obtained for all 68 items by the combined sample of 89 test participants in Phases I and II of the investigation, when the learners were tested in the Notational and Language Rich Formats.

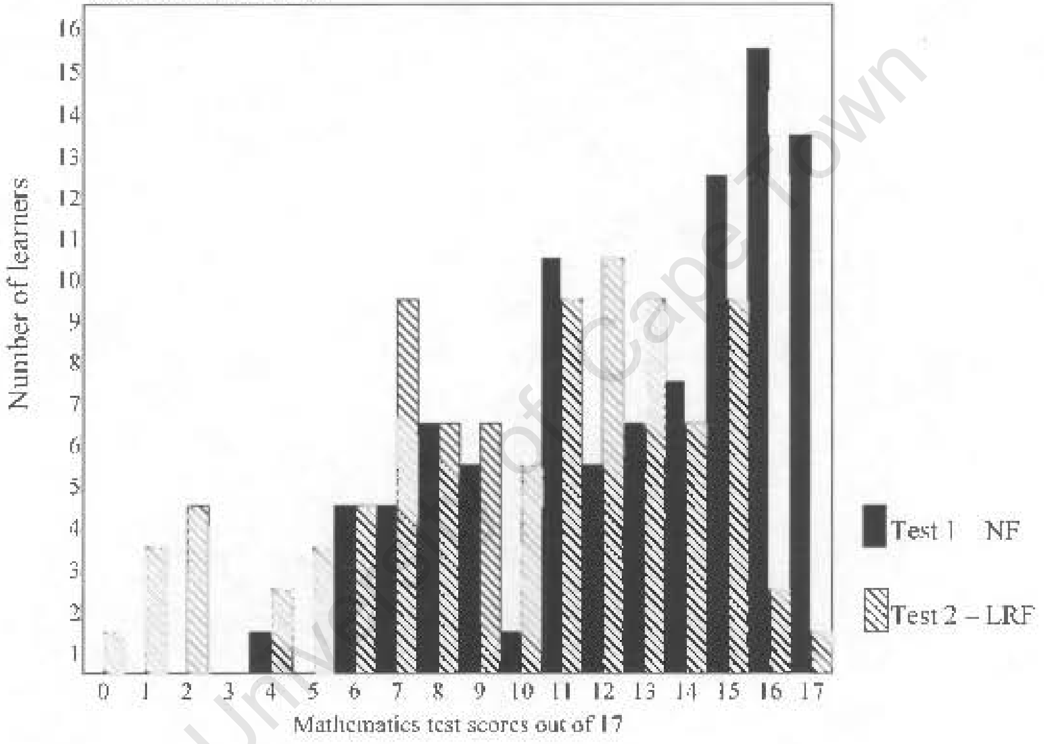
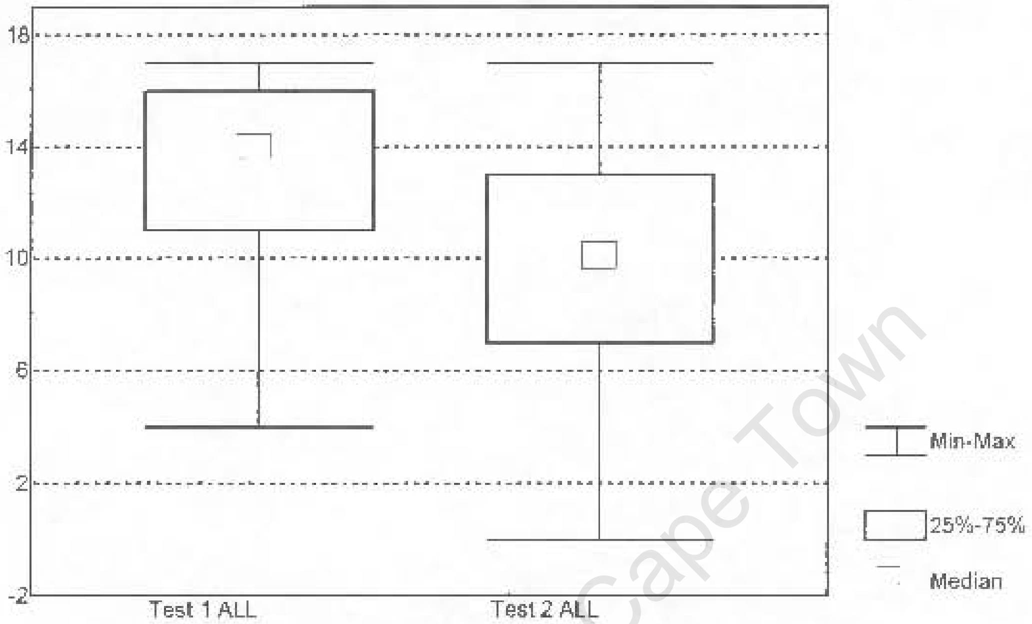


Figure 4.1 Phase I showing a comparison of the mathematics scores of 89 Grade 8 learners tested with 17 Notational Format (Test 1) sums and tested with the identical 17 sums expressed in Language Rich Format (Test 2).

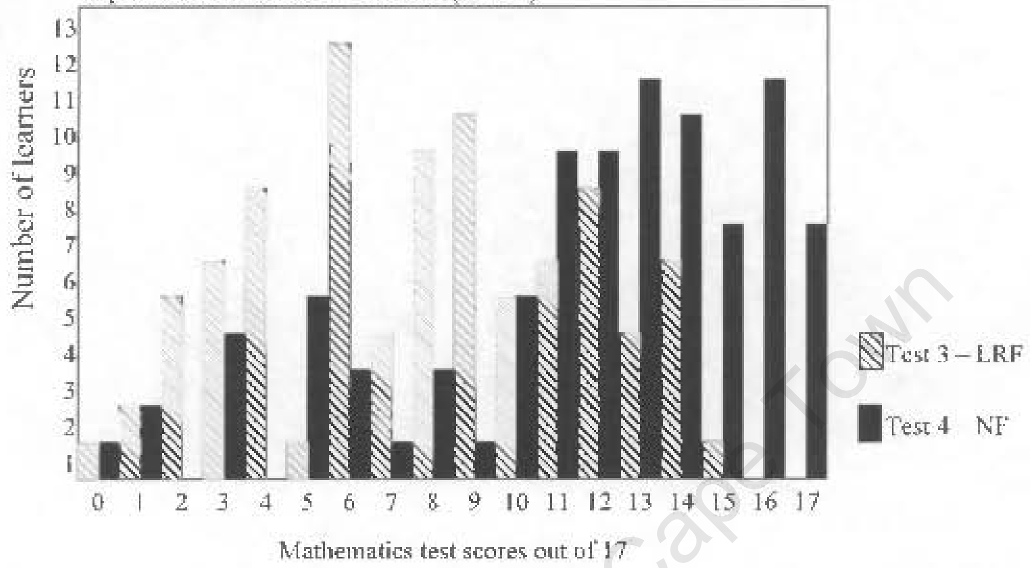
When projecting the 89 learners' results for Test 1 and 2 as a histogram showing the matches between the number of learners for each of the test scores out of 17 it was seen that the graph was heavily skewed towards scoring higher marks in Test 1, which was the Notational Format test, and that far fewer learners obtained higher marks when the test was given in the Language Rich Format – Test 2. Again this signalled that Test 2, which was the Language Rich Format test, was causing the learners some problems.

Figure 4.2 Box and Whisker Plot of the scores obtained in Phase I where Test 1 was the Notational Format and Test 2 was the Language Rich Format.



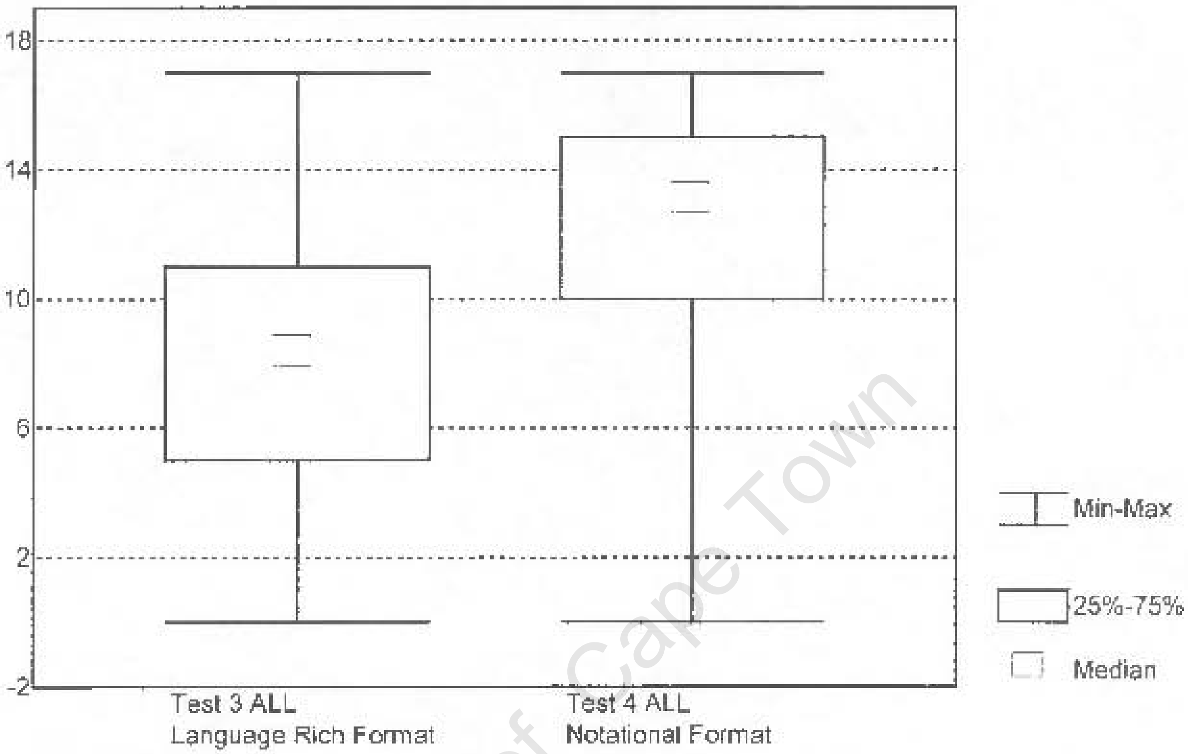
To support the histogram and the mean scores obtained above, the raw scores of all 89 grade 8 learners - where the same 17 identical sums were tested in Tests 1 and 2 - were subjected to a Box and Whisker Plot. The result of this Box and Whisker Plot clearly depicted the median and mean of Test 1(Notational Format) much higher than that of Test 2 which was the Language Rich Format test.

Figure 4.3 Phase II showing a comparison of the mathematics scores of 89 Grade 8 learners tested with 17 Language Rich Format (Test 3) sums and tested with the identical 17 sums expressed in Notational Format (Test 4).



Similarly, when scores obtained for Tests 3 and 4 were projected as a histogram showing the matches between the number of learners for each of the test scores out of 17 it was seen that the graph was heavily skewed towards scoring higher marks in Test 4 (which was now the Notational Format test) and again far fewer learners obtained higher marks when the test was given in the Language Rich Format – Test 3. This clearly signalled that the Language Rich Format test was causing the learners some problems.

Figure 4.4 Box and Whisker Plot of the scores obtained in Phase II where Test 3 was the Language Rich Format and Test 4 was the Notational Format.



Once again, to support the histogram, the raw scores of all 89 grade 8 learners - where the same 17 identical sums were tested in Test 3 and Test 4 - were subjected to a Box and Whisker Plot. The result of this Box and Whisker Plot clearly depicts the median and mean of Test 4 (Notational Format) much higher than that of Test 2 which was the Language Rich Format test.

4.2.2 Hypothesis testing

It was hypothesized that, for the sample of grade 8 learners, there would be no significant differences between the achievement score means obtained by the learners when a fixed mathematics test content was examined using two different formats of testing, irrespective of the sequence of presentation of the two pairs of equivalent formats of two different aspects of mathematics content X and Y.

The two null hypotheses were repeatedly rejected for the two different aspects of mathematics content.

A sign-test (to determine whether two sets of test performance scores are significantly different from each other at $p < 0.05$) was performed on the learners' score totals obtained for Test 1 and Test 2 in Phase I for mathematical content X. The learners scored significantly higher in the Notational Format than in the Language Rich Format.

4.2.3 Individual items: comparative performances

When viewing the data produced from the two phases of testing, it was seen in Tables 4.1 to 4.4 that there were several performances on specific sums in the mathematics content X and Y data where many of the 89 learners scored very low marks. Low percentages of correct answers were especially evident when the learners were tested in Language Rich Format. Under closer inspection it was seen that these specific test items contained words or phases that may have caused problems for the learners.

The two formats of testing in each phase were subjected to chi-square tests so as to examine the effects of the independent variable (format) on the dependent variables (item scores). A chi-square calculation as a test of independence compares two or more patterns of frequencies to see if they are different from each other (Hinton, 1995).

To support and elaborate on the results presented in Tables 4.1, 4.2 and 4.5 and in Figures 4.1 to 4.2, I will now present Table 4.7 which gives a comparison of the percentages of correct answers for all 17 items for the 89 learners when tested in Notational Format (Test 1) and in matching Language Rich Format (Test 2) seven days later in Phase I of the investigation. Using headcounts, statistically significant differences in performance occurred for two of the 17 items.

Table 4.7 A comparison of the percentages scored for each item in Phase I of the investigation when 89 learners were tested in Notational Format (Test 1) and later in Language Rich Format (Test 2) with mathematics content X held constant.

Item No.	Phase 1 Test 1 Notational Format		Phase 1 Test 2 Language Rich Format		Chi-Square value	p	Signif-icance
	Sum used	% Correct	Words used	% Correct			
1	127+ 17 =	91.0%	Find the Sum of 17 and 127.	66.2%	1.64	0.20	No
2	1725 – 1274 =	67.4%	Subtract 1274 from 1725.	55.0%	0.50	0.47	No
3	17 x 5 =	79.7%	Find the Product of 5 and 17.	48.3%	3.75	0.05	No
4	872 – 427 =	71.9%	Point A equals 427 and point B equals 872. Find the distance between point A and B.	56.1%	0.82	0.36	No
5	8276 – 984 =	62.9%	Decrease 8276 by 984.	49.4%	0.70	0.40	No
6	8721 – 4720 =	85.3%	From 8721 subtract 4720.	55.0%	3.03	0.81	No
7	90° – 82° =	77.5%	Give the complement of 82 degrees.	19.1%	20.81	0.00	Yes
8	6 x 5 =	95.5%	Karen bought 6 CD's. Each CD has 5 songs on it. How many songs did she buy in total?	85.3%	0.16	0.68	No
9	197– 87 =	89.8%	Find the difference between 87 and 197.	68.5%	1.18	0.27	No
10	105 ÷ 5 =	75.2%	Prove 5 is a factor of 105.	59.5%	0.76	0.38	No
11	3878 – 3052 =	86.5%	A plane flies non-stop from New York to London. The distance covered is 3052km. A second plane flies non-stop on the exact route but lands in Athens. The distance now covered is 3878 km How far apart is Athens and London?	67.4%	0.96	0.32	No
12	$\sqrt{121}$ =	73.0%	Give the square root of 121.	71.9%	0.00	0.96	No
13	54 ÷ 6 =	65.1%	Sid has 54 nails. He wants to put 6 nails in each row. How many rows could he fill?	66.2%	0.00	0.96	No
14	$\sqrt[3]{27}$ =	68.5%	Give the cube root of 27.	62.9%	0.06	0.81	No
15	360 ÷ 4 =	60.6%	A Revolution is divided into 4 equal parts. How many degrees will each part consist of?	56.1%	0.04	0.85	No
16	72 ÷ 2 =	70.7%	An angle of 72 degrees is bisected. Give the answer after the angle is bisected.	26.9%	11.10	0.00	Yes
17	R3.75+2.75+15.78=	66.2%	Jacki purchases bread for R3.75, cheese for R2.75 and meat for R15.78. What is the total cost of her shopping spree?	70.7%	0.03	0.87	No

Table 4.7 discloses that the Language Rich Format test items in Phase I which produced the lowest scores were the sums that contained the following words: **complement, bisected, product** and **decrease**. This can be seen in Table 4.7 as the questions that contained these words all resulted in mean scores below 50%.

In item number 7, the learners were asked to give the **complement** of 82 degrees and only 19% managed to get the sum correct. This was the lowest score in the Language Rich Format test. Some concern was noted when comparing the 19% success rate in the Language Rich Format with that of the 78% which was obtained for the sum that contained exactly the same numerals of that of the first (Notational Format) test. This significant discrepancy showed that the learners were proficient in the process of subtracting $\mathbf{90^0 - 82^0}$ but that they had a verbal problem with the term **complement** and its mathematical meaning.

In item number 16 the geometrical term **bisected** was used. However, only 27% of the 89 learners tested got it correct, in comparison to the 71% when they were asked **to divide 72 by 2**. Although this score was not merely as high as the 78% that was scored in question 7 where the process of subtraction was done, there was still an indication that somehow the word **bisected** was not fully understood by the learners.

The word **product**, which has a specific meaning in both ordinary English and mathematical English, was the next word where the learners scored only 48% correct. On the other hand, when the learners were asked to multiply 7 by 5, the 48% correct increased to 80% correct. This 80% was the fifth highest percentage scored in the Notational Format. I was surprised by the low percentage of 48% that was scored for the word product, as the term is one that was introduced to the learners in grades 3 and 4. Notably, in the interviews which I discuss later in the chapter, only two of the learners mentioned it as a word that caused problems.

The term **decrease** was the final word that resulted in scores below 50% in Test 2 of Phase 1. When the learners were asked to **decrease 8276 by 984** the percentage of correct answers was 49% compared to a score of 63% correct when they were asked the item **8276 – 984.** Even though the percentage correct was notably low for a relatively easy subtraction sum for a grade 8 learner, it still indicated a difference between the percentage of correct answers. This supports the inference that the words may have hampered the outcome of the result.

In Phase II I also used 50% as the benchmark to gauge the difficulty of test questions in which the learners under-performed. I now discovered an increase in the number of questions in which the learners scored below 50% in the Language Rich Format. This phase of the tests was given one month after Phase I but the order of testing was reversed. In Phase II the Language Rich Format was given first, followed by the Notational Format.

Even though the teacher assured me that the grade 8 learners revised the mistakes of the first phase of tests, more than 50% still struggled with three of the four previous words. These were:
Bisected - where only 17% now managed to get the item correct,
Product - where only 29% now got the item correct, and
Complement – where only 30% got the item correct.

Another interesting observation was that 30% of the 89 learners got the question correct when it contained the word **bisected**, in Phase I. This performance now dropped even lower in Phase II to an unsatisfactory 18%. In addition to the same three words mentioned above, questions that contained five new words also scored below 50%. The five words which appear in the table below (Table 4.8) are:
square of
cube
quotient
supplement, and
revolution.

To support the results of Tables 4.3, 4.4 and 4.6 and Figures 4.3 to 4.4, I present Table 4.8 which gives a comparison of the percentage of correct answers for the 89 learners when tested in Language Rich Format (Test 3) and matching Notational Format (Test 4) in Phase II of the investigation.

Table 4.8 A comparison of the percentage of correct answers for the 89 learners when tested in Language Rich Format (Test 3) and matching in Notational Format (Test 4) in Phase II of the investigation.

Item No.	Phase II Test 3 Language Rich Format		Phase II Test 4 Notational Format		Chi-Square value	p	Signif-icance
	Words used	% Correct	Sum used	% Correct			
1	Decrease 296 by 18.	66.2%	296–18 =	83.1%	0.76	0.84	No
2	Find the Sum of 517;142 & 785.	57.3%	517+ 142+ 785=	77.5%	1.33	0.24	No
3	Find the Square of 11.	29.2%	11 x 11=	62.9%	6.89	0.00	Yes
4	What would it cost to purchase 8l of cooldrink if 1 liter cost R5.26.	53.9%	R5.26 x 8 =	48.3%	0.09	0.76	No
5	Find the Square root of 81.	64.0%	$\sqrt{81}$ =	74.1%	0.26	0.61	No
6	What is the Product of 728 and 8271?	29.2%	728 + 8271 =	86.5%	15.53	0.00	Yes
7	Find the difference between 64 and 624.	52.8%	624 – 64=	67.4%	0.76	0.38	No
8	What is the complement of 28 degrees?	29.2%	90° – 28° =	73.0%	10.44	0.00	Yes
9	What is the cube of 3?	29.2%	3^3 =	52.8%	3.75	0.05	No
10	What is the supplement of 72 degrees?	39.3%	180° – 72° =	73.0%	5.24	0.02	Yes
11	If point X equals 547 and point Y equals 876. Find the distance between point X and Y.	53.9%	876 – 547 =	65.1%	0.42	0.51	No
12	Find the answer if an angle of 82 degrees is Bisected.	17.9%	82° ÷ 2° =	78.6%	22.57	0.00	Yes
13	Increase 529 by 872.	59.5%	529 + 872 =	79.7%	1.27	0.26	No
14	From 8921Subtract 8704.	64.0%	8921 – 8704 =	67.4%	0.01	0.92	No
15	Find the cube root of 27.	61.7%	$\sqrt[3]{27}$ =	55.0%	0.12	0.73	No
16	A Revolution is divided into 3 equal parts. How many Degrees does each part consist of?	43.8%	360° ÷ 3 =	60.6%	1.29	0.25	No
17	Find the quotient of 5 and 625.	33.7%	625 ÷ 5 =	59.5%	3.84	0.50	No

In item 3 of Test 3 the learners were asked to **find the square of 11**. Of the sample of 89 learners, 29% got the answer correct, compared to the 63% correct answers when they were asked **11 x 11** in the Notational Format test (Test 4).

When asked to supply the **cube of 3** in item 9, only 29% of the 89 learners managed to get it correct. On the other hand, when given the question **3^3** in the Notational Format test, 53% got it correct. The question **3^3** is exactly the same as finding the **cube of 3** but just set out or asked differently.

Only 34% of the learners were correct when the expression **find the quotient** was used in item 17. However when the learners were asked 625 ÷ 5 in the Notational Format 60% got it correct. The term **quotient** was one of the key terms introduced and used extensively in primary school arithmetic.

As for the phrase **what is the supplement** – for which five out of the eight interviewed learners complained about their lack of understanding of this term - only 39% got it correct. However, when the sum $\mathbf{180^0 - 72^0}$ was given, 73% now got it correct.

The final word which scored below 50% was **revolution**. When looking at item 16, in which learners were asked to divide a **revolution** into three equal parts, only 44% got it correct. When comparing it to the Notational Format test where the learners were asked the equivalent $\mathbf{360^\circ \div 3}$, a total of 61% now got it correct. As mentioned previously, a word like **revolution** could easily be confusing as it is also used in other subjects such as history where its meaning is completely different from its mathematical meaning.

4.3 Part Two: Interview data

In this section I offer suggestions to account for the findings in the qualitative component of this study, and I present the responses I received from the learners and educator during the interviews.

I was particularly interested in:

- why the learners thought they scored better in one phase of the tests compared to the equivalent other;
- what they thought were the stumbling blocks which caused them to do better in one task section compared to the equivalent other task section;
- what they, as learners perceived to be the easier method of testing, and why; and
- which words/terms were actually causing problems for the learners and why they were doing so.

4.3.1 The interviews

The eight learners interviewed were specifically selected on the basis of their contrasting performance /results obtained in the two phases of the investigative tests. The four boys and four girls came from diverse backgrounds, they originated from different primary schools and they spoke different home languages, but they were all in their first year of high school with the youngest being 13 years old and the eldest 15 years. Their common context was that they were all taught by the same teacher with the same medium of instruction, at the same pace and in the time period, and were all exposed to the same instructional and situational conditions at school.

Table 4.9 gives the details of the eight learners who were interviewed, in terms of their sex, home language, age and four test scores out of 17.

Table 4.9 Details of the eight interviewed learners.

				Phase I Results		Phase II Results	
Learner	Sex	Home Language	Age	Notational Format scores	Language Rich Format scores	Language Rich Format scores	Notational Format scores
A	Male	English	13	17	15	14	17
B	Female	English	13	17	14	14	17
C	Female	Xhosa	14	9	7	3	6
D	Male	English	14	8	10	6	12
E	Male	Afrikaans	14	11	1	2	13
F	Female	English	14	4	0	0	1
G	Female	English	15	6	1	3	3
H	Male	Afrikaans	15	8	2	10	5

Of the sample of 89 learners who participated in the two phases of testing, eight were selected to be interviewed for the following reasons:

Learner A, 13 years old, was purposely chosen because he had scored full marks in the Notational Formats in both phases of the tests whilst managing to score only 15 and 14 out of 17 marks respectively in the Language Rich Formats.

Learner B, who was one of the youngest females to participate in the study, was purposely selected for the interview on the basis that she scored consistently in both phases of the tests. In the first phase, in the Language Rich Format she scored 14 out of 17 and in the Notational Format she scored full marks (17 out of 17). Remarkably, this feat was repeated in Phase II when she actually scored the exact same results.

Learner C was purposely selected because her home language is Xhosa, but she was enrolled in an English first language class at a dual medium school that did not offer Xhosa as a main subject, nor as an extra-curricular subject. Her results were interesting because, even though Xhosa is her mother tongue, she scored higher than 10% of the 89 learners tested in both phases of the tests.

Learner D was selected because he was one of the very few learners to score more in the Language Rich Format (10 out of 17) than in the Notational Format (8 out of 17) in Phase I. However he did not repeat this performance in Phase II where he actually scored double in his Notational Format (12 out of 17) compared to his Language Rich Format (6 out of 17).

Learner E was selected basically because he was similar to learner C in that his home language is also Afrikaans. However, his performance in the Language Rich Format (1 out of 17 and 2 out of 17) was far weaker than that of his Notational Format performance where he scored 11 out of 17 in Phase I, and 13 out of 17 in Phase II.

Learner F was unique in that English is her mother tongue (though she sometimes struggled to articulate herself in the interview), but she scored zero in both of her Language Rich Format tests. Also, her Notational Format mathematics results were not high as she scored a total of 4 out of 17 in Phase I and a total of 1 out of 17 in Phase II.

Learner G, 15 years, was the oldest female of the sample and her Language Rich Format performances improved from 1 out of 17 in Phase I to 3 out of 17 in Phase II. Although her scores were below average, nevertheless there was an improvement. In her Notational Format performance, however, there was a decrease in score from 6 out of 17 in Phase I to 3 out of 17 in Phase II. She was also one of the very few learners to have recorded the same scores in one phase of the test, achieving 3 out of 17 for both Language Rich Format and Notational Format in Phase II.

Learner H, 15 years, was older than the rest of his peers. His home language is Afrikaans even though he was enrolled in an English first language class at a dual medium school that also offers Afrikaans as a first language option where all subjects are taught exclusively in Afrikaans. His results were below average as he scored a total of only 8 in the Notational Format in Phase I, but his score increased by 2 to 10 marks in the same format of sums in Phase II. Of note were the results he scored in the Language Rich Formats. These were 2 marks out of 17 in Phase I, improving slightly to 5 marks out of 17 in Phase II.

The final person interviewed was teacher K. She is female, 32 years of age, well qualified having a degree and nine years of teaching experience. During the interviews both the learners and teacher K were asked a series of prepared questions (reproduced in Figures 3.3 and 3.4). The presentation of the questions was structured rather than unstructured for reasons alluded to in the previous chapter.

4.3.2 Factors possibly influencing the learners' engagement with the tests

The following is an analysis of the responses received from the learners and from the teacher during the interview process, based on the questions asked in the interviews.

When the learners were asked which of the two formats (i.e. the Notational Format or Language Rich Format) was more difficult, seven of the eight learners inferred that the

Language Rich Format comprising (word sums) was much harder than the more straightforward mathematics sums (Notational Format). When reviewing the two types of tests that I set for the learners, it can be seen that both tests contained the same numerals except for the fact that one included words and sentences, whilst the other lacked words. When the learners were unable to score the same results in both tests it suggested that there may have been a discrepancy between learners' levels of mathematical ability and their mathematical language ability.

The results of the two phases of testing suggested that the occurrence of language sentence presentation was a pertinent factor that probably influenced the learner's engagement with the test. This was supported by the statistical analysis of the results (when the learners' performances on two types of equivalent tests were compared), and it was also corroborated by the interview responses.

For example many of the interviewed learners remarked that ***"there were too many terms I did not understand"*** or ***"the terms were not easily understood"*** or ***"the words are a problem, Sir"***, and that ***"it was simpler to work with the symbols and signs".*** Three learners said *"**I don't know what the terms mean**"*, *"**we don't use those terms daily so we forget what they mean**"*, and so on. The terms with which the learners said they had a problem were mainly subject-specific to mathematics. They were not ordinary English words used daily by children and this phenomenon, in the view of the learners, definitely impacted on the performance results obtained. It was apparent:

a) There were some learners who failed to understand the mathematical terms because they had not been given a clear grounding in the domain of arithmetical and algebraic language, and this severely restricted their ability to solve problems when these notational terms were being used.
b) There were some learners who found it difficult to understand the meanings of mathematically-specific concepts like "**find the cube**".

The interviewed teacher K mentioned that, when she introduced a new mathematical term in class, she wrote it down and gave a short explanation next to it. However, whether the learners wrote it down as some type of glossary was not compulsory, nor was it enforced by her. She implied that, after perusing the current research results, this classroom practice should probably become compulsory in future.

A strong factor that appeared to hamper the learners from scoring well in the Language Rich Format was their inability to comprehend the language and terms presented to them in the tests. One learner even commented, ***"If the teacher or someone could have explained some of the difficult words, we could have scored much better in the test."*** When relaying to teacher K that the learners commented that some of the words/terms were not understood or had not been explained to them, she stated that all the words/terms definitely formed part of the mathematical discourse already used in the classroom or should have been encountered previously.

One learner commented on the test layout stating, ***"maybe if there were some type of drawings included it would have helped."*** The interview with teacher K revealed that one method she employed to explain or to provide clarity on some difficult work was by means of drawings. On inspection of the actual test, it was seen that the terms presented were not supported by any other words, phrases or adjectives which could possibly assist in the construction of meaning in the specific context. In any other form of test, a presented term might possibly have had some sort of "helping words" (or auxiliary assistance) which could have helped the learners to understand the question being asked. In mathematics the terminology is highly specific and, if you do not comprehend a given term, the likelihood of understanding what must be done or what process is required could be close to zero. Research on concept literacy by Young et al. (2002), which looked at the interplay between 'language, literacy and concept formation' argued that English words and subject-specific terminology - especially in mathematics and science - presented learners with many obstacles.

4.3.3 The role of the teacher

In the interviews, the role of the teacher as a facilitator and mediator who assisted in the learning process, and who aided the learning process, was also emphasized. Some learners mentioned, ***"It is easy to do it in class because my teacher will come and explain how to do the sum when I don't understand."*** This pertinent mention of the role of the teacher showed that some learners needed more help than others. However, what will happen when the teacher is not present and how will the learning process take place? Thus we have to devise other forms of support for the learners, such as better support material or better textbooks that will be able to assist the learners to cope with the work, even when the teacher is not available.

When teacher K was asked about her role, her response was, ***"I am there to assist the learners at all times and, when I see them struggling, I will re-explain the work in a simple, concise way so that the learners understand the difficult work better."***

One other type of response revealed that the interviewed learners rated themselves from "average" to "above average" in mathematics; and one even rated himself as a "good" mathematician, even though his results did not reflect it. They all said they enjoyed mathematics more than their other subjects and commented that they scored better results in mathematics than in English. They viewed mathematics as a fun-filled learning activity, which was seen as important if you want to proceed to do tertiary studies. The teacher stated that she always tried to make the learning process interesting and fun with as much relevance to their daily lives as possible. In class the teacher helped the learners to engage meaningfully with the mathematical terms but, when the situation changed and the teacher was not present - like it was in the tests - she said that the learners experienced some difficulty completing the tasks.

The actual words that caused problems to the individual learners who were interviewed are set out in Table 4.10 below so that we can see whether they were the same words that caused problems for all eight learners who were interviewed.

Table 4.10 Mathematical terms with which the eight interviewed learners said they experienced difficulties.

	Complement	Supplement	Square root	Cube root	Bisected	Decrease	Product	Difference between
Learner A			X	X	X			
Learner B	X	X						
Learner C	X	X		X				
Learner D					X			X
Learner E	X	X			X	X		
Learner F	X	X		X		X	X	
Learner G	X	X	X	X				X
Learner H	X		X	X			X	

When summarizing the problems experienced with the words mentioned during the interview process (i.e. with the words or technical terms that caused problems to the learners), it was seen that words that were highly specific to the subject of mathematics were mentioned the most. The word **complement** caused the most difficulty as 75% (six) of the learners interviewed mentioned it to be a problem. Five of the learners mentioned both the words **supplement** and **cube root** as problems but, when I reviewed the mathematics test answers of the learners who mentioned the expression **cube root**, it was seen that they could answer the question well when $\sqrt[3]{27}$ was given in the Notational Format. With regard to the words **square root** and **"bisect",** three learners stated that the two expressions caused some confusion and two said they had problems with the words **decrease, product** and **difference between.**

Concerning the expression **difference between**, in Phase II Test 3 the learners were asked to "Find the difference between 64 and 624". One learner quoted, ***"If you take the 2 away from 624, the 2 that's in the middle, it will be 64."*** Here it seemed that the learner could not distinguish between the ordinary English meaning and the mathematical meaning of the term **difference**. This result supported the findings of Shuard and Rothery (1984:24), as I previously noted in chapter 2, when they stated that mathematical text is more complex than ordinary English text, partly because mathematics uses a technical vocabulary which overlaps with the vocabulary of ordinary English. The word **difference** also occurs in both ordinary English and mathematical English but it gives rise to somewhat different meanings. If the learner quoted above was not able to distinguish between the mathematical English and the ordinary English of the term **difference**, it could have led to the misconception that occurred.

4.4 Part Three: The learners' views on how their scores might be improved

The learners concurred unanimously that there had been an appreciable difference between the results obtained in the two different formats of testing. They offered several recommendations to narrow the gap between the performance results of the two formats of testing: -

Some of the comments were ***"…use straightforward words, not words that confuse you"; "….the words made it hard to get to the answer; just use symbols - it makes it easier"; "… I did not understand the words; maybe they must give the explanation of the words next door to it"; "… put the simpler meaning of the words of the terms next to it in brackets"; and "…we don't use terms like this daily so put in words which we use daily"***.

The above comments clearly implied that there was an inability to understand at least some of the terminology given in the tests. This implied that there were at least some learners who were unable to understand the words or the different meanings of certain concepts in mathematics.

When the learners were asked for suggestions on how to remedy the situation, many made reference to the language changes that they felt ought to be made. Even though I purposefully made no reference to textbooks, it was mentioned that it could be a viable venture to explore the printing of textbooks or books in mathematics and science with auxiliary or adjacent components that supply the language equivalents for difficult terms in learning and learning materials.

A project with which I was a part of, and which Professor Douglas Young of CALLSSA at the University of Cape Town initiated, stated that "*language has become the stumbling block that has hindered the learning and progress of many students, but now it seems that something must be done to change this in the near future*" (quoted in The Star newspaper, Wednesday 24 July 2002).

Because eight of the learners were able to make several specific recommendations, this indicates that they were aware of their shortcomings. They knew what was hindering the process of improving their results and this made it possible to see what they lacked so as to possibly remedy this problem in future. As educators we will have to heed the cry for assistance and address the difficulties, as discussed in the next chapter.

4.5 Chapter summary

In this chapter I discussed the results and findings of the research. The null hypotheses were presented both for the pairs of tests as a whole, and for pairs of individual items, and shown to be either supported or rejected; and the main results were presented and analysed. The findings from the two phases of quantitative testing were set out, and also summaries of the qualitative findings were given. The chapter then proceeded to analyse in which of the two types of testing the learners scored better and what factors or influences may have enabled them to score better in one format than the other.

The implications, recommendations and conclusion follow in Chapter 5.

CHAPTER 5: IMPLICATIONS, RECOMMENDATIONS AND CONCLUSION

5.1. Introduction

This final chapter reviews the outcomes of the research proposal that was investigated in my study. It also presents possible implications and recommendations for further research, and a conclusion. I link the aim of the study to the analysis of the generated data. I discuss several possible implications of the study for further and future research, and its influences for effective mathematics teaching. Recommendations are also made for future learners and educators.

The implications, recommendations and conclusions of the findings of this study cannot be discussed without briefly reflecting on:

- The outcomes of Curriculum 2005 and examining the Revised National Curriculum Statement (2002 and 2003);
- The TIMSS tests of 1995 and 1999; and
- The role of textbooks.

5.2 The Revised National Curriculum Statement and the General Education and Training Common Tasks for Assessment

The key aims of Curriculum 2005 are to provide equal opportunity and access in education and training to all citizens and provide education of quality in terms of relevance, learner-centredness, critical thinking and economic growth and development. (Mahomed, 1999:158). The approach to the curriculum is guided by certain key concepts such as the active involvement of the learner, an emphasis on critical thinking, reasoning skills, reflection and action, skills-based rather than content-based and learner-centred rather than teacher-centred. With regard to assessment, the Revised National Curriculum Statement for Grades R-9 (Schools) states that it should be *a continuous, planned and integrated process of gathering information about the performances of learners measured against the Learning Outcomes* (2002:93). It also states that assessment should:

- encourage learners to go beyond simple recall of data or facts;
- close the gap between the classroom and the real world;
- include opportunities for learners to perform tasks and solve problems; and
- make provision for adaptive methods of assessment.

Although it is appropriate for assessment to address the above goals, if learners have problems with mathematics and mathematical tests that are presented in language-rich format, they may not be able to produce the desired outcomes.

To illustrate, we can examine the National Mathematics General Education and Training (GET) exit examination for Grade 9, also known as the Common Tasks for Assessment (CTA) (2002; 2003). First, the learners are given a Section A to complete by integrating it into normal classroom activities in which the teacher should provide the learners with the relevant resources, making it interactive. CTA Section A should be completed in five hours. At the end of the year, Section A is followed by a Section B CTA, which is then conducted under examination conditions for a duration of two hours. In both sections the tests are heavily language-rich in format. Thus, if some of the learners do not have the ability to comprehend the language, they can or will be seriously disadvantaged.

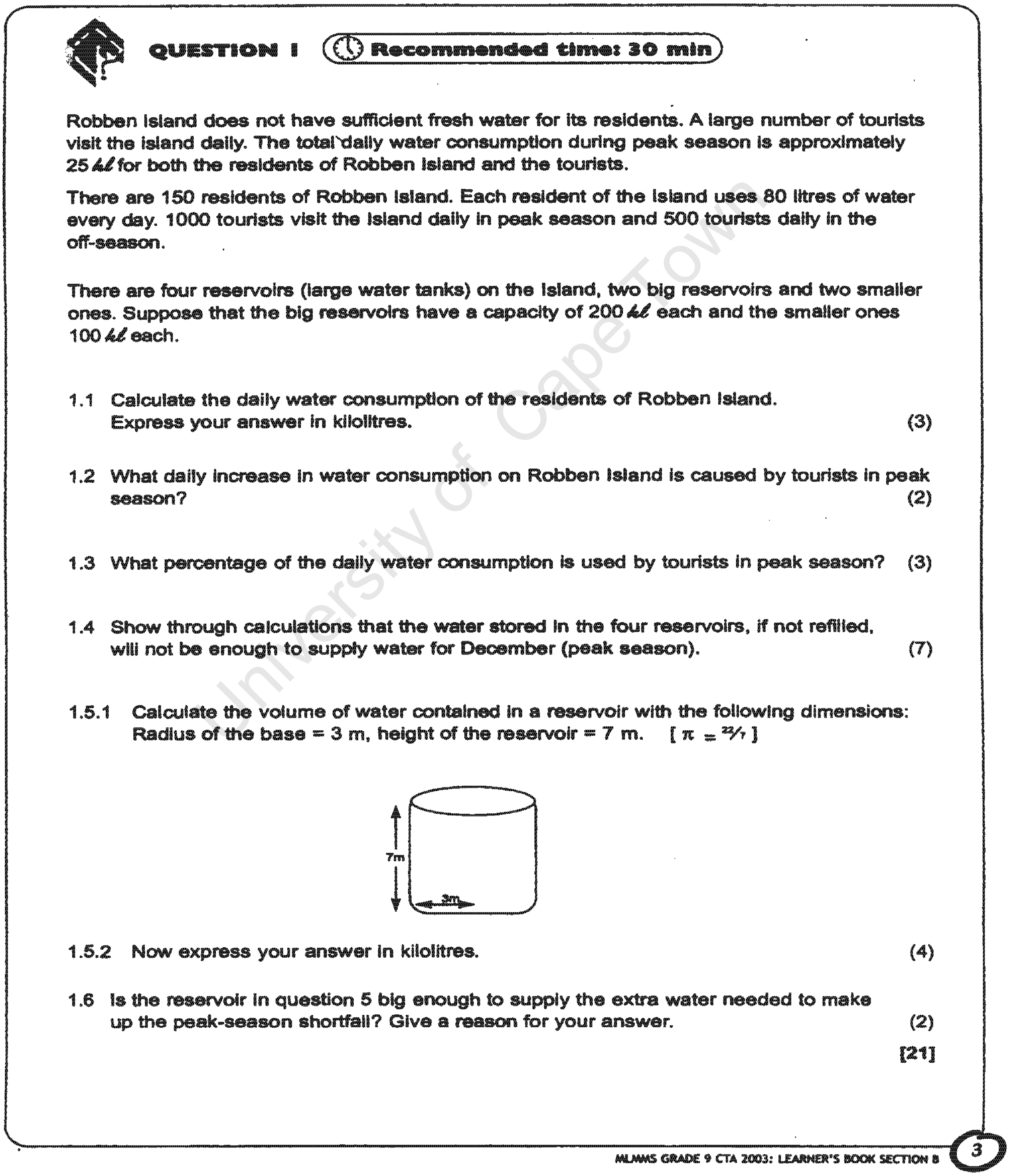
In both of the 2002 and 2003 Common Tasks for Assessment the papers, Section A and Section B, were set out in a manner that was heavily Language Rich in format. In my judgement this caused an appreciable problem for a learner who had difficulty comprehending the language, a view that is now supported by my findings with the two types of tests set out in my two phases of testing.

To further illustrate possible difficulties which some learners may encounter, I present CTA page 3 - which is a reproduction of Question 1 of Section B, Common Task Assessment for Grade 9 of 2003 Mathematics - a copy of which is reproduced in Figure 5.1.

As in all the questions found in the Section B of the Common Task Assessment for Grade 9, it has a recommended time duration given to the learners. In the case of Question 1

Common Task Assessment 2003, the recommended time is 30 minutes which serves as a guide to the learners so as they can complete the entire question paper in the total time allocated to them (2 hours).

Figure 5.1 Question 1 of the 2003 CTA for Mathematics administered by the WCED



QUESTION 1 **Recommended time: 30 min**

Robben Island does not have sufficient fresh water for its residents. A large number of tourists visit the island daily. The total daily water consumption during peak season is approximately 25 kℓ for both the residents of Robben Island and the tourists.

There are 150 residents of Robben Island. Each resident of the island uses 80 litres of water every day. 1000 tourists visit the island daily in peak season and 500 tourists daily in the off-season.

There are four reservoirs (large water tanks) on the island, two big reservoirs and two smaller ones. Suppose that the big reservoirs have a capacity of 200 kℓ each and the smaller ones 100 kℓ each.

1.1 Calculate the daily water consumption of the residents of Robben Island. Express your answer in kilolitres. (3)

1.2 What daily increase in water consumption on Robben Island is caused by tourists in peak season? (2)

1.3 What percentage of the daily water consumption is used by tourists in peak season? (3)

1.4 Show through calculations that the water stored in the four reservoirs, if not refilled, will not be enough to supply water for December (peak season). (7)

1.5.1 Calculate the volume of water contained in a reservoir with the following dimensions: Radius of the base = 3 m, height of the reservoir = 7 m. [$\pi = {}^{22}/_{7}$]

1.5.2 Now express your answer in kilolitres. (4)

1.6 Is the reservoir in question 5 big enough to supply the extra water needed to make up the peak-season shortfall? Give a reason for your answer. (2)

[21]

MLMMS GRADE 9 CTA 2003: LEARNER'S BOOK SECTION B 3

Analysing the introduction to question 1, which pertains to the supply of fresh water on Robben Island, first the learners have to read and make overall sense of what is being written and then they must comprehend the details of the language-rich introductory paragraph. This introductory paragraph consists of nine lines which require the cognitive integration of facts, concepts, sequences and principles.

In Question 1.1, reproduced in Figure 5.1, lines 10 – 11, if the learners do not understand the term ***consumption*** they will be unable to attempt and carry out the calculation.

The wording of Question 1.2 (lines 12 –13) might be perceived as ambiguous. It does not specifically stipulate what is being asked. Instead the learner has to extrapolate from what is being suggested.

In Question 1.3, even if the learner does understand the concept of ***percentage,*** it is not entirely clear what needs to be calculated because once again, as in Question 1, the term ***consumption*** is used.

In Question 1.4, the learners must be aware that the number of days in the month of December has to be taken into consideration. The other totals are given as daily amounts. Learners will not be able to calculate the correct answer because the daily consumption has to be multiplied by the number of days in December to establish whether the four reservoirs are able to store enough water for December.

Question 1.5 is the only one presented in Notational Format. The learners are asked to calculate a volume given particular values for certain dimensions.

It is evident that, although this is a mathematics test, only six out of the 21 marks have been allocated for questions presented in straight mathematical notation format. The rest are awarded for answers laden in Language Rich Format.

This external example illustrates what I have set out to investigate in my two phases of testing model, showing how different the achievement results can be when the same learners are given a Notational Rich Format test compared to a Language Rich Format test in which to perform.

In 2003, the CTA tests were available in only two of the official languages - English and Afrikaans - even though we teachers had been promised that it would also be available in Xhosa. This deficiency was of some concern to the Grade 9 educators and possibly contributed to a poor mathematics result for the Grade 9 learners who would be moving from the General Education and Training Phase into the Further Education and Training Phase.

5.3 The TIMSS tests of 1995, 1999 and 2003

Additional evidence for the language problem appeared to be prevalent in the results of the TIMSS test conducted in 1995, when the vast majority of the South African learners wrote them in a language that was not their mother tongue. Howie (1998:33) reported that about 19% indicated that they *always* or *almost always* spoke the school's language at home, whereas approximately 72% indicated that they *sometimes* spoke the language of learning at home. The remaining 9% *never* spoke the language of instruction at home. The same can be said for the TIMSS-R of 1999. Of the 8146 learners who participated, 24% *never* spoke the language in which they were tested, 53% *sometimes* spoke the language in which they were tested, and only 23% *always or almost always* spoke the language in which they were tested (Howie 2002:107). Not unexpectedly, the students with English and/or Afrikaans as their mother tongues performed significantly better than those with other mother tongues. In my research the 89 learners were asked to indicate their home language on each of the four tests. The collated results revealed that 77% indicated that English was their home language whilst 22% had indicated Afrikaans as their home language and a minuscule 1% had Xhosa as their home language. Even though the fraction of learners in my sample indicating English as their home language was far greater than that of both TIMSS and TIMSS-R, the results still remained poor when the learners were tested in Notational format than when tested with a Language Rich Format test, irrespective of the sequence of testing. The discrepancy in the difference from the test language to that of home language must also have put the learners at a disadvantage.

Adler (2001:2) sketched three dilemmas (code switching, mediation and transparency). During the interview process conducted in my research, no respondents mentioned code switching. It seemed that both the learners and the educator refrained from this practice, even though a large percentage spoke Afrikaans as their home language. The complete sample of 89 were in an English first language class, and so the educator taught only in English, not considering that some of the learners' home languages were other languages.

As for the dilemma of mediation, through which an educator validates or intervenes with learners to develop their mathematical communicative competence, this was not possible during the experimental phases of the test process. No communication along these lines took place between the educator and the learners. Hence the implicit or explicit language practice that possibly could happen in the class was absent. Although both practices were not present whilst the tests were being written, nevertheless it could have taken place during the course of regular mathematics lessons if intentionally planned to do so.

As previously seen in Chapter 2, the TIMSS results also revealed that the sampled South African learners did not perform well overall on questions relating to real world situations (Howie, 2001). However these learners performed better on some individual items when they could relate these to everyday experiences. Even though this may seem sophistry/fallacy, it could mean that our South African learners often were not able to relate a wider real world situation to their own limited local experiences. The results of my present study support the findings of the TIMSS. For example, when the learners were given three sets of numbers to add together in Question 17 of Test 1 in Phase I, only 66% managed to get it correct. However when the same sets of numbers were given in Question 17 of Test 2 in Phase I - but now the same learners were asked to total the cost of an individual's shopping spree by adding the numbers together - 71% managed to score it correctly. A similar result was obtained for Question 13 of Tests 1 and 2 in Phase I in which the learners were engaged with the notion of a real live everyday experience. Even though it was presented in Language Rich Format, they managed to achieve better scores when the equivalent was given in Notational form.

Furthermore, my finding corroborates that of Howie who concluded that one of the reasons why South African learners did not do that well in TIMSS-R was partly due to the fact that language in one form or another influenced the results obtained in mathematics achievement test scores (2002:107). She concluded that the language issue contributed to the poor subject knowledge and recommended that, unless some hard decisions are taken by policy makers, learners will continue to struggle and under-perform in mathematics and other subjects (Howie 2002: 258).

According to the Human Sciences Research Council, the comparison between TIMSS 1999 and 2003 delivered no significant difference in mathematics and science scores of the respective years. It also found that South Africa (SA) scored the lowest in science and mathematics when compared to the five other participating African countries. This is alarming in that it seems that no remediation or intervention was done so as to improve the results during the four year period between the tests. The question now is, will any remediation be instituted in the next year before the next cycle of TIMSS is administered, and does the current OBE system lend itself to improving the quality of education in SA so that we could compete with countries on the African continent and internationally? If the new OBE system we have in place does not allow for an improvement of mathematics and science results, then perhaps we should look to what and how the countries that are scoring well in TIMSS are doing so that we could improve our results. Dr Vijay Reddy of the HSRC, who co-ordinated the study in SA, stated that there was no single cause of South Africa's poor and diverse performance but linked it to multiple, complex and connected sets of issues, which included:

- That the study (in November 2002) was in the midst of the curriculum change to the Outcomes Based Curriculum 2005, and so the lack of content specification and low overlap with international curriculum contributed to the low score.

- Issues of poverty, resources and infrastructure of schools.
- The low teacher qualification and the poor learning cultures in schools.
- Although the language proficiency of the learners was seen to be a contributing factor, the issues of conceptual and cognitive demands placed on the learners in classrooms were seen to be the most significant.

These excuses offered by the HSRC should be questioned because, if the curriculum changes are blamed, then why was there no significant difference in the 1999 and 2003 results? Secondly the issues of poverty, resources and infrastructure of schools provide a convenient scapegoat so what is happening to the millions of rand being spent in the education sector? Somehow resources and infrastructures have somewhat improved in the past few years.

As for the low teacher qualifications and the poor learning cultures in schools, this problem should be directed to the National Education Department as they continue to retrench and offer severance packages to well qualified educators and refuse to offer an attractive salary to keep educators from going into the private sector or leaving the country to teach abroad and earn a living wage. Finally, the language proficiency and issues of conceptual and cognitive demands being placed on learners should be addressed by implementing recommendations offered by the various studies such as this one undertaken by researchers who want to improve the quality of education in SA.

5.4 The role of textbooks

The substantial mismatch in the levels of the learners' achievement obtained on certain test items within both phases of my testing is illuminating, since similar assumptions might be made about learners in other contexts similar to the one in this study. For example, sometimes we may assume that learners in a class where the medium of instruction is English are all first language English speakers, and textbooks that are written for this target group may assume that the language level of the text should be that of an English mother tongue speaker. Langhan (1993) conducted an extensive investigation over a period of three years in Ciskei, Transkei, and Eastern Cape schools. His evidence suggested that teaching and learning difficulties (with geography in Grade 5), experienced by both teachers and learners, were largely due to inappropriately prescribed textbooks that were too difficult to read and comprehend.

The fact that Curriculum 2005 (C2005) was introduced too rapidly meant many of the existing mathematics textbooks being used in schools became outdated in terms of the new method of outcomes-based teaching. The purchase of new textbooks to replace the old existing ones became too costly for some schools. Furthermore, no one textbook adequately covered all the new topics needed for outcomes-based teaching. Consequently, many schools have not purchased a learner's textbook (or a handbook as it is now called). Instead, some schools have bought a variety of resource materials for the teacher instead. This is now creating further problems since the learners have no formal textbooks to assist them when the teacher is absent or when their progress with a problem is impeded.

For many learners textbooks are the only sources of reading material. Apple (1991:5) states that textbooks:

> … set the curriculum, and often the facts learned, in most subjects. For many learners, textbooks are their first and sometimes only early exposure to books and reading. And teachers rely on them to organize lessons and structure subject matter…

One of the expectations of C2005 was that the learners would take more active roles in the learning process by working independently and thinking critically. It is unrealistic to expect learners to think more critically and work more independently if they have no textbook written in an appropriate language and presented at an appropriate level they can comprehend and learn mathematics.

TIMSS (1998:40) disclosed that the average number of books reported in South African homes was far fewer than the international average. 60 % of participant learners reported that they had fewer than 26 books at home. During the interview with the educator, teacher K, she was asked whether the learners have any textbooks. She replied that the learners had no mathematics textbooks, as it was too expensive to purchase a text book for each and every learner. Textbooks to support and assist the learners may be a priority if we want to improve the achievement levels of our learners. Apple (1991) stated that textbooks dominate what learners learn. They set the curriculum and often dictate what facts are learned in most subjects, and the public regards textbooks as authoritative, accurate and necessary.

5.5 The aim of the study, its outcomes and recommendations

The aim of the study was to examine how the language format adopted in short school tests and examinations might possibly influence the results of the mathematics achievement test scores, and whether it makes an appreciable difference to learners' mathematics performances. I attempted to address the following questions:

- Is the performance of a convenient sample of 89 grade 8 learners on a linguistically formatted mathematics test different from the performance of the same grade 8 learners on a symbolically presented mathematics test of similar content?
- Does the performance differential remain the same two months later with a new mathematics content test?
- Is there a statistically significant difference in learners' mathematics achievements when the same test content is presented in two different formats: symbolically and linguistically?
- Does the performance difference depend on the sequence in which the two different formats are presented?

The outcome of the study revealed that a previous lack of practice with language in a mathematical context possibly disadvantaged a selected sample of high school learners when they were tested alternatively in a language-rich format and a numerical (number-rich) format sequentially.

The findings provided evidence that an appreciable factor contributing to the learners' ease or difficulty experienced with a given mathematics test was the language of presentation by the test compiler (designer). During their interviews the learners constantly referred to specific difficulties they had experienced with the terms that were presented in the two language-rich formats of the four tests that were completed.

Some of the key findings during the interview process were that the learners remarked that:

- there were too many terms they did not understand,
- the terms were not easily understood,
- the words were a problem,
- it was simpler to work with the symbols and signs than words, and
- three learners even commented that they did not know what the terms meant, as they did not use those terms daily and thus forgot what they meant.

Further empirical findings revealed that a large performance difference occurred between the levels of scores obtained in the notational format tests compared to the content-equivalent language-rich format tests.

Arising out of the investigation are the following recommendations for further research:

- I recommend that the language competence in the LOLT of the grade 8 learners in my school be improved so that their mathematics performance on language-rich tests can also be improved. For example, this may be achieved by setting more homework tasks and continuous assessment monthly tests using language-rich format sums for the learners so that familiarity is equalised.
- Coupled to the improvement of the language competence of the grade 8 learners are my recommendations that more focused pre-service and in-service teacher education programmes be introduced which deal specifically with the language of learning issues researched in this study.

- It seems of particular importance that more current and prospective teachers be competent in all the languages which are dominant in the region or area in which they intend to teach or are teaching in.
- As for the formal qualifications of mathematics teachers it might be suggested that a bi-annual follow-up evaluation or refresher courses might be instituted. A census of all the mathematics teachers and their qualifications at all secondary schools might take place to gauge the current national position of teachers in each of the nine provinces in South Africa. The new Further Education and Training (FET) band currently being implemented from January 2006 causes a further strain on the subject of mathematics as it is given core subject status. Many of the teachers must be retrained, as a shortage of mathematics teachers will be inevitable. Furthermore a structured in - service training should be introduced with incentives, a traveling and study allowances should be given to educators so as to improve the current status quo in school mathematics.
- More educators like teacher K might pay more attention to social diversity when it appears in the classroom, with an emphasis on catering for the range of cultural contexts and linguistic characteristics of individuals. Thus educators can take the learners' prior knowledge into consideration in the preparation of their instructional and testing methods. Here I recommend that other masters students might begin to investigate this wider aspect.
- Learners sometimes rely heavily on their educators' expertise to bridge the gaps between the cognitive demands of content and the levels of their capacity, especially in the new outcomes-based method of teaching. Educators like teacher K might take cognisance of this fact and develop strategies such as teaching mathematics using the four-step method (listen, speak, write and read) examined by Capps & Pickreign (1993), reinforcing it with the specific language of mathematics so as to overcome this barrier. Furthermore it is suggested by Zevenbergen (1998) that learning mathematics is, in part, learning the unique correspondence between signifiers and the signified within a mathematical context and the teacher will have to assist with the bridging of this gap.

- The Education Department, curriculum developers and curriculum advisors might be invited to devise and research innovative methods such as providing incentives for teachers/educators, many of whom were trained in the old form of education (prior to the introduction of outcomes-based education) so that they can go back to study so as to come abreast with what's expected of them in the new dispensation. Then they might be able to bridge the gap between the old and new roles of the educator and learners, as proposed by Curriculum 2005. This might assist in overcoming some of the obstacles facing our learners.
- The role of the textbook might be carefully reviewed by the National Education Department. Maybe they should commission a selected number of textbook writers to liaise with educators and curriculum advisors so as to produce a textbook that would be practical, functional and written at the level of the learners. As for the manner in which the Department is introducing the role of textbooks for the new FET phase, this process might seriously be reviewed as they are spending a large sum of money by providing every learner in grade 10 next year with a mathematics textbook, that the educators were allowed to choose, not knowing whether the book would suffice for the assessment criteria let alone still be adequate for use in the next few years. An excellent book that the department might consider as to assist and aid the learners and educators in science and mathematics would be the one recently developed by CALLSSA which could be used as a supplement to the textbook as it offers assistance under the theme of 'concept literacy'. The name of the book is Understanding Concepts in Mathematics and Science: A Multilingual Learning and Teaching Resource Book in English, Xhosa, Afrikaans and Zulu (Young, van der Vlugt, & Qanya, 2005).

5.6 Implications

An important issue raised in this study is that there are quantitative links between the sophistication of presented language, how the learners internalize the mathematical concepts taught to them (internal conception of language by learners) and their subsequent performance in mathematics when tested. For example, if given the term **revolution** in mathematics, it should not be confused with the term revolution in history. They should be able to distinguish between the two concepts when presented with them in mathematics and history. If we want to improve the mathematical achievements of learners, we should also address the language context and factors at schools. Gxilishe (2004) aptly explained that "Language does not mediate knowledge. It rather constitutes and constructs knowledge, and concept formation precedes meaning" (personal conversation during a CALLSA seminar at the University of Cape Town).

Although one cannot attribute weak mathematics performance to context-specific language competence alone, nevertheless sometimes it can be seen as a significant variable, as shown in this study.

Although spontaneous concepts are developed in everyday interactions (Vygotsky 1962), mathematical concepts are subject-specific and they have to be learned within the subject. Thus, if an individual has been taught a particular concept through everyday interactions, and if this concept in one context differs from that of the mathematical concept in another context, then the clear distinction between the two concepts should be taught so that the misconception can be avoided. Typical examples are where a word like "straight" equates to the word linear, but "straight" could also mean honest in personal character; or a word like "degree" would be the angle measure in mathematics, but "degree" could also be a university qualification; or "mark" is a score, but generally "mark" is a blemish. These are but three examples in the myriad number of apparently ambiguous words used in mathematics. Integrating language learning with mathematical learning may also help to eradicate the problem of misconceptions.

5.7 Contextual content and misconceptions

This study has established an empirical link between language and performance in mathematics in the context of the research site and sample used. If we want to improve the mathematics performance of learners, we should also address the relevant language factors at schools. Although one cannot attribute weak mathematics performance exclusively to limitations in language competence, nevertheless it can be seen as one likely factor, as shown in this study. To support this suggestion, my study agrees with the findings of Pier (1998) in that the learners in my study also experienced problems with the subtraction symbol "-" when words such as "subtract", "take away" and "difference" were used. An example of this problem is found in Phase II item number 1 when 83% of my sample could answer the question **296 – 18 =** but when asked to **Decrease 296 by 18** only 66% could answer it correctly.

From my daily classroom experience, I agree with Otterburn and Nicholson (1977) that teaching children to identify contextual words (look for context clues) can assist learners when they have to disseminate the meanings that the words construe. However, contextual clues occur far less frequently in mathematics than in other school subjects such as English, history or geography. An example of how contextual clues assist the learner is when the word "revolution" is used. The following are examples of questions:

In geography: What do we call the revolution of the Earth around the Sun?
Here the context clues are Earth around the Sun, which aid the learner to understand the word "revolution" in this context.

In history: Which king was ousted during the French revolution of 1776?
Once again the date, the use of king and French could assist the learner to answer the question given.

In mathematics: When measured, a revolution is an angle which equals ……. degrees.

In the mathematical example, the learner is given very little assistance with the other words given in the sentence. If the learners have no idea what a revolution is in this context, and have no idea of the total number of degrees it contains, then they would not be able to give the correct answer.

In both the geography and history examples it is evident that there are enough clues provided to assist the learner to answer the questions asked. In the mathematics example it is very specific and, if the learner does not comprehend the term "revolution" here, the question would be so much more difficult to answer.

Earps (1971) remarked that the context provided by a mathematical passage is often less rich than the context of an ordinary English passage. This suggests why learners may experience problems with at least some word sums in mathematics.

Although a spontaneous concept such as "power" is often developed in everyday interactions, the mathematical concept "power" is subject-specific and has to be learned within the subject as it has a totally different meaning. Thus, if an individual has acquired a concept through everyday interactions, and if this concept differs from that of the mathematical concept, then the clear distinction between the two concepts should be taught to avoid misconceptions. Vygotsky (1962) stated that the scientific concepts that a child acquires in school have relationship to some object or some other concept. He went on to say, "...the very notion of scientific concepts implies a certain position in relation to other concepts" (Vygotsky 1962: 93).

Integrating language learning with mathematical learning may also help to eradicate the problems of misconceptions which the learners may have.

Shuard and Rothery (1984:24) emphasized that mathematical text is more complex than ordinary text. This becames very apparent in my study. When the learners were asked to **find the cube root of 27** they were unable to do the process. However when asked the same question in mathematical symbol form ($\sqrt[3]{27}$) they found it relatively easier to complete the task.

5.8 The role of practice-in-context

The analysed results from both Phase I and Phase II suggest that the performance scores decreased considerably either because the learners' language competencies influenced their mathematical test results, or because the learners were less familiar with mathematics tests being set in a Language Rich Format. Their implied earlier lack of practice with language competence in a mathematical context might possibly have disadvantaged them when they were tested in Language Rich Format. If the mathematical language skills of grade eight learners are improved, then their mathematics performance scores might also improve. For example, setting and marking more homework tasks and prescribing continuous assessment monthly tests with language-rich format sums, so that familiarity is equalized, might be a possible remedy. Textbooks and learner support material should be developed that are pitched to the level of the learner and which act as an aid so that the learning process and language problem can be improved. It is seen that the learning and teaching of mathematics depends very much on the learners' and educators understanding and use of the core concepts, which are a big part of the knowledge needed to succeed in this learning area (Young 2005:i). Such an innovative resource book could be one such resource that would be able to assist with the language development in the mathematics classroom as it contains concepts in four of the eleven languages of South Africa and would be able to assist both the learners and educators in the development of the language of mathematics.

Other aspects to consider are pre-service and in-service teacher education. Personally I agree with the recommendations in her key findings aptly summed up by Howie (2002:260) where she recommends that, in pre-service teacher training, the language of learning should be a core part of the training and that it is essential that all teachers are competent in another language which is dominant in the region.

As for the formal qualifications of mathematics teachers, Howie stresses that a follow-up evaluation of the qualifications of teachers in mathematics at secondary level should be undertaken to assess the current national position in South Africa. This is of particular importance in the light of the new Further Education and Training (FET) band currently being implemented as from January 2006, in which mathematics and mathematical literacy are deemed core subjects. Furthermore, one of the two subjects are compulsory for all learners from Grades 10 to 12. Many of the teachers who have not previously taught mathematics or mathematical literacy will be obliged to do so because there will be a shortage of mathematics teachers as it becomes compulsory for all Grade 10 to 12 learners. A structured in-service training programme, with incentives such as bursaries, may have to be considered to improve the current status quo in school mathematics.

5.9 Recommendations for further research

The foregoing research may be further developed if we address the following:

a) The research might be conducted with a larger sample, as this would improve the basis for a statistical comparison between learners' language competence and mathematical performance.
b) It could also be conducted with other grades, not only the grade 8 learners studied in this investigation.
c) It could also be repeated with all mother tongue speakers in their own vernacular.
d) Interviewing could occur with the learners who managed to score the same individual results in both of the tests in phase 1, and additional interviews could occur with the two learners who managed to score the same individual results in both of the tests in phase 2. The interviews could be useful in finding out what they were doing differently from the rest of the learners who were under-performing.
e) A future research investigation could be designed to equalise the pre-testing practice (familiarity - unfamiliarity) factors for both methods of testing format.
f) An example of the exit examination for the General Education and training phases (grade 9) was presented in Figure 5.1 to illustrate further how a Language-Rich Format may influence results obtained, and also to highlight the need for a change in the way we present and teach mathematics. It is recommended that publishers become pro-active and encourage all textbook writers to consult teachers and learners, and

become aware of what the assessment criteria are for the specific subject so as to improve the type of textbook which is produced.

Looking at what the study revealed, the following additional recommendations for further research should be noted.

g) Language appears to be of key importance, at least in some instances, if we want to foster competence in mathematics. We may need to develop mathematical concepts so that the learners can distinguish how and when they should be used and where they can be used effectively. In future studies, the processes of learning and developing mathematics concepts might also have to be on par with that of developing science concepts and be brought closer to one another. Furthermore, this learning and development must also be brought on par with the achievement performance levels of the rest of the African continent and the rest of the world so that when future studies like the Fourth or Fifth International Mathematics and Science Study are conducted, the South African results might reflect a much better level of achievement.

h) The difference between Ordinary English and Mathematical English may have to be addressed further by curriculum advisors and curriculum developers. They may also devise strategies to assist educators in closing the gap between the new and old roles of educator and learners, as proposed by the Outcomes-based Curriculum 2005. Furthermore, the conflict between spontaneous and formal knowledge and learning might also be researched by engaging with school mathematics tasks.

i) The question of pre-service and in-service teacher education will have to be addressed. What needs to be researched is the claim that language of learning should be a core part of the training and that it is essential that all teachers are competent in another language which is dominant in the region. As for the formal qualifications of mathematics teachers I would strongly recommend that follow-up evaluation qualifications in mathematics at senior primary and secondary level be undertaken to assess the current national position of mathematics teachers in South Africa. This should be seen as urgent as the new Further Education and Training (FET) band is now being implemented from January 2006, where mathematics and mathematical literacy are compulsory for all learners from grades 10 to 12.

5.10 Conclusion

In teaching, and especially when teaching mathematics in the South African context/situation, every lesson is unique. It requires careful consideration of the language issues, as South Africa has eleven official languages which result in a diverse learner composition in many school classes. In many schools in South Africa at least three or four languages are covertly involved at any given time in the class. These are the mother tongue of the learner, the language of learning and teaching in which the learners receive their teaching, the perceived choice of first language, possibly refugee languages as well and, finally, the one element which is specific to this research - the "language" of mathematics itself.

Despite the unique eleven language equity policy followed only in South Africa, the use of English as a medium of instruction is still the most favoured and this fact might perpetually disadvantage English second language learners or learners who study mathematics through the medium of English. As reflected in my study, mathematics as such is not always the problem; however, language can sometimes be the obstacle that causes our learners to under-achieve when compared to learners from all over the world in studies such as TIMSS.

The results obtained with the two methods of testing (notational and language rich) reflect that the learners' scores were significantly better when tested with sums without words. I am not advocating dropping language from mathematics or removing sums that are word-laden, but rather that we deal with the problem of language at hand by tackling the problem so as to improve our learners' mathematics results.

The use of different language aspects within the classroom context accentuates the difficulties and complexities of teaching and learning mathematics, and the results obtained in this study underscore the importance of language in mathematics learning and teaching. Thus we have to find solutions to the problem, but I am not mooting dropping "word sums". What may be needed is serious pre-service, in-service and classroom practice; and attention to how language-rich mathematical problems are understood and solved in the mathematics classroom. Potenza & Monyokulu (1999:231) felt strongly that the three pillars of curriculum transformation – curriculum development, teacher development and the development, selection and supply of learning materials – need to be in place and in alignment for the successful translation of C2005 into practice. I would concur that we need all the role players - i.e. mathematics teachers, all language teachers, language specialist, applied linguists, the education departments' curriculum advisors, the textbook writers and learners - should come together so as to create awareness of the language problem and equip themselves to become competent in dealing with the issues I developed and raised in my research.

5.11 Chapter Summary

I have looked at how the finding of my research related to the TIMSS study results and to the National Curriculum Statement criteria, and how it dovetails with the latest resource guides produced for language, science and mathematics teachers by CALLSSA (Young, 2005).

An example from the exit examination for the General Education and Training phases (Grade 9) was presented to further illustrate how a Language Rich Format can influence the results obtained, and to highlight the need for a change in the way we present and teach mathematics. Other issues, such as the roles of textbooks and assessment, were highlighted as well.

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APPENDIX

1

Photocopies of published papers and articles in various journals and conference proceedings

LIST OF PUBLICATIONS

1- Abrahams, M. (2001). A Comparison of the Mathematics Scores of Grade 8 Learners when Tested in Two Different Assessment Formats- Traditional (textbook) Format and Sentence Format. Proceedings of the Conference on Intergrating Content and Language: Providing Access to Knowledge Through Language, Cape Town, Peninsula Technikon. (http://www.pentech.ac.za/pil88/abstract2.htm).

2- Abrahams, M. (2001). The Mathematics Achievement Scores of Grade 8 Learners when Tested in Two Different Formats. Proceedings of the Education Students' Regional Research Conference. Graduate School of Humanities University of Cape Town, 71 – 85.

3- Young, D. & Abrahams, M. (2002). Some Words on Word Sums and Concept Literacy. Partners in Diversity – Linguistic and Cultural Perspectives. Proceedings of the Joint SAALA & LSSA Conference. University of Natal Pietermaritzburg.

4- Young, D., Mbatha,T., Abrahams, M., Deyi, S., van der Vlugt, J. Farragher, M. (2002). Towards Concept Literacy. Proceedings of the Association Internationale de Linguistique Appliquee. Singapore.

5- Abrahams, M. (2004). Some Words on Word Sums. Proceedings of the Education Students' Fourth Regional Research Conference. Graduate School of Humanities University of Cape Town, 1.

CONFERENCE

INTEGRATING CONTENT AND LANGUAGE: PROVIDING ACCESS TO KNOWLEDGE THROUGH LANGUAGE

2 to 4 July 2001

PROGRAMME AND ABSTRACTS

PENINSULA TECHNIKON

Bellville
Western Cape

TUESDAY 3 July 2001 CLASSROOM 2 (first floor)
11.30 - 13.00
PAPER 6

A COMPARISON OF THE MATHEMATICS SCORES OF GRADE 8 LEARNERS WHEN TESTED IN TWO DIFFERENT ASSESSMENT FORMATS - TRADITIONAL (TEXTBOOK) FORMAT AND SENTENCE FORMAT

M ABRAHAMS

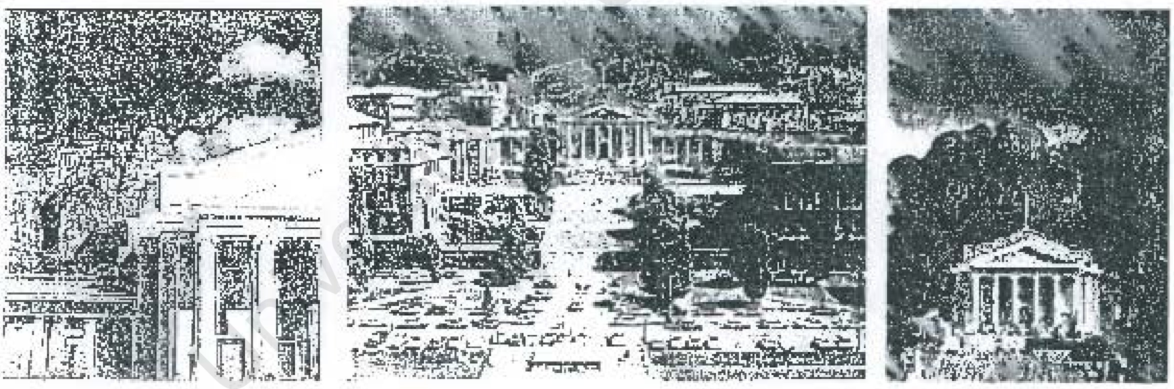
UNIVERSITY OF CAPE TOWN

This study was carried out in March 2001 and reports on the performance scores of 89 Grade 8 learners when they answered a mathematics test composed of 17 items. The first achievement test was presented in **traditional** textbook format; and one week later the learners answered the **same** 17 mathematical items (the second achievement test), but presented in a **sentence** format. Another set of tests was administered, but this time the sentence format test was done first and it was then followed by the 'traditional' test. This paper presents the findings on these different tests and discusses some of the conclusions on learners' performance in the tests.

Conference
EDUCATION STUDENTS' RESEARCH CONFERENCE

28 - 29 SEPTEMBER 2001

PROGRAMME, ABSTRACTS, PAPERS AND DISSERTATIONS



GRADUATE SCHOOL IN HUMANITIES
UNIVERSITY OF CAPE TOWN

THE MATHEMATICS ACHIEVEMENT SCORES OF GRADE 8 LEARNERS WHEN TESTED IN TWO DIFFERENT ASSESSMENT FORMATS

MARK ABRAHAMS
University of Cape Town
Markie019@yahoo.com

ABSTRACT

This study reports on the changes which occurred in the performance scores of Grade 8 first language English speakers when they answered two mathematics tests. The research methodology engaged a flip-flop design with consecutive testing formats over a period of two months in 2001. The first achievement test was presented in traditional textbook format; and one week later the learners answered the same 17 mathematical items (the second achievement test), but presented in a sentence format. In order to corroborate the effect of assessment format as an independent variable, two months later a second phase of testing was conducted with the same sample and the same number of mathematical items. In the second phase the order of testing was reversed: the sentence format was administered first, followed by the traditional signs and symbols format, with content constant. This paper presents the findings on these different tests and discusses some of the conclusions on learners' performance in the tests.

Partnerships in diversity

Linguistic and Cultural Perspectives
Joint SAALA & LSSA Conference
8-10 July 2002
University of Natal
Pietermaritzburg

Partnerships in
diversity

Linguistic &
Cultural Perspectives

Conference booklet
kongresbundel

Vennote in diversiteit

Linguistiese en kulturele perspektiewe
Gesamentlike SAALA en LVSA-kongres
8-10 Julie 2002
Universitet van Natal
Pietermaritzburg

Some words on word sums and concept literacy.

Douglas Young and Mark Abrahams
CALLSSA, UCT

The newly established CALLSSA project in concept literacy in maths and science teaching and learning is outlined as work in progress, both from a theoretical perspective and in terms of data thus far gleaned. We critique the role and impact of textbooks in maths and sciences in identifying and elucidating key concepts. In these learning areas. The correspondence is explored between theses Latinate/Greek-based concepts coded in English and the African mother tongues of learner…

We present a case study of grade 9 ESL learners' attempt to do maths using word sums in comparison with their attempts to do maths minus the word sums. Our findings thus far indicate that traditional maths notation and problem statements facilitate more successful maths problem solving in this context than current word-sum problem statements.

AILA 2002 Paper (Singapore)
Association Internationale de Linguistique Appliquee
Proceedings editor: Lionel Wee

Towards Concept Literacy

Douglas Young, Thabile Mbatha, Mark Abrahams, Somakazi Deyi, Julie van der Vlugt, Mary Farragher
CALLSSA, UCT

The idea of concept literacy is explored in the context of the teaching and learning of maths and the sciences in grades 5 – 9 in Western Cape schooling. The interplay between language, literacy, concept formation and the textbook as a source of concept induction is examined.

This project identifies key specialised maths and sciences concepts as these appear in English as language of instruction textbooks used by Xhosa and Afrikaans speaking learners. Mother tongue Xhosa terms are sought and placed in a communicative context as annotations to the textbooks, to establish concept literacy in Xhosa, particularly where speakers of Xhosa claim that no such barrier to concept literacy and concept formation is explored. Results of research involving word sums in maths are presented. Evidence is shown that when the words are removed from word sums and the more traditional symbolic maths notation is used, learning and problem solving in maths improves.

PROCEEDINGS OF THE EDUCATION STUDENTS' FOURTH REGIONAL RESEARCH CONFERENCE

15-16 OCTOBER 2004

ABSTRACTS, PAPERS AND DISSERTATIONS

GRADUATE SCHOOL IN HUMANITIES
UNIVERSITY OF CAPE TOWN

SOME WORDS ON WORD SUMS

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ABSTRACT

This study reports on the changes which occurred in the performance scores of 89 Grade 8 English first language speakers when they attempted two mathematics tests, each comprised of 17 items.

The research methodology engaged a flip-flop design with repeat testing formats consecutively over a period of two months. The first achievement test was presented in Notational (signs and symbols) mathematics format; and one week later the learners answered the same 17 mathematical content items (the second achievement test), but presented instead in a Language Rich format.

In order to corroborate the effect of assessment format as an independent variable, a month later a second phase of testing was conducted with the same sample and the same number of mathematical test items. In the second phase the order of the testing was now reversed: the Language Rich format was administered first, followed by the Notational format, with mathematical content once again held constant.

The findings were that, irrespective of sequence of presentation, the learners significantly under-performed on the same content by an average of 18% to 22.8% when tested with the Language Rich format by comparison with the Notational format which used the traditional signs and symbols.

APPENDIX

2

Samples of test 1, 2, 3 and 4 completed
by the learners.

PHASE I

Mathematics Test 1

NAME:………………………………………………… AGE:…12……

HOME LANGUAGE:…English……… GENDER: Male/[✓ Female]
(circle the correct one)

Starting Time:…8:50…

$\frac{13}{17}$

signature removed

1. 127 + 17 = 144 ✓
2. 1725 – 1274 = 451 ✓
3. 17 x 5 = 85 ✓
4. 872 – 427 = 445 ✓
5. 8276 – 984 = 7292 ✓
6. 8721 - 4720 = 401 ✗
7. $90^0 - 82^0 =$ 8° ✓
8. 6 x 5 = 30 ✓
9. 197 – 87 = 110 ✓
10. 105 ÷ 5 = 21 ✓
11. 3878 – 3052 = 826 ✓
12. $\sqrt{121}$ = 14 ✗
13. 54 ÷ 6 = 9 ✓
14. $\sqrt[3]{27}$ = 7 ✗
15. $360^0 \div 4 =$ 90° ✓ ← REMEMBER UNITS
16. $72^0 \div 2 =$ 36° ✓
17. R3.75 + R2.75 + R15.78 = R20,39 ✗

Finishing Time:…9:02…

PHASE I Mathematics Test 2

NAME:.. AGE: 12

HOME LANGUAGE: English GENDER: Male [✓ Female]

(circle the correct one)

Starting Time: 8:50

$\frac{12}{17}$

signature removed

1. Find the sum of 17 and 127.

   110 X

2. Subtract 1274 from 1725.

   451 ✓

3. Find the product of 5 and 17.

   85 ✓

4. If point A equals 427 and point B equals 872. Find the distance between point A and B. 445 ✓

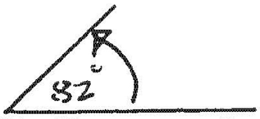
5. Decrease 8276 by 984.

   7292 ✓

6. From 8721 subtract 4720.

   4001 ✓

7. Give the complement of 82 degrees.



X

8. Karen bought 6 CD's. There were 5 songs on each CD. How many songs did she buy in total? 30 Songs ✓

9. Find the difference between 87 and 197.

110 ✓

10. Prove by means of division that 5 is a factor of 105.

✓

5X 21 = 105. or $\frac{105}{5} = 21$

11. A plane flies non-stop from New York to London. The distance covered is 3052 kilometers. A second plane flies non-stop on the exact route but lands in Athens. The distance now covered is 3878 kilometers. How far apart is Athens ~~and~~ from London? 826 km apart ✓

12. Give the square root of 121. 11 ✓

13. Sid has 54 nails. He wants to put 6 nails in each row. How many rows could he fill? 11 in each row X

14. Give the cube root of 27? 3 ✓

15. A revolution is divided into 4 equal parts. How many degrees will each part consist of? (~~Acute angle~~)

↑

Right Angle x READ YOUR QUESTION.

16. A angle of 72 degrees is bisected. Give the answer you would have after the angle is bisected. 144° X

17. Jacki goes to the shop and purchases a bread for R3.75, a piece of cheese for R2.75 and R15.78 worth of meat. What is the total cost of her shopping spree?

R22,28 ✓

Finishing Time:.....9:06

PHASE II

Mathematics Test 3

NAME:…………………………………………………… AGE:……12……

HOME LANGUAGE:…English GENDER: Male/[✓ Female]
(circle the correct one)

Starting Time:…8:50

9/17

signature removed

1. Find the answer when 296 is decreased by 18.
278 ✓

2. Find the Sum of 517;142 and 785.
1444 ✓

3. What is the Square of 11? 121 ✓

4. What would it cost to purchase 8 liters of cooldrink if 1 liter cost at R5.26.
R42,08 ✓

5. Find the Square root of 81. 1440 ✗

6. What is the Product of 728 and 8271?
7551 ✗

7. Find the difference between 64 and 624.
540 ✗

8. What is the complement of 28 degrees?
62 ✗

9. What is the cube of 3? 27 ✓

10. What is the supplement of 72 degrees?

112° X

11. If point X equals 547 and point Y equals 876.
Find the distance between point X and Y

320 X

12. Find the answer when an angle of 82 degrees is bisected.

8° X

13. Increase 529 by 872. 140 X

14. From 8921 subtract 8704. 217 ✓

15. Find the cube root of 27. 3 ✓

16. A Revolution is divided into 3 equal parts. How many degrees does each part consist of. 120° ✓

17. Find the quotient of 5 and 625 625 ÷ 5 = 125 ✓

Finishing Time: 9:03

PHASE II

Mathematics Test 4

NAME:…………………………………………………… AGE:……12……

HOME LANGUAGE:…English……… GENDER: Male/[✓ Female]
(circle the correct one)

Starting Time:…8:50…

$\frac{14}{17}$

signature removed

1. 296 -18= 278 ✓
2. 517+142+785= 1444 ✓
3. 11 x 11= 121 ✓
4. R5.26 x 8= R42,08 ✓
5. $\sqrt{81}$ = 9 ✓
6. 728 + 8271= 8999 ✓
7. 624 - 64= 596 ✗
8. $90^0 - 28^0$ = 62° ✓
9. 3^3 = 27 ✓
10. $180^0 - 72^0$ = 108° ✓
11. 876 - 547= 329 ✓
12. $82^0 \div 2$ = 41° ✓
13. 529 + 872= 1401 ✓
14. 8921 - 8704= 37 ✗
15. $\sqrt[3]{27}$ = 9 ✗
16. $360^0 \div 3$ = 120° ✓
17. 625 ÷ 5 = 125 ✓

Finishing Time:…8:59…

APPENDIX

3

The Raw Scores for the Phase Tests

PHASE 1 TEST 1 NOTATIONAL FORMAT

Learners	Q 1	Q 2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	TOTAL
1	1	0	0	0	1	1	1	1	1	1	0	1	1	0	1	1	0	11
2	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	15
3	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	15
4	1	0	0	1	1	1	0	1	1	1	0	1	0	0	0	0	1	9
5	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15
6	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	0	13
7	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	14
8	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	15
9	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	16
10	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	16
11	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
12	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
14	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	11
15	1	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	8
16	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	7
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
19	1	1	1	1	0	1	1	1	1	0	1	0	0	1	0	1	1	12
20	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	4
21	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	15
22	1	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0	1	7
23	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	15
24	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	15
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
26	0	1	0	1	0	1	1	1	1	0	0	1	1	1	0	0	0	9
27	0	1	1	0	0	0	0	1	1	1	0	1	1	1	0	1	1	10
28	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	9
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
30	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	15
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
32	1	0	0	0	1	1	0	1	0	1	0	0	0	1	0	0	0	6
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
34	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	11
35	1	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	0	6
36	1	1	0	1	0	1	1	0	1	1	1	1	1	1	0	1	1	13
37	1	1	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	13
38	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1	0	0	12
39	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	13
40	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	14
41	1	0	1	0	0	1	1	1	1	0	1	1	1	1	0	1	0	11
42	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	15
43	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	0	1	11
44	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
45	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1	1	0	13
46	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	14
47	1	0	1	0	0	1	0	1	1	0	1	0	0	0	0	1	1	8
48	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
49	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	15
50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17

51	1	0	0	1	0	1	0	1	1	0	0	0	1	1	0	1	1	9
52	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	16
53	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	16
54	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
55	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	16
56	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	16
57	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	14
58	1	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	8
59	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	16
60	1	0	1	0	0	0	0	1	0	1	1	1	0	1	1	0	0	8
61	0	1	1	1	0	0	1	1	1	1	1	1	1	0	1	1	1	13
62	1	0	1	1	0	1	1	1	1	1	1	0	0	1	1	0	0	11
63	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
64	1	0	1	0	0	0	1	1	1	0	0	1	1	0	0	1	0	8
65	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
66	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
67	1	0	1	0	0	0	1	1	1	1	1	1	1	0	1	0	1	11
68	1	1	1	1	0	1	1	1	1	0	1	0	0	1	0	0	1	11
69	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	16
70	0	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	9
71	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	14
72	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	14
73	1	1	0	1	1	1	1	1	1	0	1	0	1	0	0	1	1	12
74	0	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	1	6
75	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	16
76	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	14
77	1	1	0	1	1	1	1	1	1	1	1	0	1	0	0	0	0	11
78	1	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	7
79	1	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	11
80	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	16
81	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	15
82	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
83	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15
84	1	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	1	8
85	1	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	1	7
86	1	0	1	1	1	1	0	1	1	1	1	0	0	0	1	1	1	12
87	1	1	0	1	1	1	1	1	1	0	1	1	0	1	0	1	0	12
88	1	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	6
89	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	16
Out of 8'	81	60	71	64	56	76	69	85	80	67	77	65	58	61	54	63	59	

PHASE 1 TEST 1 NOTATIONAL FORMAT

Learners	Q 1	Q 2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	TOTAL
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2	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	15
3	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	15
4	1	0	0	1	1	1	0	1	1	1	0	1	0	0	0	0	1	9
5	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15
6	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	0	13
7	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	14
8	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	15
9	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	16
10	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	16
11	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
12	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
14	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	11
15	1	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	8
16	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	7
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
19	1	1	1	1	0	1	1	1	1	0	1	0	0	1	0	1	1	12
20	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	4
21	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	15
22	1	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0	1	7
23	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	15
24	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	15
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
26	0	1	0	1	0	1	1	1	1	0	0	1	1	1	0	0	0	9
27	0	1	1	0	0	0	0	1	1	1	0	1	1	1	0	1	1	10
28	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	9
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
30	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	15
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
32	1	0	0	0	1	1	0	1	0	1	0	0	0	1	0	0	0	6
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
34	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	11
35	1	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	0	6
36	1	1	0	1	0	1	1	0	1	1	1	1	1	1	0	1	1	13
37	1	1	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	13
38	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1	0	0	12
39	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	13
40	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	14
41	1	0	1	0	0	1	1	1	1	0	1	1	1	1	0	1	0	11
42	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	15
43	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	0	1	11
44	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
45	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1	1	0	13
46	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	14
47	1	0	1	0	0	1	0	1	1	0	1	0	0	0	0	1	1	8
48	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
49	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	15
50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17

51	1	0	1	0	0	0	0	1	0	1	0	1	1	1	0	1	1	9
52	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
53	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
54	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	13
55	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	15
56	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	13
57	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	15
58	1	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	1	7
59	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1	13
60	1	1	0	0	0	0	1	1	0	1	0	1	1	1	1	0	1	10
61	1	1	0	0	1	0	0	0	1	1	1	1	1	1	1	0	1	11
62	1	1	1	0	0	0	0	1	0	1	0	1	1	0	0	1	1	9
63	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	15
64	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	7
65	1	1	1	1	1	1	0	1	1	0	1	0	1	1	1	0	0	12
66	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	1	14
67	0	1	0	1	1	1	1	1	1	0	1	1	1	0	1	0	1	12
68	1	0	0	0	1	0	0	1	1	0	0	1	0	1	1	0	1	8
69	1	1	1	1	1	1	0	1	1	0	0	1	0	1	1	0	1	12
70	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
71	1	0	1	0	0	1	0	1	1	0	0	1	1	1	1	0	1	10
72	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	12
73	0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	0	1	10
74	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	1	5
75	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	15
76	0	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1	12
77	1	0	0	0	1	1	0	1	0	0	1	0	1	0	0	0	0	6
78	0	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	6
79	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	15
80	1	1	0	1	0	1	0	1	1	1	0	1	1	1	1	0	1	12
81	1	0	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	7
82	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	15
83	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	15
84	1	0	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	11
85	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2
86	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0	0	1	8
87	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	11
88	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	4
89	0	1	1	0	1	0	0	1	1	0	1	1	1	1	1	0	1	11
	59	49	43	50	44	49	17	76	61	53	60	64	59	56	50	24	63	

PHASE 2 TEST 3 NOTATIONAL FORMAT

Learners	Q 1	Q 2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	TOTAL
1	1	1	0	0	1	0	1	1	0	1	1	0	0	1	0	0	0	8
2	1	1	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	6
3	1	0	0	1	1	0	1	0	1	0	1	0	0	1	1	1	0	9
4	0	0	0	1	1	1	0	0	0	0	1	0	1	1	0	0	0	6
5	1	1	0	1	1	0	1	1	0	1	1	1	1	1	1	0	0	12
6	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	6
7	0	1	0	0	1	0	1	0	0	1	1	0	0	1	0	1	0	7
8	1	0	1	0	0	1	0	0	1	1	0	1	1	1	1	0	1	10
9	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	14
10	1	1	1	0	1	0	0	1	1	1	1	0	0	1	1	1	0	11
11	1	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1	0	13
12	1	1	0	0	1	0	1	0	0	0	1	0	1	1	1	0	0	8
13	1	1	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	13
14	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	3
15	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	3
16	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	3
17	1	1	0	0	1	0	1	0	0	1	0	1	0	0	1	1	1	9
18	1	1	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	11
19	1	1	0	1	1	0	1	0	0	0	0	1	1	0	1	1	0	9
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	1	1	0	0	1	1	1	0	0	0	0	1	1	0	1	0	0	8
22	0	1	0	1	1	0	1	0	0	0	0	0	1	0	1	0	0	6
23	1	1	0	1	0	1	1	0	0	1	1	0	1	1	1	1	1	12
24	1	1	0	1	0	0	1	1	0	0	1	1	1	1	0	1	1	11
25	1	1	1	1	1	0	1	0	1	0	1	0	1	1	1	1	1	13
26	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
27	1	1	0	1	1	1	0	0	0	0	1	0	1	1	0	0	0	8
28	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	3
29	1	0	0	1	1	1	0	0	0	1	1	0	1	1	1	0	1	10
30	0	1	0	1	0	1	1	1	0	1	1	0	0	1	1	0	0	9
31	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	14
32	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	4
33	1	0	0	1	1	1	1	1	0	1	0	1	1	1	1	0	1	12
34	1	1	0	1	0	1	1	0	0	0	0	0	1	1	0	0	0	7
35	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	4
36	1	1	0	0	1	0	0	0	0	0	1	0	1	1	1	0	1	8
37	1	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1	0	6
38	1	1	0	1	1	1	0	0	0	0	0	0	1	0	1	0	0	7
39	1	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1	9
40	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	4
41	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
42	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	0	0	6
43	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2
44	1	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	6
45	1	1	1	1	0	0	0	0	1	0	0	0	0	1	1	1	1	9
46	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0	1	0	8
47	1	0	1	0	1	0	1	0	1	1	1	0	0	1	1	1	1	11
48	0	0	1	1	0	0	1	0	0	0	1	0	0	1	1	1	1	8
49	0	0	0	1	1	0	1	0	0	0	1	0	1	1	0	0	0	6
50	1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0	10

51	1	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	6
52	1	1	0	0	0	0	1	1	0	1	1	0	0	1	0	1	1	9
53	1	1	0	1	1	1	1	1	0	0	0	0	1	1	1	1	1	12
54	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1	1	1	14
55	0	0	0	0	1	0	1	0	0	1	1	1	1	1	0	1	1	9
56	1	0	0	0	1	0	1	0	0	1	0	0	1	1	1	0	0	7
57	1	1	0	0	1	0	0	1	0	1	0	0	1	1	1	0	0	8
58	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	8
59	1	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	0	12
60	1	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	6
61	1	0	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	12
62	1	0	1	1	1	0	0	0	1	0	0	0	0	0	1	0	0	6
63	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	14
64	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	4
65	1	1	1	1	1	0	1	0	1	0	1	0	1	1	1	1	1	13
66	0	0	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	12
67	1	0	0	1	1	0	1	1	0	1	1	0	1	1	0	0	0	9
68	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	7
69	1	1	1	1	0	0	1	0	1	0	1	1	1	1	0	1	0	11
70	0	0	1	0	1	0	0	0	1	0	1	0	0	1	0	1	0	6
71	1	1	0	1	1	0	1	0	1	1	1	0	0	1	1	1	0	11
72	1	1	0	0	0	1	1	1	0	1	1	0	1	1	0	0	0	9
73	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	4
74	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2
75	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	1	1	14
76	1	0	1	1	1	0	1	1	0	1	1	0	1	1	1	0	1	12
77	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
78	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	4
79	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	4
80	1	0	1	1	0	0	1	1	1	0	0	0	1	1	1	0	1	10
81	0	1	0	0	1	0	0	0	0	0	0	1	0	1	1	0	0	5
82	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	15
83	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1	1	1	14
84	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	3
85	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2
86	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2
87	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	4
88	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2
89	0	0	1	0	1	0	1	0	1	0	1	0	1	1	1	1	1	10
	59	51	26	48	57	26	47	26	26	35	48	16	53	57	55	39	30	

PHASE 2 TEST 4 NOTATIONAL FORMAT

Learners	Q 1	Q 2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	TOTAL
1	1	0	1	0	1	1	1	0	0	1	1	1	1	1	0	0	0	10
2	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	14
3	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	16
4	1	1	0	0	1	1	1	1	0	1	1	0	1	1	1	0	0	11
5	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	14
6	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	13
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	15
8	1	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	1	11
9	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	11
10	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
11	1	1	1	0	1	1	1	1	1	1	1	1	0	1	0	1	1	14
12	1	1	0	1	1	1	1	1	0	1	1	0	1	1	0	0	0	11
13	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	16
14	1	1	1	0	0	1	1	1	1	1	0	1	1	1	0	1	1	13
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	3
17	1	0	1	1	1	1	0	1	0	1	1	1	1	0	1	1	1	13
18	1	1	1	0	1	1	0	1	1	0	1	1	1	1	1	1	0	13
19	1	1	1	0	0	1	1	1	1	1	1	1	0	1	0	1	0	12
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
21	1	1	0	1	0	1	1	0	1	0	1	1	1	0	0	0	0	9
22	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	0	0	5
23	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15
24	1	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1	1	14
25	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	14
26	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	3
27	1	0	1	1	1	1	1	1	0	1	0	1	1	0	1	0	1	12
28	1	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	6
29	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	15
30	1	1	1	1	1	1	0	1	0	0	1	1	1	1	1	0	0	12
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
32	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	3
33	1	1	0	1	1	1	1	1	0	0	0	1	0	1	0	0	1	10
34	1	1	0	0	0	1	0	1	0	1	1	0	1	1	0	0	0	8
35	0	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	5
36	1	0	1	0	1	0	1	1	0	0	1	1	1	1	0	0	1	10
37	1	1	1	0	1	1	0	0	0	1	0	0	1	0	1	0	0	8
38	1	1	0	0	1	1	0	1	1	0	1	1	1	1	1	0	0	11
39	1	1	0	1	1	1	1	0	0	0	1	1	0	1	1	1	0	11
40	1	1	1	1	1	0	1	1	0	1	0	1	1	1	0	1	1	13
41	1	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	5
42	1	1	1	0	1	1	1	0	1	0	1	1	1	0	1	1	0	12
43	1	1	0	1	1	1	0	1	1	0	1	1	0	1	1	1	1	13
44	1	1	0	0	1	1	0	1	1	1	1	1	1	1	0	1	1	13
45	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	14
46	1	0	1	0	0	1	1	1	0	0	0	1	1	0	1	1	1	10
47	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	5
48	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
49	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	16
50	1	1	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	13

51	1	0	1	0	1	1	1	0	1	1	0	1	0	0	1	1	1	11
52	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	13
53	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	16
54	1	1	1	1	1	1	0	1	1	1	0	1	1	0	0	1	1	13
55	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
56	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	14
57	1	1	0	0	1	1	1	0	0	1	1	1	1	1	0	1	1	12
58	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1	1	1	14
59	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	15
60	0	1	1	1	0	1	1	0	1	1	0	1	1	1	1	1	0	12
61	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1	14
62	1	1	1	0	1	1	1	1	1	1	0	1	0	0	1	1	1	13
63	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
64	1	0	0	0	0	1	1	1	0	1	0	0	1	0	0	0	0	6
65	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	15
66	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
67	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	14
68	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	15
69	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
70	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
71	1	0	1	0	1	1	1	1	0	1	0	1	1	1	1	0	1	12
72	1	1	1	0	0	1	1	1	0	1	1	1	0	1	0	1	1	12
73	1	1	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	12
74	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	5
75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
76	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	15
77	1	1	1	0	0	1	0	1	0	1	1	1	1	1	0	0	0	10
78	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	16
79	1	0	1	0	1	0	1	1	1	0	1	1	1	1	0	1	0	11
80	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	16
81	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
82	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
83	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	16
84	1	1	1	0	1	1	0	0	0	1	1	0	0	0	0	0	0	7
85	0	0	0	0	1	0	1	1	1	0	1	1	1	0	0	0	1	8
86	1	1	1	1	0	0	1	1	0	1	1	1	1	1	0	0	0	11
87	0	1	0	0	1	1	0	0	0	0	0	1	0	0	1	1	0	6
88	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	3
89	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
	74	69	56	43	66	77	60	65	47	65	58	70	71	60	49	54	53	

APPENDIX

4

Memorandum of Marking of the Phase Tests

PHASE I

Mathematics Test 1

MEMORANDUM

1. 127 + 17 = **144** ✓
2. 1725 – 1274 = **451** ✓
3. 17 x 5 = **85** ✓
4. 872 – 427 = **445** ✓
5. 8276 – 984 = **7292** ✓
6. 8721 - 4720 = **4001** ✓
7. $90^0 - 82^0$ = **8^0** ✓
8. 6 x 5 = **30** ✓
9. 197 – 87 = **110** ✓
10. 105 ÷ 5 = **21** ✓
11. 3878 – 3052 = **826** ✓
12. $\sqrt{121}$ = **11** ✓
13. 54 ÷ 6 = **9** ✓
14. $\sqrt[3]{27}$ = **3** ✓
15. $360^0 \div 4$ = **90^0** ✓
16. $72^0 \div 2$ = **36^0** ✓
17. R3.75 + R2.75 + R15.78 = **R22.28** ✓

PHASE I Mathematics Test 2

MEMORANDUM

1. Find the sum of 17 and 127. **144** ✓
2. Subtract 1274 from 1725. **451** ✓
3. Find the product of 5 and 17. **85** ✓
4. If point A equals 427 and point B equals 872. Find the distance between point A and B. **445** ✓
5. Decrease 8276 by 984. **7292** ✓
6. From 8721 subtract 4720. **4001** ✓
7. Give the complement of 82 degrees. **8^0** ✓
8. Karen bought 6 CD's. There were 5 songs on each CD. How many songs did she buy in total? **30** ✓
9. Find the difference between 87 and 197. **110** ✓
10. Prove by means of division that 5 is a factor of 105. **21** ✓
11. A plane flies non-stop from New York to London. The distance covered is 3052 kilometers. A second plane flies non-stop on the exact route but lands in Athens. The distance now covered is 3878 kilometers. How far apart is Athens and London? **826km** ✓
12. Give the square root of 121. **11** ✓
13. Sid has 54 nails. He wants to put 6 nails in each row. How many rows could he fill? **9** ✓
14. Give the cube root of 27? **3** ✓
15. A revolution is divided into 4 equal parts. How many degrees will each part consist of? **90^0** ✓
16. A angle of 72 degrees is bisected. Give the answer you would have after the angle is bisected. **36^0** ✓
17. Jacki goes to the shop and purchases a bread for R3.75, a piece of cheese for R2.75 and R15.78 worth of meat. What is the total cost of her shopping spree? **R22.28** ✓

PHASE II

Mathematics Test 3

MEMORANDUM

1. Find the answer when 296 is decreased by 18.	**278** ✓
2. Find the Sum of 517;142 and 785.	**1444** ✓
3. What is the Square of 11?	**121** ✓
4. What would it cost to purchase 8 liters of cooldrink if 1 liter cost at R5.26.	**R42.08** ✓
5. Find the Square root of 81.	**9** ✓
6. What is the Product of 728 and 8271?	**8999** ✓
7. Find the difference between 64 and 624.	**560** ✓
8. What is the complement of 28 degrees?	**62^0** ✓
9. What is the cube of 3?	**27** ✓
10. What is the supplement of 72 degrees?	**108^0** ✓
11. If point X equals 547 and point Y equals 876. Find the distance between point X and Y.	**329** ✓
12. Find the answer when an angle of 82 degrees is bisected.	**41^0** ✓
13. Increase 529 by 872.	**1401** ✓
14. From 8921 subtract 8704.	**217** ✓
15. Find the cube root of 27.	**3** ✓
16. A Revolution is divided into 3 equal parts. How many degrees does each part consist of.	**120^0** ✓
17. Find the quotient of 5 and 625	**125** ✓

PHASE II

Mathematics Test 4

MEMORANDUM

1. 296 -18= **278** ✓
2. 517+142+785= **1444** ✓
3. 11 x 11= **121** ✓
4. R5.26 x 8= **R42.08** ✓
5. $\sqrt{81} =$ **9** ✓
6. 728 + 8271= **8999** ✓
7. 624 - 64= **560** ✓
8. $90^0 - 28^0 =$ **62^0** ✓
9. $3^3 =$ **27** ✓
10. $180^0 - 72^0 =$ **108^0** ✓
11. 876 - 547= **329** ✓
12. $82^0 \div 2 =$ **41^0** ✓
13. 529 + 872= **1401** ✓
14. 8921 - 8704= **217** ✓
15. $\sqrt[3]{27} =$ **3** ✓
16. $360^0 \div 3 =$ **120^0** ✓
17. $625 \div 5 =$ **125** ✓

APPENDIX

5

Samples of audio-captured conversations
of the participants that
were Interviewed.

A Sample of audio-captured conversations of the participants that were Interviewed.(May)

1- I think I did not do so well in the test 2 and test 3 because I got less than in the other two tests

2- In Phase I test 2 is more difficult

3- In Phase II test 3 is more difficult

4- The one that was straight forward maths like we do it in class

5- The one without the words is easier (pause) the words make the other one more difficult

6- I think I done better because my teacher went over the word we got in the first two tests and made us understand it better

7- Definitely the one without the long sentences(referring to Notational Format)

8- Cube root, complement, supplement and square root

9- Teacher K helps us in class when we don't understand the work

10- I think I score ok in mathematics I always aim to score a 50%

APPENDIX

6

Year 8 Mathematics Assessment and result from the University of New South Wales Educational Testing Centre (2004) a test which was undertaken by the Western Cape Education Department.

YEAR
8

MATHEMATICS
ASSESSMENT

SOUTH AFRICA

WES-KAAP
ONDERWYSDEPARTEMENT
WESTERN CAPE EDUCATION
DEPARTMENT
ISEBE LEMFUNDO
LENTSHONA KOLONI

THE UNIVERSITY OF
NEW SOUTH WALES

EDUCATIONAL
TESTING CENTRE

40 QUESTIONS
TIME ALLOWED: 1 HOUR

STUDENT'S NAME: ZAAHIR ABDURAMAN

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED.

Read the instructions on the **ANSWER SHEET** and fill in your **NAME, SCHOOL YEAR, GENDER** and the **LANGUAGE YOU FIRST SPOKE.**

QUESTIONS 1 – 35: MULTIPLE CHOICE
Use the information provided to choose the BEST answer from the four possible options.
On your ANSWER SHEET blacken the oval that matches the answer you choose.
Mark only ONE answer for each question.

QUESTIONS F1 – F5: FREE RESPONSE
On the ANSWER SHEET write your answer in the boxes provided.

Your score will be the number of correct answers.
Marks are NOT deducted for incorrect answers.

Use a 2B or B pencil. Do NOT use a biro or pen.
Rub out any mistakes completely.
You may use a ruler and spare paper.
Calculators ARE required.

SYDNEY AUSTRALIA www.etc.unsw.edu.au ETC is a division of New South Global Pty Limited.
ABN 62 086 418 582

2004 SCHOOLS INTERNATIONAL ASSESSMENT TASK - MATHEMATICS

Section 7. Performance on Individual Items

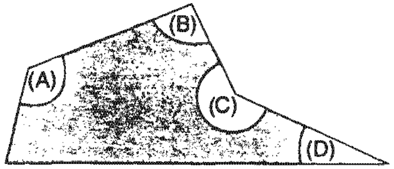
Grade 8

For each question the correct response is given with the percentage of students in your school who answered correctly, whether this is a strength ("S") or weakness ("W"), the percentage of students in the province who answered correctly (in parentheses), and a description of the question.

Q1	'A'	20%	W	(28%)	Measurement. Identify angle type from diagram
Q2	'C'	27%	W	(34%)	Number. Find ratio of lengths as percentage
Q3	'D'	30%	W	(38%)	Measurement. Given duration, find finishing time
Q4	'B'	57%		(59%)	Chance and Data. Select graph that best suits data
Q5	'D'	38%	W	(46%)	Number. Select order of operation
Q6	'B'	26%		(26%)	Space and Geometry. Identify coil shape when view altered
Q7	'A'	36%	W	(42%)	Algebra. Identify suitable algebraic expression
Q8	'D'	13%	W	(18%)	Algebra. Collect terms in algebraic expression
Q9	'C'	72%	S	(64%)	Space and Geometry. Compare symmetry in given shapes
Q10	'A'	29%	S	(23%)	Measurement. Read meter with four alternating faces
Q11	'C'	17%	S	(13%)	Chance and Data. Rearrange table to find median
Q12	'D'	15%		(14%)	Space and Geometry. Identify coordinates of right triangle
Q13	'C'	22%	W	(26%)	Measurement. Select measurements for ribbon length
Q14	'D'	23%		(25%)	Algebra. Identify error in equation solution
Q15	'A	25%		(25%)	Number. Express a given proportion as a number
Q16	'B	23%	W	(30%)	Number. Select correct value on number line
Q17	'*'	100%		(100%)	Space and Geometry. Find true statement of symmetry
Q18	'B'	20%		(21%)	Measurement. Estimate length of curved line
Q19	'C'	15%		(17%)	Number. Add and subtract fractions in context
Q20	'A	13%		(13%)	Algebra. Interpret equation and solve problem
Q21	'D'	37%		(39%)	Chance and Data. Read time periods from tide chart
Q22	'C'	26%	W	(31%)	Measurement. Identify mass order for similar objects
Q23	'D'	8%	W	(12%)	Number. Solve money problem
Q24	'B'	29%		(32%)	Measurement. Determine overlap in a chain
Q25	'D'	11%	W	(15%)	Space and Geometry. Identify net of a given cube
Q26	'A'	23%		(25%)	Space and Geometry. Count joined faces of hexagonal prisms
Q27	'C'	31%		(32%)	Number. Convert revs/min to degrees/sec
Q28	'C'	26%		(27%)	Chance and Data. Select barcode matching coded number
Q29	'D'	11%	W	(17%)	Number. Calculate rate of water leakage
Q30	'D'	25%		(25%)	Algebra. Complete subtraction pattern
Q31	'A'	19%		(19%)	Algebra. Select equation to represent problem
Q32	'C'	31%		(32%)	Algebra. Calculate time given work rates
Q33	'B'	12%		(14%)	Space and Geometry. Identify tessellating unit from pattern
Q34	'A'	18%		(18%)	Number. Solve proportion problem
Q35	'B'	10%		(12%)	Measurement. Estimate arrival time using diagram
Q36	93	0%		(0%)	Measurement. Deduce time taken from study schedule
Q37	300	3%		(4%)	Space and Geometry. Find position after transformations
Q38	54	1%		(2%)	Number. Find common value in recycling patterns
Q39	116	0%		(0%)	Algebra. Evaluate by rearranging and substituting
Q40	38	0%		(0%)	Chance and Data. Find number of combinations of colours

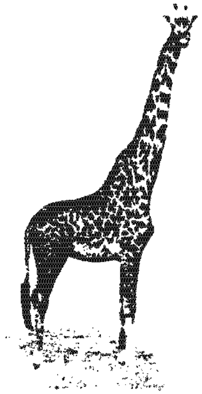
'*' indicates all answers are correct

1. Which of the angles labelled is an obtuse angle?



20%

2. The length of a giraffe's neck is about three-fifths of the giraffe's total height.



What is the length of a giraffe's neck as a percentage of its total height?

(A) about 35%
(B) about 40%
(C) about 60%
(D) about 65%

97%

3. Jodie and her friends watched a movie.

It began at 6:30 pm and ran for 105 minutes.

At what time did the movie finish?

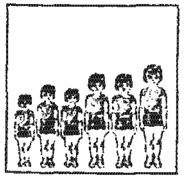
(A) 7:21 pm
(B) 7:35 pm
(C) 8:05 pm
(D) 8:15 pm

30%

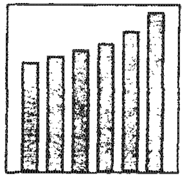
4. Here is a record of Jamie's height every birthday for six years.

Age	9	10	11	12	13	14
Height (cm)	90	95	100	105	115	130

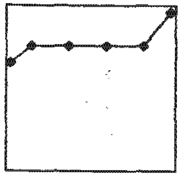
Which of these diagrams could represent Jamie's height over these years?



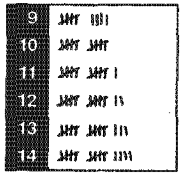
(A)



(B)



(C)



(D)

57%

5. Felipe wants to evaluate this expression.

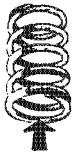
$$12 + 4 \times (10 - 3)^2$$

Which part of the expression should he calculate first?

(A) 3^2
(B) 4×10
(C) $12 + 4$
(D) $10 - 3$

38%

6. Boris has the coil of wire shown.



He looks through the coil in the direction shown by the arrow.

Which diagram shows what the coil looks like from this direction?

(A)

(B)

(C)

(D)

7. Brian had $\$a$.
His father gave him another $\$a$.
Brian then gave $\$b$ to his sister.

Which expression gives the total number of dollars Brian then had?

(A) $2a - b$
(B) $2a + b$
(C) $a - b$
(D) $a + b$

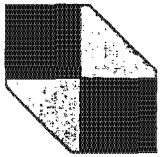
8. Jenny has written the algebraic expression shown.

$$\boxed{\frac{1}{2}x - 2 + \frac{1}{2}x + 3}$$

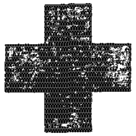
Which of these expressions is equivalent to Jenny's expression?

(A) $x - 1$
(B) $x + 1$
(C) $2x - 1$
(D) $2x + 1$

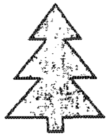
9. Brent has this symmetrical logo.



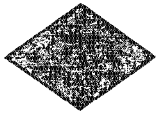
Which of these figures has the same number of axes of symmetry as Brent's logo?



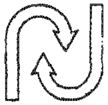
(A)



(B)

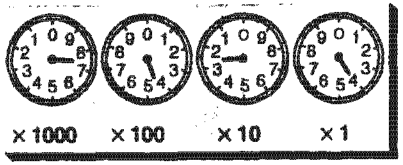


(C)



(D)

10. The diagram shows a type of meter where the adjacent dials read in opposite directions.



What is the reading on this meter?

(A) 7424
(B) 7534
(C) 8424
(D) 8534