ASSESSMENT OF ERRORS MADE BY SECONDARY SCHOOL STUDENT’S THAT INFLUENCE ACHIEVEMENT IN SOLVING WORD PROBLEMS IN MATHEMATICS IN GATANGA SUB-COUNTY, KENYA

BY

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OCTOBER, 2015
DECLARATION

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

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DEDICATION

This thesis is dedicated with love, to my wife Mary, our children Maureen and Eddie whose support and motivation encouraged me to complete this study.
ACKNOWLEDGEMENTS

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## ABBREVIATIONS AND ACRONYMS

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<thead>
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<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>DEO</td>
<td>District Education Officer</td>
</tr>
<tr>
<td>KCSE</td>
<td>Kenya Certificate of Secondary Education</td>
</tr>
<tr>
<td>KICD</td>
<td>Kenya Institute of Curriculum Development</td>
</tr>
<tr>
<td>K.L.B</td>
<td>Kenya Literature Bureau</td>
</tr>
<tr>
<td>K.N.E.C</td>
<td>Kenya National Examinations Council</td>
</tr>
<tr>
<td>MG</td>
<td>Mean Grade</td>
</tr>
<tr>
<td>MOEST</td>
<td>Ministry of Education Science and Technology</td>
</tr>
<tr>
<td>MS</td>
<td>Mean Score</td>
</tr>
<tr>
<td>NCTM</td>
<td>National Council of Teachers of Mathematics</td>
</tr>
<tr>
<td>SMT</td>
<td>Students Mathematics Test</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
</tr>
<tr>
<td>TMTQ</td>
<td>Trained Mathematics Teachers Questionnaire</td>
</tr>
<tr>
<td>TPT</td>
<td>Total Points</td>
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</table>
ABSTRACT

The purpose of this study was to analyze and establish the errors made by secondary school students that influence achievement in solving word problems in mathematics in Gatanga sub-county, Murang’a County, Kenya. The objectives of the study were to: establish the errors made by secondary school students; investigate the sources of these errors; identify the gender differences in the errors made and determine the methods used to remediate these errors in solving word problems in mathematics. The study hypotheses were: $H_01$: There is no significant relationship between errors made by students and type of school they attend in solving word problems in mathematics; $H_02$: There is no significant relationship between the errors made by students and their sources in solving word problems in mathematics. $H_03$: There is no significant relationship between errors made and gender of student in solving word problems in mathematics. The literature review highlighted studies, opinions, suggestions and recommendations on errors made and their effects on achievement in solving word problems in mathematics. The research adopted a cross-sectional descriptive survey employing correlation methods. A total of thirty two secondary schools and fifty eight trained mathematics teachers were targeted for the study. Nine secondary schools were selected using stratified sampling. Two hundred and seventy eight students and twenty four teachers were selected for the study using random sampling. Students’ Mathematics Test, Trained Mathematics Teachers Questionnaire and Interview schedule for students were used to collect data on errors made in solving word problems in mathematics in Gatanga sub-county. Data was analyzed by use of SPSS (Statistical Package for Social Sciences). Data obtained was presented in tabular and graphical forms. The findings of this study showed that students made a variety of errors in solving mathematics word problems. These errors included computational errors, wrong equations, wrong facts, premature approximations and wrong formulation. A chi square test revealed that there was no significant relationship between errors made and the gender of the students in solving word problems in mathematics ($\chi^2 (4, N=278) = 3.22, p<0.522$). However, there was significant relationship between errors made by the students and the types of schools they attended. The study concluded that student’s ability to master basic facts, concept attainment, prerequisite skills, false generalizations and ability to carry out multi-step calculations were areas of concern. Most students made errors due to inability to give adequate interpretation to the word expressions, the language of the problem as well as use of incorrect mathematical operations that were required for a particular transformation of a mathematical statement into its equivalent algebraic equation. The study recommended remediation of errors which should be based upon careful analysis of students’ errors, in the light of specific identified errors. Word problems given out to students should be attended to, by mathematics teachers through immediate scoring, identification of particular errors made and giving adequate corrections to students in form of feedback. KNEC should ensure that the yearly reports on performance of national examinations with details of the students’ errors reach all the secondary schools on time. Kenya Institute of Curriculum Development should ensure that teaching resources such as textbooks are designed in such a way that those activities that would enhance word problem interpretation are suggested at the end of every topic. This would help in learning of mathematics in secondary school and would guide students to solve word problems with minimum or no errors.
CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Mathematics plays a central role in scientific progress and development of any country. Its fundamental role lies in its everyday application in most social sciences, physical sciences, biological sciences, engineering and medicine, military, aerodynamic advancements, business transactions and household chores. This has made it necessary for the subject to be declared compulsory in the school curriculum in Kenya (Mutunga and Brekel, 1992; Republic of Kenya, 1999). This is because students are expected to apply the knowledge of mathematics in both familiar and unfamiliar situations. However, the literature indicates that a considerable number of students in secondary schools have inadequate understanding of mathematical concepts and skills in solving word problems (KNEC, 2007; MOEST, 2001).

The National Council of Teachers of Mathematics (2000) has emphasized that the goal of mathematics education reform is to produce students who are skilled in resolving problems, in addition to fostering attitudes, interests and a high motivation towards mathematics. Students should be exposed to skills in interpreting problems, planning solutions strategy, implementation of plan and rechecking of answers. In order for the students to think mathematically, they should be exposed to various strategies of solving word problems by doing each step carefully and systematically. There was therefore a need to determine whether students in secondary schools have skills in interpreting word problems.
Mathematics is a highly structured discipline and has two structures defined as conceptual and syntactic. The conceptual structure deals with the products of mathematics such as defined concepts, undefined concepts, postulates and theorems. On the other hand, the syntactic structure consists of the processes used in solving word problems such as induction, deduction and idealization. For any successful word problem solving, the problem solver is required to have adequate understanding of the two structures: The problem solver must have adequate grasp of the conceptual content; understanding the process recommended; and knowing when and where to apply them in solving word problems. It is inadequate understanding of concepts featuring in mathematics word expressions and ability to choose the appropriate process that usually lead students into making errors while solving word problems in mathematics (Fajemidagba, 1986). This study evaluated whether students in secondary schools had adequate understanding of concepts in mathematics word problems in a given task.

During the process of teaching and learning mathematics, students face many obstacles such as comprehension because solving word problems in mathematics is a skill that may be very complex. Sometimes students know how to answer the question stated, but make errors in computation. Errors in solving mathematical problems often occur in writing during calculations. Dickson & Gibson (1984) found out that teachers usually favour an algorithmic approach where all mathematical problems are reduced to a formula that can be completed easily by substituting and manipulating numbers. In such cases, the students only reflect on whatever approaches they have been taught in solving word problems. Many researchers have argued that to promote learning of mathematics with understanding, mathematics educators must consider the tasks, problem-solving situations, and tools used to represent mathematical ideas (Dienes, 1960; Bruner, 1961).
Although mathematics is always emphasized in school, students’ errors in word problems have been questioned by many researchers (Anghileri, 2001; Stadler, 2002; Wanjala, 1996) who have studied the different levels of difficulty presented in word problems. In the US, studies in mathematics word problem solving by Schoenfeld (1985) showed that students were not actually weak in solving word problems but lacked the proper skills to interpret word problems resulting in errors in calculations. In Holland, a research by Anghileri (2001) showed that students were unable to relate the given word problem statements to mathematical statements and therefore made errors in comprehension, translation and process skill stages in solving these problems. The results of this study showed that more than sixty per cent of the students had made errors before performing any calculation. Studies done in Singapore by Radiah (2001) on errors made by secondary school students in solving word problems concluded that fifty four per cent of the students had wrong formula or defective algorithm errors. These errors occurred in the transformation stage where students were supposed to choose appropriate process or algorithm to solve the problem in context. This study also revealed that the students were not clearly exposed to the heuristics of solving word problems in mathematics such as understanding the problem, devising a plan, carrying out the plan, and looking back (Polya, 1985). This study therefore aimed at establishing errors made by secondary school students in solving word problems in mathematics.

In Nigeria, a study by Adeniyi (1998) on types of errors made by concrete and formal operational junior secondary school students in solving word problems in mathematics revealed that students identified as formal operational thinkers made fewer errors than the concrete operational students. The study also showed that there were no major gender differences in the errors made by the two categories of students. In the Third International Mathematics and Science Study repeat survey
(TIMMS-R) of the worldwide trends in performance in mathematics, it was confirmed that students in Nigeria had performed better than those of South Africa whose mathematics learners' performance was significantly poorer than the vast majority of other participating countries in tests that measured basic mathematical skills. South African learners struggled to arrive at correct solutions especially with problems involving language. In general, learners made numerous errors while communicating their answers in the language of the test and they revealed that they did not have the basic mathematical knowledge that was required to solve word problems (Howie, 2003).

This study aimed at identifying gender and school differences in errors made by secondary school students in solving mathematics word problems.

In Kenya, a study by KNEC (2010) showed that candidates made errors in solving word problems because of inadequate coverage of the syllabus content. They also made more errors in questions that required higher analysis, such as in word problem solving, evaluation and application. Most of the candidates failed to interpret questions correctly and therefore made errors in transformation of the problem that resulted in incorrect answers. The government of Kenya, through the Ministry of Education, has tried to solve some of these problems by training more mathematics teachers, revising mathematics syllabus to review content as well as appropriateness of topics but students continue to make errors in word problems that has significantly affected the achievement in mathematics in national examinations. This study aimed at investigating the sources of errors made by secondary school students in solving mathematics word problems.

The most recent effort by the Ministry of Education was the introduction of SMASSE program in 1998. This initiative was to address among other things, the challenges faced by secondary school
students while solving word problems in mathematics. Some of these challenges were identified as: negative attitudes towards mathematics; common errors made while solving word problems; and mathematics topics that students perceived to be difficult. Despite this effort, the analysis of KCSE results of 2012 in mathematics in Gatanga Sub-County showed that 33.5% of the candidates scored grade E which is the lowest grade. The analysis is summarized and presented in Table 1.1

Table 1.1: Gatanga Sub-County Mathematics KCSE Analysis 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Entry</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>2012</td>
<td>2913</td>
<td>110</td>
</tr>
</tbody>
</table>

Source: D.E.O. Gatanga Sub-County 2013

From Table 1.1, it is evident that 69.1% of the 2012 candidates in KCSE scored grades D plain and below in mathematics in the Sub-County. This implied that most of the students had a low achievement in mathematics. This would have serious implications in future due to the fact that majority of the students scoring such low grades in mathematics would not be able to join competitive courses offered at the higher institutions of learning in the country. Students’ errors in solving word problems as discussed earlier have been associated with achievement in mathematics. It was therefore important to conduct a study in order to analyze and establish the errors made by students in solving mathematics word problems in secondary schools in Gatanga Sub-County in Murang’a County and suggest ways of remediating these errors.

1.2 Statement of the Problem

Mathematics is the foundation of science and technology. The functional role of mathematics in science and technology is multifarious. Thus, no areas of science, technology and business
enterprise lack the application of mathematics. The level of mathematics needed for intelligent citizenry has increased dramatically and so has the level of mathematical knowledge needed in areas such as healthcare, education, graphic designing and banking. Beside its importance, it is observed that students in secondary schools make errors in solving word problems in mathematics which usually lead to low achievement in the subject. Student’s low achievement may also be attributed to factors such as the society view that mathematics is difficult, shortage of qualified teachers, lack of mathematics laboratory and lack of attractiveness and novelty in the teaching methods (Okereke, 2006).

According to KNEC (2010), students do not pay much attention to the mathematical statements involved in answering the question and do not read the terms used in the word problems very closely and therefore make errors in solving such problems. They make more errors in questions that require higher analysis, such as problem solving, evaluation and application in mathematics examination. Most students fail to interpret word problem questions correctly, thus making numerous errors and end up answering the questions incorrectly. The Ministry of Education has made efforts to solve the problem of low achievement in the subject by training of more mathematics teachers; revising mathematics syllabus; and introduction of SMASSE. The SMASSE initiative aimed at equipping mathematics teachers with knowledge on how to introduce learning which is centered on students so as to develop active and motivated learning, problem interpretation skills and broad field knowledge based on solving problems in mathematics. Despite the efforts made, students’ errors in solving word problems in mathematics have significantly continued to affect the students’ achievement in mathematics in national examinations.
Evidence of low achievement in mathematics by secondary school students in Gatanga sub-county highlight the fact that the most desired technological, scientific and business application of mathematics cannot be sustained in the country. It is within this background that this study sought to establish the errors made in solving word problems in mathematics in secondary schools in Gatanga Sub-County, Murang’a County, Kenya.

1.3 Purpose of the Study

The purpose of this study was to analyze and establish the errors made by secondary school students in solving word problems in mathematics. The studies of learners’ errors in solving mathematics word problems help in understanding the learning process. Corder (1982) concluded that the study of errors is a useful tool in investigating the mechanisms used by students in obtaining, processing, retaining and reproducing the information contained in mathematical tasks. This study therefore focused on analyzing Form 3 secondary school students’ errors in solving word problems in mathematics and how to remediate them.

1.4 Objectives of the Study

The specific objectives of the study were to:

(i) Analyze and establish the errors made by students when solving word problems in mathematics.

ii) Investigate the sources of errors made by students when solving word problem in mathematics.

iii) Identify gender differences in the errors made when solving word problems in mathematics.

(iv) Determine the strategies used to overcome the errors made in solving word problems in mathematics
1.5 Research Hypotheses

i) $H_{o1}$. There is no significant relationship between errors made by students and type of school they attend in solving word problems in mathematics.

ii) $H_{o2}$. There is no significant relationship between the errors made by students and their sources in solving word problems in mathematics.

iii) $H_{o3}$. There is no significant relationship between errors made and gender of student in solving word problems in mathematics.

1.6 Significance of the Study

(i) Teachers

The findings of this study would benefit the teachers in secondary schools in undertaking remedial teaching in mathematics. This is in line with the ministry of education policy that schools should identify students with learning difficulties and design appropriate programs for them. By analyzing and establishing the errors in word problem solving, this study provides teachers with appropriate strategies and approaches in teaching of word problems consistently, persistently and full of patience that would improve achievement in mathematics in secondary schools. The study will also become a bench-mark for mathematics teachers to be better designers of the teaching and planning by looking at the strategies and the level of language that suit the ability of the secondary school students in solving word problems in mathematics. Teachers have been shown that they should give the students more alternative approaches in solving mathematical word problems so that they can arrive at correct solutions without errors.
(ii) Ministry of Education Science and Technology (MOEST)

It is hoped that this study will encourage teacher educators to instill in teacher training programs the importance of effective teaching methods that would reduce mathematical errors among the students in word problem solving in secondary schools.

(iii) Kenya Institute of Curriculum Development (K.I.C.D)

Overall, this study has provided information to curriculum developers and officers who are responsible for the development and implementation of the Secondary school mathematics curriculum. The study highlighted that there is need to review the resources used in learning of mathematics so as to reflect the everyday life. Objectives of mathematics should be achieved in the implementation stage if the most desired technological advancements are to be realized as envisaged in vision 2030.

(iv) The Kenya National Examinations Council (KNEC)

While constructing the test items, this study proposes that the examination council will be considering the length of the test items in mathematics in terms of wording. This will provide the students with the opportunity to recognize the question requirements and therefore solve word problems without difficulties.

(v) Students

This study was instrumental in establishing the errors made by the students in secondary schools. The sources of these errors were highlighted. Other factors that contributed to students’ errors were brought out and ways of reducing these errors were provided by this study.
1.7 Scope and Limitation of the study

1.7.1. Scope of the Study

The study was delimited to Form 3 students in selected secondary schools in Gatanga Sub-County in Murang’a County, Kenya. The study used a student mathematics test to assess the student’s ability to solve word problems on a few topics: trigonometry; quadratic equations; and linear motion, all covered in Form 2 and Form 3 syllabuses. The study focused on errors made in solving word problems in mathematics such as: computational errors; defective algorithm; premature approximations; wrong formulation; carelessness; omission of work; and wrong equation errors made by secondary school students while solving word problems in mathematics. A total of nine schools were sampled for the purpose of this study to make the results more general.

1.7.2. Limitations of the Study

The study covered Gatanga Sub-County for the purposes of this research. The Sub-County had no National school and therefore the study dealt with County, District boarding and District day schools. The study was generalized for the Kenya Certificate Secondary Education and therefore should be utilized to stimulate further research in other Sub-Counties to establish whether similar results would be obtained. The Sub-County was curved from the larger Thika District now Thika Sub-County and therefore had records for KCSE results analysis for only two years by the time of this study.

1.8 Assumptions of the Study

The study was guided by the assumptions that all secondary schools under investigation:-

i) Had students who made errors while solving word problems in mathematics.

ii) Were following the same syllabus in mathematics.

iii) Had mathematics teachers who were adequately trained.

iv) Had similar resources for teaching and learning mathematics.
v) Had students who had completed form one and two mathematics syllabuses.

1.9 Theoretical Framework

The study was based on Conditions of Learning Theory by Gagne (1985) that stipulates that there are several different types or levels of learning. The significance of these classifications is that each different type requires different types of instruction. He identifies five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills and attitudes. Different internal and external conditions are necessary for each type of learning. For example, for cognitive strategies to be learned, there must be a chance to practice developing new solutions to problems; to learn attitudes, the learner must be exposed to a credible role model or persuasive arguments.

Gagne (1985) suggests that learning tasks for intellectual skills can be organized in a hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving. This is an essential aspect in learning mathematics where use of mathematics terminologies, concept formation, application and problem solving must be developed in the learners so as to enable them to perform mathematical tasks easily. The primary significance of the hierarchy is to identify prerequisites that should be completed to facilitate learning at each level. Prerequisites are identified by doing a task analysis of learning or training task. Learning hierarchies provide a basis for the sequencing of instruction in a mathematics classroom. Lack of prerequisite skills in mathematics would lead the students in making errors when solving word problems.

According to Prakitipong and Nakamura (2006), there are two kinds of obstacles that hinder students from arriving at correct answers in the process of solving word problems:
i) Problems in linguistic fluency and conceptual understanding that correspond with level of simple reading and understanding meaning of problems.

ii) Problems in mathematical processing that consists of transformation, process skills, and encoding answers.

This classification implies that the students have to interpret the meaning of the question before they proceed to mathematical processing to obtain appropriate answer.

Mathematics learning involves a number of variables such as the learner, teacher, mathematics content, methods of instruction and resources. The learners are expected to interact with the content during instruction by the teacher. These content forms mathematics curriculum which include the four basic areas namely; concepts, computations, applications and problem solving. Inadequate understanding of concepts featuring in mathematics word expressions, wrong computations and inability to choose the appropriate processes in solving word problems usually lead students into making errors in mathematics (Sainah, 1998).

The errors made by the students in solving word problems in mathematics will depend on reading, comprehension, transformation, process skills and encoding given questions in word problems. Sources of errors can therefore be attributed to methods of instruction, syllabus coverage, strategies used in solving word problems and availability of learning resources in mathematics. Teaching experience is necessary so as to guide the students to have skills in problem interpretation in solving word problems in mathematics.
1.10 Conceptual Framework

These variables are conceptualized in figure 1.1

Fig 1.1: Relationship between variables on errors made by secondary school students in solving word problems in mathematics.

INDEPENDENT VARIABLES
Errors
- wrong formula, wrong equations
- Defective Alogarithm
- Computational errors

INTERVIEWING VARIABLES
- Time
- Students interest in mathematics
- Discussions in class
- Mathematical language

DEPENDENT VARIABLE
- Achievement in solving word problems in mathematics in secondary schools

Source: Adapted from Gitonga (2010)

According to Newman (1977) students in secondary schools make errors when solving word problems. He classified the errors according to student’s inability to read, failure to comprehend problems, wrong transformation of problems, lack of skills in processing of mathematical
statements, poor encoding and carelessness. They may also make errors due to the strategies used by the teachers during instruction. This study was concerned with errors made in solving word problems in mathematics that included: defective algorithms, wrong formulation, premature approximations, wrong equations, computational errors and omission of work. However, if students are involved in classroom discussions, they are likely to conceptualize the ideas easily as they become more interested in solving problems. In situations where the school is not providing enough resources such as mathematics models and textbooks, it impacts negatively on students’ ability to make mathematical representation which may lead to errors in solving word problems in mathematics. Other measures such as: elaborate teaching methods that would accord more time to the students in problem interpretation skills and familiarization with mathematics language in the classroom would be vital in their problem solving ability. These would enhance skills in solving word problems that would further impact positively in the overall students’ achievement in solving word problems in mathematics in secondary schools.
1.11 Operational definition of key terms

**Concept**
An abstract idea describing some relationship within a group of facts and may be designated by some sign or symbol

**Conceptual understanding**
to understand meaning of problems in solving word problems in mathematics

**Errors**
Incorrect or wrong calculations in a given word problem

**Hypothesis**
An assumption taken to be true for the purpose of argument or investigation

**Intelligent citizenry**
Mathematics awareness among the people in the country

**Linguistic fluency**
Level of simple reading such as grammar and syntax in word problems

**Mathematics achievement**
Students score in a given mathematics examination

**Prerequisite skills**
Prior knowledge that is required in a topic in mathematics

**Remediating**
To correct or improve deficient skills in mathematics

**Semantic error**
The error made as a result of inadequate understanding of the language of the problem.

**Static syntactic error**
The error made due to direct translation of the given problem or word matching

**Word problems**
a mathematical problem that is stated in words rather than in symbols or as an equation
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature considering the following important aspect of problems encountered while solving word problems in mathematics: Mathematics word problem solving, sources of errors in word problem solving, language difficulties encountered by students in solving word problems, gender and errors in mathematics word problem solving, types of errors made in word problem solving and summary of the existing gaps in the review.

2.2 Mathematics Word Problem Solving

In the most recent documentation by the National Council of Teachers of Mathematics (NCTM 2000), word problem solving is listed as one of the five Process Standards. “Problem solving is an integral part of all mathematics learning, and so it should not be an isolated part of the mathematics program” (NCTM, 2000; 52). Since word problem solving has been accorded such prominence, it is necessary to have an understanding of what word mathematical problem is.

Mathematics Thesaurus defines word problem as “A mathematical problem that is stated in words rather than in symbols or as an equation”. Most of the students find word problems challenging. A word problem is a verbal description of a problem situation wherein one or more questions are posed, the answers to which can be obtained by the application of mathematical operations to information usually numerical data available in the text. In its most typical form, a word problem describes the essentials of some situation assumed to be familiar to the solver. Within the text, certain quantities are explicitly given, while others are not. The student is required to give a
numerical answer to a stated question by making exclusive use of the quantities given and of the mathematical relationships between these quantities.

Despite its label, a word problem need not constitute a problem in the cognitive-psychological sense of the word. The higher-order thinking going beyond the application of a familiar routine procedure is not necessarily required. Indeed, in typical elementary mathematics instruction, many word problems provide thinly disguised practice in the four basic operations in arithmetic: adding, subtracting, multiplying, or dividing. Several structural dimensions can be distinguished in word problems that affect how they are solved leading to errors:

i) *Mathematical structure* which includes the nature of the given and unknown quantities of the problem and the mathematical operations by which the unknowns can be derived from what is given.

ii) *Semantic structure* which includes the ways in which an interpretation of the text points to particular mathematical relationship. For example; addition or subtraction is indicated when the text implies a combination of two disjoint subsets into a superset, a change from an initial quantity to a subsequent quantity by addition or subtraction, or the addition comparison between two collections.

iii) *Context* which means the nature of the situation described. For example, an additive word problem involving combination of disjoint sets might deal with physically combined collections of objects or with conceptually combined collections of people in two locations.
Iv) The format which means how the problem is formulated and presented. Format involves such factors as the placement of the question, the complexity of the lexical and grammatical structures and also the presence of superfluous information.

Bruner (1961) cited the work of Weldon who claimed that one needs to consider ‘troubles’, ‘puzzles’, and ‘problems’ when defining a word problem. A ‘trouble’ is a circumstance or situations which make one upset and uncomfortable while a ‘puzzle’ has a nice tight form, clear structure, and a neat solution. Kantowski (1977; 163) observes that;

An individual is faced with a problem when he encounters a question he/she cannot answer or a situation he/she is unable to resolve using the knowledge immediately available to him/her. He/she must then think of a way to use the information at his/her disposal to arrive at the goal, the solution of the problem.

He further differentiates between a word problem and an exercise. In the case of a word problem, an algorithm which will lead to a solution is unavailable while in an exercise one determines the algorithm and then does the manipulation of the problem. According to Kilpatrick (1985; 2) a word problem is “a situation in which a goal is to be attained and a direct route to the goal is blocked”. In a similar way, Mayer (1985) claims that a problem occurs when one is faced with a given state and one wants to attain a goal. Blum & Niss (1991) identified two kinds of mathematical problems: The applied mathematical problems in which the situation and question belong to the real world or outside mathematics and the pure mathematical problems which are embedded entirely in mathematics. Over several decades, numerous studies have analyzed the role of these task variables on the difficulty of problems, on the kind of strategies students use to solve these problems, and on the nature of their errors, particularly for simple word problems involving addition and subtraction.
or multiplication and division. This study established errors made by students in solving mathematics word problems.

Studies in Malaysia conducted by Sainah (1998) shows that despite the use of modern teaching methods, the availability of modern teaching materials and the provision of specialized training for all teachers, teachers still find difficulties in teaching mathematics because their pupils have many problems in learning it. For example, some pupils can perform arithmetical computation quite well but often have difficulty solving word problems that require the application of those same computational skills. An issue of “I can’t do word problems” syndrome arises due to comprehension difficulties or when the pupil doesn’t know what the question is asking him/her to find out. This study dealt with errors made by secondary school students.

In Kenya, the importance of word problem solving has been taken into great consideration in the Mathematics syllabus for secondary school classes. Its importance has strongly been emphasized as early as in form one class. According to KLB (2010; 15) ‘to work out word problems, one must read the information carefully, identifying the operations required. The solution should be presented in an orderly and logical manner.’ This study investigated errors made by secondary school students while solving word problems.

2.3 Sources of Errors in Solving Word Problems

Although mathematics is always emphasized in school, students’ abilities to master the subject are always being questioned by researchers. Schoenfeld (1985) states that “students are not actually weak in solving word problems but lack the skill to marshal strategies that help to solve particular problems”. In their extensive review of research on problem solving approaches of novices and
experts, The National Research Council (1985) concluded that the success of the word problem solving process hinges on the problem solvers’ representation of the problem. Students with less ability tend to represent problems using only the surface features of the problem, while those with more ability represent problems using the abstracted, deeper-level features of the problem and eventually make fewer errors. The recognition of important features within the problem is directly related to the “completeness and coherence” of each problem solvers’ knowledge organization. Lester and Kehle (2003: 510) typify word problem solving as an activity that involves the students’ engagement in a variety of cognitive actions including accessing and using previous knowledge and experience. They further observe:

Successful problem solving involves coordinating previous experiences, knowledge, familiar representations and patterns of inference, and intuition in an effort to generate new representations and related patterns of inference that resolve the tension or ambiguity (lack of meaningful representations and supportive inferential moves) that prompted the original problem-solving activity.

In her study in Malaysia, Salleh (2004) discovered that students who can successfully solve a word problem possess good reading skills, are able to compare and contrast, have the ability to identify important aspects of the problem, are able to estimate, create analogies and are flexible in attempting various strategies. In another study Mahmud (2003) found out that the main source of secondary school students’ errors in solving word problems was the students’ inability to understand the problem. She found out that almost ninety eight per cent of students admitted to having difficulties in comprehending what a question required. Students did not pay much attention to the strategies involved in answering the question and did not read the terms used in the problem very closely. This implies that students made errors in the reading and comprehension stages of solving word problems in mathematics. Studies in Holland conducted by Anghileri (2001) found
out that students made errors in comprehension of the problem, transformation of the problem to appropriate algorithm and process skill stages of solving word problems and suggested that students should be introduced to real life problems.

In Kenya a report by KNEC (2010) showed that candidates made errors in their work, usually because of inadequate coverage of the syllabus content. The study concluded that most candidates had made more errors in questions that required higher analysis, such as word problem solving, evaluation and application. Most candidates fail to interpret questions correctly, thus finding them difficult to answer correctly. This study aimed at investigating the possible sources of errors in solving word problems in mathematics by secondary school students.

2.3.1 Language difficulties encountered by students in solving mathematical word problems

In recent years, increasing attention has been given to the effects of language in Mathematics learning. Students like mathematics as long as they understand the process of solving problems. Understanding of mathematical concepts is one major goal of mathematics teaching at all levels in the educational system (Stadler, 2002). One way to capture mathematical understanding is to describe it as a process where a mathematical object transforms from being a process to become a mental object (Sfard, 1991). Thus, a deep understanding of a mathematical object is not mainly about manipulating complicated mathematical expressions but instead, to be able to create an internal picture of an abstract mathematical concept that seems to be a major part of mathematical ability (Stadler, 2002). An important part of the mathematical expression is all its signs and symbols’ meaning that Mathematical understanding is both a linguistic and a conceptual matter (Vergnaud, 1998). To understand mathematics, a learner should not only be able to identify
relationships between the mathematical symbols, but also their relation to natural everyday language.

A statement by the Cockcroft Report (1982:6) confirms that mathematics is a difficult subject both to teach and to learn. This is more so if mathematics is studied in a second language. A survey by Eagle cited in Bell et al (1983; 287) on learning mathematics in a second language, reveals that some retardation may be attributable to weak understanding of the language being used. Findings by Dawe (1983:325) also found that first language competence is an important factor in the child’s ability to reason in English as a second language. He suggested that published weaknesses in mathematics found among certain Asian and West Indian pupils growing up in England may well be due to language factors. A child who cannot understand the language of a mathematics word problem cannot possibly find the solution because the Cockcroft Report (1982; 89) claims that language plays an essential part in the formulation and expression of mathematical ideas. From the findings of a study by Sainah (1998), it was concluded that in most cases, students find word problem solving tasks more difficult than the symbol manipulation of corresponding computational tasks.

Although teachers always associated pupils’ incorrect solution to word problems from a lack of understanding of mathematical concepts or poor computing skills, in fact, the errors may have been a language difficulties presented in the word problems statement. Therefore this study attempts to gain insight into language factors that contribute to the difficulties in terms of complexity of wording of the mathematical word problems being posed or explained. For example, in response to the question “What is the difference between 16 and 31?” Answers often include “16 is a small number than 31” or 31 is odd and 16 is even”. Much confusion can occur as a result of differing
linguistic usage with the teacher most often speaking Mathematical English while the pupils interpret it as ordinary English.

The findings of a recent research done in Maara District in Kenya on relationship between English language competence and mathematics competence leaves one in no doubt that most secondary school students struggle to cope with mathematics word problems that are presented in the English Language (Gitonga, 2010). Since difficulties in solving word problems are always associated with language, this study also aimed at getting insight into the level of language difficulties experienced by the pupils and to identify to what extent it had affected their word problem solving skills.

2.4 Gender and Errors in Mathematics.

The current education reform in general and mathematics education reform in particular emphasize the importance of thinking, understanding, reasoning, and problem solving in students' learning (NCTM, 1989; National Research Council, 1989). Such reform effort in mathematics curriculum and instruction requires examination of male and female students' thinking, reasoning, and problem solving rather than merely computation and symbol manipulation. In the past, researchers have explored how the gender differences in mathematics were related to various levels of tasks and age groups. Researchers consistently found that male students are superior in geometry and visualization (Geary, 1996). On the other hand, female students show superiority in computation based on the data available.

With respect to the gender differences in mathematical word problem solving, however, there are mixed results. For example, in the USA, (Marshall, 1984) examined general differences of sixth-grade students' mathematical performance in solving problems involving whole numbers, fractions, decimals and word problems. She found that female students were more likely than male students
to perform computations successfully, while male students were more likely than female students to solve word problems successfully. In another study, Marshall and Smith (1987) explored the gender differences of third grade and sixth grade students on various tasks, including computations, word problems, and non-traditional problems. They concluded that, third grade female students performed better than male students for both computational tasks and non-traditional problems, but there was no significant gender difference on word problems. Sixth grade female students again performed better than male students for computational tasks, but there were no significant differences on word problems and non-traditional problems.

The magnitude or direction of the gender differences on word problem-solving tasks has also an age trend. Johnson (1984), in the USA, found out that male college students outperformed female students in the solving of word problems based on a series of experiments. In the meta-analysis by (Hyde et al. 1990), it was found that in the high school and college years there is a gender difference in problem solving, favoring males, but the gender difference favored females slightly in the elementary and middle school years. In Kenya, (Wanjala, 1996) observed in his study that no gender differences were revealed except in the area of factorization where the difficulties were experienced by girls more than boys. This study investigated whether there were gender differences in errors made while solving word problems by secondary school students.

2.5 Types of Errors in Word Problems.

Student’s errors can be informative, being illustrative of certain misconceptions, patterns of thoughts and beliefs (Pimm, 1987). It has been observed that students perform poorly in word problems solving in mathematics. In the light of that, Rosnick (1981); Fajemidagba (1986); and Clement (1982) investigated factors responsible for students' poor achievement in mathematics
word problems. Factors identified included misconception of mathematical statement, which resorted to errors. The two types of reversal errors usually made in mathematics word problem solving are static syntactic error and semantic error. The static syntactic error as defined by the researcher is the error made due to direct translation of the given problem or word matching while semantic error is made as a result of inadequate understanding of the language of the problem. In view of the identified areas of learners’ difficulties with mathematical statements, such aspects of mathematics are poorly responded to in both qualifying and terminal mathematics examinations. They also observed that students excel more in numerical problems than word problem that resort to low achievement in mathematics.

Studies in Singapore by Lim (2000) also found that students’ weakness in solving word problems was that they made avoidable preliminary errors. Students’ carelessness, as well as inabilities to understand what they read, to plan and to choose suitable mathematical operations, was among the factors that prevented them from solving word problems correctly. It was found that students’ inabilities to understand a question and their weak semantic skills involving symbols and meanings of terms as well as vocabulary were the main factors that caused errors in solving word problems. Studies by Ashlock (1994) showed that students made all kinds of computational errors in solving mathematical problems which were not necessarily the result of carelessness or not knowing how to proceed, but could be caused by applying the “failure strategies”.

Clements (1982; 140- 141) conducted a research that connected a student’s confidence and the amount of time spent on an assessment with how many errors were made. He observed that;

…Significantly negative correlations were obtained with two variables, total time and misplaced confidence. This suggests that students who had a sound grasp of arithmetic and mathematical language, who worked relatively quickly on mathematical problems, or who believed they knew how to obtain correct answers, tended to make a higher proportion of careless errors than slower, less confident, and mathematically weaker students.
The above quotation suggests that students make careless errors during computations in mathematics regardless of their level of understanding. In order to analyze errors made by students when solving word problems, Newman (1977) developed a model to classify errors in a sequence of steps such as; reading, comprehension, transformation, process and encoding. The steps are elaborated as follows (Dickson et al, 1994):

i) **Reading abilities:** can the student actually decode the question? Does the student recognize the words or symbols within the question?

ii) **Comprehension:** Once the student has decoded the words or symbols, can he or she understand the question; in terms of general understanding related to mathematical topic or specific mathematical expressions?

iii) **Transformation:** can the student choose an appropriate process or algorithm to solve the problem?

iv) **Process skills:** can the student accurately do the operations he or she has selected at the transformation stage?

v) **Encoding:** can the student relate his or her answer back to original question to record the answer in appropriate form?

This study focused on these steps due to their relationship with errors made by secondary school students in solving word problems.

A study carried out to investigate errors made by Kenyan pupils in five areas of secondary school algebra, namely; expressions involving brackets, inequalities, factorization, equations and fractions identified variety of errors which revealed that children experience difficulties with algebraic
symbols; over generalize algebraic ideas; lacked facility with number and used manipulative approaches in tackling algebraic tasks. The children's difficulties were found to exist at three definable levels with the lowest and highest level reflecting with algebraic notation and convention. While the highest level reflected a high degree of competence in manipulations, there was little meaningful understanding. Most of the difficulties were found to persist throughout the school years, but no gender differences were revealed except in the area of factorization where the difficulties were experienced by girls more than boys (Wanjala, 1996).

In another study carried out to investigate generic errors committed by secondary students when dealing with problems involving algebra in Kisii District in Kenya, it was found out that students have difficulties in remembering facts and algorithms meaningfully, they lacked computational skills and mastery and most of them reconstructed knowledge wrongly (Ogolla, 1997). This study dealt with specific errors made by secondary school students while solving word problems in a given mathematics examination.

2.6 Summary of Existing Gaps in Literature Review

The literature reviewed highlighted studies, opinions, suggestions and recommendations on sources of difficulties faced by students while solving mathematical problems. The literature also showed that despite the efforts made, students’ errors in solving problems in mathematics had affected the achievement in national examinations significantly. This study therefore focused on analyzing and establishing the errors made by secondary school students in solving word problems that influences achievement. The study also set out to identify whether there were any gender differences in solving word problems by secondary school students in mathematics. Students’ errors in solving word problems arise from various sources and this study aimed at investigating some of the sources
of errors in solving word problems in mathematics. After establishing and analyzing the errors, the study also determined the strategies used by mathematics teachers to overcome errors made in solving word problems in mathematics in a given task. This chapter revealed that for effective understanding of mathematics problems and high achievement in mathematics, good reading skills, skillful interpretation of problems and choice of appropriate strategies in solving problems were necessary. This study aimed at establishing the errors made in solving word problems in mathematics and recommend measures that would help students in secondary schools solve word problems in mathematics better.
CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology that was used in the study: design of the study, variables, location of the study, target population, sampling techniques and sample size, research instruments, pilot study, validity and reliability, data collection techniques and logistical and ethical considerations.

3.2 Research Design

The study adopted a descriptive survey employing correlation methods to analyze and establish the errors made by secondary school students in solving word problems in mathematics. The survey is the most frequently used method for collecting information about education or social issues while correlation enables us to assess the degree of relationship between two or more variables (Orodho, 2009). The study utilized both quantitative and qualitative techniques. Quantitative methods provide the hard data needed to meet the required objectives and to test the hypothesis while the qualitative methods provide the in-depth explanations (Mugenda and Mugenda, 2003: 156). The study involved collection of data from three types of schools that included; County, District Boarding and District Day schools. This design was appropriate for the study since it aimed at establishing the errors and tests the hypothesis regarding the errors made in solving mathematics word problems in Gatanga Sub-County, Murang’a County.

3.2.1 Variables

The following were considered the main variables used in the study:

3.2.2 Independent Variables
The study considered errors that students make while solving word problems in mathematics. These errors included: Wrong formulation, defective algorithms, premature approximations, wrong equations, omission of work, computational errors and carelessness. Errors made by secondary school students in solving word problems may occur due to reading abilities; failure to comprehend the given word problems; wrong transformations of mathematical statements; inappropriate choice of the process to solve word problems and wrong encoding of the solution to the problems. According to KNEC (2010), candidates made more errors in questions that required higher analysis, such as in word problem solving, evaluation and application. Most of the candidates failed to interpret questions correctly and therefore made errors in transformation of the problem that resulted into incorrect answers.

3.2.3 Intervening Variables

The study considered intervening variables that would help to reduce students’ errors in solving word problems in mathematics. Allocating more time to mathematics discussion in the classroom would give the students the opportunity to enhance problem interpretation skills as well as familiarize themselves with mathematics language which is vital in their problem solving ability. When the students become involved, they are likely to conceptualize the ideas easily as they become more interested in solving problems. In situations where the school is providing enough resources such as mathematics models and textbooks, it impacts positively on students’ ability to make mathematical representation. Elaborate teaching methods on the other hand, would help the students solve word problems in mathematics successfully.
3.2.4 Dependent Variable

Students’ achievement in solving word problems in mathematics in secondary schools was considered as the dependent variable for the study. Students’ errors in solving word problems in mathematics have significantly continued to affect the students’ achievement in mathematics in national examinations.

3.3 Location of the Study

The study was located in Gatanga Sub-County in Murang’a County, Kenya. The Sub-county was curved from the former larger Thika district now Thika Sub-County. It is located to the west of the Aberdare ranges where tea growing is the main economic activity. The geographic location of the sub-county was therefore conducive for the study. The schools in the sub-county are also located near the main roads and therefore transport to the selected schools was not a problem. The Sub-County was considered for the study since 65% of the students came from within the sub-county while 20% of the students in county schools came from the county of Murang’a and only 15% of the students come from outside the County and therefore had the desired characteristics for the study. Sub-County boarding and Sub-County day schools had majority of their students drawn from within the Sub-County and therefore a suitable location for the study. The Sub-County was ranked position seven out of eight sub-counties that constitute Murang’a County in 2012 KCSE results analysis. From the sub-county 2012 KCSE mathematics analysis, it was also observed that students scored very few quality grades with majority of them (69.1%) scoring grades D and below in mathematics.
3.4 Target Population

The study targeted all the secondary schools, trained mathematics teachers and form three students in Gatanga Sub-County. A list obtained from Sub-County Director of Education in Gatanga Sub-County showed that there were thirty one public schools and one private school. However, the private school did not participate in the study due to the fact that the desired characteristics of the population would be different.

The total enrolment for the schools was 11,673 while that of the form three was 2,785. The trained mathematics teachers were 55 as summarized in Table 3.1

<table>
<thead>
<tr>
<th>Type of school</th>
<th>Number of Schools</th>
<th>Total Enrolment</th>
<th>Form 3 Enrolment</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>County schools</td>
<td>2</td>
<td>1135</td>
<td>360</td>
<td>9</td>
</tr>
<tr>
<td>Sub-county boarding schools</td>
<td>7</td>
<td>3870</td>
<td>675</td>
<td>12</td>
</tr>
<tr>
<td>District day schools</td>
<td>22</td>
<td>6668</td>
<td>1750</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>11,673</td>
<td>2,785</td>
<td>55</td>
</tr>
</tbody>
</table>

Source: DEO Gatanga Sub-County 2013

3.5 Sampling Techniques and Sample Size

This section elaborates sampling techniques and how the sample was obtained. The sample comprised of students and teachers in nine selected schools in Gatanga Sub-County in Murang’a County.
3.5.1 Sampling Techniques

Gatanga sub-county was purposively selected due to the students’ low achievement in mathematics in KCSE examinations. From the KCSE analysis of 2012, out of 2913 candidates who had sat for the mathematics examination, nine hundred or 33.5% had scored grade E which is the lowest grade in the KNEC grading system.

School type was selected by use of stratified sampling in order to have the desired representation. The advantages of this method are that you will be able to represent not only the overall population, but also key subgroups of the population (Kombo & Delno, 2002). Individual schools were put into the three strata; County, Sub-County boarding and Sub-County day schools. Each school was assigned a number that was used when picking from each strata. From County schools strata, there were only two public schools; one for boys and the other for girls and therefore, they were both selected for the study. There were seven Sub-County boarding schools where three schools representing 42.8% were selected while the Sub-County day category had twenty two schools and four schools, representing 18.2% were selected. The private school was not selected for the study due to the fact that the desired characteristics of the population would have differed with those of public schools. This selection was adequate for the purpose of the study. The selection of schools was done as follows; 2 County, 3 Sub-County Boarding and 4 Sub-County Day schools of the targeted schools in the Sub-County.

Trained Mathematics teachers were purposively selected for the purposes of this research. Stratified sampling was then used to select the teachers by proportional allocation. In this method, stratum contributes to the sample a number that is proportional to its size in population (Orodho, 2009). The Sub-County had 55 trained mathematics teachers whose selection was based on the three
categories of schools. There were nine teachers in county schools and seven were selected. From twelve teachers in sub-county boarding, six were selected while eleven were selected from thirty four teachers in sub-county day schools. A total sample of 24 teachers was therefore selected.

The study selected form three students since form four students were preparing for K.C.S.E. examinations. Form three students were able to respond to the questions in the SMT due to the fact that they had completed form one and two syllabus. Simple random sampling was used to ensure a representative sample was obtained (Gay 1992).

3.5.2 Sample Size

There were thirty one public schools in Gatanga Sub- County and nine schools were therefore selected. The nine schools represented 29.03% of all the targeted schools in the sub-county and thus, a good representation for this study. A total of 24 teachers representing 43.6% of the total number of targeted trained mathematics teachers in the sub-county were selected. In cases where there is a small population, a sample size of at least twenty percent of the population is a good representation for research (Gay, 1992). There were two thousand seven hundred and eighty five form three students in the Sub-county. A sample size of two hundred and eighty five students was randomly selected from this population representing 10.23%. According to Mugenda &Mugenda (2003) a sample size of ten percent of the total population in descriptive research is acceptable. The samples are summarized and presented in Table 3.2
Table 3.2: Sampling Table for Students, Teachers and Schools.

<table>
<thead>
<tr>
<th>Category</th>
<th>County Schools</th>
<th>Sub-County Boarding</th>
<th>Sub-County Day Schools</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Sample</td>
<td>Target</td>
<td>Sample</td>
</tr>
<tr>
<td>Schools</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Teachers</td>
<td>9</td>
<td>7</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Students</td>
<td>360</td>
<td>42</td>
<td>675</td>
<td>68</td>
</tr>
</tbody>
</table>

Source: D.E.O Gatanga Sub-County 2013

3.6 Methods of Data Collection

The study utilized both student achievement test and the teacher’s questionnaire, two of the methods of data collection as outlined in Cohen and Manion (1994). The study also used students’ interview schedule as outlined by Newman (1977). The methods used to collect the data were as follows:

a) Students Mathematics Test (SMT)

A total of two hundred and eighty five form three students in Gatanga Sub-County were required to sit for the SMT within a forty minutes lesson in all the nine schools in the study. However, seven students were absent during the time the others sat for the SMT and thus, the returns from the SMT was 97.5%. The test was done at the times agreed upon by the school authority and the researcher to avoid disruptions on the normal school time-table. From the SMT, students’ errors in solving word problems; gender differences; and sources of errors made were obtained.

b) Trained Mathematics Teachers Questionnaires (TMTQ)

A questionnaire for trained teachers (TMTQ) was filled by all the twenty four teachers in all the sampled schools in Gatanga Sub-County. The teachers’ questionnaire was administered and
collected by the researcher after some time according to the agreement reached by both the researcher and the respondents. The return of the teachers’ questionnaires was 100%. This was because the researcher gave the questionnaires to mathematics teachers and made arrangements of picking them after they were filled. This was better than postal questionnaires whose return is usually low.

c) Interview schedule

In order to establish at what point the student made errors while solving word problems, a random sample of thirty students who had sat for the SMT from all the schools under the survey were selected for interviews. This was done by use of an interview schedule developed by (Newman 1983). From the interviews, sources of errors made by the students in solving word problems in mathematics were obtained.

3.6.1. Research instruments

a) Achievement Test: This was the Students Mathematics Test (SMT). The SMT had five word problems from topics that student’s achievement in solving word problems is usually low in mathematics in the Kenya Certificate of Secondary Examinations. These topics included: trigonometry, area and volumes, algebra and linear motion for the purposes of this research. The test items were adopted from KNEC past examination papers (KNEC 2008; 2009; 2010).

b) Self-Administered Questionnaires: This was the Trained Mathematics Teachers Questionnaires (TMTQ). The questionnaire was preferred because it is the best data collecting tool of survey in an educational enquiry (Cohen and Manion, 1994). It is also more efficient and requires less time to administer (Gay, 1992). From the questionnaires, teaching experience, knowledge of errors and strategies used in class by teachers to help students overcome the errors were obtained
c) **Interview Schedule:** This was the Students Interview Schedule (SIS). It is a simple format that helps in error classification at different stages of solving word problems in mathematics. The stages according to this classification are reading, comprehension, transformation, process skills and encoding. According to Newman (1983) questions or requests are used by the researcher at each stage that are carried out in order to classify students' errors on written mathematical tasks.

### 3.7 Pilot Study

Pilot study was necessary in order to enhance clarity; appropriateness of language used and removal of any ambiguities in the questionnaires. The questionnaire for teachers contained structured items on errors made by students in solving word problems. Pilot study involved five teachers, two from one sub-county boarding and three from one sub-county day school that had been randomly selected for the purposes of piloting. The drafted test items were adapted from KNEC past examination papers and were piloted in two randomly selected schools in Gatanga Sub-County in order to refine them in terms of assessing the time allocated to students test items. Twenty form three students were selected randomly to do the test. Ten of the selected students were from the sub-county day school and the other ten from the sub-county boarding school. After marking the test, a sample of ten form three students, five from each pilot school was obtained by random sampling for the purposes of interviews. This helped in establishing the time that the interviews would require. The two schools used for piloting did not participate in the actual survey. All the necessary amendments were made on the research instruments before the actual study.

#### 3.7.1 Validity

Validity is the degree to which results obtained from the analysis of the data actually represent the phenomenon under investigation. Content validity is defined as the degree to which the sample of the test represents the content that the test is designed to measure. Construct validity on the other
hand refers to measure of degree to which data obtained from an instrument actually represent a theoretical concept (Orodho, 2009). Since the test items for the Students Mathematics Test (SMT) were adopted from KNEC past examination papers (KNEC, 2003; 2008; 2009; 2010), they were considered to have both content and constructs validity. The results of the test items from the two different pilot schools were entered into SPSS computer programme. Pearson Product moment correlation coefficient was used to compare the results and a positive correlation coefficient (r) of 0.65 was obtained indicating that the test was valid.

3.7.2 Reliability

Reliability is a measure of the degree to which a research instrument yields consistent results of the data across two or more attempts (Orodho, 2009). Since the test items in the Student’s Mathematics Test (SMT) were adapted from KNEC past examination papers (KNEC 2003; 2008; 2009; 2010) the items were considered to be reliable. Test-retest method was used to obtain reliability of teacher’s questionnaire. The questionnaires were administered to five teachers in the pilot schools. The completed questionnaires were scored and analyzed. After two weeks the same questionnaires were administered to the same teachers and again scored and analyzed. A correlation of the responses was made using Pearson Product Moment Correlation Coefficient to establish the extent to which the contents of the questionnaires were consistent in eliciting the same responses every time the instrument was administered. A correlation coefficient (r) of about 0.75 should be considered high enough to judge the reliability of the instrument (Orodho, 2009). Using SPSS computer software programme, a correlation coefficient (r) of 0.78 was obtained. This implied that the information from the teachers’ questionnaires was reliable for the purposes of this study.
3.8 Data Collection Procedures

An introductory letter from Kenyatta university graduate school was issued to enable the researcher obtain a research permit from the National Council for Science and Technology, Ministry of Higher Education. A three months research permit from the National Council for Science and Technology, Ministry of Higher Education was therefore issued with a copy to the Sub-County Director of Education, Gatanga. Permission from the D.E.O. Gatanga Sub-County was then granted through an introductory letter to all the principals of the schools that were sampled in the study. The letter gave details and purpose of the research. For the purposes of effective data collection, the researcher visited all the sampled schools in the sub-county before the actual date of the study in order to minimize the Hawthorne effect. It was also important to discuss with mathematics teachers the modalities of administering the test and also the questionnaires in order to attain optimal returns for both SMT and TMTQ.

3.8.1 Data Analysis

Data collected were analyzed both qualitatively and quantitatively. A total of two hundred and seventy eight form three students sat for the SMT, twenty four trained mathematics teachers filled the questionnaires and thirty students were interviewed. The data obtained from the SMT were both qualitative and quantitative while the data from TMTQ were qualitative. Further, data obtained from students interviewed was qualitative but was statistically organized to provide quantitative data on sources of errors in solving word problems in mathematics. The data obtained in both SMT and TMTQ were first cleaned to remove any errors before entering it into SPSS. The content was then entered into SPSS, a comprehensive computer program which was used to analyze the data and produced tables, figures and charts while a Chi-Square test was used to test hypothesis one, two and three as reported in chapter four of this study.
3.9 Logistical and Ethical Considerations

Prior to the actual study, the researcher ensured that the questionnaires were in order in terms of easy to use, to code and analyze. Further, consent of the mathematics teachers in the sampled schools was sought in order to assure them of the confidentiality of the data for both the SMT and TMTQ. It was important to assure them that the data collected would be used only for the purposes of the research and no unauthorized person would have access to it. Other considerations were that names of the respondent would not be included in SMT and TMTQ as well as no discussions with any teacher, students or individual schools on the results of the study. Data collected were stored in safe and secure place to ensure confidentiality of the results.
CHAPTER FOUR

DATA INTERPRETATIONS, REPORTS AND DISCUSSION OF RESULTS

4.1 Introduction

The purpose of this study was to analyze and establish the errors made by secondary school students that influence achievement in solving word problems in mathematics in Gatanga Sub-County in Murang’a County. The results of the study are presented as per the following research objectives and hypotheses:

(i) To establish the errors made by students in solving word problems in mathematics

(ii) To investigate the sources of errors made in solving word problems in mathematics

(iii) To identify gender differences in the errors made by students in solving word problems in mathematics

(iv) To determine the strategies used to overcome the errors made in solving word problems in mathematics.

The following hypotheses were considered for the study:

i) \( H_01 \). There is no significant relationship between errors made by students and type of school they attend in solving word problems in mathematics.

ii) \( H_02 \). There is no significant relationship between the errors made by students and their sources in solving word problems in mathematics.

iii) \( H_03 \). There is no significant relationship between errors made and gender of student in solving word problems in mathematics.

Both qualitative and quantitative methods were used for the study. Qualitative analysis considered the inferences that were made from the opinion of both the students and teachers while quantitative
analysis considered the errors made by the students and testing of hypotheses. This analysis was presented in narrative form and where possible in tabular or graphical forms. Explanation was given after each table or figure based on descriptive and inferential statistics. This chapter presents in details the results and discussion of the results from the SMT, TMTQ and students interview schedule using descriptive and inferential statistics.

4.2. Preliminary Data

4.2.1. Response Rate

During the study, a total of two hundred and seventy eight students of form three in Gatanga sub-county responded to the SMT. The students in the survey had been randomly selected from the three categories of secondary schools in the District that included; County, District boarding and District day schools. The response rate is summarized and presented in Figure 4.1

Figure 4.1: Response Rate
From Figure 4.1, it can be shown that 62.9% of the respondents were from district day schools, 21.9% from district boarding schools while 15.2% were from district day schools. The sample had more students from district day schools due to the fact that most of the schools in the sub-county falls in this category. The sample gave the diversity required in terms of school types that enabled the researcher capture the students’ errors in solving word problems in mathematics.

4.2.2 Students interest in Mathematics

Students under the survey were requested to state whether they liked or disliked mathematics. Their responses are summarized and presented in Table 4.1

**Table 4.1: Students interest in Mathematics**

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>229</td>
<td>82.4</td>
<td>82.4</td>
</tr>
<tr>
<td>No</td>
<td>49</td>
<td>17.6</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>278</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

From table 4.1, it can be shown that 82.4% of the respondents said that they liked mathematics while 17.6% of the respondents did not like mathematics. Students’ like or dislike of mathematics would affect the way they solve word problems. Motivation is the drive that makes someone to desire to carry out a particular action. If students are highly motivated in studying mathematics, they would definitely do well in solving word problems but if they were de-motivated then they would make more errors while solving word problems in mathematics. Therefore efforts spent fostering positive attitudes to learning mathematics is likely to make a significant reduction to students errors in solving word problems in mathematics. Teachers should adopt approaches to teaching mathematics that promote engagement and interactivity. Mathematics teachers should also
make mathematics learning a more fulfilling experience that would promote positive attitudes in students. Therefore teachers need to work on the students’ motivation in learning mathematics so as to move it to a higher level.

### 4.2.3 Availability of Teaching and learning Resources

Teachers were requested to give their views on whether mathematics textbooks were adequate in secondary schools in Gatanga sub-county. Teachers responses are summarized and presented in Figure 4.2

**Figure 4.2: Adequacy of Mathematics Text books**

![Bar chart showing student-textbook ratios](image)

From Figure 4.2, it could be shown that 50% of the respondents gave student-text book ratio of 1:2, 20.3% a ratio of 1:3, 16.7% a ratio of 1:1 and 12.5% a ratio of 1:5. This showed that the ratio of 1:
1 had not been achieved in the sub-county. A ratio of 1:5 was worrying as this suggested that most of the students could not do independent work. Availability of textbooks would eventually affect the way students solve word problems in mathematics. Students’ textbooks as a resource is used to support, consolidate or extend students mathematical learning through linking selected aspects to the unit of work planned by the teacher. They also allow the teachers to make decisions on the appropriateness of the material, which groups of students may benefit from the set task. Students also plan for independent work that focuses on understanding. In these ways textbook activities, in particular, are used as a springboard into further problem-solving tasks with the benefit of students making stronger connections in mathematical activities leading to successful word problem solving. Availability of resources such as mathematics text books could have contributed to students’ errors. A ratio of one textbook to five students in 12.5% of the schools indicated that students could not do independent work.

4.2.4 Syllabus Coverage

Teachers were requested to give their views on whether the mathematics syllabus was covered within the year. Their responses are summarized and presented in Table 4.2

**Table 4.2: Time when syllabus is covered within the year**

<table>
<thead>
<tr>
<th>Time</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term 2</td>
<td>5</td>
<td>20.8</td>
<td>20.8</td>
</tr>
<tr>
<td>Term 3</td>
<td>15</td>
<td>62.5</td>
<td>83.3</td>
</tr>
<tr>
<td>Not possible</td>
<td>4</td>
<td>16.7</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

From Table 4.2, it can be shown that 62.5% of the respondents said that they completed the syllabus in term 3, 20.8% in term 2 while 16.7% said it was impossible to complete the syllabus.
Completing the syllabus on time would allow the students enough time to practice what they have learnt in class. This would enhance their skills in solving word problems. In some schools, syllabus was not covered on time. This would impact negatively on the student’s ability to solve word problems due to the fact that they would not have enough time to practice and gain skills in solving word problems. Report by KNEC (2010) concluded that candidates failed to arrive at the correct solutions because of inadequate coverage of the syllabus content. It is important for mathematics teachers to complete the syllabus on time. This would give the students enough time to practice the concepts learnt and therefore do well in solving word problems in mathematics.

4.2.5 Time Spent in Discussing Mathematics Problems

Students were requested to indicate time they spent in discussing mathematics during the lesson. The student’s responses are summarized and presented in Figure 4.3

Figure 4.3: Time spent in discussing mathematics during the lesson
Figure 4.3 shows that 57.9% of the respondents said that 1–5 minutes was given for discussing mathematics problems during the lesson, 21.9% of the respondents said 1–10 minutes was given, 15.1% said less than a minute was given while 5% of the respondents said that no time was given to discussions during the lesson. The study showed that limited time was given to discussions in class and in some cases no time was given. Discussion is considered as a multidimensional teaching and learning tool that gives unique opportunities for students to engage in classroom discourse about learning to create solutions to shared problems and even honing their own positions towards contentious problems (Hess, 2009). As a multifaceted invitational classroom practice, discussion also presents possibilities for classroom teachers to engage learners in academic content while developing their discussion skills and preparing solutions to common problems. Mathematics teachers should give students more responsibility for their own learning by use of discussion groups, a powerful tool in mathematics classrooms that helps the students to understand concepts easily. Lack of students understanding of concepts usually results into errors. This would also help the students to examine multiple representations interactively and examine meanings of representations and their relationships. Furthermore, they can assess their work and discover errors made in solving word problems on their own.

4.2.6: Teaching Experience

Teachers were requested to give their teaching experience in mathematics. Their responses are summarized and presented in Table 4.3
Table 4.3: Teaching Experience

<table>
<thead>
<tr>
<th>Period (years)</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>1</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>11-20</td>
<td>17</td>
<td>70.8</td>
<td>75.0</td>
</tr>
<tr>
<td>21-30</td>
<td>6</td>
<td>25.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

From table 4.3, it can be shown that 70.8% of the respondents had teaching experience of eleven to twenty years, 25% had teaching experience of twenty one to thirty one years while 4.2% had teaching experience of one to ten years. Most of the respondents had a good experience in teaching of mathematics in the sub-county. Effective mathematics teachers have a sound grasp of relevant content and can critically evaluate students’ processes, solutions, and understanding in solving word problems. They also give appropriate and helpful feedback in relation to students work. Teachers’ organization of the classroom instruction is very much dependent on what they know and believe about mathematics and on what they understand about mathematics teaching and learning. In order to teach mathematical content effectively, teachers need a grounded understanding of their students in learning of mathematics so as to be aware of likely conceptions and misconceptions. They use this awareness to make instructional decisions that strengthen conceptual understanding in solving word problems in mathematics. In their extensive review of research on problem solving approaches of novices and experts, The National Research Council (1985) concluded that the success of the word problem solving process hinges on the problem solvers’ representation of the problem as guided by their teachers. The school’s primary function is to provide resources for teaching and learning. In situations where the school is not providing enough resources such as adequate teaching staff, mathematics textbooks and enough time, it impacts negatively on students’
ability to read mathematics which may lead to errors. Teacher quality remains a critical school resource in terms of student achievement in mathematics in secondary schools.

4.3 Errors Made in Solving Word Problems in Mathematics

The study sought to analyze and establish the errors made by secondary school students in solving mathematics word problems in Gatanga Sub-County in Murang’a County. Five word problems were administered to the students through the SMT.

4.3.1 Students’ Errors in Solving Word Problems

Students work was marked and the errors made from each given problem (one, two, three, four and five) were analyzed and established as follows:

4.3.1.1 Problem One

A man standing 20 meters away from the foot of a vertical pole observes the top of the pole at an angle of elevation of $30^\circ$. He begins to walk along a straight line on the level ground towards the pole. Calculate how far he walked before the angle of elevation of the top of the pole becomes $80^\circ$. Give your answer to two significant figures.

The errors made by students in problem one are summarized and presented in Table 4.4

<table>
<thead>
<tr>
<th>Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational errors</td>
<td>38</td>
<td>13.7</td>
<td>13.7</td>
</tr>
<tr>
<td>Carelessness</td>
<td>15</td>
<td>5.4</td>
<td>19.1</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>25</td>
<td>9.0</td>
<td>28.1</td>
</tr>
<tr>
<td>Omission of work</td>
<td>30</td>
<td>10.8</td>
<td>38.9</td>
</tr>
<tr>
<td>Premature approximations</td>
<td>101</td>
<td>36.3</td>
<td>75.2</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>6</td>
<td>2.2</td>
<td>77.4</td>
</tr>
<tr>
<td>Wrong formula</td>
<td>11</td>
<td>4.0</td>
<td>81.4</td>
</tr>
<tr>
<td>Wrong equations</td>
<td>12</td>
<td>4.3</td>
<td>85.7</td>
</tr>
<tr>
<td>Not attempted</td>
<td>22</td>
<td>7.9</td>
<td>93.6</td>
</tr>
<tr>
<td>No errors</td>
<td>18</td>
<td>6.4</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>278</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

49
From Table 4.4, it can be shown that, 36.3% of the respondents made premature approximation error in the final answer, 13.7% made computational errors, 10.8% had omission of work, 9% defective algorithm, 7.9% did not attempt the question, 6.4% had no errors in their work, 5.4 carelessness, 4.3% wrong equations, 4% used wrong formulae and 2.2% applied wrong facts. This question tested the students’ ability to calculate distance using trigonometric ratios. It was observed that 36.3% of the respondents failed to give the answer in two significant figures as required while 7.9% did not attempt the question at all, meaning that they did not understand it. From the SMT, it was observed that students had not mastered trigonometric ratios as well as angles of elevation and depression. This made them use wrong facts in their work that led to computational errors due to rounding off and truncations. This was in line with studies done in Singapore by (Lim, 2000) that had concluded that students’ carelessness, as well as inabilities to understand what they read, to plan and to choose suitable mathematical operations, is among the factors that prevent them from solving word problems correctly. According to KNEC (2007), candidates were unable to solve word problems related to trigonometry and advised teachers of mathematics to guide their students in solving word problems by use of real life experiences so as to help them understand the topic.

4.3.1.2 Problem Two

Two metal spheres of diameter 2.3 cm and 3.86cm are melted down and recast as one sphere. Determine the diameter of the new sphere if 5% of the metal is lost during recasting.

The errors made by students in problem two are summarized and presented in Table 4.5
Table 4.5: Errors Made by Students in Problem Two

<table>
<thead>
<tr>
<th>Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational errors</td>
<td>11</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Carelessness</td>
<td>9</td>
<td>3.2</td>
<td>7.2</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>20</td>
<td>7.2</td>
<td>14.4</td>
</tr>
<tr>
<td>Omission of work</td>
<td>25</td>
<td>9.0</td>
<td>23.4</td>
</tr>
<tr>
<td>Premature approximations</td>
<td>37</td>
<td>13.3</td>
<td>36.7</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>33</td>
<td>11.9</td>
<td>48.6</td>
</tr>
<tr>
<td>Wrong formula</td>
<td>116</td>
<td>41.7</td>
<td>90.3</td>
</tr>
<tr>
<td>Wrong equations</td>
<td>0</td>
<td>0.0</td>
<td>90.3</td>
</tr>
<tr>
<td>Not attempted</td>
<td>0</td>
<td>0.0</td>
<td>90.3</td>
</tr>
<tr>
<td>No errors</td>
<td>27</td>
<td>9.7</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>278</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.5, it can be shown that 41.7% of the respondents used wrong formula, 13.3% made premature approximations errors, 11.9% used wrong facts, 9.7% had no errors, 9% had omission of work errors, 7.2% had defective algorithm, 4% computational errors, 3.2% had careless errors made in their work and no student had wrong equation nor did not attempt. This question tested the students’ ability to recall formula for calculating the volume of a sphere. From their work, it was evident that over 40% of the respondents did not distinguish between spheres and cylinders and therefore used the wrong formula. They also failed to understand that once the metals were melted down, they resulted into both volume and area. A study by Gitonga (2010) had concluded that most secondary school students struggle to cope with mathematics word problems that are presented in English Language. Mathematics teachers should therefore put more emphasis on mathematical language and applications of mathematical formulae in real life situations.

**4.3.1.3 Problem Three**

A certain number of people agreed to contribute to buy novels worth sh1200. Five of them pulled out while those who remained had to contribute an extra sh.10 each. Their contributions bought novels worth sh.200 more than they had originally expected. If the original number of people was $x$, how much did each contribute?
The errors made by students in problem three are summarized and presented in Table 4.6

**Table 4.6: Errors made by Students in Solving Problem Three**

<table>
<thead>
<tr>
<th>Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational errors</td>
<td>10</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Carelessness</td>
<td>19</td>
<td>6.8</td>
<td>10.4</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>58</td>
<td>20.9</td>
<td>31.3</td>
</tr>
<tr>
<td>Omission of work</td>
<td>13</td>
<td>4.6</td>
<td>35.9</td>
</tr>
<tr>
<td>Premature approximations</td>
<td>0</td>
<td>0</td>
<td>35.9</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>30</td>
<td>10.8</td>
<td>46.7</td>
</tr>
<tr>
<td>Wrong formula</td>
<td>0</td>
<td>0</td>
<td>46.7</td>
</tr>
<tr>
<td>Wrong equations</td>
<td>103</td>
<td>37.1</td>
<td>83.8</td>
</tr>
<tr>
<td>Not attempted</td>
<td>17</td>
<td>6.1</td>
<td>89.9</td>
</tr>
<tr>
<td>No errors</td>
<td>28</td>
<td>10.1</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>278</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.6, it can be shown that 37.1% of the respondents had wrong equations, 20.9% had defective algorithm, 10.8% used wrong facts, 10.1% had no errors made in their work, 6.8% made careless mistakes, 6.1% had not attempted, 4.6% had omission of work, 3.6% had computational errors and neither had wrong facts nor premature approximations. It was evident that thirty seven percent of the students were unable to form a quadratic equation that was required to solve this problem. They were unable to put the given word statement into mathematics relation and made errors in the initial stage of solving the problem. The primary source of errors for students in solving algebraic word problems is translating the story into appropriate algebraic expressions (Bishop et al, 2008). This involves a triple process: assigning variables, noting constants, and representing relationships among variables. Among these processes, relational aspects of the word problem are particularly difficult to translate into symbols for most of the students. It is therefore advisable to the mathematics teachers in secondary schools to pay much attention to word problems.
involving algebra. This would require more emphasis on application of mathematical concepts in everyday life.

4.3.1.4 Problem Four

Two passengers train A and B which are 240 meters a part are travelling at 164 km/h and 88 km/h respectively as they approach one another on a straight railway line. Train A is 150 meters long and train B is 100 meters long. Determine the time in seconds that elapses before the two trains completely pass each other.

The errors made by students in problem four are summarized and presented in Table 4.7

<table>
<thead>
<tr>
<th>Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational errors</td>
<td>69</td>
<td>24.8</td>
<td>24.8</td>
</tr>
<tr>
<td>Carelessness</td>
<td>36</td>
<td>12.9</td>
<td>37.7</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>61</td>
<td>21.9</td>
<td>59.6</td>
</tr>
<tr>
<td>Omission of work</td>
<td>16</td>
<td>5.8</td>
<td>65.4</td>
</tr>
<tr>
<td>Premature approximations</td>
<td>9</td>
<td>3.2</td>
<td>68.6</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>6</td>
<td>2.2</td>
<td>70.8</td>
</tr>
<tr>
<td>Wrong formula</td>
<td>11</td>
<td>4.0</td>
<td>74.8</td>
</tr>
<tr>
<td>Wrong equations</td>
<td>16</td>
<td>5.8</td>
<td>80.6</td>
</tr>
<tr>
<td>Not attempted</td>
<td>23</td>
<td>8.3</td>
<td>88.9</td>
</tr>
<tr>
<td>No errors</td>
<td>31</td>
<td>11.1</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>278</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.7, it can be shown that 24.8% of the respondents made computational errors, 21.9% had defective algorithm, 12.9% made careless mistakes, 11.1% had no errors in their work, 8.3% did not attempt the question, 5.8% had omission of work as well as wrong equations, 4% had wrong formula, 3.2% had premature approximations and 2.2% had wrong facts. It was evident that over eighty percent of the students could not compute the distance and the relativity in speed of approaching bodies in motion and thus, made numerous errors in solving this problem. A significant number of students translating to eight percent did not attempt this question, suggesting that they did not understand. Those who understood the question also failed to convert units at some point and therefore got incorrect solutions. The KNEC (2010) examination report had concluded that candidates do not pay much attention to the strategies involved in answering the
question and do not read the terms used in the word problems very closely and therefore make errors in solving such problems. They made more errors especially in questions that require higher analysis, such as word problem solving, evaluation and application. Most candidates fail to interpret word problems questions correctly, thus making numerous errors and hence answer the questions incorrectly. Teachers of mathematics need to regularly read the reports from the KNEC to enable them put more emphasis on the areas that are poorly responded to by the students in word problem solving in national examinations.

4.3.1.5 Problem Five

A bus takes 195 minutes to travel a distance of (2x+30) km at average speed of (x-20) km/calculate the actual distance traveled by the bus.
The errors made by students in problem five are summarized and presented in Table 4.8

Table 4.8: Errors made by students in problem five

<table>
<thead>
<tr>
<th>Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational errors</td>
<td>66</td>
<td>23.7</td>
<td>23.7</td>
</tr>
<tr>
<td>Carelessness</td>
<td>7</td>
<td>2.5</td>
<td>26.2</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>57</td>
<td>20.5</td>
<td>46.7</td>
</tr>
<tr>
<td>Omission of work</td>
<td>30</td>
<td>10.8</td>
<td>57.5</td>
</tr>
<tr>
<td>Premature approximations</td>
<td>0</td>
<td>0</td>
<td>57.5</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>12</td>
<td>4.4</td>
<td>61.9</td>
</tr>
<tr>
<td>Wrong formula</td>
<td>15</td>
<td>5.4</td>
<td>67.3</td>
</tr>
<tr>
<td>Wrong equations</td>
<td>27</td>
<td>9.7</td>
<td>77</td>
</tr>
<tr>
<td>Not attempted</td>
<td>35</td>
<td>12.6</td>
<td>89.6</td>
</tr>
<tr>
<td>No errors</td>
<td>29</td>
<td>10.4</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>278</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.8, it can be shown that, 23.7% had computational errors, 20.5% of the respondents had defective algorithm, 12.6% did not attempt the question, 10.8% had omission of work and 10.4% had no errors in their work, 9.7% had wrong equations, 5.4% had wrong formula, 4.4% had wrong facts, 2.5% had careless errors and no student had premature approximations error. This question tested the students’ ability to calculate distance by relating speed and time. It was observed that over twenty percent of the respondents could not relate distance, speed and time and
ended up with a defective algorithm. Computational errors resulted from the respondent’s failure to apply same units of measurements for the time in their calculations. This could be attributed to students having problems with comprehension of the problem. These results were in line with those of Mahmud (2003) in Malaysia who found out that the main source of secondary school students’ errors in solving mathematical problems is their inability to understand the problem. She found out that almost ninety eight per cent of students admitted to having difficulties in comprehending what a question required. Mathematics teachers should therefore guide the students in reading the question so as to understand its requirements.

4.3.2 Summary of Analyzed Errors

The errors from all the five problems were analyzed and the summary presented in Table 4.9

Table 4.9: Summary of Analyzed Errors

<table>
<thead>
<tr>
<th>Errors</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>Four</th>
<th>Five</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational errors</td>
<td>38</td>
<td>11</td>
<td>10</td>
<td>69</td>
<td>66</td>
<td>194</td>
<td>14</td>
</tr>
<tr>
<td>Carelessness</td>
<td>15</td>
<td>9</td>
<td>19</td>
<td>36</td>
<td>7</td>
<td>86</td>
<td>6.2</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>25</td>
<td>20</td>
<td>58</td>
<td>61</td>
<td>57</td>
<td>221</td>
<td>15.9</td>
</tr>
<tr>
<td>Omission of work</td>
<td>30</td>
<td>25</td>
<td>13</td>
<td>16</td>
<td>30</td>
<td>114</td>
<td>8.2</td>
</tr>
<tr>
<td>Premature approximations</td>
<td>101</td>
<td>37</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>147</td>
<td>10.6</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>6</td>
<td>33</td>
<td>30</td>
<td>6</td>
<td>12</td>
<td>87</td>
<td>6.3</td>
</tr>
<tr>
<td>Wrong formula</td>
<td>11</td>
<td>116</td>
<td>0</td>
<td>11</td>
<td>15</td>
<td>153</td>
<td>11</td>
</tr>
<tr>
<td>Wrong equations</td>
<td>12</td>
<td>0</td>
<td>103</td>
<td>16</td>
<td>27</td>
<td>158</td>
<td>11.3</td>
</tr>
<tr>
<td>Not attempted</td>
<td>22</td>
<td>0</td>
<td>17</td>
<td>23</td>
<td>35</td>
<td>97</td>
<td>7</td>
</tr>
<tr>
<td>No errors</td>
<td>18</td>
<td>27</td>
<td>28</td>
<td>31</td>
<td>29</td>
<td>133</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>278</td>
<td>278</td>
<td>278</td>
<td>278</td>
<td>278</td>
<td>1390</td>
<td>100</td>
</tr>
</tbody>
</table>

From table 4.9, it can be shown that defective algorithm had 15.9% of the errors made; computational errors had 14%, wrong equations had 11.3%, wrong formula 11%, premature approximations 10.6%, no errors 9.5%, omission of work 8.2%, not attempted 7%, wrong facts 6.3%, and carelessness 6.2%. Defective algorithm errors had the highest frequency of occurrence
(15.9%). This could be associated with lack of prerequisite skills as was noted in the students’ work. It was observed that fourteen percent of the students made computational errors due to generalizations as was evident in their work, when they failed to distinguish between a sphere and a cylinder. The fact that ten percent of the students made premature approximations errors suggested that they had not attained the concept of place value. The study compared well with a study carried out by Ogolla (1997), that investigate generic errors committed by secondary students when dealing with problems involving algebra in Kisii District in Kenya. The study concluded that students’ had difficulties in remembering facts and algorithms meaningfully, they lacked computational skills and mastery and most of them reconstructed knowledge wrongly.

Another study conducted by Clement (1982) to investigate factors responsible for students' poor achievement in mathematics word problems concluded that students’ misconception of mathematical statements resorted into errors. In the present study, more than eight percent of students did not attempt the questions suggesting that they did not understand how to answer them. They did not read the terms used in the given word problems very closely as observed in the SMT question one, which required the solution to be given in two significant figures. From the results of the study, it was observed that computational errors, premature approximations, wrong formulation, wrong facts, carelessness, defective algorithm, omission of work and wrong equations errors were prevalent in solving word problems in mathematics. These errors could be attributed to students’ inability to give adequate interpretation to the word expressions, the language of the problems as well as failure to identify the correct mathematical operations that was required for a particular transformation of a mathematical statement into its equivalent algebraic equation. A study by Lim (2000) had concluded that student inabilities to understand what they read, to plan
and to choose suitable mathematical operations, is among the factors that prevent them from solving word problems correctly.

It was also observed that students made most errors in questions that required higher analysis, such as problem three in SMT which tested evaluation and application. Studies by Ashlock (1994) showed that students made all kinds of computational errors in solving mathematical problems which were not necessarily the result of carelessness or not knowing how to proceed, but could be caused by applying the “failure strategies”. Mathematics teachers should adopt teaching methods that would enable the students pay more attention to word problem solving in secondary schools. For mathematics teachers to assist their students develop word problem solving ability, it is essential that they are aware of their errors first.

4.3.3: Teachers’ Identified Errors Students Make in Solving Word Problems

Teachers were requested to list some of the errors made by secondary students while solving word problems in mathematics. Their responses are summarized and presented in Table 4.10

Table 4.10: Teachers’ Identified Errors

<table>
<thead>
<tr>
<th>Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propagation errors</td>
<td>8</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Round off errors</td>
<td>6</td>
<td>25.0</td>
<td>58.3</td>
</tr>
<tr>
<td>Application errors</td>
<td>9</td>
<td>37.5</td>
<td>95.8</td>
</tr>
<tr>
<td>Careless errors</td>
<td>1</td>
<td>4.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.10, it can be shown that 37.5% of the respondents said that students made application errors, 33.3% propagation errors, 25% rounding off errors and 4.2% careless errors in solving word problems. The National Research Council (1985) had observed that recognition of important features within the problem is directly related to the completeness and coherence of each problem.
solvers’ knowledge organization. Teachers’ prior knowledge of the students’ errors in solving word problems would help them to design teaching strategies that would help the students to solve word problems correctly.

4.3.4: Frequency of student’s errors in solving word problems

The teachers were requested to give their views on frequency of students’ errors in solving word problems in mathematics. The teacher’s views are summarized and presented in Figure 4.4

Figure 4.4: Frequency of students’ errors in solving word problems

From Figure 4.4, it can be shown that a significant number of respondents (79.2%) agreed that students often made errors while solving word problems while 20.8% made errors very often. When a student does not possess the necessary prerequisite skills, facts, and concepts to solve a problem, he or she will not be able to solve the problem correctly. For example, if a student does not know how to combine like-terms, he or she may face difficulty solving multistep equations involving combining like-terms. A study in Singapore (Lim, 2000) concluded that students’
weakness in solving word problems was that they made avoidable preliminary mistakes. Students’
carelessness, as well as inabilities to understand what they read, to plan and to choose suitable
mathematical operations, is among the factors that prevent them from solving word problems
correctly. Mathematics teachers should develop appropriate programs that would help the students
understand word problems better.

4.3.5 Types of Errors Made Across Types of Schools

The study sought to identify the errors made by students from county, district boarding and district
day schools. Students’ errors from the three categories of schools in Gatanga sub-county are
summarized and presented in Table 4.11

Table 4.11: Types of Errors across Types of Schools

<table>
<thead>
<tr>
<th>Types of error</th>
<th>Types of School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>County</td>
<td>District boarding</td>
</tr>
<tr>
<td>Wrong equation</td>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Carelessness</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>No errors</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42</strong></td>
<td><strong>61</strong></td>
</tr>
</tbody>
</table>

From Table 4.11, it can be shown that out of 103 students with wrong equation error, 10(9.7%) were in county, 38(36.9%) in district boarding and 55(53.4%) in district day schools. Those with
defective algorithm errors, 6(8.5%) were in county, 11(15.5%) in district boarding and 54(76%) in
district day schools. In carelessness error, 5(17.2%) were in county, 2(6.9%) in district boarding
and 22(75.9%) in district day schools. In wrong facts error, 4(8.5%) were in county, 7(14.9%) in district boarding and 36(76.6%) in district day schools. Those who had no errors in their work, 17(60.7%) were in county, 3(10.7%) in district boarding and 8(28.6%) in district day schools.

Hypothesis one (H₀₁) of the study stated that ‘‘There was no significant relationship between the errors made by students and types of schools in solving word problems in mathematics’’. In order to test this hypothesis, data presented in the Table 4.11 above was used. A chi-square test was carried out on the data and the results are summarized and presented in Table 4.12

**Table 4.12: Chi-square test statistics for types of errors across types of schools**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>72.409</td>
<td>8</td>
<td>.001</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>57.707</td>
<td>8</td>
<td>.001</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>5.627</td>
<td>1</td>
<td>.018</td>
</tr>
<tr>
<td>No of Valid Cases</td>
<td>278</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \chi^2 (8, N=278) = 72.409, \ p<0.001 \]

From Table 4.12, it can be shown that the relationship between types of errors made and school attended was significant, \( \chi^2 (8, N=278) = 72.409, \ p<0.001 \). The value 72.41 was greater than the critical value at 0.001 significant level and therefore the null hypothesis three (H₀₁) was rejected. Students from County schools were less likely to make errors than were those from District boarding and District day schools. In her study, Ogolla (1997) found out that students in single sex schools had made fewer generic errors as compared with mixed schools. The errors made by students from County, District boarding and district day schools in solving word problems in
mathematics showed great variations. Mathematics teachers in day secondary schools should work towards improving the attitude of the students in learning mathematics.

4.4 Sources of Errors in Solving Word Problems.

The study sought to investigate sources of errors made by secondary school students in solving word problems in mathematics. The following word problem was administered to the mathematics teachers so as to point out the sources of students’ errors in solving word problems;

Two passenger trains A and B which are 240m apart are traveling at 164 Km/h and 88 km/h respectively as they approach one another on a straight railway line. Train A is 150m long and train B is 100m long. Determine the time in seconds that elapses before the two trains completely pass each other.

The trained mathematics teachers’ responses on sources of errors made by students while solving such a problem are summarized and presented in Table 4.13

Table 4.13: Teacher’s views on sources of errors

<table>
<thead>
<tr>
<th>Sources of Errors</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to distinguish between units of measurements</td>
<td>17</td>
<td>70.8</td>
<td>70.8</td>
</tr>
<tr>
<td>Applying facts wrongly: Relative speed</td>
<td>7</td>
<td>29.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.13, it can be shown that (70.8%) of the respondents agreed that students do not distinguish between units of measurements while 29.2% said that students apply facts wrongly such as the relative speed. This was evident in students work while solving problem four as earlier reported in section 4.3.1. The students should draw a sketch to represent the problem before solving it. This would assist them to interpret the problem and therefore arrive at correct solution.
Interpretation of the problems is therefore an important aspect in solving word problems in mathematics as Askew (2003; 85) observes;

... if the essence of mathematics is the setting up of and working with mathematical models, and if we treat word problems in such a way, then they might have a role to play in helping children better understand the process of mathematizing. And with the increasing mathematizing of the world (from national test scores to pension prospects), informed and critical citizens need to be aware that mathematizing is not something that arises from the world, but something that is done to the world. In a small way, working on word problems might help begin to develop this awareness.

The above quotation suggests that students would gain from problem interpretation when real life situations are used as examples. Pointing out at students errors in solving word problems in mathematics in Gatanga Sub-County was a step towards developing awareness in mathematics. Mathematics teachers should make use of resources such as models to represent situations in real life when introducing topics in mathematics.

4.4.1 Relationship between errors and their sources

During the interviews, thirty students were requested by the researcher to respond to questions using problem three (4.2.1). Questions followed (Newman, 1983) format of errors analysis on reading, comprehension, transformation, process skills, and encoding. The students responses are summarized and presented in Table 4.14
Table 4.14: Types of errors and their Sources

<table>
<thead>
<tr>
<th>Type of error</th>
<th>Sources of Error</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading</td>
<td>Comprehension</td>
</tr>
<tr>
<td>Wrong equation</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Carelessness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wrong fact</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>13</td>
</tr>
</tbody>
</table>

From Table 4.14, it can be shown that 3 students (10%) made errors in the reading, 13 students (43.3%) made errors in comprehension stage, 8 students (26.7%) made errors in transformation stage, 1 student (3.3%) made errors in process skill stage and 5 students (16.7%) made errors in encoding. Most errors occurred in the comprehension of the problem while few errors occurred in the processing stage of solving word problems in mathematics.

Hypothesis two (H₀₂) of the study stated that “There was no significant relationship between types of errors made by students and the sources of errors in solving word problems in mathematics”. A chi-square test of independence was conducted using the data in Table 4.14 above to find out whether there was relationship between types of errors made by students and the various sources of errors. The result are summarized and presented in Table 4.15.
From Table 4.15, it can be shown that the relationship between these two variables was significant, \( \chi^2 (12, \text{N}=30) = 22.877, p<0.029 \). The value 22.88 was greater than the critical value at significance level of 0.029 and therefore the null hypothesis (H_0) was rejected. This implied that students making wrong equation errors were more likely to have problems with comprehension, while those making defective algorithm and wrong fact errors were more likely to have problems with comprehension and transformation. The results also showed that students experiencing problems in encoding were more likely to make errors related to wrong facts and carelessness. This was in line with studies conducted in Holland by Anghileri (2001) which found out that students made most errors in comprehension and transformation stages but made few errors in the process skill stage of solving word problems in mathematics. Mathematics teachers should therefore guide students in reading the questions so as to help them understand. This would improve the students’ ability in comprehending the questions resulting to improved achievement in word problems in mathematics.

### 4.5 Relationship between Errors and Gender of Student

The study sought to identify gender differences in the errors made when solving mathematics word problems. The students’ errors are summarized and presented in Table 4.16
Table 4.16: Types of Errors Made Across the Gender of Students

<table>
<thead>
<tr>
<th>Types of Errors</th>
<th>Gender of Students</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy</td>
<td>%</td>
</tr>
<tr>
<td>Wrong equation</td>
<td>45</td>
<td>43.7</td>
</tr>
<tr>
<td>Defective algorithm</td>
<td>38</td>
<td>53.5</td>
</tr>
<tr>
<td>Carelessness</td>
<td>13</td>
<td>44.8</td>
</tr>
<tr>
<td>Wrong facts</td>
<td>20</td>
<td>42.6</td>
</tr>
<tr>
<td>No error</td>
<td>16</td>
<td>57.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>132</td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.16, it can be shown that out of all the students who had made wrong equation error, 43.7% were boys and 56.3% were girls. In defective algorithm error, 53.5% were boys while 46.5% were girls. In carelessness error, 44.8% were boys and 55.2% were girls. In wrong facts error, 42.6% were boys and 57.4% were girls while 57.1% boys and 42.9% girls had no errors.

Hypothesis three (H03) of the study stated that ‘There was no significant relationship between types of errors and gender of student in solving word problems in mathematics’. In order to test this hypothesis, data presented in the Table 4.16 above was used. A chi-square test was carried out on the data and the results are summarized and presented in Table 4.17

Table 4.17: Chi-square test statistics for types of errors across gender

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>3.220</td>
<td>4</td>
<td>.522</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>3.223</td>
<td>4</td>
<td>.521</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.328</td>
<td>1</td>
<td>.567</td>
</tr>
<tr>
<td>No of Valid Cases</td>
<td>278</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

65
From Table 4.17, it could be shown that there was no significant relationship between gender and types of errors made. $\chi^2 (4, N=278) = 3.22, p<0.522$. The value 3.22 was less than the critical value at 0.5 significance level and therefore hypothesis three ($H_03$) was accepted. This showed that male and female students did not differ in the types of errors made in solving word problems in mathematics. Ogolla (1997) concluded that girls had better verbal ability in mathematics as compared to boys but there was no gender differences in generic errors made in solving given mathematical tasks. The results also compared well with the results of the study carried out in USA by Marshall and Smith (1987) which had explored the gender differences of third grade and sixth grade students on various tasks, including computations, word problems, and non-traditional problems. They concluded that, third grade female students performed better than male students for both computational tasks and non-traditional problems, but there was no significant gender difference on word problems. Mathematics teachers should be aware of the students variation in terms of errors made and develop programmes that would address any disparity in solving word problems in mathematics.

**4.6 Strategies Used to Overcome Errors in Solving Word Problems in Mathematics**

Teachers were requested to give their views on ways to overcome errors in solving word problems in mathematics. Their responses are summarized and presented in Table 4.18
Table 4.18: strategies used to overcome errors in solving word problems in mathematics

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample marking scripts with the learners</td>
<td>9</td>
<td>37.5</td>
<td>37.5</td>
</tr>
<tr>
<td>Encouraging preview of work before submission</td>
<td>4</td>
<td>16.7</td>
<td>54.2</td>
</tr>
<tr>
<td>Guiding learners to estimate</td>
<td>5</td>
<td>20.8</td>
<td>75.0</td>
</tr>
<tr>
<td>Remedial lessons</td>
<td>6</td>
<td>25.0</td>
<td><strong>100.0</strong></td>
</tr>
<tr>
<td>Total</td>
<td><strong>24</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.18, it could be shown that 37.5% of the respondents said that sample marking the examination scripts with the learners would help to overcome the errors, 16.7% insisted on guiding the learners through estimations, 20.8% agreed that encouraging students to preview their work before submitting would overcome the errors while 25% agreed that remedial lessons would help to overcome errors in solving word problems in mathematics. Students usually have difficulties in transforming the given statement into mathematical language necessary to be able to solve a given problem. According to Salleh (2004), students who can successfully solve a word problem in mathematics possess good reading skills, are able to compare and contrast, have the ability to identify important aspects of the problem, are able to estimate, create analogies and are flexible in attempting various strategies. These can be developed in students by imparting reading and comprehension skills that are required to interpret the information needed to solve a word problem. Mathematics teachers should therefore develop remedial programs within the lesson for the students in mathematics so as to guide them to solve word problems successfully.
CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction
The summary of the study, the findings of the study, implications of the study, conclusion, recommendations and suggestions for further research have been summarized in this chapter.

5.2 Summary of the Study
The purpose of the study was to analyze and establish the errors made by secondary school students that influence achievement in solving word problems in mathematics. It also identified gender differences in errors made in solving word problems in mathematics. It further investigated sources of errors in solving word problems in mathematics and determined the strategies used to overcome these errors. The findings of the study would be beneficial to the students, teachers and curriculum developers in enhancing achievement in solving word problems in mathematics. The study was guided by Gagne’s (1985) Conditions of Learning Theory and adopted a descriptive survey design. It was conducted in Gatanga sub-county in Murang’a County, Kenya. Data was collected from the form three students and trained mathematics teachers through the SMT and TMTQ. These data was then analyzed by use of SPSS, a comprehensive computer programme.

5.3 Summary of Findings
The study found that:

i) The students made a variety of errors in solving word problems in mathematics. These errors were identified and classified as follows: Defective Algorithm (15.9%); Computational errors (14%); Wrong equations (11.3%); Wrong formula (11%); Premature approximations (10.6%); No errors (9.5%); Omission of work 8.2%, Not attempted 7%, Wrong facts (6.3%); and Carelessness (6.2%). This could be attributed to lack of skills in word problems interpretation.
(ii) Sources of errors made by students in solving word problems included: Reading (10%), Comprehension (43.3%), Transformation (26.7%), Process skills (3.3%), and Encoding (16.7%). From the students’ interviews, it emerged that comprehension of word problems was the major source of errors made by the students. Forty three percent of the students lacked the ability to connect the question and the method of approach and therefore made errors while three percent of students made errors in process skills stage which is related to the four basic mathematical operations; addition, subtraction, multiplication and division.

Provision of resources such as textbooks in some schools was found to be inadequate. It was found that 12.5% of the schools had student- textbook ratio of one textbook to five students while only 16.7% had achieved a ratio of one textbook to one student. This was worrying as it suggested that the students could not do independent work and therefore were denied the opportunity to do well in solving word problems in mathematics.

Mathematics syllabus was not covered on time according to 16.7% of the teachers. This was a clear indication that the students had limited time to practice and gain skills in solving word problems.

(iii) There was significant relationship between errors made by students and the various sources of errors in solving word problems in mathematics. A chi-square test ($\chi^2 (12, N=30) = 22.877, p<0.029$), showed that the relationship between the two variables was significant. Students who had wrong equation had problems with comprehension while those who had defective algorithm and wrong facts had problems with comprehension and transformation. Students experiencing problems in encoding had made errors related to wrong facts and carelessness.
(iv) There was no significant relationship between gender of the student and the errors made in solving word problems in mathematics. A chi-square test ($\chi^2 (4, N=278) = 3.22, p<0.522$), showed that male and female students did not differ in the errors made in word problem solving in mathematics in the Sub-County. Both female and male students were able to perform computations to word problems successfully as well as made same errors across the given problems. Most of the students under the survey (82.4%) were interested in mathematics while only 17.6% were not interested. Students’ interest in mathematics would affect the way they solve word problems.

(v) There was significant relationship in errors made by students of county, district boarding and district day schools. A chi-square test ($\chi^2 (8, N=278) = 72.409, p<0.001$), showed that there was significant relationship between the errors made by the students and the type of school they attended. Students from County schools were less likely to make errors than those from District boarding and District day schools.

vi) There was need to remediate errors made in solving word problems. Twenty five percent of the teachers agreed that remedial lessons would help to overcome errors in solving word problems in mathematics.

5.4 Conclusions

From the aforementioned findings of the study, it can be concluded that a variety of errors were made by secondary school students in solving word problems in mathematics in Gatanga Sub-County. These errors point out to specific causes and areas of concern for mathematics teachers,
such as: the student’s ability to master basic facts; concept attainment; prerequisite skills; false generalizations and ability to carry out multi-step calculations.

Sources of errors made by students in solving word problems were related to the students’ ability to read, comprehend, transform and process a given mathematical task. Other factors such as provision of resources, syllabus coverage and time given for discussions in the class were found to have contributed to the students’ errors in solving word problems in mathematics. Teaching methods and materials used in teaching mathematics in secondary schools should therefore reflect the propensity of the error patterns.

There were no gender differences in the errors made in solving word problems in mathematics in the Sub-County. Both female and male students were able to perform computations to word problems successfully as well as made same errors across the given problems. The fact that 82.4% of the students under the survey were interested in mathematics implied that their attitude towards the subject was positive despite the errors made. However, students’ errors in solving word problems in mathematics were related to the type of school the student attended. This can be attributed to the fact that students’ entry behavior in the three categories of schools was different.

Remediation of errors must be based upon careful analysis and establishment of students’ errors, in the light of listed specific errors identified. It is therefore important for the teachers of mathematics to pay much attention to language used in word problems during mathematics instruction. They should also apply problem solving strategies that would help the students to understand word problems without much difficulty.
5.5 Implications for Practice

The errors made in solving word problems in mathematics as shown in this study were errors that are easily observed in the students’ work. It is therefore the responsibility of mathematics teachers to diagnose student errors and then make the appropriate corrections. Teachers must have the content knowledge and ability to provide appropriate and focused instruction to correct students’ misconceptions and errors. Improving the ability of teachers to recognize error patterns and plan more appropriate instruction can be addressed through pre-service programs, professional development opportunities in mathematics and refining curriculum materials. Textbooks for example should emphasize the five strands in mathematics outlined by the National Research Council (2002). Further, mathematics educators should study and adopt trends currently seen in the area of reading.

The analysis of students’ errors in solving word problems in mathematics is therefore important not only to the mathematics teachers but also to the secondary school mathematics curriculum developers who will analyze the curriculum objectives to be attained by the learners before formulating the syllabus. Students in secondary schools must possess relevant knowledge and be able to coordinate their use of appropriate skills so as to solve word problems in mathematics successfully. Furthermore, other factors such as algorithmic knowledge, linguistic knowledge and conceptual understanding are vital traits of word problem solving ability as shown in this study. As long as students in secondary schools make errors in solving word problems, the achievement in mathematics will remain low in national examinations.
5.6 Recommendations

The following recommendations were made based on the findings of the study;

1. The study recommended the use of remedial programmes in mathematics. Teachers should therefore be retrained on the effectiveness of undertaking remedial programme in mathematics either through seminars or workshops. Remediation should be seen as an ongoing process during normal class instruction. Teachers should therefore be encouraged to use such teaching strategies that would allow remedial activities to be carried out during normal class lessons as errors are observed. The identified errors may be remediated as follows;

(i) **Defective algorithm:** Students should be given enough practice activities on covered topics during mathematics lessons that may enhance their mastery of content. Such activities should be properly supervised by teachers so that it does not degenerate into mere play. During such practice the teacher should give assistance that would help the students to overcome any initial difficulty they may have in choosing the correct algorithm to solve word problems.

(ii) **Premature approximations:** Teachers should put more emphasis on place value of numbers. They should assist the students to connect new knowledge to previous learning.

(iii) **Wrong facts:** Teachers should guide the students in word problem representation. This may be done by use of concrete objects where necessary before solving it. They should also guide students to interpret mathematical terms such as angle of elevation and depression, relative speed, tangents, sine and cosine among others in order to improve students’ deficiencies in mathematics language.

(iv) **Wrong equations:** Teachers should guide the students to interpret word problems. Word problems given out to students should be attended to immediately through scoring. Identification of particular errors made and adequate corrections to students’ work should be given in form of feedback.
(v) **Computational errors:** Teachers should use different forms of solving word problems and show their students that though different forms are used, the results are the same.

(vi) **Wrong formulation:** Teachers should address students’ misconceptions in formulae used in calculations. They should also use concrete objects to represent mathematical ideas so as to help students understand concepts easily. Students should be able to distinguish between volume and area of solids. Discussion and reflection of meaning could be utilized for they are essential features of successful approach to resolve students’ misconceptions in solving word problems.

(vii) **Omission of work:** Teachers should pay attention to word problems involving multi-steps. The use of calculators by students to perform calculations had considerable contribution to these errors and therefore students should be assisted to show all the steps in their working.

(viii) **Carelessness:** Teachers should guide the students to arrive at correct solutions. It was observed that at some point in their working, students arrived at correct solutions but they ended up giving incorrect answers.

For the remediation to be successful, use of students’ interviews would be necessary in order to identify the difficulties faced by students in solving word problems in mathematics. Interviews provide comprehensive knowledge of a student’s thinking process and can assist the mathematics teachers to focus on their students’ difficulties during remediation. Teachers also need to work on the reading culture among the students by giving them word problems regularly.

3. Kenya Institute of Curriculum Development should ensure that teaching resources such as textbooks are designed in such a way that those activities that would enhance word problem interpretation are suggested at the end of every topic or may include specific instructional directions for teachers and re-teaching procedures to better assist teachers in correcting students’ errors. If not corrected, students will continue to make the same errors. This would help in teacher preparedness
in the planning of the lessons and therefore bring the real life situations to the mathematics classrooms.

3. Quality assurance and standards should be ensured in all the schools. Despite the Ministry’s requirement, that all the schools should complete the syllabus at the end of each school year, some schools had not complied. This had impacted negatively on students’ ability to solve word problems in mathematics.

4. KNEC should ensure that the yearly reports on performance of national examinations with details of the students’ weaknesses reach all the secondary schools on time. It was found out that in some schools, the reports had not been sent. Schools which had received the report had only one copy with all the subjects. This was found to be inadequate and therefore all the schools need to be provided with more copies of the report so as to enable the mathematics teachers to document the weaknesses given by these reports. This would help them guide the students especially in solving word problems in mathematics.

5.7 Suggestions for Further Research

The study found out that secondary school students in Gatanga sub-county made a variety of errors in solving word problems in mathematics. These errors include; wrong equations, computational errors, wrong facts, carelessness, premature approximations, defective algorithm and wrong formulae. The study also investigated the sources of these errors in solving word problems in mathematics and found out that students’ errors resulted from reading, comprehension, transformation, process skills and encoding. There was a significant relationship between types of errors made by students and the various sources of errors. There was no gender difference in errors made in solving word problems in mathematics but there was significant relationship in errors
made by students of county, district boarding and district day schools. Therefore, the study was not exhaustive;

- A study needs to be carried out in any other Sub-County in Kenya on errors made by secondary school students in solving word problems in mathematics in order to get a better picture. The sample of respondents were drawn from some selected secondary schools in Gatanga sub-county, the results of this study mainly reflect the situation in the sub-county and therefore may not be a representation of all secondary schools in Kenya.

- Research that compares two strands in mathematics such as geometry and algebra on errors made by secondary school students in solving word problems in mathematics should be carried out. The data can be used to determine if there is any significant difference in errors made in the two strands in mathematics.

- Research on the extent to which availability of teaching and learning resources for mathematics has affected students’ ability in solving word problems in mathematics should be carried out. This will facilitate better decision making as regards students errors in solving word problems in mathematics.
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APPENDICES

APPENDIX A1: STUDENTS MATHEMATICS TEST (SMT)

TIME: 40 MINUTES

PART I

Fill this part as honestly as possible

a) Type of the school: County [ ] District Boarding [ ] District Day [ ]

b) Sex Boy [ ] Girl [ ]

Opinion about mathematics

1 a) Do you like mathematics?

-------------------------------------------------------------

b) Give reasons for your answer in (a) above

   i)-----------------------------------------------------------

   ii)----------------------------------------------------------

   iii)---------------------------------------------------------

2 a) A normal mathematics lesson takes 40 minutes. How much time are you given by your teacher to discuss mathematics problems within the lesson?

   i) Less than 1 min [ ]

   ii) 1-5 min [ ]

   iii) 1-10 min [ ]

   iv) 1-20 min [ ]

   v) None [ ]
PART II

SOURCE: KNEC PAST PAPERS

Answer all the questions in the spaces provided showing all the working

1. A man standing 20 metres away from the foot of a vertical pole observes the top of the pole at an angle of elevation of $30^0$. He begins to walk along a straight line on level ground towards the pole. Calculate how far he walked before the angle of elevation of the top of the pole becomes $80^0$ leaving your answer to two significant figures. (4 marks)

2. Two metal spheres of diameter 2.3cm and 3.86cm are melted down and recast as one sphere. Determine the diameter of the new sphere if 5% of the metal is lost during recasting. (4 marks)

3. A certain number of people agreed to contribute to buy novels worth sh. 1200. Five of them pulled out and the others agreed to contribute an extra sh. 10 each. Their contribution bought novels worth sh.200 more than they originally expected. If the original number of people was $x$, how much did each contribute? (10mks)

4. Two passenger trains A and B which are 240M a part are traveling at 164 Km/h and 88 km/h respectively as they approach one another on a straight railway line. Train A is 150 metres long and train B is 100metres long. Determine the time in seconds that elapses before the two trains completely pass each other. (3mks)

5. A bus takes 195 minutes to travel a distance of $(2x + 30)$ km at an average speed of $(x – 20)$ km/h. Calculate the actual distance traveled by the bus. Give your answer in kilometers. (4 marks)
APPENDIX A2: TRAINED MATHEMATICS TEACHERS QUESTIONARE

Students’ errors in mathematics are a major concern in Kenya today. This study intends to establish the types of errors committed by secondary school students in word problem solving in assessments. The results will help improve achievement in mathematics. The information provided will be treated with confidentiality. You are requested to answer the questions honestly. Tick as appropriate

**Personal Data**

a. Indicate your sex
   - Male [ ]
   - Female [ ]

b. Indicate your qualification
   - Med [ ]
   - Bed [ ]
   - Diploma Ed [ ]
   - Others [ ]
   For others specify----------------------------------------

c. School type where you are teaching
   - County [ ]
   - District Boarding [ ]
   - District Day [ ]

**Teaching information**

a. Subjects trained to teach -----------------------------------

Teaching experience ------------------------------------------

b. How would you rate your student’s motivation towards learning mathematics
   - High [ ]
   - moderate [ ]
   - low [ ]

C. How often do your students make errors while solving word problems?
   - Very often [ ]
   - Often [ ]
   - rarely [ ]
   - Not sure [ ]
d. Briefly describe the types of errors made by students

i) -----------------------------------------------------------------------------------------------

ii) ---------------------------------------------------------------------------------------------

iii) ---------------------------------------------------------------------------------------------

iv) ---------------------------------------------------------------------------------------------

e. Suggest ways that can be used to overcome these errors

i) ---------------------------------------------------------------------------------------------

ii) ---------------------------------------------------------------------------------------------

iii) ---------------------------------------------------------------------------------------------

f. Consider the following question;

Two passenger trains A and B which are 240 metres a part are traveling at 164 Km/h and 88 km/h respectively as they approach one another on a straight railway line. Train A is 150 metres long and train B is 100 metres long. Determine the time in seconds that elapses before the two trains completely pass each other.

i) Suggest common errors that students make while solving such a problem

---------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------

ii) How can these errors be overcome?

---------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------

g. When a problem in mathematics is presented in words, students normally find it difficult to calculate. What are the possible reasons for this?
i)  

ii)  

h. Suggest three ways to overcome the reasons in (g) above

i)  

ii)  

iii)  

i. How often do you allow discussions in class during 40 minutes lesson?

Often [ ] rarely [ ] not possible [ ] no time [ ]

j. How adequate are mathematics text books in terms of student-book ratio?

1:1 [ ] 1:2 [ ] 1:3[ ] 1:4[ ] 1:5[ ]

k. When do you complete the mathematics syllabus?

Term one [ ] Term two [ ] Term three [ ] Not possible [ ]
APPENDIX A3: Interview Schedule

Newman (1983: 11) recommended that the following questions or requests be used in interviews that are carried out in order to classify students' errors on written mathematical tasks:

1. Please read the question to me. (*Reading*)

2. Tell me what the question is asking you to do. (*Comprehension*)

3. Tell me a method you can use to find and answer to the question. (*Transformation*)

4. Show me how you worked out the answer to the question. Explain to me what you are doing as you do it. (*Process Skills*)

5. Now write down your answer to the question. (*Encoding*)
APPENDIX A4: EXPECTED RESPONSES AND POSSIBLE AREAS WHERE ERRORS OCCURRED

1. \[
\tan 80^\circ = \frac{h}{x} \quad \text{and} \quad \tan 30^\circ = \frac{h}{20}
\]

\[h = x \tan 80^\circ \quad \text{or} \quad h = 20 \tan 30^\circ \]

Wrong formula (Sine or cosine used)

Computational errors

Defective Algorithm

Premative Approximations (2sf at this point)

\[x = \frac{20 \tan 30^\circ}{\tan 80^\circ} \]

Premative Approximations (2sf at this point)

\[x = \frac{11.547}{5.671} \]

\[x = 2.036 \quad \text{(Omission of work)}\]

\[y = 20 - 2.036 \quad \text{(Carelessness: Ans not in 2sf)}\]

\[d = 18\, (2\, sf)\]

2. \[
V = \frac{4}{3} \pi r^3
\]

Wrong formula \(\left(\frac{4}{3} \pi r^2\right)\)

Computational error (not added)

Premative Approximations (using less than 4sf)

\[25.5 + 120.5 + 241.00 = 146\]

89
\[ \frac{95}{100} \times 146 = 138.7 \quad \text{← Defective Algorithm (105\% used)} \]

\[ \frac{4}{3} \pi r^3 = 138.7 \quad \text{← wrong equation used} \]

\[ r^3 = 138.7 \times \frac{2}{3} \times \frac{7}{22} \]

\[ r^3 = 33.1 \quad \text{← omission of work} \]

\[ r = \sqrt[3]{33.1} \]

\[ r = 3.2 \quad \text{← carelessness (Ans as radius)} \]

**Diameter = 6.4cm.**

---

3.a) \( \frac{1200}{x} \) \quad \text{← wrong facts \( \frac{1200}{x} + 200 \) used}

b) \( \frac{1400}{x-5} \) \quad \text{← wrong facts \( \frac{1200}{x-5} \) used}

c) \( \frac{1400}{x-5} - \frac{1200}{x} = 10 \) \quad \text{← wrong equation}

\[ 1400x - 1200(x-5) = 10x (x-5) \quad \text{← computational error} \]

\[ 200x + 6000 = 10x^2 - 50x \]

\[ 10x^2 - 250x - 6000 = 0 \]

\[ x^2 - 25x - 600 = 0 \]

\[ x - 40x + 15x - 6000 = 0 \quad \text{← defective Algorithm} \]

\[ x(x - 40) + 15(x - 40) = 0 \]

\[ x - 40 = 0, x = 40 \]

40 - 5 = 35 people

d) \( \frac{1400}{35} \) \quad \text{← omission of work (sh 40 given)}

\[ = \text{Ksh 40 each.} \]
4. R.s = 164km/h + 88km/h
   \[= \frac{252 \times 1000}{60 \times 60} = 252\text{km/hr}\]  
   \[\text{R.s} = 70\text{m/s}\]
   Distance = 240 + 150
   \[= 390\text{m}\]
   Time = \[\frac{390\text{m}}{70}\]
   \[= 5.57\text{ seconds}\]

5. D= S X T
   \[2x + 30 = (x - 20) \times \frac{13}{4}\text{ hr}\]
   \[4(2x + 30) = 13(x - 20)\]
   \[8x + 120 = 13x - 260\]
   \[380 = 5x\]
   \[x = 76\]
   Distance = 2 \times 76 + 30
   \[= 152 + 30\]
   \[= 182\]
# APPENDIX A5: GATANGA DISTRICT SECONDARY SCHOOLS LIST

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<thead>
<tr>
<th>SCHOOL</th>
<th>TYPE</th>
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</thead>
<tbody>
<tr>
<td>GATANGA GIRLS</td>
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</tr>
<tr>
<td>PIONEER GIRLS</td>
<td>County girls private school</td>
</tr>
<tr>
<td>GATUNYU</td>
<td>District mixed day school</td>
</tr>
<tr>
<td>KIRWARA</td>
<td>District boys boarding</td>
</tr>
<tr>
<td>NDAKA-INI</td>
<td>District mixed day school</td>
</tr>
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<td>District mixed day school</td>
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<tr>
<td>CHOMO</td>
<td>District mixed boarding</td>
</tr>
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</tr>
<tr>
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<tr>
<td>KIMANDI</td>
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<td>MWAGU</td>
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</table>
APPENDIX A6: STUDY PERMIT

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Our Ref: NCST/RCD/14/013/1367

Date: 25th July 2013

Stephen Chege Ngigi
Kenyatta University
P.O Box 43844-00100
Nairobi.

RE: RESEARCH AUTHORIZATION

Following your application dated 23rd July, 2013 for authority to carry out research on “Types of errors made by secondary school students in solving word problems in mathematics in Gatanga District in Murang’a County, Kenya.” I am pleased to inform you that you have been authorized to undertake research in Gatanga District for a period ending 30th November, 2013.

You are advised to report to the District Commissioner and District Education Officer, Gatanga District before embarking on the research project.

On completion of the research, you are expected to submit two hard copies and one soft copy in pdf of the research report/thesis to our office.

Said Hussein
FOR: SECRETARY/CEO

Copy to:
The District Commissioner
The District Education Officer
Gatanga District.

“The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development.”
APPENDIX A7: MURANG'A COUNTY MAP
APPENDIX A8: GATANGA SUB-COUNTY MAP