RELATIONSHIP BETWEEN MATHEMATICAL
LANGUAGE AND STUDENTS' PERFORMANCE IN
MATHEMATICS IN PUBLIC SECONDARY SCHOOLS IN
NAIROBI PROVINCE, KENYA

BY

NJOROGE BENSON

A Thesis Submitted in Partial Fulfilment of the
Requirements for the Degree of Master of Education
of Kenyatta University

MARCH, 2003
Declaration.

This thesis is my original work and has not been presented for a degree in any other university.

NJOROGGE BENSON

We confirm that the candidate under our supervision carried out the work reported in this thesis.

PROF. Mutunga, P.K.
Associate Professor
Department of Educational Communication and Technology
Kenyatta University

DR. Rukangu, S.M.
Lecturer
Department of Communication Skills
Kenyatta University
Dedication

This work is dedicated to my beloved mother, Wanjiru, N.Kimana for her inspiration, support and commitment to my education.

Glory and honour to God.
Acknowledgements

I would like to acknowledge those who positively contributed towards the success of this study. My heartfelt appreciation goes to my supervisors, Prof. P.K.Mutunga and Dr. S. M. Rukangu, who ceaselessly devoted their time to ensure that the study succeeded.

Much thanks go to the entire staff of Educational Communication and Technology. In particular, I thank Prof. M. M. Patel, Dr. E. Gitau, Dr. J. Maundu, Dr. V. Kimui, Dr. M. N. Ole Shanguya and Dr. S. Muthwii who taught me the various courses. Much gratitude also goes to my colleagues in the academic battle: Nicholas, Miheso, and Michieka for their moral support and social warmth throughout the entire course.

I extend my sincere thanks to Mr. P.M. Gachanja for his support and encouragement. I would also like to thank the students and teachers who participated in this study.

I am heavily indebted to members of my family, relatives and friends for their support, encouragement and assistance. Last but not least, I am grateful to Kenyatta University for having awarded me a partial scholarship to enable me successfully go through my M.Ed course in Mathematics Education. Mr. A.D. Bojana deserves special gratitude for editing and proof reading the final work.
# Table of contents

Declaration ...................................................................................................................... ii  
Dedication ....................................................................................................................... iii  
Acknowledgements ......................................................................................................... iv  
Table of contents ........................................................................................................... v  
List of tables .................................................................................................................... x  
List of figures .................................................................................................................. xii  
List of abbreviations and acronyms .............................................................................. xiii  
Abstract .......................................................................................................................... xiv  

## CHAPTER I: INTRODUCTION ...................................................................................... 1  
1.1 Background to the problem .................................................................................... 1  
1.2 Statement of the problem ....................................................................................... 6  
1.2.1 Conceptual framework ..................................................................................... 7  
1.3 Objectives of the study ......................................................................................... 9  
1.4 Research hypotheses ............................................................................................. 10  
1.5 Significance of the study ...................................................................................... 10  
1.6 Basic assumptions of the study ............................................................................ 12  
1.7 Scope and limitations ........................................................................................... 12  
1.7.1 Scope ............................................................................................................... 12  
1.7.2 Limitations ....................................................................................................... 13  
1.8 Definition of terms .............................................................................................. 13  
1.9 Organisation of the thesis .................................................................................... 14  
1.10 Chapter summary ............................................................................................... 15
CHAPTER II: LITERATURE REVIEW

2.0 Introduction

2.1 Students' performance in mathematics

2.2 Language used in mathematics

2.2.1 Language use in formation of mathematics concepts

2.2.2 Mathematics as a scientific language

2.2.3 Essence of mathematical language in learning and teaching of mathematics

2.2.4 Language used in mathematical texts

2.3 Chapter Summary

CHAPTER III: METHODOLOGY

3.0 Introduction

3.1 Design of the study

3.2 Location of the study

3.3 Study population

3.4 Sampling and sample size

3.4.1 Sample description

3.4.2 Sample selection techniques

3.4.3 The sample size

3.5 Research instruments

3.5.1 Reliability and validity

3.5.2 Piloting of the instruments

3.5.3 Administration of the research instruments
CHAPTER IV: DATA PRESENTATION, ANALYSIS AND DISCUSSION ........................................ 57

4.0 Introduction ................................................................................................................ 57
4.1 Methods of data analysis ............................................................................................ 57
4.2 School-related variables ............................................................................................ 59
4.3. Student-related variables ........................................................................................ 61
4.3.1 Relationship between students’ scores in some terminologies used in mathematics and their performance in mathematics ................................................................. 61
4.3.2 Relationship between class levels, terminologies test scores, and hours devoted to study mathematics and performance in mathematics ............................................. 63
4.3.3 Relationship between students’ gender and performance in mathematics ........... 66
4.3.4. Relationship between school type and performance in mathematics ................ 68
4.3.4. Relationship between school type and performance in mathematics ............................................. 68

4.4. Mathematical terminologies that students viewed as difficult ........................................................................ 70

4.5. Problems faced by students in studying mathematical language and their solutions .................. 72

4.5.1. Problems .................................................................................................................. 72

4.5.2. Solutions to the problems cited by the students .......... 74

4.6. Styles for learning symbolic and mathematics word problems ........................................................................ 75

4.7. Analysis of students performance on SMLT questions ..... 77

4.8. Teacher-related variables .............................................................................................................. 78

4.8.1. Teachers’ professional qualification and experience ...... 79

4.8.2. Mathematical terminologies that teachers viewed as difficult to teach ......................................................... 81

CHAPTER V: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0. Introduction .................................................................................................................. 84

5.1 Summary of research findings ......................................................................................... 84

5.2. Conclusion ...................................................................................................................... 86

5.3. Recommendations of the study .................................................................................... 86

5.4. Suggestions for further research .................................................................................. 87
Appendix A: Students' Mathematics Language Test (SMLT)............. 95
Appendix B: Mathematics Teachers' Questionnaire (MTQ)............. 101
Appendix C: List of public secondary schools in Nairobi Province as at
14/10/2001. .............................................................................. 104
List of tables

Table

1.1: KCSE percentage mean scores in maths and science subjects from 1990 to 1996 at national level by gender.........................2

3.1: Distribution of public secondary schools in Nairobi Province..........................................................................................41

3.2: Sampling grid.........................................................................................................................................................46

4.1: Mathematics textbooks as viewed by teacher preferences(N=12).................................................................................59

4.2: Number of students and their scores in terminologies test (x) and mathematics test (y) (N= 384)..............................................61

4.3: Regression output....................................................................................................................................................64

4.4: Students’ scores in the SMLT by gender......................................................................................................................66

4.5: Students’ t-value for the terminology and mathematics tests..............................................................................................67

4.6: Mean scores of the various school types........................................................................................................................68

4.7: Analysis of variance (ANOVA) results for school types.................69

4.8. Problems associated with mathematical language as viewed by students........................................................................73

4.9. Solutions to problems associated to mathematical language as viewed by students (N=384).................................................74

4.10: Students’ study methods for learning mathematical language..........................................................................................75
4.12: Analysis of students performance on SMLT questions ................................................................. 77

4.13. Distribution of mathematics teachers by academic qualifications, teaching experience and gender................................................................. 79
List of figures

Figure

1.1: Relationship between mathematical language and mathematics learning ................................................................................................................8

2.1: A theoretical model of communicative mathematics class ...........................................................................................................................................30

3.1 Design of the study .................................................................................................................................................................................................39
List of abbreviations and acronyms

B.E.R.C: Bureau of Educational Research Centre
INSET: In service Training
K.C.S.E: Kenya Certificate of Secondary Education
K.I.E: Kenya Institute of Education
K.N.E.C: Kenya National Examinations Council
P.G.D.E: Post-graduate Diploma in Education
Abstract

The purpose of this study was to establish the relationship between mathematical language and students' performance in mathematics. In addition to the main purpose, the study sought to find the problems experienced by teachers and students in teaching and learning mathematical language and their perceived solutions respectively.

The study was a cross-sectional descriptive survey employing correlation methods to investigate the relationship between mathematical language and students' performance in mathematics. The study comprised 10 stratified selected public secondary schools in Nairobi Province. A total of 384 students responded to a 20-item, Students' Mathematics Language Test (SMLT) questionnaire comprising terminology and mathematics tests. The teachers filled the Mathematics Teachers' Questionnaire (MTQ) on problems they encounter in teaching mathematical language and their possible solutions.

Quantitative data obtained from the SMLT were analysed using Statistical Package for Social Sciences (SPSS). The statistics derived included percentages, mean, Pearson r, standard deviation, student 't' test scores and Analysis of Variance (ANOVA) values. Pearson product-
moment correlation coefficient was used to determine the relationship between mathematical language i.e. scores in terminologies test and scores in mathematics test.

The study found that there was a relationship between mathematical language and students' performance in mathematics \( r = 0.3608, \ p > 0.001 \). It also found that girls (overall mean score = 11.617) performed better than boys (overall mean score = 9.3284) in the SMLT.

Based on the research findings of the study, it is recommended that a simplified mathematical language in communicating mathematical ideas is fundamental and hence a pre-requisite to the successful pursuit of learning mathematics in secondary schools. The study further recommends a course in mathematics language be designed to demystify mathematical language in order to improve students' mathematics performance.
CHAPTER I
INTRODUCTION

This chapter introduces the problem that was investigated by discussing the following eight issues: Background to the problem, statement of the problem, objectives of the study, research hypotheses, significance of the study, assumptions of the study, scope and limitations and definition of unique terms used in the study.

1.1 Background to the problem

The importance of school mathematics can be explained by its usage in various contexts. People working in industries, government offices, individual private enterprises, schools and even at home require some basic knowledge of mathematics in their day-to-day work. While most people in our society recognise and appreciate the essential role of mathematics in everyday life, it remains one of the poorly performed subjects in the KCSE national examinations (KNEC, 1995). The gravity of the situation is shown in Table 1.1.
Table 1.1: **KCSE percentage mean scores in maths and science subjects from 1990 to 1996 at national level by gender**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MATHS</td>
<td>G</td>
<td>B</td>
<td>G</td>
<td>B</td>
<td>G</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15</td>
<td>14</td>
<td>20</td>
<td>9</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>BIOLOGY</td>
<td>17</td>
<td>19</td>
<td>23</td>
<td>25</td>
<td>19</td>
<td>22</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>35</td>
<td>38</td>
<td>33</td>
<td>35</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>PHYSICS</td>
<td>21</td>
<td>25</td>
<td>16</td>
<td>20</td>
<td>19</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>CHEMISTRY</td>
<td>26</td>
<td>28</td>
<td>26</td>
<td>29</td>
<td>30</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>PHYSICAL SCIENCE</td>
<td>17</td>
<td>19</td>
<td>16</td>
<td>19</td>
<td>19</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>BIOLOGICAL SCIENCE</td>
<td>18</td>
<td>20</td>
<td>17</td>
<td>20</td>
<td>21</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

**Key:** G-Girls, B-Boys

**Source: Kakonge (2000)**

From Table 1.1, a number of observations can be made:

- Performance of both boys and girls in the stated subjects over the years has been poor.
- Even though the performance fluctuated over the years, it is evident that gender disparity in performance exists: females continue to score poorer than males in all the subjects.
- Students’ performance in mathematics was generally poor as compared to science subjects.
Poor performance in mathematics has been attributed to several factors. Works by Shiundu (1987), Thuo (1985) and Eshiwani (1983) have identified factors such as over-enrolment, inappropriate syllabus and students' poor attitudes towards the subject as some of them. Kathuri (1986) and Mwangi (1983) identified inadequate resources (teachers and teaching aids) as other causes for the poor performance in mathematics examinations. The Ministry of Education in Kenya through its various organs has made considerable efforts to curb the above causes. Such efforts have included among others, adequate training of mathematics teachers, provision of teaching materials and in some occasions revision of the secondary school mathematics curriculum. Despite the above efforts, students still perform poorly (KNEC, 1995). Due to the unrelenting poor performance of students in KCSE mathematics examinations, the need to investigate whether there are other related factors to the phenomenon is crucial. This study intended to investigate the relationship between mathematical language and students' performance in mathematics.

Mathematics is viewed as a language, which consists of terminologies and symbols (Orton, 1992; Mutunga & Breakwell, 1992; Pimm, 1991). Unlike English language, it is a specialised language that mainly uses ideograms: symbols for communicating ideas as opposed to phonograms: symbols for sounds. Communication in mathematics
embraces the usage of various symbols and notations for brevity. Presentation and explanation of symbols and notations would require effective articulation for the learners to easily perceive and conceptualise mathematical instruction.

In discussing symbols, Skemp (1971) used the idea of surface and the deep structures. The surface structures are the forms of symbol while the deep structures convey meanings. The symbols $5c^2$, $5c_2$, $5c_2$, $\Sigma c^2$ and $\Sigma C2$ all have the same surface structure but their deep structures are very different. Thus, the use of mathematical symbols, without adequate understanding of the deep structures could be a likely cause of alienation from mathematics. Cockcroft (1982) agrees with Skemp and says that ‘Algebra is... a source of considerable confusion and negative attitudes among students’. Mathematical language uses Algebra, which uses symbols for communication. This shows that mathematical symbols can cause confusion amongst students leading to development of negative attitudes towards mathematics. It also can cause students difficulty in conceptualising mathematical ideas when learning the subject. This is a likely cause of students’ poor performance in mathematics.

Mathematical terminologies, which are part of mathematical language, are neither standardised nor unambiguous but have some lexical
ambiguities (Pimm, 1987). Thus if such terminologies are used in mathematical contexts (classrooms, textbooks and in assessment items) without clarity, they are likely to confuse students. This study was designed to investigate the relationship between mathematical terminologies and students’ performance in mathematics.

Mathematical language is used in several contexts: in mathematics classrooms, in mathematics textbooks, reference books and in assessment items. Mathematics examinations and continuous assessment tests are often written in mathematical language as well as in English language. The learner may know the algorithms required for use in the solution of a problem, but the mathematical language used may impede the learner from rightly answering it. Hence, this could lead to poor performance. It would seem reasonable therefore, to contend that the mathematical language could be a likely cause of the difficulty experienced by learners of mathematics in understanding mathematical concepts, assessment tests and hence poor performance in the subject. However, there exists no systematic study, at least in the Kenyan context on the relationship between mathematical language and students’ performance in the subject. Hence the need for the study.
1.2 Statement of the problem

Students' poor performance in mathematics in Kenya has been blamed on factors such as: poor attitudes towards the subject, shortage of teaching aids, poor teaching methodologies, shortage of qualified teachers, school ethos and overloaded curriculum among others. The Ministry of Education, Science and Technology in Kenya through its various organs has made considerable efforts to curb the above causes. Such efforts have included, among others, adequate training of mathematics teachers, provision of teaching materials and in some occasions revision of the secondary school mathematics curriculum. Nevertheless, poor performance in mathematics still persists. This shows that the problem has not all been adequately addressed.

While the above factors, identified by various researchers, may contribute to such poor performance, there could be other related factor that contributes to the phenomenon. This could be, as proposed by this study, the mathematical language which is used in mathematics' teaching, learning and assessment. At any rate the relationship between mathematical language and students performance in mathematics has not been explored at least in Kenya.
1.2.1 Conceptual framework

Mathematics learning involves a number of variables: personnel (teachers), learners, mathematics content, mathematical language and teaching aids. The relationships between these variables and other details are shown in figure 1.1.
It LEARNING MATHEMATICS

SOURCES OF DIFFICULTIES

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Learner</th>
<th>Mathematics</th>
<th>Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>. Shortage</td>
<td>. Background</td>
<td>. Language</td>
<td>. Language aids</td>
</tr>
<tr>
<td>. Training</td>
<td>. Age, Gender</td>
<td>. Semantics</td>
<td>. Textbooks</td>
</tr>
<tr>
<td></td>
<td>. Attitudes</td>
<td>. Maths as a language</td>
<td>. Test papers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>. lexical inputs</td>
<td></td>
</tr>
</tbody>
</table>

INTERVENTION: APPROPRIATE MATHEMATICAL LANGUAGE

- Classroom communication
  - Friendly and simplified
- Language used in assessment
  - Appropriate and simplified

IMPACT: ENVIRONMENT FOR LEARNING MATHEMATICS

- Proper classroom communication.
- Simplified language used in mathematics classrooms, textbooks and in assessment.
- Good students' performance in mathematics

Figure 1.1: Relationship between mathematical language and mathematics learning

Source: Adapted from Cooney (1975).
Figure 1.1 shows that the main difficulties associated with learning of mathematics emanate from personnel, learners, teaching aids, mathematics content and mathematical language used in communicating, reading and assessing content. The mathematics teachers who are the main curriculum implementers communicate mathematical concepts in the classroom. They also assess the learning outcomes using mathematical language. Students too communicate mathematical concepts using mathematical language. They also read mathematics textbooks and respond to assessment items written in mathematical language. All these variables are conceptually tied together by mathematical language. This implies that if a simplified, non-ambiguous mathematical language were used in communicating mathematical concepts, setting assessment items, then students may succeed in the subject.

1.3. **Objectives of the study**

The study was undertaken to establish:

a) Difficult terminologies used in mathematics.

b) The relationship between some terminologies used in mathematics and students’ performance in mathematics.

c) The relationship between class levels, some terminologies used in mathematics, hours devoted to study symbolic & word problems and performance in mathematics.
d) The relationship between school type gender and students’ performance in mathematics language test.

e) Problems faced by both teachers and students in the use of mathematics language during teaching and learning of mathematics.

1.4 **Research hypotheses**

The study used primary data to test the following four null hypotheses:

H0₁: There is no relationship between some terminologies used in mathematics and students’ performance in mathematics.

H0₂: There is no relationship between class levels, some terminologies used in mathematics, hours devoted to study symbolic & word problems and performance in mathematics.

H0₃: There is no significant difference between students’ gender and performance in mathematics language test.

H0₄: There is no significant difference between school type and performance in mathematics language test.

1.5 **Significance of the study**

The findings of the study will be beneficial to the following:

a) **Mathematics teachers**

Teachers are the main implementers of any school mathematics curriculum. The findings will enlighten them on problems associated
with language used in mathematics; hence alert them in the use of simplified and unambiguous mathematical language when teaching mathematics to enhance students' appropriate learning of mathematics.

b) Mathematics teacher trainers
Mathematics teacher trainers will find the findings useful while preparing their teacher trainees. This will include equipping teacher trainees with appropriate mathematical language base to be used in mathematics classroom.

c) Textbook authors
The findings will enable the textbook authors to prepare materials for mathematics learning and teaching with simplified language devoid of ambiguities as well as suited for a particular level.

d) Mathematics examiners
Mathematics examiners are probably unaware of the language competence of the students. Therefore, the findings of the study will alert them of the various terminologies that cause ambiguities and problems in examinations. This would enable them to use simplified language in setting examination items for mathematics.

e) K.I.E Curriculum developers
The findings will enable the K.I.E curriculum developers to prepare materials for mathematics learning and teaching with appropriate
language, which is simple, as possible in vocabulary and syntax: devoid of ambiguities and well suited for a particular level.

f) Mathematics learners
The findings of the study would help learners to follow appropriate ways of learning mathematical language and mathematics in general.

1.6 Basic assumptions of the study
The study was guided by the following basic assumptions.
That all secondary schools under investigation: -

a) Were adhering to a uniform syllabus of mathematics.
b) Had their mathematics teachers adequately trained in mathematics education.
c) Were adequately equipped with appropriate mathematics learning resources.
d) The learners were assumed to have positive attitude towards mathematics.

1.7 Scope and limitations

1.7.1 Scope
The study dealt with students and their teachers in stratified randomly selected public secondary schools in Nairobi Province, Kenya. Nairobi Province was used as it was assumed that, as the only urban province,
it had its population comprising a large number of ethnic communities and races that speak different languages (Rukangu, 2000).

1.7.2 Limitations

The following are considered the study limitations:

a) Since the sample respondents were drawn from some selected public secondary schools in Nairobi Province, the effects found mainly reflected the situation in the province. Hence, the findings may not be representative of all secondary schools in Kenya.

b) Resources (time and funds) were other limitations of the study. Inadequate funds and time for the programme (one year for research work) hindered the extension of the research to other parts of the country but concentrated in Nairobi Province only.

1.8 Definition of terms

In this study, the following words were used for the purpose and with the intention as explained below:

**Appropriate mathematical language:** Appropriate mathematical language is the usage of simplified mathematical terminologies devoid of ambiguities.

**Concept:** A concept is an abstract idea describing some relationship within a group of facts and may be designated by some sign or symbol.
Language competence: Language competence is the ability to have efficient command of grammar, vocabulary to interpret texts and applying certain language structures effectively for the intended purpose.

Mathematical competence: Mathematical competence is the ability to communicate ideas by means other than verbal representation.

Mathematical language: Mathematical language is the language used in expressing mathematical ideas including terminologies and symbols and technical terms.

Performance: Performance is the action of a pupil or group of students when given a learning task.

Simplified mathematical language: Simplified mathematical language is a language that is adaptable to the learner's level of knowledge, which is finding the right place to use demonstrative, relative or functional language on one hand and procedural or descriptive language on the other.

1.9 Organisation of the thesis

This thesis has been divided into five chapters. Chapter one (1) is the introduction, which outlines the context of the study including the background, statement of the problem, study objectives, hypothesis,
significance of the study, basic assumptions of the study, scope and limitations and the definition of terms.

Chapter two (2) is the review of the related literature with regard to the study. This is reviewed under two subsections: Students' performance in mathematics and Language used in teaching, learning and assessment of mathematics.

Chapter three (3) provides the design of the study and the methodology used in carrying out the study. In this section, a full description of the locale (sample sites) is given. There is a discussion on sampling techniques, research instruments, and procedures of data collection, data analysis techniques and the rationale for choosing them.

Chapter four (4) presents, analyses the data collected and discusses the results. The research objectives have been discussed mainly under the school, teacher and pupil related variables. Finally, chapter five (5) summarises the findings, gives conclusions of the study and suggestions for additional research. A bibliography and appendices are presented at the end of the thesis.
1.10 Chapter summary

This chapter has conceptualised the problem of the study to the fact that language used in mathematics could be one of the main causes of pupils' poor performance in mathematics. The purpose of the study was to establish the relationship between mathematical language and students' performance in mathematics. Other highlights include the background to the study, statement of the problem, its significance and definition of terms used in the study. The chapter also identified secondary school students as the main unit of analysis in the study. Issues relating to language used in mathematics are further reviewed in the next chapter.
CHAPTER II
LITERATURE REVIEW

2.0 Introduction

Learning mathematics begins and proceeds in language and its outcomes are often assessed in language. Such observations are true for all secondary school curricula, but interweaving of mathematics and language is particularly intricate and intriguing. This chapter therefore aims to account for and discusses some of the ways in which language and mathematics intersect. It also highlights students' performance in mathematics in national secondary examinations. The chapter discusses these issues under the following two headings:

♦ Students’ performance in mathematics.
♦ Language used in teaching, learning and assessment of mathematics.

2.1 Students’ performance in mathematics

Several factors have been found to have an influential effect on students’ performance in mathematics. Thuo (1985) carried out a survey that involved 22 secondary schools in Kenya on the factors that influence poor performance of mathematics among secondary school students. He found that adequacy of resource materials for teaching mathematics, attitudes towards the subject, school ethos, teacher and pupil characteristics exerted significant influence on the students'
performance in mathematics. Despite efforts to provide adequate resources, campaigns to change students and teachers' attitudes and improving school's discipline, student's poor performance in the subject persists. This implies that the problem that leads to students' poor performance in the subject has not been adequately addressed. While the above factors may contribute to such performance, there could be yet another critical and key factor that contributes to poor performance in the subject. This is, as proposed by this study the mathematical language.

Gender is another factor that has been identified as having some effects on performance of mathematics (Kakonge, 2000). The gravity of the situation in KCSE mathematics examinations is as shown on Table 1.1.P.2. It is evident from the table that there exists gender disparity in students' performance in mathematics in Kenya. Various studies have also been conducted to investigate the factors behind the disparity.

While studying gender differences that existed in the learning of mathematics, Eshiwani (1975), found that high school boys in Kenya performed better than high school girls on arithmetic tests and girls performed better than boys on probability tests.
Mondoh (1986), carried a similar study on the relationship between gender and mathematical ability but found no overall significant gender differences in mathematical abilities. The question of gender difference in cognitive abilities has been observed to have no influence on performance. Several scholars have identified attitude related factors such as low self-esteem, poor self-concept, fear of success, and lack of confidence as having an influence on girls' achievement in mathematics and sciences (Gichura, 1999: Neyland, 1994). Therefore, gender effect on mathematical achievement can be attributed to psychological, social and cultural factors other than mathematical ability of the students. Despite spirited gender awareness efforts, gender disparity in students' performance in mathematics persists. At any rate, the relationship between mathematical language and gender disparity in students' performance in mathematics has not yet been explored at least in Kenya. This was a concern of this study.

Bali et al. (1984), in their on CPE mathematics performance reported the correlation coefficient of CPE mathematics performance with gender, urban/ rural, linguistic background and attitudes towards mathematics to be 0.34, 0.15, 0.11 and 0.25 respectively. The correlation coefficient between performance and linguistic background (0.11) shows a positive low relationship. This indicates that student's linguistic background has some influence on mathematics
performance. It was therefore necessary to find out if similar results can be recorded in secondary schools.

Kithyaka (1994) investigated the extent to which various test items—symbolic and word problems account for the variation in mathematics performance in Machakos district. The study involved standard eight students in five (5) rural and two (2) urban primary schools in the district. She found out that, the urban school students found the word problems relatively more difficult to tackle compared to the rural school students. However, she found no significant difference between the performance of rural and urban students on symbolic item scores at $\alpha=0.05$. She recommended additional research to determine the extent to which language used in mathematics accounts for variation in performance on symbolic and word problems in mathematics. It was therefore a matter of importance to find out whether similar results could be found in Nairobi secondary schools, bearing in mind the diversity of students’ language backgrounds. The study further investigated the relationship between mathematical language and students’ performance in mathematics.

2.2 **Language used in mathematics**

This section describes the use of mathematical language in mathematics teaching and learning of mathematics. This includes
language use in formation of mathematical concepts, mathematics as a scientific language, essence of mathematical language in learning and teaching of mathematics, language used in mathematical texts

2.2.1 **Language use in formation of mathematics concepts**

Mathematical concepts are mental abstractions of common properties of a set of experiences or phenomena (Johnson and Rising, 1972). The name of a concept is a sound, or a mark on paper associated with it. In teaching concepts, the teacher mentions the characteristics or properties that enable students to find examples and non-examples.

Language therefore plays an important role in the formation of concepts (Skemp, 1971). A concept is exclusively imagery and is inaudible and invisible. We have neither a way of seeing directly the content of someone’s mind nor that of allowing others to view our own. Therefore have to use other means, which are either audible or visible to represent a concept. Such means are the spoken sounds and written words or marks (notations) on paper. This shows that sound, words and marks form the bases for the mathematical language, which was the basis of this study.

Vygotsky (1962), carried out an experimental study of concept formation with pre-school children. The main purpose of his study was
to find out the dependence of the understanding of concepts on the language, which describes them. He found that the children explained the names of objects by their attributes. His conclusions were not simply that concept and language are inextricably linked, but that concept formation depends on linguistic developments. A particular conclusion that can be made from the foregoing is that the development of terminology appears to be important for concept formation. This implies that development of terminologies is fundamental in concept formation and by extension crucial in the successful pursuit of mathematics. Hence, appropriate language is essential in communicating mathematical terminologies.

2.2.2 Mathematics as a scientific language

Mathematics can be described as a language that uses highly precise and concise symbols (Mutunga & Breakwell, 1992; Orton, 1992). This does not mean that mathematics is a language like English or Dholuo. Its nature makes it useful in scientific communication for general development of individuals and societies (Rukangu, 2000). It uses peculiar language and symbolism to communicate ideas.

Sidhu (1982) rightly points out that mathematics is “a language of physical sciences”. This means that it is used as a language that communicates scientific ideas of physical sciences. Physics and
chemistry utilize mathematical language and symbols to express complex phenomena. Most scientific discoveries are expressed using mathematical language. An observation can be made here that appropriate use of mathematical language could not only lead to better mathematics performance but also lead to successful pursuit of sciences. However, mathematics as a scientific language has its own limitations and problems in learning the discipline. Its symbolic representation of ideas, unique terminologies and technical terms can be a possible source of students' difficulties in learning the subject. Hence affecting students' performance in the subject.

Symbols cut short lengthy mathematical statements and help in expressing ideas in an exact form. They are usually free from verbosity and help to express ideas in a clear and exact manner. For example, instead of saying that the square of sum of two terms is equal to the sum of the square of the first term, square of the second term and double the product of the two terms, we write,

\[(a + b)^2 = a^2 + 2ab + b^2.\]

The symbolic form helps in solving numerous complicated problems. Symbolism is heavily exploited in mathematics. Kline (1973) identified three main purposes of symbolism as to:

i) Communicate ideas effectively.

ii) Conceal ideas.
iii) Conceal the absence of ideas.

Thus, symbols can help in communicating mathematical concepts effectively. On the other hand, they can conceal ideas and therefore could impede communication of concepts. For example, consider the following: Given an expression,

\[ f(x, y) = 3x - 2y = 1, \]

determine the set,

\[ A = \{(x-y) : x \in N, y \in N, f(x, y) = 1\}, \]

where \( N \) means the set of all integers. The above symbolism is an effective way of communicating mathematical ideas. Unfortunately, it is likely to conceal the ideas therein. In the above example, all that symbolism amounts to the statement: determine all the integral solutions of \( 3x - 2y = 1 \). Thus, such kind of symbolism is likely to frighten students and add extra burden of remembering what the symbols stand for. This necessitated the designing of the present study to investigate how symbolic items relate to students' performance in mathematics in secondary schools.

Mathematical language is not devoid of ambiguities. It is neither so precise nor consistent as might be popularly purported (Durkin & Shire, 1991:71; Kithyaka, 1994). Several ambiguities are associated with this highly concise and precise language. Linguists have identified several types of lexical ambiguities including homonymy, polysemy, homophony and shifts of application (Deanne, 1988).
Homonymy denotes the property of some words that share the same meaning form but distinct meanings. For example in mathematics, a word like leaves, which in everyday use refers to the outgrowths of a tree or goes away, means the process of subtraction.

Polysemy refers to the property of some words that they have two or more different but related meanings. For instance, a mathematical example would be the word product. In everyday use it refers to a thing, which has been made, whereas in mathematics it refers to a quantity obtained by multiplication.

Homophony refers to the phenomenon where two distinct words have the same pronunciation. For example two|too|to, four | for, pi | pie. Shifts of application refer to occasions where the same sense can be considered from different perspectives. For example, the word number is subject to shifts of application. This is so when ‘number’ used to describe nominal (the ‘number 5’), ordinal (the ‘second number’ she said), cardinal (the ‘number you contend’) or visual (the ‘number 7’ is crooked) properties. The above ambiguities ‘may impede the learners’ understanding of certain mathematical concepts (Durkin & Shire, 1991:71). The present study was designed to establish the effects of such ambiguities on students’ mathematics performance.
Several studies have been carried out on lexical ambiguities. Otterburn and Nicholson (1976) investigated the understanding of mathematical terminologies of three hundred (300) students following Certificate of Secondary Education (CSE) courses. They found that the terminologies used in arithmetic were found to be better understood than those used in geometry. They also reported that only about 20% of the sample understood the word product as used in mathematics. The above study is significant to the present study because the background of the study is not the same as in Kenya but mathematics is taught using English, which is a second language. The present study, however, extended and established the relationship of such terminologies and students' performance in mathematics.

Shuard and Rothery (1984), proposed that words in mathematics fall into various categories:

i) Those that are found exclusively in the context of mathematics classroom. For instance trapezium, hypotenuse.

ii) Those that are found in everyday English and mathematics but have radically different meaning in mathematics depending on the context. For example difference, similar, indexes.

iii) Those, which are found in both contexts with more or less the same meaning, for example square, diagonal.
The potential problem with those words in category (i) above stems from teacher's tendency to define them once, and then assume that they have been apparently understood. There is need to renegotiate meaning of such words later, or give reinforcement. The problem with those words in category (ii) is to differentiate the conflicting meanings while those in (iii) need to be used carefully depending on the context. If the teacher is aware of the above categories of mathematical terminologies and appropriately negotiates their meaning then better performance in the subject is likely to result.

2.2.3 Essence of mathematical language in learning and teaching of mathematics

Most of mathematics learning takes place in the classroom and in mathematical language. This is so because the teachers discuss mathematical concepts using language. There is need therefore to look at the essence of mathematical language in a communicative classroom.

Various studies have been carried out on 'classroom interaction analysis' in mathematics classroom. Works on classroom interaction analysis provide some evidence that mathematics teachers talk more than teachers of other subjects. For example, they ask more
convergent questions, more directing statements, and elicit and reject few students’ responses. In Kenya, various studies have been carried out on verbal classroom interaction (Muthwii, 1981; Kirembu, 1992). They used Flanders Interaction Analysis Categories (FIAC) research tool. They observed that most mathematics teachers exhibit direct verbal classroom behaviour, which does not motivate students to learn. However, no studies have been carried out on the essence of mathematical language in mathematics in teaching and learning mathematics at least in the Kenyan context. This was the main thrust of the present study.

Mathematics educators recognize the role of mathematics as a tool for communication. However, the view that mathematics is difficult creates a mythology that it is a difficult language for human communication (Rukangu, 2000). Establishing the link between mathematics knowledge and language competence can minimize such a myth.

Language competence is the ability to have efficient command of grammar, vocabulary to interpret texts and apply certain language structures effectively for the intended purpose (Rukangu, 2000). This calls for the reduction of ambiguity not only in general language but also in mathematical language. Students can know without being able
to state their thoughts verbally but they should be able to express themselves in formal language. Indeed, they should be able to "listen, talk, manipulate objects and communicatively write about them. These are the bases for communication.

**Mathematical competence** is the ability to communicate ideas by means other than verbal representation. It is achieved through the mentioned skills amongst other learning resources. The combination of language competence and mathematical competence breeds communicative competence. This requires one to know how to use language to communicate information in various contexts and for the various purposes. In mathematics context, it means one's ability to understand certain mathematical concepts in a certain context, that is, assimilation of mathematical and language concepts into a schema. The crucial linguistic abilities in a mathematics classroom are those of being able to assign meaning to what is read or heard and of conveying one's intentions through spoken and written channels. This is what partly makes language to have meaning- language without meaning is not useful. In order to construct a meaning from mathematical language, one needs to know that mathematics is about logical proofs. The proofs should be deductively valid.
According to Rukangu (2000), a mathematics teacher is required to consider various variables as he prepares to start a communication process. The variables considered have been modelled for an ideal mathematics class is as shown in figure.2.1.

Figure 2. 1: A theoretical model of communicative mathematics class

Source: Adapted from Rukangu (2000); Pimm (1987:xv)
Figure 2.1 represents a mathematical concept, which the teacher intends to communicate to students in the classroom using mathematical language. The teacher therefore needs to have knowledge of the students’ entry behaviour. He/she needs to reflect on the students’ competence in both written and spoken languages used as a medium of instruction (Rukangu, 2000). For effective mathematics classroom interaction, the teacher needs to know the level of students’ mathematical knowledge competence through either spoken or written systems. The formation of mathematical concepts requires the learners to effectively apply styles of reading and writing mathematical concepts. They should also be able to recognise the mathematical language structure to suit the context being studied. The teacher should be able to evaluate the communication effects of the mathematical concept, which is the product in form of symbolised mathematical concepts (Also see figure 2.2). This is why the study used the mathematics language test for students in different contexts.

Algebra is used to simplify mathematical language in the classroom through symbolisation and notations. It also enhances a track for mathematical argumentation and reasoning. However, there are difficulties that arise in Algebra, most of which are associated with syntactic and semantic as well as the usage of lexical and technical languages while communicating in mathematics. Some of the
problems could also have their sources in the cultural background, which are then passed on to the development and presentation of mathematical concepts. For example, in a certain cultural language, it is known that the word for a hen is “nguku” while that of a rabbit is “mbuku”. Similarly, another word for two in the same language is “igiri” while “ithatu” is the word for three. If these four words are put together, one can say “nguku igiri na mbuku ithatu”.

In Algebra, if x stands for “nguku”: and y for “mbuku”, then the model statement “nguku igiri na mbuku ithatu”

\[(x) (2) + (y) (3)\]

can be written as \(x 2+ y 3\). The above statement is not semantically correct and the source of error is the syntax in cultural perspective.

While concepts may be correctly formed, their mathematical representation can create difficulty to the reader. However, if it was written as \(2x + 3y\), it would be acceptably correct because, as Rukangu (2000) notes, it is an agreed principle in mathematics. The nature of language used in communicating mathematical concepts in classroom situations not only influences concept formation, but also the mathematical knowledge and language competencies. This study was designed to establish how cultural factors such as first language influence students’ understanding of mathematical terminologies and hence students’ performance in mathematics.
2.2.4 Language used in mathematical texts

Study by Preston (1978) analysed mathematical terminology in primary texts and work cards. In eight schemes, he identified eighteen (18) ways in which addition is presented. He also observed that in one text, designed for average, and below average children, had fourteen (14) of the eighteen (18) alternatives in two pages. This is likely to confuse students. It may be argued that, the recognition of different forms is a worthwhile objective in mathematics, but is certainly bad practice in terms of the standards relating to normal language development.

A number of studies exist in the readability of mathematics textbooks. Rothery (1980), studied the factors that affect readability of mathematical texts. In general discussion on how to ameliorate language problems in the use of textbooks, he suggested three approaches, to:

i) improve the text;

ii) improve the teacher’s use of textbook and

iii) Improve the reading ability of the reader.

For vocabulary problems, he suggested the following points of prose styles:

i) Use short sentences.

ii) Use simple words.
iii) Remove unnecessary expository material.

iv) Keep to the present time and particularly avoid the conditional "would".

v) Avoid sentence structures that involve the reader, that is, those that the reader has to remember clauses presented initially.

This implies that authors for mathematics textbooks should be aware of the kind of the language they use. They should use a language that is adaptable to the students' level of knowledge. This does not however imply using broken, infantile language, or using only words and sentence structures that are familiar to students. It means, finding the right place to use demonstrative, relative or functional language on the one hand and procedural or descriptive language on the other. This will improve the readability of mathematics textbooks. In addition, this will improve the teaching and learning of mathematics since mathematics textbooks dictate, largely, what is taught in mathematics classroom. Improved teaching and learning culminates to good performance of the subject. However, the contribution of mathematical language used in mathematics textbooks to students' performance in the subject has not been explored in Kenya. It was therefore necessary to investigate the relationship between mathematical language used in mathematics textbooks and students' performance in the study.
2.3 Chapter Summary

This chapter has reviewed literature related to mathematical language and the factors affecting students' performance in mathematics in national examinations. Various studies have identified several factors as having an influential effect on students' performance in mathematics. They include resources for teaching and learning mathematics, personnel (professionally qualified mathematics teachers), attitudes toward mathematics, mathematics curriculum and school ethos among others (KNEC, 1995; Shiundu, 1987; Kathuri, 1986; Thuo, 1985; Eshiwani, 1983).

The chapter has further reviewed the efforts made by the Ministry of Education, Science and Technology through its various organs to provide for the above factors. The efforts include provision of qualified mathematics teachers, resources for teaching, demystifying mathematics and review of the mathematics curriculum. (Eshiwani, 1983). However, despite these efforts, mathematics performance in national examinations has been dismal. This implies that there is another related factor that contributes to the phenomenon.

The chapter has conceptualised mathematical language as a likely factor that influence mathematics performance. This is because
learning mathematics begins and proceeds in language and its outcomes are often assessed in language. Such observations are true for all secondary school curricula, but interweaving of mathematics and language is particularly intricate and intriguing. Hence, the chapter has accounted for and discussed some of the ways language and mathematics intersects. Mathematical language has been identified as been crucial in the formation of mathematical concepts (Vygotsky, 1962, Skemp, 1971). However, the language is not devoid of ambiguities (Kithyaka, 1994; Durkin & Shire, 1991). In response to this, the ambiguities related to mathematical language were examined.

Several studies pertaining to mathematical language have been reviewed in this chapter. Otterbum and Nicholson (1976) investigated the understanding of mathematical terminologies of three hundred (300) students following CSE courses. They found the terminologies used in arithmetic were found to be better understood than those used in geometry. The above study was found to be significant ‘to the present study although the background of the study is not the same. The present study, however, extended and established the relationship of such terminologies and students’ performance in mathematics. Kithyaka (1994) investigated the extent in which various test items – symbolic and word problems account for the variation in pupils’
mathematics performance in Machakos District. She found that urban pupils found word problems relatively more difficult to handle compared to the rural school pupils. In addition she found no significant difference between the performance of rural urban pupils on symbolic item scores. However, her study did not establish the relationship between the mathematical language and mathematics performance. The present study was designed in order to investigate whether similar results would be recorded in Nairobi secondary schools, bearing in mind their diversity of students’ language backgrounds. It further aimed at investigating the relationship between mathematical language and students performance in mathematics.

In addition to the above, the chapter has detailed a theoretical model of a communicative mathematics class (fig 2.1 Pg. 30). According to the model, mathematics language is central in the introduction of mathematical concept in a class, their internalisation, subsequent assessment and performance in mathematics examination. From the foregoing, it can be noted that, at any rate, the relationship between mathematical language and students performance in mathematics has not been explored at least in Kenya. It is in view of this gap that the present study was designed. The next chapter describes the methodology that was employed to meet the above objective.
CHAPTER III
METHODOLOGY

3.0 Introduction

This chapter describes the methodology that was employed in the fulfilment of the research objectives. To this end, the following seven issues are discussed:

- Design of the study
- Location of the study
- Study population
- Sampling
- Research instruments
- Variables
- Ethical considerations

3.1 Design of the study

The study design selected was a cross-sectional descriptive survey method. It was chosen because it involves collecting data in order to test hypotheses or answering questions concerning the current status of the subjects of the study. It is also used to assess attitudes and opinions about events, individuals or procedures (Gay, 1992:13). In this regard, it enabled the researcher to obtain students' and teachers' opinion about the language used in mathematics in secondary school curriculum in Kenya. The study had four phases. Phase 1 involved proposal preparation and the development of research instruments. Phase II was the piloting of the research instruments with an intention to refine and validate them. Phase III was the actual data collection
from sample sites: selected secondary schools in Nairobi Province, using the validated instruments. The last phase involved the analysis of data collected after which conclusions and recommendations were made. This process is summarised in figure 3.1.

Figure 3.1: Design of the study

Source: Adapted from Cohen and Manion (1994:89)
3.2 Location of the study

The study was carried out in Nairobi Province. It is among the eight administrative provinces in Kenya and is considered as an urban province. It was used as it is assumed that, as the only urban province, it has its population comprising a large number of ethnic communities and races that speak different languages. Because of the above reason, Nairobi Province was purposively chosen.

Nairobi has a population of 2,143,254 persons: 1,153,828 males and 989,426 females, forming 649,420 households. The area of the province is 696 KM² with a density of 3079 persons per square kilometre. Private and public secondary schools have been established to cater for this large population. By 1998, the enrolment of secondary schools in the province stood at 242,000 students.

3.3 Study population

The study comprised some stratified randomly selected public secondary school students and some mathematics teachers in Nairobi Province of Kenya. A list obtained from the Provincial Education Office in Nairobi shows that the Province has a total of 47 public secondary schools (see appendix c). The enrolment statistics obtained from the same source indicate there are 23,043 students in those schools: 12,143 males and 10,900 females.
The distribution of the schools is shown in Table 3.1.

Table 3.1: Distribution of public secondary schools in Nairobi Province

<table>
<thead>
<tr>
<th>School Category</th>
<th>Number of schools</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>18</td>
<td>10,767</td>
</tr>
<tr>
<td>Girls</td>
<td>18</td>
<td>8,166</td>
</tr>
<tr>
<td>Mixed</td>
<td>11</td>
<td>4,110</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>23,043</td>
</tr>
</tbody>
</table>

Source: Provincial Education Office, Nyayo House; 14th Floor, Nairobi.

3.4 Sampling and sample size

This section describes the sample, techniques used in the sample selection and methods of determining the sample size used in the study.

3.4.1 Sample description

The primary sources of information in the study regarding language used in mathematics and students' performance in the subject were:

a) Form two (II) and three (III) students in the stratified randomly selected secondary schools in Nairobi Province.

b) Some secondary school mathematics teachers in the randomly sampled schools and classes.
b) Some secondary school mathematics teachers in the randomly sampled schools and classes.

The criteria for the consideration of these sources were influenced by the following factors:

i) **Students:** Form two (II) and form three (III) students were included in the study. Form one (I) and four (IV) were omitted. Form one (I) was considered as not adequately exposed to the secondary school mathematics curriculum. Form four (IV) students are considered to be busy preparing for KCSE examinations and therefore excluded from the study.

ii) **Mathematics teachers:** They were used in the survey, as they are considered instrumental to the implementation of the school mathematics curriculum. The language they use in the teaching of mathematics is important for the students' understanding of mathematical concepts.

### 3.4.2 Sample selection techniques

This section elaborates sampling techniques and explains how the sample was obtained. Since all the schools in Kenya compulsorily teach mathematics, the terminologies used in mathematics syllabus would be assumed same in Kenya. For this reason, the sample comprised students and their teachers in selected public secondary
schools in Nairobi Province. Various sampling techniques were used to select different samples as explained below:

a) **Province**: Nairobi Province was selected purposively. It was used as it is assumed that, as the only urban province, it has its population comprising a large number of ethnic communities and races that speak different tribal and ethnic languages (Rukangu, 2000).

b) **School category**: The study was restricted to public secondary schools. The private category schools were excluded in the study as some of them use other curricula from that of 8.4.4.

c) **School type**: The selection of the sample was done through stratified sampling. This technique was chosen because it guaranteed desired representation of relevant sub-groups thus increasing the efficiency of the population estimate (Gay, 1992:129). Schools in Kenya are classified into school types; **mixed**, **boys** and **girls**. To ensure the above representation stratified sampling was therefore favoured over random sampling.

d) **Individual Schools**: The schools were first divided into three strata, that is, boys, girls and mixed schools. The schools from each stratum were then selected using simple random technique. This technique was selected since it is the best single way of
obtaining a representative sample (Gay, 1992:126). Each school was assigned a number. The numbers were then written down on small pieces of paper, which were folded and placed in three containers representing each stratum. The researcher then picked at random a specified number from each container.

e) **Mathematics Teachers**: The selection of this sample followed purposive sampling. This method is acceptable in empirical research (Rukangu, 2000). Some of the mathematics teachers teaching the students selected in the study were used in the study.

f) **Students**: The sample of students was selected using simple random sampling technique. Gay (1992:126) rightly identifies the following advantages for using this technique. They include:

- It ensures that a representative sample is obtained.
- It is required by inferential statistics. This is important since these statistics permits the researcher to make inferences about the population based on the behaviour of samples.

In this regard, the names of students in each class register were written down on pieces of paper and put in a basket. The required number of students in each form/class was then picked randomly from the container.
mathematics. In this study, the proportion was taken to be 0.5. Q is \((1-p)\).

d=significance level to this study, which was taken to be 0.05.

This calculation yielded 384.2 students. For practical reasons, 384 students were involved in this study. The sampling grid is shown in Table 3.2.

**Table 3.2: Sampling grid**

<table>
<thead>
<tr>
<th>School type</th>
<th>Number of schools</th>
<th>Sample of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Schools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Girls</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Mixed</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Students</th>
<th>Enrolment</th>
<th>Sample of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>10,767</td>
<td>180</td>
</tr>
<tr>
<td>Girls</td>
<td>8,166</td>
<td>136</td>
</tr>
<tr>
<td>Mixed</td>
<td>4,110</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>23,043</td>
<td>384</td>
</tr>
</tbody>
</table>

By using the above procedures, 10 public secondary schools in Nairobi Province were selected for the purposes of the study: 4 boys, 4 girls and 2 mixed schools. Forty-five (45) students were randomly selected
from boys' schools, 34 each from girls and mixed schools. At least one mathematics teacher in each sampled school filled the MTQ. In total 12 mathematics teachers were involved in the study.

3.5 Research instruments

A cross-sectional descriptive survey employing correlation methods was used in order to achieve the objectives of the study. According to Cohen & Manion (1992: 83), the collection of data in survey method typically involves one or more of the following data-gathering techniques;

i. Structured or semi-structured interviews

ii. Standardised tests of attainment or performance

iii. Self-administered or postal questionnaires

iv. Attitude scales.

In response to the above, the present study used two sets of instruments:

a) Standardised tests of attainment or performance.

This was effected by administering Students' Mathematics Language Test (SMLT)(See appendix A).

b) Self-administered or postal questionnaires.

In this approach a Mathematics Teachers' Questionnaire (MTQ)(See appendix B) was used.
The above instruments were found appropriate for this kind of study as outlined below.

a) Self Administered or Postal Questionnaire

The MTQ questionnaire was preferred because it is the best form of survey in an educational enquiry (Cohen & Manion 1994: 94) In addition, a questionnaire has the following advantages:

(i) It's more efficient in that it requires less time to administer (Gay, 1992:224)
(ii) Less expensive (Davidson, 1970: 56)
(iii) It permits collection of data from a large sample (Mugenda & Mugenda, 1999)
(iv) It allows the anonymity of the respondent
(v) It is fairly reliable (Cohen & Manion, 1994: 272)

To ensure the appropriateness of the MTQ questionnaire, pretesting was done. Three fellow students were given the MTQ to complete in order to discover the major flaws. The revised instruments were then administered to the sample respondents in the pilot study.

b) Standardised Tests of Attainment or Performance.

Achievement test, SMLT was found appropriate for this study because it was considered an important tool in correlational research like this one (Gay, 1992).
The instruments were used because of the following purposes:

i) **Students' Mathematics Language Test (SMLT)**. It was an achievement test that aimed at determining some of the mathematics terminologies that secondary school students in Kenya find difficult and the students' performance in problems that utilise such terminologies. It was newly constructed with some items adapted from KNEC (1995). It also provided more details about individual student's characteristics, including first language, class level, and gender. It also contained two tests: Terminology Test and Mathematics Test. The Terminology Test consisted of ten matching questions while the Mathematics Test consisted of ten multiple-choice questions.

ii) **Mathematics Teachers' Questionnaire (MTQ)** was used to find out the terminologies that teachers find difficult to teach and those that their students find difficult to comprehend, and how such terminologies relate to students' mathematics performance. It was newly constructed with some items adapted from Rukangu (2000). This instrument was also used to provide more information about the teachers, schools and curriculum characteristics as concern language used in mathematics.
3.5.1 Reliability and validity

This section describes the procedures used in validating and verifying the reliability of the instruments used in the study. Thus, it includes the validity and the methods of checking for the reliability of the instruments.

a) Validity

Content and construct validity of the research tools were initiated at the design stage. Some of the items used in this study were adapted from Rukangu (2000), Ogolla (1997) and KNEC (1995). This strengthened content and construct validity. This stage was followed by pilot study whose main purposes were to check the appropriateness of the language used in the tools and to conceptualise them for predictability and reliability.

b) Reliability

Since the Students' Mathematics Language Test (SMLT) items had dichotomous scores with varied levels of difficulty, its reliability coefficient was determined using Kuder-Richardson (Formula 20) estimates.

KR- Formula 20, as an estimate of reliability has the following advantages:

i) Requires less time than any other method of estimating reliability. (It is administered once)(Gay, 1992:167).
ii) It provides the mean of all possible split half coefficients (Wiersma, 1980:214)

This was determined using the formula adapted from Sattler (1988:27). Thus,

\[ r_{tt} = \left( \frac{n}{n-1} \right) \left( \frac{S_t^2 - \sum pq}{S_i^2} \right) \]

Where, \( r_{tt} \) = reliability estimate

- \( n \) = number of items on the test
- \( s_t^2 \) = Variance of the total test
- \( p \) = proportion of the respondents getting an item correct.
- \( q \) = proportion of the respondents getting an item incorrect
- \( \sum pq \) = sum of the product of \( p \) and \( q \) for each item.

Using the above formula, the pilot findings showed a reliability coefficient of 0.864. This coefficient led to the determination of the reliability index of 0.9295, using the formula \( r_1 = \sqrt{r} \), which was high.

The reliability of the non-dichotomous score tool, MTQ was determined using the Cronbach coefficient formula adapted from Sattler (1988:27):
\[ r_{tt} = \left( \frac{n}{n-1} \right) \left( \frac{\sum \sigma^2_i}{\sigma^2_{tt}} \right) \]

Where, \( n \) and \( \sigma^2_i \) are as defined above and 

\[ \sigma^2_{tt} = \text{coefficient alpha reliability estimate.} \]

\[ \sum \sigma^2_i = \text{Sum of variance of individual items.} \]

### 3.5.2 Piloting of the instruments

The instruments used in the study were designed using simple English to enhance easy understanding of their content by the sample respondents. The drafted instruments were piloted in one mixed public secondary school in Nairobi in order to refine them and enhance their validity and reliability. In this regard, the time allocated for the SMLT, which was previously one and a half-hour, was set for one hour. The items in the instruments did not have any flaws and thus were retained. The refined instruments were then administered to the sample respondents in the main study. The process of refinement was necessary for the following reasons:

i) Determine the difficulty of the items in the instruments.

ii) Checking the difficulty of the language used.

iii) Estimating the time allocation for items and

iv) Enhancing the validity and reliability of the items.
3.5.3 Administration of the research instruments

The pilot study was conducted in one public mixed secondary school in Nairobi Province in the month of January. This school was not used in the main study. Twenty (20) students (10 girls and 10 boys) were randomly selected and the SMLT was administered to them. This number was sufficient in order to discover the major flaws in the questionnaires (Sudman, 1976). A mathematics teacher was given the MTQ to fill. The data collected at that stage were analysed and the results used for appropriate amendment of the instruments.

The actual administrations of the research instruments and data collection were conducted in the first term of the school calendar, in the months of January and February. It was preceded by the researcher's preliminary visits to the schools sampled out for the study. During these visits, the researcher sought to accomplish two tasks:

- Strike rapport with the school authorities and to explain the purpose of the study verbally. This was aimed at minimising Hawthorne effect.
- Make necessary arrangements for the actual administration of the instruments and data collection.
The instruments were administered with the assistance of mathematics and class teachers. The study was conducted during break time so as not to interfere with students' class time.

3.6 Variables

The following were considered the main variables of the study.

3.6.1 Student-related variables

The students' independent variables included class, gender, time spent practising word symbolic and problems and scores obtained in the terminologies section of the SMLT. Other variables included study habits and home background that is, their first language. Scores obtained by students in the mathematics problem section of the SMLT formed the dependent variable. Class level was considered a dummy variable taking the values '2' for form two and '3' for form three respectively. The number of hours was used as the parameter to measure the time students spent in practising symbolic and word problems in mathematics.

3.6.2 Teacher-related variables

The teacher-related variables included gender, training background, qualification (professional and academic), INSET attendance, teaching load and experience. Others included their ability to help students with difficulties in terminologies used in mathematics. Teaching aids and
language considerations in assessing their students were other teacher-related variables considered.

3.6.3 School-related variables

The school-related variables included school type, size (streams), teaching aids and mathematics textbooks.

3.6.4 Control variables

Mathematics performance could be a function of factors such as resources (personnel and teaching aids), school ethos, learners and teachers' attitudes towards the subject, and mathematical language among others. Since this study intended to establish the relationship between mathematical language i.e. terminologies used in mathematics and students' performance in mathematics, certain factors needed to be controlled. These factors included teacher's qualifications and mathematics teaching aids. In order to take care of these factors, only schools with qualified teachers in mathematics education and adequate mathematics textbooks were considered.

3.7 Ethical considerations

In each school, permission was sought from the principal before involving students and teachers. The consent of the respondents was also sought before they were given the questionnaires to fill. They
were assured that the information they gave would be treated with confidentiality and only for the purposes of the study.

3.8 Chapter summary

In this chapter the procedures and strategies that were used in the study are described. The chapter also describes the premises on which related variables were explored. In particular, the chapter describes the research design, the sampling procedures, the research instruments and the methods used in data collection. It also describes the methods followed in designing the research instruments (MTQ and SMLT), that were used to enhance the exploration of the relationship between mathematical language and students' performance in mathematics.
CHAPTER IV

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.0 Introduction

This study focused on the relationship between mathematical language and students’ performance in mathematics. This chapter analyses, interprets the findings and discusses their resulting and associated issues respectively. For systematic presentation and analysis of data, the chapter specifically considers and explains methods of data analysis, school-related variables, student-related variables and teacher-related variables respectively.

4.1 Methods of data analysis

The data collected underwent various stages of preparation before the analysis was done using the Statistical Package for Social Sciences (SPSS) computer software. First, the data were edited and coded. A code book was then used to prepare computer code sheet, which was later used to synthesise the data. Upon completion of data entry, the data were cleaned to detect and remove any errors committed during data entry. Simple frequency analyses on the variables were run and random cross-tabulation done to clean the data.
Data germane to the study were both quantitative and qualitative. Quantitative analysis involved presentation of statistical data in form of frequency distribution tables whose explanation was mainly based on descriptive and inferential statistics. Quantitative data were analysed using Pearson product-moment correlation coefficient, multiple regression, student t-test and one-way ANOVA. Pearson product-moment correlation coefficient was used to determine the relationship between students’ scores in the terminologies test and their scores in the mathematics test. Multiple regression was used to analyse the relationship between student’s class level, hours spent studying symbolic and mathematical word problems, terminologies test score (independent variables) and student’s score in mathematics test (dependent variable). Student ‘t’-test was used to compare the means in students’ performance of SMLT between genders. One-way ANOVA (Analysis of variance) was used to compare the variance in students’ performance in the SMLT with school type. The statistical significance of the results were then examined at $\alpha = 0.05$ statistical significance level.

Qualitative analysis considered the inferences that were made from the opinions of the respondents. This analysis was narratively presented and where possible in tabular form. Specific analysis for the various variables is presented and discussed in the next sections.
4.2 School-related variables

This section of the chapter presents the results of school-related variables. The main one is discussed in the section 4.2.1.

4.2.1. Mathematics resources

All of the schools included in the study were found to have adequate mathematics textbooks and teaching aids. The three main textbooks that the schools used and their preference are shown in Table 4.1.

Table 4.1 Mathematics textbooks as viewed by teacher preferences (N=12)

<table>
<thead>
<tr>
<th>Mathematics Textbook</th>
<th>Textbook order of preference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First (%)</td>
</tr>
<tr>
<td>Secondary mathematics by K.I.E.</td>
<td>42</td>
</tr>
<tr>
<td>Mathematics by Malkiat Singh</td>
<td>0</td>
</tr>
<tr>
<td>Mathematics for Kenya schools by N.M.Patel</td>
<td>58</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

The mathematics textbooks considered above are among the list of the recommended textbooks by the Ministry of Education, Science and Technology. Table 4.1 shows that (58%) of the teachers use Mathematics for Kenya Schools (MKS) textbook series by N.M.Patel as their choice followed by Secondary Mathematics by K.I.E. In addition,
the same series was considered as using simple and appropriate mathematical language by majority (10 out 12 i.e. 83%) of the teachers. The latter made the series to be popular and preferred by majority of the teachers and students alike.

The above finding implies that mathematics teachers should help their students to make choices of the textbook containing appropriate mathematical language. In order to make informed judgements, it appears that there are certain facets that they must take into account. They include:

a) A detailed scrutiny of the vocabulary, length of words and structure of sentences in the text.

b) Particular features of mathematical text like graphs, tables, diagrams and special symbols need to be inspected.

c) Detailed analysis of the flow-in- meaning of the text in order to find out how it presents useful information, from the relatively elementary to the more difficult; the content must be correctly and appropriately sequenced.

Thus, other authors should emulate N.M.Patel and write mathematics textbooks with a simplified and appropriate language in order to improve on their readability. This will eventually lead to students' successful pursuit in the subject.
4.3. Student-related variables

This section presents the analysis of the data obtained from the Students Mathematics Language Test (SMLT). It attempts to test the four hypotheses listed in chapter 1: section 1.4 (pg.10).

4.3.1 Relationship between students' scores in some terminologies used in mathematics and their performance in mathematics

During the survey, the Students' Mathematics Language Test (SMLT) tool was administered to 384 students: 204 boys and 180 girls. Each of the two sections of the SMLT tool (Terminologies Test and Mathematics Test) was marked out of 10. The students' scores in the two sections are presented in Table 4.2.

<table>
<thead>
<tr>
<th>Scores</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Mean</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test X</td>
<td>29</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>22</td>
<td>30</td>
<td>72</td>
<td>126</td>
<td>78</td>
<td>11</td>
<td>6.008</td>
<td>2.266</td>
</tr>
<tr>
<td>Test Y</td>
<td>11</td>
<td>36</td>
<td>42</td>
<td>57</td>
<td>56</td>
<td>68</td>
<td>32</td>
<td>25</td>
<td>48</td>
<td>9</td>
<td>4.393</td>
<td>2.330</td>
</tr>
</tbody>
</table>

Key: S.D = standard deviation.

Pearson correlation coefficient, \( r=0.3608 (\alpha>0.001) \)*

* Significant at \( \alpha=0.05 \)

From Table 4.2, it can be observed that the students performed better in the Terminologies Test than in the Mathematics Test. This could be
due to the fact that even though the Mathematics Test required the understanding of terminologies, it also required them to know the algorithm to use in solving the same. This implies that a student may understand the mathematics terminologies in a mathematics problem but may not know the algorithm to compute the same. On computing the Pearson product moment correlation coefficient (r) of the scores obtained from the Terminologies Test (x) and Mathematics Test (y), a value of 0.3608 at $\alpha > 0.001$ was yielded. This shows that the r-value is significant at 0.05 significant level.

Hence, the null hypothesis, $H_0$: $r=0$, that there is no relationship between mathematical language and student's performance in mathematics, was rejected. Hence the alternative hypothesis, $H_1$: $r>0$ was accepted. Thus, there is a positive correlation between terminologies used in mathematics and by extension mathematical language and students' performance in the subject. Thus, the more a student understands mathematical language, the higher the performance in mathematics. Since $r=0.3608$, the terminologies score account for $r^2 = 0.1301766$ or 13.02% of the total proportion in mathematics performance. This total proportion is within the range of the national mathematics performance (Table 1.1, Pg. 2). This implies that students must conceptualise and understand mathematical terminologies and by extension mathematical language in order for
them to perform well in mathematics examinations. Thus, mathematics teachers should be aware of this relationship and hence design mathematical language course. In this course, mathematics teachers should teach mathematical terminologies and symbols as an isolated topic as used to occur, and sometimes still does, in language classes. In this course, mathematical terminologies (particularly vocabularies) should be taught in the context of problem solving.

4.3.2 Relationship between class levels, terminologies test scores, and hours devoted to study mathematics and performance in mathematics

A number of factors were investigated to determine how they influence students' performance in mathematics. They included: class levels \(x_1\), hours devoted to studying both symbolic \(x_2\) and word problems \(x_3\) and terminologies test scores \(x_4\). Mathematics Test scores \(Y\)(dependent variable) were regressed against the values of the above factors (independent variables). The variables are related by the following equation:

\[
y' = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots + b_k x_k \quad \ldots \quad \text{Equation(i)}
\]

Where \(b_1\) to \(b_k\) = regression coefficients of the \(k\) variables

\(X_1\) to \(X_k\) = scores of the independent variables. \(a\) = intercept constant and \(k\) = is the number of predictor variables.
The results are tabulated in Table 4.3.

Table 4.3. Regression output

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Beta</th>
<th>T</th>
<th>Sig T</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₁</td>
<td>0.752456</td>
<td>0.221843</td>
<td>0.161561</td>
<td>3.392</td>
<td>0.0008*</td>
</tr>
<tr>
<td>X₂</td>
<td>0.040410</td>
<td>0.107933</td>
<td>0.018332</td>
<td>0.374</td>
<td>0.007*</td>
</tr>
<tr>
<td>X₃</td>
<td>0.113613</td>
<td>0.103474</td>
<td>0.053992</td>
<td>1.098</td>
<td>0.003*</td>
</tr>
<tr>
<td>X₄</td>
<td>0.354562</td>
<td>0.048808</td>
<td>0.344826</td>
<td>7.264</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.530371</td>
<td>0.616968</td>
<td></td>
<td>0.860</td>
<td>0.03905*</td>
</tr>
</tbody>
</table>

R Square = 0.15798   * Significant at α=0.05

From Table 4.3, the regression equation (i) on page 53 becomes,

\[ y' = 0.530371 + 0.752456 x₁ + 0.040410 x₂ + 0.113613 x₃ + 0.354562 x₄. \]

This equation shows the relationship between the independent variables: \( x₁, x₂, x₃, \) and \( x₄ \) and the dependent variable \( Y \). In addition, it can be noted that all the independent variables are significant in relation to student's performance in mathematics. Thus, the null hypothesis, \( H₀₂ \), that there is no relationship between class levels, terminologies test scores, hours devoted to study mathematics and student's performance in mathematics, i.e. \( H₀₂ : B₁, B₂, B₃ \) and \( B₄ = 0 \), failed and the alternative hypothesis was accepted. Thus, there was a relationship between hours devoted to study mathematics symbolic \( (x₂) \) and word problems \( (x₃) \), terminologies test scores \( (x₄) \), and student's performance in mathematics \( (Y) \).

From the 't'-values, it can be observed that class level variable \( (x₁)(3.392 \text{ at } α>0.0008) \) is significant. Since the variable was a
dummy, it shows that there is a difference in the performance of students in the Mathematics Language Test between Form Two (2) and Form Three (3). This could be attributed to the fact that those students in Form Three have practised the language for more years than the Form Two students. It can also be noted that the hours students spend practising symbolic and word mathematics contribute significantly to students' performance mathematics. In addition, mathematical terminologies significantly account for the variability of students' performance in mathematics.

This implies that hours devoted to study mathematics language and understanding of the terminologies used in mathematics contributes significantly to students' performance in mathematics. Thus, learners must be allowed to have many contact hours with the mathematics teachers and for private study in order to study Algebra (symbolic) and word mathematical problems for the successful pursuit of the subject. This would give them adequate time to understand mathematical language, which like other languages requires adequate time and practise to be internalised.

The value of $R^2$ obtained was 0.15798. This showed that 15 % of total variability of students' performance in mathematics could be accounted for by the variables $x_1$, $x_2$, $x_3$ and $x_4$. The value of $1-R^2 (1-0.015798)= 0.84202$ implies that about 84.2% of the total variability of students' performance in mathematics could be accounted for by other variables. This could include resources available for learning mathematics (well-trained personnel and teaching aids), attitude towards mathematics and school ethos, among others. This implies that besides the above variables ($x_1$, $x_2$, $x_3$ and $x_4$), teaching aids, qualified personnel, positive attitude towards the subject and
conducive learning environment should be provided for students' successful pursuit of mathematics.

4.3.3 Relationship between students' gender and performance in mathematics

The study involved 204 boys and 180 girls. Table 4.4 shows the scores, frequencies and means obtained in the two sections of the SMLT by gender.

Table 4.4. Students scores in the SMLT by gender

<table>
<thead>
<tr>
<th>Ge</th>
<th>T</th>
<th>Scores and frequencies</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>X</td>
<td>25 4 1 6 15 18 38 54 43 0</td>
<td>5.5098</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>1 24 30 32 33 37 12 12 1 0</td>
<td>3.8166</td>
</tr>
<tr>
<td>G</td>
<td>X</td>
<td>4 2 3 0 7 12 34 72 35 11</td>
<td>6.5722</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>2 12 12 25 23 31 20 18 8 0</td>
<td>5.0444</td>
</tr>
</tbody>
</table>

Legend: Ge=Gender, B=Boys, G=Girls, X=Terminologies Test, Y=Mathematics Test, T=test, M=marks

From Table 4.4, it can be noted that girls obtained higher mean scores in both tests. For the terminologies test (x), the boys and girls obtained mean scores of 5.5098(n=204) and 6.5722(n=180) respectively. For the mathematics test (y), boys attained a mean score of 3.8166 and girls, 5.0444. This shows that in both sections of the SMLT, girls performed better than boys. In order to test whether there is a significance difference between students' gender and performance
in mathematics in the two sections of the SMLT, students’ ‘t’- values were computed using SPSS program. The results of the Terminology Test and Mathematics Test are presented in Table 4.5.

Table 4.5. Students’ t-value for the Terminology and Mathematics Tests

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean Score</th>
<th>SD</th>
<th>SE of mean</th>
<th>Mean difference</th>
<th>t-value</th>
<th>df</th>
<th>2-Tail Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOY</td>
<td>204</td>
<td>5.5098</td>
<td>2.555</td>
<td>0.179</td>
<td>-1.0624</td>
<td>-4.71</td>
<td>382</td>
<td>0.000</td>
</tr>
<tr>
<td>GIRL</td>
<td>180</td>
<td>6.5722</td>
<td>1.727</td>
<td>0.129</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mathematics Test (x/10)

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean Score</th>
<th>SD</th>
<th>SE of mean</th>
<th>Mean difference</th>
<th>t-value</th>
<th>df</th>
<th>2-Tail Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOY</td>
<td>204</td>
<td>3.8186</td>
<td>2.200</td>
<td>0.154</td>
<td>-1.2258</td>
<td>-5.32</td>
<td>382</td>
<td>0.000</td>
</tr>
<tr>
<td>GIRL</td>
<td>180</td>
<td>5.0444</td>
<td>2.308</td>
<td>0.172</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at $\alpha=0.05$

From table 4.5, it can be noted that, the absolute t-values for the Terminology Test and Mathematics Test, 4.71($p>0.001$) and 5.32($p>0.001$) respectively are significant. Consequently, the null hypothesis $H_0$ that **there is no significant difference between students’ gender and performance in Mathematics Language Test** was rejected. Thus, there was a significant difference between the gender of student and performance in mathematics language test. Girls performed significantly higher than boys did. This is not the case in national examinations. This could be attributed to the fact that national examinations test many aspects in mathematics like psychomotor skills that were not covered in SMLT; where boys do
better. Girls performed better than boys in the SMLT perhaps because they are innately endowed with language skills and the SMLT largely tested on the same. This implies that boys need to be given special attention while being taught mathematical language.

4.3.4. Relationship between school type and performance in mathematics

Three school types were considered in the study: boys, girls and mixed school. The overall means scores of the SMLT (x/20) for the school types are shown in table 4.6.

Table 4.6. Means scores of the various school types

<table>
<thead>
<tr>
<th>School type</th>
<th>Girls</th>
<th>Boys</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score of SMLT (x/20)</td>
<td>12.1691</td>
<td>9.3611</td>
<td>9.6196</td>
</tr>
</tbody>
</table>

From table 4.6, it can be noted that girls’ schools had a higher mean score than that of boys’ and mixed schools. On the other hand, the mixed schools had a higher mean score than boys’ schools. This probably can be attributed to the fact that girls are endowed with innate language ability. This enabled them to perform better in both Terminology and mathematics Sections of the SMLT. In order to
determine the difference in the means for the school types, one-way analysis of variance (ANOVA) test was performed. The SPSS output results are shown in Table 4.7.

**Table 4.7 Analysis of variance (ANOVA) results for school types**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>F-ratio</th>
<th>F-prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2</td>
<td>661.5427</td>
<td>330.7713</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within groups</td>
<td>381</td>
<td>4844.6969</td>
<td>12.7157</td>
<td>26.0127</td>
<td>0.0000*</td>
</tr>
<tr>
<td>Total</td>
<td>383</td>
<td>5506.2296</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at α=0.05

From table 4.7, it can be observed that the F-value 26.0127 (p<0.0001) is significant. Therefore, the probability that the school types means are the same was 0.0000. Following the above results, the hypothesis $H_0$ that there is no significant difference in the mean scores between the school types failed and the alternative hypothesis is accepted. Thus, there was a significant difference in the mean scores between boys' and girls' school types. The girl schools performed significantly higher (12.1691) than the boys' schools (9.3611). They also show that there was a significant difference in the mean scores between the boys' (9.3611) and mixed school types (9.6196). This significant difference in the performance can be attributed to the girls' innate language ability. Girls are endowed with special language ability and hence they are able to
master the mathematics terminologies better than boys. This probably could account for the mean differences between boys, mixed and girls' schools.

4.4. **Mathematical terminologies that students viewed as difficult**

The students cited some mathematical terms to be too difficult to understand. They include loci, rationalisation, and propagation of errors, stretch, polynomials, radicals, roots, hence, bearings, track, course, inscribing, mutually inclusive, difference, similar, indexes, at least, escribing, greater than, difference, and inequalities among others. These terminologies can be seen to fall in the following categorises:

i) Terminologies in the context of mathematics class. For instance polynomials, propagation of errors etc.

ii) Terminologies in 'everyday' English and mathematics but have radically different meanings in mathematics depending on the context. For example greater than, difference, similar, indexes, roots, radicals etc.

iii) Terminologies in either contexts (i and ii above) with more or less the same meaning, for example stretch.

The students cited the following as creating the difficulties on each category of terminologies. For those in category (i), they considered the difficulties as arising from the teachers' tendency to define them
once, and then assume that they have been apparently understood. For those in category (ii), they considered the difficulties, as stemming from the conflicting meanings (lexical ambiguity) while those in (iii) needed careful use depending on the context.

The inference that can be made from the above finding is that the teachers should oftenly redefine terminologies and symbols used in mathematics, every time they encounter them. This would lead to students' internalisation of these terminologies and thus improved performance in mathematics. Different meanings of similar terminologies should always be taught while highlighting the different contents where they should be used. In addition, mathematics textbooks authors should also explicitly define such terms in their textbooks showing their different meanings, why and where they are applicable. This implies that ambiguities in mathematical terminologies are monitored. In planning for teaching (from textbooks to lesson plan preparation), mathematics authors and teachers should consider the terminologies that are likely to have a different meaning to the student from the intended or assumed meaning in the specialists' context. If the teacher is aware in advance of potential problems, it increases his/her sensitivity to students' performance.
The above finding also implies that contextual cues should be enriched since successful decoding of a specific use of an ambiguous word is dependent upon use of the context. The context provided by the mathematics lessons may not be readily expected to access the appropriate mode of discourse and terminology. Some students may be confused over the teacher's use of certain terminologies. Therefore creative and sensitive preparation on the part of the teacher can help guide the student to the context-specific meaning of the target terminologies.

4.5. Problems faced by students in studying mathematical language and their solutions

The students cited a number of problems that they encounter when learning mathematical language and suggested some solutions. Sections 4.5.1 and 4.5.2 discusses the problems and their perceived solutions respectively.

4.5.1. Problems

The problems cited by the students as being associated with the learning of mathematical language are as shown in Table 4.8.
### Table 4.8. Problems associated with mathematical language as viewed by students

<table>
<thead>
<tr>
<th>Problem</th>
<th>F</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complicated spellings of certain mathematical terminologies</td>
<td>125</td>
<td>10.72</td>
</tr>
<tr>
<td>Use of symbols to represent abstract ideas in real life</td>
<td>383</td>
<td>32.85</td>
</tr>
<tr>
<td>Different meanings for the same term</td>
<td>378</td>
<td>32.42</td>
</tr>
<tr>
<td>Complicated mathematical language in textbooks</td>
<td>280</td>
<td>24.01</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1166</td>
<td>100</td>
</tr>
</tbody>
</table>

*F = frequency of the students*

From Table 4.8, it can be seen that 32.85% and 32.42% of the students cited use of symbols to represent abstract ideas in real life and different meanings to represent same terminology as the major problems that they face in learning mathematical language respectively. The inference here is that the teachers should explicitly define the different meanings of the same term when they are encountered during teaching. The right meaning for a certain context should then be highlighted. This will enable the learners to understand when to apply the different meanings for a certain term in different contexts and thus improved students' performance in mathematics. In addition to the above, teachers and mathematics textbooks authors
should use simplified and proper language when discussing mathematical concepts.

4.5.2. Solutions to the problems cited by the students

In response to the problems cited in section 4.6.1, the students suggested the following measures as likely to counter the problems cited. The results are as shown in Table 4.9.

**Table 4.9. Solutions to problems associated to mathematical language as viewed by students (N=384)**

<table>
<thead>
<tr>
<th>Solutions</th>
<th>F</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of simplified mathematical language by teachers and in textbooks</td>
<td>329</td>
<td>26.13</td>
</tr>
<tr>
<td>Getting synonyms for the technical terms</td>
<td>162</td>
<td>12.87</td>
</tr>
<tr>
<td>Teachers redefining terms more often</td>
<td>384</td>
<td>30.50</td>
</tr>
<tr>
<td>Regular practise by the student in order to internalise the terms</td>
<td>384</td>
<td>30.50</td>
</tr>
<tr>
<td>Total</td>
<td>1259</td>
<td>100</td>
</tr>
</tbody>
</table>

From table 4.9, it can be observed that regular practice, redefining of mathematical terms often and use of simplified mathematical language are the main methods or solutions to counter the problems associated with mathematical language as viewed by the students. This implies that the authors of mathematical textbooks as well as teachers should liaise in order to come up with suitable mathematical content, which
has simplified mathematical language. Students, on the other hand, should do a lot of exercises since practice makes perfect.

4.6. Styles for learning symbolic and mathematics word problems

Students' study styles also contribute to effective learning of mathematical language. Pupils named some study methods they found useful for learning mathematical language. Their responses are presented in Table 4.10.

Table 4.10: Students’ study methods for learning mathematical language (N=384)

<table>
<thead>
<tr>
<th>Style of studying</th>
<th>Useful (%)</th>
<th>Not useful (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memorisation of mathematics terminologies and symbols</td>
<td>13.2</td>
<td>96.8</td>
</tr>
<tr>
<td>Discussion of mathematics symbols and terminologies with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>96.4</td>
<td>3.60</td>
</tr>
<tr>
<td>Teachers</td>
<td>97.7</td>
<td>2.30</td>
</tr>
<tr>
<td>Parents</td>
<td>2.90</td>
<td>97.10</td>
</tr>
<tr>
<td>Solving word and symbolic problems regularly</td>
<td>93.2</td>
<td>6.80</td>
</tr>
</tbody>
</table>

Table 4.10 shows that students' study habits were among the contributory factors to their learning mathematical language. The most useful study style was discussion with mathematics teachers as well as with other students. It was however, found that discussion method
was rarely practised in secondary schools, at least for the learning of mathematical language. This means that most students do not share their ideas with either mathematics teachers or other students. Students tend to avoid consulting their mathematics teachers probably because of their nomothetic characteristics. Such a situation reduces students' chances of being properly guided in their learning. Lack of guidance would lead to students' reduced level of self-confidence and ability to understand mathematics language. But even with some reduced confidence, students use some methods that they consider useful in learning mathematical language.

Table 4.10 also shows that 93.2% of the students felt that it was important to solve mathematics words and symbolic problems regularly. This method of studying mathematical language is useful since like other languages, it requires regular practice in order to internalise the concepts. It was established that pupils do not regard memorisation as a useful style for learning mathematical language (Table 4.10). Yet, many students are often drilled to master it for examination purposes. In this process, they can lose interest in the learning mathematical language. Discussion methods should therefore be emphasised. In view of the above findings, it is right to suggest that while the teacher becomes a guide in a mathematics class, it is
the responsibility of the student to organise his/her learning habits and be able to effectively discuss in class.

4.7. Analysis of students performance on SMLT questions

This section presents the students’ performance on the SMLT. The SMLT consisted of two sections with 10 questions each. The first section was the Terminology Test whereas the second one was the Mathematics Test. The results of students’ performance per question are as shown in Table 4.11.

Table 4.11: Analysis of students’ performance on SMLT questions

<table>
<thead>
<tr>
<th>Terminology test</th>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rs</td>
<td></td>
<td>320</td>
<td>49</td>
<td>30</td>
<td>93</td>
<td>312</td>
<td>340</td>
<td>258</td>
<td>309</td>
<td>232</td>
<td>306</td>
</tr>
<tr>
<td>Ws</td>
<td></td>
<td>64</td>
<td>335</td>
<td>354</td>
<td>291</td>
<td>72</td>
<td>44</td>
<td>126</td>
<td>75</td>
<td>152</td>
<td>78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mathematics Test</th>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rs</td>
<td></td>
<td>194</td>
<td>45</td>
<td>167</td>
<td>157</td>
<td>96</td>
<td>294</td>
<td>261</td>
<td>146</td>
<td>179</td>
<td>181</td>
</tr>
<tr>
<td>Ws</td>
<td></td>
<td>190</td>
<td>339</td>
<td>217</td>
<td>227</td>
<td>288</td>
<td>90</td>
<td>123</td>
<td>238</td>
<td>205</td>
<td>203</td>
</tr>
</tbody>
</table>

Key: Rs= No. of students who got the question right, Ws= No. of students who got it wrong
From Table 4.11, it can be observed that students performed well in majority of the questions. On terminologies, question 3 was poorly done. In this question, the students were required to write the meaning of the term times as used in mathematics. 8% of the students only managed to rightly identify it as meaning the same as product. This also was reflected on the their performance on question 3 of the mathematics test where only 167 students (43.5%) managed to get it right. A similar pattern was observed for question 2 of the terminology test where only 30 students (12.7%) knew the meaning of the term simplify as used in mathematics. This was reflected on their performance on question 2 of the mathematics test where only 45 students (11.7%) managed to get it right. This shows that there was a relationship between mathematical terminologies and students’ performance in the subject. Therefore, mathematics teachers, authors of mathematics textbooks and examiners should use mathematical language that the learners can understand and apply for improved performance in the subject.

4.8. Teacher-related variables

This section presents the analysis of teacher-related variables based on the data collected using the Mathematics Teachers’ Questionnaire (MTQ)(Appendix 2).
4.8.1 Teachers' professional qualification and experience

The study only involved the graduate teachers. This was so because it was considered as a control variable. A total of 12 graduate teachers filled the Mathematics Teacher's Questionnaire (MTQ). Their academic qualifications, teaching experience and gender are as shown in Table 4.12.

Table 4.12. Distribution of mathematics teachers by academic qualifications, teaching experience and gender

<table>
<thead>
<tr>
<th>Qualification Combination</th>
<th>Gender</th>
<th>Average teaching experience (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male %</td>
<td>Female %</td>
</tr>
<tr>
<td>B.E.D. Maths only</td>
<td>16.7</td>
<td>0</td>
</tr>
<tr>
<td>B.E.D. Maths/chemistry</td>
<td>16.7</td>
<td>8.35</td>
</tr>
<tr>
<td>B.E.D. Maths/physics</td>
<td>25</td>
<td>8.35</td>
</tr>
<tr>
<td>B.SCIENCE Maths/Physics</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>B.SCIENCE Maths/electricity</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>B.SCIENCE+PGDE Maths/chemistry</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>83.3</td>
<td>16.7</td>
</tr>
</tbody>
</table>

The table 4.12 shows that 83.3% of the teachers were male. It also shows that majority (75.1%) of teachers were initially trained as teachers. The rest (24.9%) were scientists but later did a PDGE to qualify as teachers. The study therefore involved only graduate
teachers as a control variable (see section 3.6.4). This means that, as trained mathematics teachers, they are exposed to situations that can help them to deal with incidents in classrooms and their associated problems as well as effectively teach mathematical language.

In addition, it can be observed from Table 4.12 that the teachers had an average teaching experience of 9 years. Similarly, the average continuous teaching experience in a single school was found to be 4 years. Only 8.3% of the teachers taught in one school for at least five years. This would mean that the teacher turnover is high in secondary schools. This implies that the trained mathematics teachers are frequently transferred from one school to another or they leave the profession for others. It was beyond the scope of this study to establish the number of mathematics teachers who leave the profession for other jobs. However, such turnover causes the low teaching experience in one school. Therefore, the professional movement of the teachers needs to be checked and sustained. These results imply that a high teacher turnover can lead to a period when students do without a professionally trained teacher. The students would therefore be subjected to different professional, emotional treatment and guidance. This can lead to students' lack of continuity in mathematical language development, confusion, loss of self-confidence and therefore poor performance in mathematics. Hence, sustainability
of the teachers in the profession and gaining of teaching experience in one school can be beneficial to students who learn mathematics and its mathematical language.

4.8.2. Mathematical terminologies that teachers viewed as difficult to teach

The sampled teachers (n=12) cited some terminologies as difficult to teach. They included words such as integrals, derivatives, rationalisation, track, loci, indexes, similar, inequalities, and elevation among others. They considered the following as the reasons behind these difficulties:

- Lack of simpler terms or words to explain the above terminologies
- Abstractness of the terms
- Complicated spellings and pronunciations
- Lack of textbooks with simple mathematical language, which explains the terminologies explicitly.
- Different meanings for various terms in different contexts.
- Students’ failure to recall their meaning later.

The above results imply that teachers must design rich mathematical activities that would enhance students’ understanding of mathematical language. They should renegotiate the meaning of the terminologies
often and give different meanings of such terms. In addition, they should liaise with mathematics textbook authors in order to produce texts with simplified mathematical language.

In order to facilitate the learning of mathematics ideas, it is important that students are given help in the language that they are expected to use in discussing and generally processing those ideas. In this case, mathematics teachers should design a mathematics language course with rich mathematical language activities that are well known to the students through other subjects and puzzle books which can be used in learning of mathematical vocabulary. They include:

i. A simple word search based on the mathematical topic just completed can help in consolidating words and their spellings.

ii. An elementary crossword can be used to attach the word to its meaning.

iii. Unscrambling words, matching lists of meanings or a set of pictures and a mixture of unscrambling and matching words can be used in classroom practice.

iv. Selecting the best description for a word from a number of alternatives is another activity.

The above activities can be applied in classroom practice since they are an important part of learning mathematical language.
4.9. Chapter summary

This chapter has presented the data, analysed, interpreted them and discussed the results in relation to the set research objectives and hypotheses. The main general finding was that there was a relationship between mathematical language and students' performance in mathematics. Specifically, the following results were found related to students' understanding of mathematical language and consequently their performance in mathematics.

- There was a relationship between mathematical terminologies and students' performance in mathematics.
- There was a relationship between class level, hours devoted to studying symbolic and mathematical word problems and students' performance in mathematics.
- Girls performed better than boys in mathematical language test.
- Study habits are important in students' understanding of mathematical language.
- Mathematical terminologies are not devoid of ambiguities.

The next chapter (Chapter V) presents the summary, conclusion and recommendations arising from data analysis.
CHAPTER V
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0. Introduction
This chapter presents a summary of the research findings, conclusion, recommendations of the study and suggestions for further study.
The purpose of this study was to investigate the relationship between mathematical language and student's performance in mathematics. The study adopted a correlation cross-sectional survey design. It was conducted in Nairobi Province, Kenya. Data germane to this study were collected by use of a questionnaire (MTQ) and an achievement test (SMLT).

5.1 Summary of research findings
The study found that:
- There was a positive correlation \( r=0.3608, \alpha>0.001 \) between mathematical language and students' performance in mathematics.
- There was a relationship between class levels \( (x_1) \), hours devoted in studying mathematics symbolic \( (x_2) \) and word problems \( (x_3) \); terminologies test scores \( (x_4) \), and student's performance in mathematics \( (Y) \). Students understanding of mathematics terminologies have a direct positive relationship to their performance in mathematics \( r=0.354562 \) at \( p>0.001 \).
• There was a significant difference between gender and students’ performance in mathematics. The girls performed significantly higher than the boys in mathematics language test.

• There was no relationship between student’s first language and their performance in mathematics.

• There was a significant difference in the performance of mathematics language test between school types. Girls’ schools performed better than the boys’ schools.

• Both teachers and students identified the following terminologies as difficult to teach and learn respectively: Navigation: track, loci, integration: integrals, derivatives, surds: rationalisation of the denominator, polynomials, inequalities, bearings, and elevation.

• Teachers and students cited the following problems as being associated with mathematical language. They include: poor pronunciation of certain technical terms in mathematics, complicated spellings of certain mathematical terminologies, use of symbols to represent abstract ideas in real life, different meanings for the same term and complicated mathematical language in textbooks.

• Teachers and students considered the following as solutions to the problems associated with mathematical language: use of simplified mathematical language by teachers and in textbooks,
getting synonyms for the technical terms, teachers redefining terms more often, regular practice by the students in order to internalise the terms.

5.2. Conclusion

From the aforementioned findings, it can be concluded that there is a positive correlation between mathematical language and students' performance in mathematics.

5.3. Recommendations of the study

The study therefore recommends that:

i. Since there is a positive relationship between mathematical language and students' performance in mathematics, simple and appropriate mathematical language should be used in the teaching, learning and assessment of mathematics.

ii. The Kenya National Examinations Council and other examination bodies should take into account the issue of mathematical language in setting mathematics items.

iii. The Kenya Institute of Education, mathematics authors as well as mathematics teachers should design mathematics textbooks with simplified and appropriate language for teaching and learning mathematics. This would enhance students' understanding of mathematical language and improve on the
readability of such textbooks. This perhaps would lead to improved students' performance in mathematics.

iv. Mathematics teachers should be aware of the ambiguities in mathematical language. In this case, they should design a mathematics language course with rich mathematical language activities, enriched contextual cues and monitor mathematical ambiguities in order to improve on students' understanding of the language. In this course, they should teach mathematical terminologies and symbols as an isolated topic as used to occur, and sometimes still does, in language classes. This will eventually lead to students' improved performance in mathematics.

5.4. Suggestions for further research

* Since the sample respondents were drawn from some selected public secondary schools in Nairobi Province, the effects found may mainly reflect the situation in the province. Hence, the findings may not be representative of all secondary schools in Kenya. Thus, this study needs to be replicated in other provinces in order to get a better general picture of the whole country. This will facilitate better decision-making as regards relationship between mathematical language and students' performance in mathematics.
- The study evaluated on the aspect of language used in the teaching and learning of mathematics. Another study can be carried out to investigate the relationship between social language and students' performance in mathematics.

- The study evaluated on mathematical language only. Thus, another study can be carried out on the relationship between proficiency of English language and mathematics achievement. On the same issue, another study on the effects of multilingualism on mathematics achievement can also be carried out.
Bibliography


Bell, J (1993). Doing your research project: A guide for first time researchers in education and social science. Buckingham: OUP.


APPENDICES

APPENDIX A: STUDENTS' MATHEMATICS LANGUAGE TEST
(SMLT)

Source: KNEC(1995)

This is a test on mathematics ideas relating to terminologies used in mathematics whose main purpose is establishing the relationship between mathematical language and students' performance in mathematics. Answer all the questions carefully and honestly as much as possible. Your answers to the questions will be useful in improving the learning and teaching of mathematics in secondary schools, as well as confirming your great mathematical ability and need.

Part I: Students' Personal Information.

1. Student's characteristics
   a) Name of school ________________ class: Form __
   b) Gender: Boy [ ] Girl [ ]
   c) Your first language (e.g. Kikuyu, Kikamba) is _____________

   a) How many hours per day do you spend studying the following?
      Word problems------------hours/ Day, symbolic-------------hours per day.
3)  (a) List 3 problems that are associated with symbols used in mathematics, which probably hinder your learning of mathematics
   i)
   ii)
   iii)

   (b) Suggest three possible solutions to the problems you have listed in (3a) above
   i)
   ii)
   iii)

   (c) List 3 problems that are associated with the terminologies used in mathematics, which probably hinder your learning of mathematics
   i)
   ii)
   iii)

   (d) Suggest three possible solutions to the problems you have listed in (3c) above
   i)
   ii)
   iii)
4) Which of the following styles of studying do you think is useful in learning terminologies and symbols used in mathematics?

<table>
<thead>
<tr>
<th>Style of studying</th>
<th>Not useful (1)</th>
<th>Useful (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memorisation of mathematical terminologies and symbols.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion of the symbols with other students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion of the symbols and word problems with mathematics teacher.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion of the symbols with parents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PART II: Terminology Test**

**INSTRUCTIONS:** In the Table below column I are terminologies commonly used in mathematics. Match these terminologies with their possible meaning(s) from the list provided on column III and write the answer in column II.

**Time: 1hr.**
<table>
<thead>
<tr>
<th>No.</th>
<th>Column I Terminologies</th>
<th>Column II Meaning(s)</th>
<th>Column III List of meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Difference</td>
<td></td>
<td>Spaced out, separately,</td>
</tr>
<tr>
<td>2.</td>
<td>Simplify</td>
<td></td>
<td>Add, period, facing right</td>
</tr>
<tr>
<td>3.</td>
<td>Times</td>
<td></td>
<td>side, sum, knob for</td>
</tr>
<tr>
<td>4.</td>
<td>More than</td>
<td></td>
<td>increasing sound, Divide,</td>
</tr>
<tr>
<td>5.</td>
<td>Constant speed</td>
<td></td>
<td>proportion, product,</td>
</tr>
<tr>
<td>6.</td>
<td>Right-angled triangle</td>
<td></td>
<td>Same velocity, loud, make</td>
</tr>
<tr>
<td>7.</td>
<td>Ratio</td>
<td></td>
<td>easier, Carry out the</td>
</tr>
<tr>
<td>8.</td>
<td>Volume</td>
<td></td>
<td>mathematical process,</td>
</tr>
<tr>
<td>9.</td>
<td>Apart</td>
<td></td>
<td>Sum, product of base area</td>
</tr>
<tr>
<td>10</td>
<td>Total</td>
<td></td>
<td>and height, subtraction,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>triangle with one angle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>equal to 90°,</td>
</tr>
</tbody>
</table>

**Part III: Mathematics Test**

**Instructions:** Answer all questions. Work out the problems and circle the correct answer from the choices given.

1. If $a^x=4$ and $a^y=5$, what is the **difference** between $a^y$ and $a^x$?

   (a) One has x and the other has y
   (b) $a^x$ represents 4, an **even** number while $a^y$ represents 5, an **odd** number. (c) -1 (d) No difference since both represent numbers 4 and 5. (e) 1
2. **Simplify** \( X^2 + x^2 + y^2 + y^2 \)

(a) \(2x^2 + 2y^2\)  (b) \(x^2X^2 + y^2Y^2\)  (c) \(X^2 + x^2 + y^2 + y^2\)  (d) \((2x2y)^2\)  (e) \(8xy\)

3. Three years ago Carol was three **times** as old as Ali. In two years time, the sum of their ages will be 62. Determine their present ages.

(a) Ali is 16 and Carol 41 yrs  (b) Ali is 18 and Carol 43 yrs  (c) Ali is 16 and Carol is 48 yrs  (d) year 2002  (e) none of the answers

4. Tom bought 4 pencils and 6 biro pens for sh.66 and Mary bought 2 pencils and 5 biro pens for sh.51. Beth spent sh.288 to buy the same type of pencils and biro pens. If the number she bought were 4 **more than** the number of pencils, find the number of pencils she bought.

(a) 4  (b) 9  (c) 21  (d) 25  (e) 3

5. In a race, Ogot, running at a **constant speed** of 8m/s is five meters ahead of Atieno. If Atieno maintains a constant speed of 10m/s, how far does Atieno run before catching up with Ogot?

(a) 25m  (b) 80m  (c) 8m  (d) 5m  (e)

6. Which of the following is a **right-angled** triangle? (Not drawn to scale)

(1)  
(2)  
(3)

(a) 1 only  (b) 2 only  (c) 1 and 2 only  (d) 3 only  (e) all
7. Three business partners, Kioko, Njau and Mwikali, are to share sh.12,000 in the ratio 5:6:x respectively. If Kioko received sh. 4,000, determine the value of x.

(a) 15 (b) 4 (c) 11+x (d) 60000 (e) 44000

8. A pool of water with surface area of 0.6 ha has a uniform depth of 3m. A pipe drains the pool at the rate of 200 litres per second.

iv) What is the volume of the pool in litres?

(ii) How many hours does it take to empty the pool?

(i)(a) 1800000 (b) 18000000 (c) 180000 (d) 1.8 (e) no volume

(ii)(a) 2.5 hours (b) 25 hours (c) 900 seconds (d) 15 hours (e) 15 seconds

9. To fence one side on his farm, a farmer requires 25 posts placed 4m apart. How many posts would he require if the posts were 3m apart.

(a) 33\(\frac{1}{3}\) (b) 34 (c) 32 (d) 33 (e) 128

10. A shopkeeper sells two types of pangas, type \(x\) and type \(y\). Twelve type \(x\) and five type \(y\) pangas cost sh. 1260 while nine type \(x\) and fifteen type \(y\) pangas cost sh. 1620. If Tom bought eighteen type \(y\) pangas and one type \(x\), find the total cost of these pangas.

(a) 80 (b) 60 (c) 1080 (d) 18y+x (e) 1160
APPENDIX B: MATHEMATICS TEACHERS’ QUESTIONNAIRE (MTQ)

Student’s performance of mathematics is a major concern world-wide. This study is designed to investigate the relationship between mathematical language and students’ performance in mathematics. The results of this study will go a long way in improving students’ poor performance in mathematics. The information you provide will be accepted unanimously and treated with strict confidentiality. It will be used only for the purposes of the study and in no way against you. You are required to answer the following questions honestly.

Instructions: Tick (✓) or complete where appropriate.

1. Teachers Self-Information

I. Teachers characteristics

a) Gender: Male: [ ] female [ ]

b) Academic qualification: Graduate [ ] Non-graduate [ ]
   year: _______

c) Type of qualification: B.Ed [ ] Dip. Ed. [ ] BSc. [ ] BA [ ],
   others(Specify)____ Where trained (institution)____________

II. Teaching information

a) Subject(s) trained/studied i) ___________ ii) ___________

b) Subject now teaching i) _______ ii) _______

c) Current teaching load ___________ periods per week.

d) Total teaching experience ___________

e) Teaching experience at the present school ___________
f) How many times have you attended in-service course?  
_____times. For mathematics?_______times. Year____

g) State 3 problems that you and your students encounter in the use of mathematical language in the teaching of mathematics and suggest their solutions.

(I) Problems you face as a teacher. Solutions
i)  

ii)  

iii)  

(II) Problems faced by students. Solutions
i)  

ii)  

iii)  

2. Teacher's information about his/her school and class as regard mathematical language

a) Name of school________________

Type of school: Boys [ ] Girls [ ] mixed [ ] No. of streams_______

b) Which class do you teach?_______ No. of students_______

c) How adequate are the following items in your class?

<table>
<thead>
<tr>
<th>Item</th>
<th>Adequate</th>
<th>In adequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbooks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference books</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
d). i) List 3 mathematics textbooks, which you use in your class in order of preference.

   i) __________________________
   ii) __________________________
   iii) __________________________

e) Among the listed books above, which do you find or consider as using simple and appropriate language?

f) List the terminologies used in mathematics that you find difficult to teach. __________________________________________________
   __________________________________________________

   Reasons: __________________________________________________
   __________________________________________________

  g) List the terminologies used in mathematics that your students find difficult

   __________________________________________________
   __________________________________________________

h). Do you consider the issue of mathematical language during setting of mathematics items?

   Yes [ ] No [ ]

i) In your opinion, do you think that KNEC considers mathematical language in setting exams?

   Yes [ ] No[ ]
Appendix C: List of public secondary schools in Nairobi Province as at 14/10/2001.

1. Nairobi School
2. Lenana School
3. Moi Forces Academy
4. Kenya High School
5. Starehe Boys Centre
6. Pumwani Secondary School
7. St.Teresa’s Girls Secondary
8. St.Teresa’s Boys Secondary
9. Uhuru Secondary School
10. Kangemi Secondary School
11. Kambu High School
12. H.H Aga Khan High School
13. Muslim Girls Secondary School
15. Aquinas High School
16. Parklands Secondary School
17. Our Lady Of Fatima
18. Maina Wanjigi Secondary
19. Nile Road Secondary School
20. Muhuri Muchiri Secondary
21. Ofafa Jericho Secondary
22. Our Lady of Mercy Secondary
23. Parklands Arya Girls
24. Ruthimitu Secondary School
25. Nairobi Milimani Secondary
26. Precious Blood Girls
27. Buruburu Girls Secondary
28. Dagoretti High School
29. Langata High School
30. Ruaraka High School
31. Mutuini High School
32. Moi Nairobi Girls Secondary
33. Highway Secondary School
34. Embakasi Girls Secondary
35. Hospital Hill Secondary School
36. Jamhuri High School
37. Dandora High School
38. Kayole Secondary School
39. Kamukunji Secondary School
40. Pangani Girls Secondary
41. Upper Hill Secondary School
42. Eastleigh Secondary School
43. Huruma Girls High School
44. State House Girls Secondary
45. Kamiti High School
46. St.Georges Secondary School
47. Ruthimitu Girls Sec School

Source: PDE, Office,Nyayo Hse:14th Floor, Nairobi.