EFFECTS OF MATHEMATICAL VOCABULARY INSTRUCTION ON STUDENTS' ACHIEVEMENT IN MATHEMATICS IN SECONDARY SCHOOLS OF MURANG'A COUNTY, KENYA

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DECLARATION

I confirm that this thesis is my original work and has not been presented for a degree in any other university/institution for certification. The thesis has been complemented by referenced works duly acknowledged. Where text, data, graphics, pictures or tables have been borrowed from other works – including the internet, the sources are specifically accredited through referencing in accordance with anti-plagiarism regulations.

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DEDICATION

This thesis is dedicated to my Children:

Alvin Njoroge Junior

Ivy Wanjiru

Amy Wanjiku,

and

To my beloved wife

Veronicah Njoroge

Glory and honour be to God.

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ABBREVIATIONS AND ACRONYMS

8.4.4	An education system in Kenya where a pupil takes eight (8) years in Primary School, 4 years in Secondary school and 4 years of University Education.
ASEI	Activities Student Experiments and Improvisation
CGI	Cognitively Guided Instruction
ESL	English as a Second Language
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examinations Council
M.D	Mean Difference
MTQ	Mathematics Teachers' Questionnaire
NCTM	National Council of Teachers of Mathematics
PDSI	Plan, Do, See, Improve
S.D	Standard Deviation
S.E	Standard Error
S.E.D	Standard Error Difference
SMAQ	Students Mathematics Attitudes Questionnaire
SMASE	Strengthening of Mathematics and Science Education
SMAT	Students' Mathematics Achievement Test
SMVD	Students' Mathematics Vocabulary Dictionary
SMVT	Students' Mathematics Vocabulary Test

ABSTRACT

The purpose of the study was to explore the influence of mathematical vocabulary instruction on students' Mathematics achievement. The study was guided by the following objectives: to determine the extent to which mathematical vocabulary instruction influences students' performance in Mathematics, to establish the attitudinal change towards Mathematics due to mathematical vocabulary instruction, to establish the strategies that can be used to enhance the mastery of mathematical vocabulary and to develop a prototype for a lesson plan for Mathematics vocabulary based instruction. The study was a non-equivalent control group pretest-posttest quasi-experimental design. The target population was 98,200 students from 257 secondary schools in Murang'a County. It was conducted in two purposively selected secondary schools in the County. The study sample was 216 Form Two students and 6 Mathematics teachers. Both the experimental and the control groups consisted of 54 students from each school. The experimental groups were taught mathematical vocabulary using the Graphical Organizer based on the Frayer Model with ICT integration instructional approach for 10 weeks while the control groups were taught mathematical vocabulary using the definition-only method for the same period. The study employed 7 instruments namely: Students Mathematics Attitudes Questionnaire, Pre-test Students' Mathematics Vocabulary Test, Post-test Students' Mathematics Vocabulary Test, Students' Mathematical Vocabulary Dictionary, Pre-test Students' Mathematics Achievement Test, Post-test Students Mathematics Achievement Test and Mathematics Teachers' Questionnaire to collect both qualitative and quantitative data. Data was analysed using one-way ANOVA, independent t-test and paired t-test. The statistical significance of the results were then examined at $\alpha = 0.05$ statistical confidence level. The findings indicated that: there was a positive association between mathematical vocabulary instruction and students' performance in Mathematics, there was a statistically significant difference between the students' performance in Mathematics for the group taught Mathematics vocabulary using the Frayer Model and those taught Mathematics using the definition-only method, the students' attitude towards Mathematics improved due to exposure to the Mathematics vocabulary instruction and the most effective strategy for mathematical vocabulary instruction was the use of Graphical Organizer based on the Frayer Model with ICT integration because it is learner centered. A prototype lesson for mathematical vocabulary instruction based on the Frayer model with ICT integration was developed. The study recommends the use of Frayer Model with ICT integration as an instructional strategy for Mathematics based Vocabulary instruction and a further study to investigate the effects of social language (motivation) on students' performance in Mathematics.

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.0 Introduction

This chapter introduces the problem that was investigated by discussing the following ten background issues: Background of the problem, statement of the problem, theoretical framework, conceptual framework, objectives of the study, research hypotheses, significance of the study, assumptions of the study, scope and limitations and operational definitions of terms.

1.1 Background to the Study

Mathematics is a compulsory subject in Kenyan secondary school curriculum. The importance of school Mathematics cannot be overemphasized. Mathematics is crucial for an increased student's achievement in school, for producing informed citizens, success in careers, as well as in personal fulfilment. In today's technology driven society, greater demands have been placed on individuals to interpret and use Mathematics to make sense of information and complex situations. Mathematics is an essential tool in many fields, including natural science, engineering, medicine, and the social sciences. It is also used in day-to-day activities at home, in the market places and in offices (Neyland, 1994).

Despite the critical value of Mathematics in society, the students' performance in the subject in KCSE has been dismal (KNEC, 2010). Every year KNEC reports low students' performance in Mathematics in KCSE. For instance, the students mean mark was 19.04 (2006), 19.73 (2007), 21.295 (2008), 21.13 (2009), 21.19 (2010), 22.0 (2011), 28.7 (2012) respectively (KNBS, 2014). The Council attributes this to lack of conceptual understanding among the students (KNEC Report, 2010, 2011, 2012). A key component in understanding Mathematics is the learning of mathematical vocabulary. Vocabulary is the knowledge of a word and meanings (Stahl, 2005). However, it also encompasses comprehension of how words are used in oral and written formats. According to Miller (1993, p. 12), students are likely to be handicapped in their effort to learn Mathematics if they do not understand the vocabulary that is used in Mathematics classrooms, textbooks and assessment tests.

Mathematical vocabulary refers to words that label Mathematical concepts such as quotient, volume, vertex, dividend, and hexagon (Vacca & Vacca, 1996). One of the obstacles that make mathematical vocabulary difficult to learn is lack of opportunity to learn and practise the words (Monroe & Orme, 2002). This is because many of the vocabulary used in Mathematics classroom are rarely encountered in everyday life. In addition, Mathematics teachers often neglect meaningful vocabularies instruction. In addition, many terms have meanings in the realm of Mathematics differ from their meanings in everyday usage (Njoroge, 2003). These include power, difference, volume, factors among others. Without appropriate vocabulary instruction, students are likely to experience difficulties and interference in the learning of concepts for which they have background knowledge that appears unrelated to Mathematics. According to Vacca and Vacca (1996), the abstract nature of mathematical vocabulary is another factor contributing to difficulty in learning mathematical vocabulary. This is because many mathematical words represent concepts and not objects. Words such as quotient, fraction, and factor describe concepts but they have no unique unambiguous representations in the real world.

The importance of language in the learning of Mathematics cannot be overemphasized. Mathematics ideas can be understood by making connections between language, symbols, pictures and real-life situations (Haylock and Thangata, 2007). For the mathematical concepts to be understood and used, it requires to be associated with a word or phrase. An integral part of learning Mathematics is using vocabulary to communicate Mathematics ideas; to explain, conjure and defend one's ideas orally and writing about Mathematics (NCTM, 1989). Students need to understand the meaning of mathematics vocabulary whether written or spoken-in order to understand and communicate Mathematics ideas. According to Rubenstein & Thompson (2002), terms, phrases, and symbols are essential in communicating Mathematical ideas; and becoming fluent in them is vital for children's mathematical learning which is in line with 21st century pedagogy skills. Research reveals that the knowledge of Mathematics vocabulary directly affects achievement in arithmetic, particularly problem-solving (Stahl & Fairbanks, 1986). Biemiller (2001) established that vocabulary knowledge is strongly related to the overall academic achievement in school. Although students may excel in computation, their ability to apply their Mathematics skills will be hindered if they do not understand the vocabulary required to master content or are unable to apply the skills in future situations. Thus, teaching vocabulary in the Mathematical content area is a critical element of effective instruction.

Mathematics can be described as a specialized language. It is viewed as a language, which is concise, and precise (Mutunga & Pimm, 1987, Breakwell, 1992). It consists of both terminologies (vocabulary) and symbols. Unlike English language, Mathematics language is highly symbolized and it mainly uses ideograms (symbols for communicating ideas) as opposed to phonograms (symbols for words). Communication in Mathematics embraces the usage of various symbols and notations for brevity. Mathematics textbooks, examinations and instruction classrooms are often in mathematical language as well as in English Language. Moreover, it is a universal language with syntactical and rhetorical structures (Njoroge, 2003). Its rhetorical structures consist of indefinite terms, definite terms, axioms and theorems (Aiken, 1972).

Mathematical language, like other languages, has its peculiar grammar, syntax, vocabulary, word order, synonyms, negations, conventions, abbreviations, sentence structure, and paragraph structure. It has certain language features unparalleled in other languages. For example, theorems expressed using the letter “x” also applies to "*b*" and "2*x*-5". Likewise, Mathematics vocabulary is not commonly used in daily settings because of its technical nature and due to fact that is it is often narrowly defined. Krussel (1998) views language as an essential part of the Mathematics construct as language is an indispensable tool in Mathematics. Students are therefore likely to face difficulties in solving word problems loaded with difficult and unfamiliar vocabulary (Abedi & Lord, 2001; Solano-Flores & Trumbull, 2003).

The current study investigated the relationship between students’ English language proficiency and Mathematics performance among secondary school students. The syntax-language structure-used in Mathematics is highly complex and very specific. Mathematics uses syntactic features that many students find both cumbersome, and also quite confusing.

For example, the use of comparatives−*higher than, greater than, as much as*, passive voice (for example X is added to Y), reversed ways of stating the known and unknown variables (for example X is 2 less than Y; the correct equation is X = Y - 2, not X - 2 = Y) can exacerbate confusion (Chamot & O'Malley, 1994). Unlike the language of literary narratives, reduced redundancy in Mathematical expressions makes it extremely hard for students to comprehend what they read in Mathematics textbooks, which lack the built-in contextual cues found in language arts.

Students' reading skills affect their Mathematics performance. Many studies have shown that there are high correlations between Mathematics and reading scores. McGhan (1995) reported a correlation of 0.84 between fourth graders' reading comprehension and Mathematics test scores for 139 District schools in Michigan. Problem solving in Mathematics can be approached differently based on cultural differences. Mathematics word problems cannot be solved if the students are not familiar with the cultural context of the mainstream society or the cultural knowledge that is taken for granted.

Shuard and Rothery (1984) proposed that words in Mathematics fall into three categories. In the first category, there are those that are found exclusively in the context of Mathematics classroom; trapezium, hypotenuse, and ogive. The next category covers those found in everyday English and Mathematics but have radically different meanings in Mathematics depending on the context. Words such as difference, face, similar, indices can have more than one meaning. Finally, there are other words that are found in both texts and have more or less the same meaning, example of these are; square, diagonal and hypotenuse.

Considerable research demonstrates that Mathematics alone is a language that is more complex than everyday English (Cuevas, 1984; Khisty, 1995). The language of Mathematics is described as a “register” of words, expressions, and meanings that differ from those of everyday language (Cuevas, 1984; Mestre, 1988, Secada, 1992). For instance, the language of Mathematics has specialized meanings for words and phrases such as “horizontal,” “vertical,” “subtract,” “difference,” “equivalence,” and “inverse,” . These words differ in meaning from the everyday conversational and academic meanings that English learners are learning in their English-language arts courses (Ron, 1999). Given the important differences between the language of Mathematics and the everyday English language, non-native English speakers with low levels of proficiency face the added difficulty of becoming proficient in English as they also develop proficiency in the language of Mathematics.

From the foregoing, a number of observations can be made. First, mathematical vocabulary is a key component in understanding Mathematics. Since mathematical vocabulary encompasses a number of mathematical concepts, it can be argued that without understanding the vocabulary used routinely in Mathematics instruction, textbooks, and word-problems, students would be handicapped in their efforts to learn Mathematics (Marzano, 2011). Secondly, research has shown that knowledge of Mathematics vocabulary directly affects achievement in arithmetic, particularly problem solving. In addition, it has been reported that students’ achievement would increase by 33 percentile points when direct vocabulary instruction focuses on specific words that are important to what students are learning (Stall and Fairbanks, 1986). Although Mathematics is a visual language of symbols and numbers, it is expressed and explained through written and spoken words. Thus, for students to excel in Mathematics, they must recognize, comprehend and apply the requisite Mathematical vocabulary.

1.2 Statement of the Problem

Every year KNEC reports low students' performance in Mathematics in KCSE. Students have not managed to attain a mean mark of 29% or D + (plus) (KNEC KCSE Reports, 2006-2013). The Council attributes this to lack of conceptual understanding among the students. Many reasons can be postulated to explain why students lack conceptual understanding. Some of the researchers have identified the use of teacher-centred approaches in teaching Mathematics, lack of practical modelling activities, lack of spatial skills, teachers' and students' negative attitudes towards Mathematics, high teacher: student ratio, high student: book ratio, teachers' absenteeism, missing link between primary and secondary Mathematics among other factors (Njoroge, 2003; Rukangu, 2003; Miheso, 2012; Amadalo, 2013). Several interventions have been put into place to address this low students' performance in Mathematics in KCSE. The issues of inadequate resources have been addressed through KESSP programme. The SMASSE programme on the other hand has addressed the teacher pedagogical issues. However, the students' low performance in Mathematics in KCSE persists. This implies that there could be other issues responsible for the low students' achievement in mathematics.

The KNEC in its yearly reports of 2006-2013 on students' performance in KCSE has continuously indicated that the most poorly performed questions in Mathematics are those that involve word problems. As indicated earlier, mathematical vocabulary routinely is a key component in understanding Mathematics. Since mathematical vocabulary are words that label mathematical concepts, it can be argued that without understanding the vocabulary used routinely in Mathematics instruction, textbooks, and word-problems, students would be handicapped in their efforts to learn Mathematics. The study contended that perhaps the lack of understanding of mathematical vocabulary among the students could be a key factor in low performance of Mathematics in national examinations in Kenya.

Mathematics vocabulary instruction in classrooms has been carried out through giving simple definitions of mathematical vocabulary. There has not been any deliberate effort for direct instruction of mathematical vocabulary (Njoroge, 2003). To be effective, mathematical vocabulary instruction must provide more than simple definitions. Students need not just surface knowledge of the vocabulary but conceptual knowledge. Teaching mathematical vocabulary words solely as definitions as is the practice in most Kenyan schools does not assist students in comprehending the word when found in Mathematics textbooks and examination items. Students must be actively engaged in building background knowledge using key content - specific vocabulary. Development of vocabulary is crucial to any experience involving language.

An important component in mathematical language is learning mathematical vocabulary. Mathematical language is an essential element of learning, thinking, understanding and communicating Mathematics. The Frayer model is one the best strategy of direct instruction of Mathematics vocabulary (Marzano, 2004). However, there is no study so far in the Kenyan context and by extension in Murang'a County on the effects of Mathematical vocabulary instruction on students' achievement in Mathematics. It is in view of this gap that the study was designed to determine the effects of mathematical vocabulary instruction on students' achievement in Mathematics in secondary schools in Murang'a County, Kenya.

1.3 Purpose of the Study

The purpose of the study was to determine the effects of Mathematical vocabulary instruction on students' achievement in Mathematics.

1.4 Objectives of the Study

The study was guided by the following four (4) specific objectives:

i. To determine the extent to which mathematical vocabulary instruction influences students' performance in Mathematics.
ii. To establish the influence of mathematical vocabulary instruction on students' attitude change towards Mathematics.
iii. To establish the strategies used and how they influence students' mastery of mathematical vocabulary.

iv. To develop a prototype lesson plan for Mathematics vocabulary based instruction.

1.5 Research Hypotheses

The study was guided by five (5) hypotheses:

H_O1: There is no relationship between students' level of Mathematics vocabulary and level of Mathematics achievement.

H_1: There is a relationship between students' level of mathematical vocabulary and level of Mathematics achievement.

H_O2: There is no significant difference between mean scores on vocabulary assessments for students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught Mathematical vocabulary using the definition-only method.

H_2: There is a significant difference between mean scores on vocabulary assessments for students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the definition-only method.

H_O3: There is no significant difference between students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the definition-only method.

H_3: There is a significant difference between students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer

Model with ICT integration and those taught mathematical vocabulary using the definition-only method.

H_O4: There is no significant difference between students' performance in Mathematics for students English Language proficient group taught mathematics vocabulary using the Frayer Model with ICT integration and non-English Language proficient group taught using the definition-only method.

H_4: There is a significant difference between students' performance in Mathematics for students English Language proficient group taught mathematical vocabulary using the Frayer Model with ICT integration and Non-English Language proficient group taught using the definition-only method.

H_O5: There is no significant difference in the students' attitudes toward Mathematics between students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the definition-only method.

H_5: There is a significant difference in the students' attitudes toward Mathematics between students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the definition-only method.

1.6. Significance of the Study (Rationale)

The findings of this study will be significant to the following:

i. The findings will contribute to the theory and practice of Mathematics Education. The prototype lesson plan for Mathematics vocabulary based instruction may be used by Mathematics teachers to develop lesson plans for teaching mathematical vocabulary. This is the study's contribution to the body of knowledge.

ii. The research findings may be used to sensitize secondary school students on the factors that contribute to the mastery of Mathematical vocabulary.

iii. The findings may be used to sensitize Mathematics teachers on the need to design Mathematical vocabulary instruction strategies for Mathematics classes. They can also use the prototype lesson plan for Mathematics vocabulary instruction in their classrooms.

iv. The study findings may be used to sensitize Mathematics teachers' trainers on the need to equip Mathematics teachers' trainees with appropriate mathematical vocabulary instruction strategies for use in a Mathematics classroom.

v. The findings may be used to inform the development of policy by Kenya Institute of Curriculum Development on Mathematics vocabulary instruction course. The Institute may use the findings as a basis for redesigning the current Mathematics curriculum and prepare materials for the teaching and learning of Mathematical vocabulary.

1.7 Assumptions of the Study

The study was guided by three assumptions. The first one was that all the target population students were English Language learners. Secondly, the study assumed that the target schools adhered to a uniform syllabus of Mathematics. Finally, the study assumed that the target schools had professionally trained teachers in Mathematics Education.

1.8 Delimitations and Limitations

1.8.1. Delimitations

The study involved Form Two students and their Mathematics teachers of two County schools in Mugoiri Location, Kahuro District of Murang’a County, Kenya. This is because they were the only schools in the District equipped with computer laboratories and had internet connectivity, which was a requirement for the study. In addition, the two schools had almost similar demographics as homogeneity was a requirement required in the study. It involved 108 Form Two (II) students from each of the schools totalling to 216 students. Form Two (II) students were preferred because they were deemed to have acquired adequate Mathematical and English language skills. Form one (I), three (III) and Four (IV) were omitted for various reasons. Form One (I) was not considered as students were not adequately exposed to the Secondary School Mathematics and English curricula. The Principals of the selected sample schools did not feel comfortable to allow the involvement of Form (III) because they were considered potential candidates. Forms (IV) students were considered to be too busy preparing for KCSE examinations. The study also involved six (6) secondary school Mathematics teachers from the selected schools and classes.

Since the study involved only two secondary schools in Kahuro District of Murang'a County, the findings mainly did not reflect the situation in other schools. Hence the findings may not be representative of all secondary schools in the County and in Kenya. The study was delimited to Form one syllabus. This was because the Form Two students, who were the main unit of analysis, had covered the syllabus. The Mathematics vocabulary and concepts were drawn from Form one work. They were limited to 15 vocabulary words that the participating teachers in the study had chosen since they considered them the most challenging and significant in Form one syllabus.

1.8.2. Limitations

The study had a number of limitations:

First, the Head Teachers of the two County schools were unwilling to host the study. However, the study overcame this limitation by explaining to them the purposes of the study. They were also assured that the findings will be used for the purposes of the study only and would in no way be used for the evaluation of their schools.

Another limitation was limited resources. The principals and teachers of the participating schools did not receive compensation for their participation. However, they were made to understand that the study would benefit their students and contribute to Mathematics Education.

1.9. Theoretical and Conceptual Frameworks

1.9.1. Theoretical Framework

Development of vocabulary is crucial to any experience involving language. An important component in Mathematical language is learning Mathematical vocabulary (Monroe, 2002). According to Riordain & O'Donoghue (2009), mathematical language is an essential element of learning, thinking, understanding and communicating Mathematics. The theoretical framework underpinning the research design was the cognitively guided instruction by Fennema, Carpenter & Lamon (1991) (Appendix O).

In a cognitively guided instruction (CGI) classroom, the teacher poses a problem and asks students to think about ways to solve the problem. A variety of student-generated strategies are used to solve this problem such as using locally available materials. The teacher then asks the students to explain their reasoning process. They share their explanations with the class. The teacher may ask the children to compare different strategies. Children are expected to explain and justify their strategies, and the children, along with the teacher, take responsibility for evaluating the suitability of the strategy that is presented.

This type of instructional process puts more responsibility on the students in a number of ways. First, rather than simply asking students to apply a formula to several virtually identical Mathematics problems, learners are challenged to find their own solutions. Secondly, they are expected to publicly explain and justify their reasoning to their fellow learners and the teacher. Thirdly, teachers are required to open up their instruction to students' original ideas, and to guide each student according to his or her own developmental level and turn of reasoning. This leads to relational understanding in Mathematics. Expecting students to solve problems using strategies that have not been taught to them and asking students to explain and justify their thinking has a major impact on students' learning. Not only are students learning specific ways to solve problems, but they are also increasing their knowledge of the fundamental principles of Mathematics. Student using their own strategies to solve problems and justifying these strategies also contributes to a positive disposition toward learning Mathematics. CGI is based on research that shows that children come to school with rich informal systems of mathematical knowledge and problem-solving strategies that can serve as a basis for learning Mathematics with understanding. A major goal of CGI is to help teachers build on this informal mathematical knowledge so that they understand the new ideas that they are learning. This method of teaching is innovative and therefore it offers classroom teachers help in understanding how children's mathematical ideas develop. The focus is on children's thinking and not on specifying specific teaching procedures or curriculum materials.

In cognitively guided instruction (CGI) classrooms, learners are able to solve problems without direct instruction by drawing upon the informal knowledge of everyday situations. Learners are able to use the problem solving approach to learn and solve problems. They can use models to represent their thought for a problem in multiple ways. Children are not shown how to solve the problems. They decide how and when to use materials, fingers, paper; or to solve the problem mentally. The teachers then make instructional decisions based on their knowledge of individual children's thinking. The model relates to ASEI-PDSI in a number of ways. The CGI model is based on the thinking of individual learners. It relates to the ASEI model of instruction which advocates use of Activities based on Students' Experimentation and Improvisation. The teacher gives a task and the learners find solutions to it by manipulating the materials. It is a guided discovery approach as advocated by CGI and involves hands-on experience where learners construct knowledge. The second aspect has four aspects: Plan, Do, See and Improve. It deals with the teacher who develops a task and learners who do the task. This is then followed by discussion and harmonization of results which climax at seeing/evaluating the outcomes with an aim to improve.

Adams, Thangata & King (2005) suggested that one of the ways of helping students deal with mathematical vocabulary is by supporting them to develop visual skills through encouraging them to use pictures and diagrams to understand Mathematical vocabulary. To this end, the Frayer Model advocates the use of Graphical Organizers to explain the meaning of a word. The learners begin by defining a word, followed by writing examples and non-examples, and finally the characteristics of the word in graphical organizer. They also make a foldable to represent the vocabulary. The use of guided instruction based on the students' knowledge is the focus at this point and can only be possible in ASEI-PDSI approach in lesson planning. During presentations, the learners use English and Mathematical language to explain the solution. This leads to the contextualization and development of Mathematical vocabulary. The learner then represents the concepts in diagrams or in Mathematical notations (symbolism). The teachers are expected not only to recognize the students' efforts but also reward them. This modifies the students' behaviour making it possible repeat it in similar tasks which eventually leads to students' learning.

1.9.2. Conceptual Framework

Students' achievement in Mathematics entails understanding Mathematical concepts. Development of Mathematical vocabulary is a prerequisite for understanding Mathematical concepts. The relationship between these variables and other details are shown in Figure 1.1.

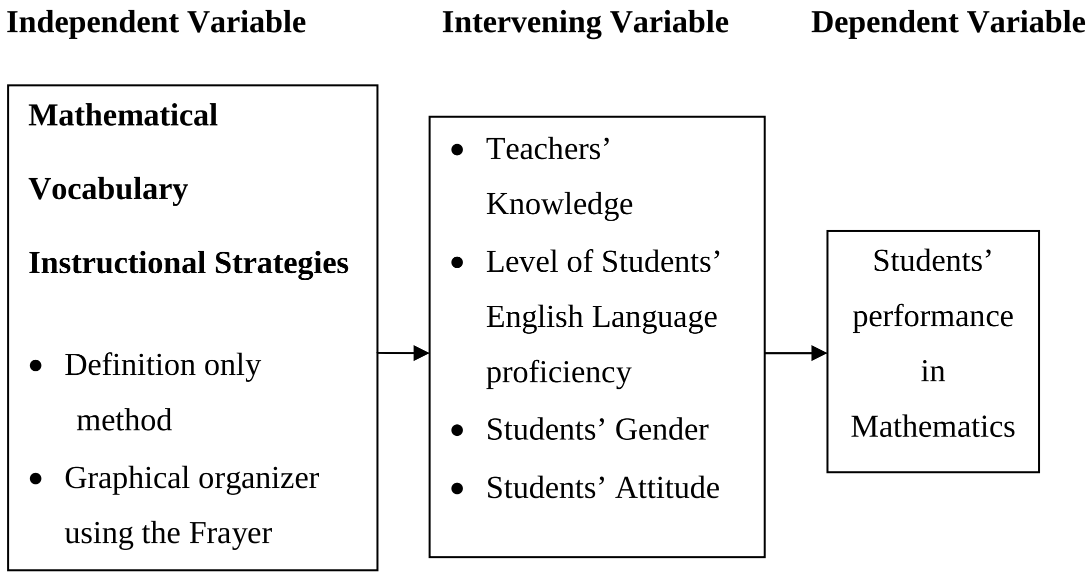


Figure 1.1 A conceptual framework of the relationship between Mathematical Vocabulary Instruction strategies and Mathematics performance

Mathematics is a language and to be fluent in that language one must be able to use and understand mathematical vocabulary. In the Figure 1.1, development of mathematical vocabulary requires mathematical instruction in the classroom. This instruction is done in English language using Direct Instruction, Meaningful Context or a combination of both approaches. Direct instruction may entail the use of definition-only method and use of graphic organizers (graphical or spatial representation of Mathematical text concepts). In the definition-only method, students typically look up the word in the dictionary or are told its definition, write the meaning of the word, and memorize it. In using of a graphic organizer, learners receive visual representation of concepts and their relationships. This involves the use of Frayer Model with ICT integration.

In meaningful contexts, teachers provide students with a foundation of meaningful experiences from which they can negotiate understanding of words from contexts. After the instruction, students should use mathematical vocabulary to communicate Mathematics ideas, to explain, conjecture and defend one's ideas in writing. They are then able to represent Mathematical concepts graphically through diagrams and by means of Mathematical notation (symbols). This eventually leads to understanding of Mathematical concepts and hence students' achievement in Mathematics.

However, in the course of Mathematical vocabulary instruction, there are some intervening variables. These include the teachers' content and pedagogical knowledge, teaching methods, students' level of English language proficiency, teachers' and students' attitude towards Mathematics and students' gender. These intervening variables influence the level of Mathematics understanding and eventually their performance in Mathematics.

1.10 Operational Definition of Key Terms

The following words have been operationalized the purpose of this study:

Achievement test: An achievement test is a test of what an individual knows at a particular time.

Attitude change: Attitude Change is the modification of students' interest and emotion towards Mathematics as a result of receiving mathematical vocabulary Instruction.

Concept: A Concept is an abstract idea describing some relationship within a group of facts and may be designated by some sign or symbol.

Definition-only method: Definition of mathematical vocabulary only without explaining its facts/ characteristics, examples and non-exam

Frayer Model: The Frayer model is a graphical organizer used for word analysis and vocabulary building. This strategy stresses understanding words within the larger context of reading selection by requiring students, first, to analyse the items (definition and characteristics) and second, to synthesize/ apply this information by thinking of examples and non-examples.

Graphic Organizer: A Graphic Organizer (GO) is a graphical or spatial representation of Mathematical text concepts.

Mathematical Vocabulary understanding: Mathematical Vocabulary understanding is the knowledge of a word's meaning and its use.

Mathematical Vocabulary: Mathematical vocabulary refers to words that label Mathematical concepts e.g. quotient, chord, power, area among others.

Performance: Performance is the ability of a pupil or group of students to interpret Mathematical vocabulary in a given task for problem solving.

1.11 Organization of the Thesis

This thesis has been divided into five chapters. Chapter One (1) is the introduction, which outlines the context of the study including the background, statement of the problem, purpose of the study, study objectives, hypotheses, significance of the study, basic assumptions of the study, scope and limitations and the definition of terms. Chapter Two (2) is the review of the related literature with regard to the study. This is reviewed under subsections: Mathematical Vocabulary, Role of Mathematical Vocabulary in the learning of Mathematics and Methods of Instruction of Mathematical Vocabulary.

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

Chapter Four (4) presents' analyses of the data collected and discuss the results. In this chapter, fieldwork logistics and problems have also been discussed. Finally, chapter Five (5) summarizes the findings, gives conclusions of the study and suggestions for further research. A bibliography and appendices are presented at the end of the thesis.

1.12 Chapter Summary

This chapter has conceptualized the problem of the study to the fact that lack of Mathematical Vocabulary Instruction could be one of the main causes of Students poor performance in Mathematics. The purpose of the study was to establish the effects of Mathematics Vocabulary Instruction on Students' Performance in Mathematics. Other highlights included the background to the study, statement of the problem, its significance and definition of terms used in the study. The chapter also identifies secondary school pupils to be the main unit of analysis in the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

This chapter reviewed the literature relating to Mathematical vocabulary and Mathematics performance under the following subheadings: mathematical vocabulary, role of mathematical vocabulary in the learning of Mathematics, methods of instruction of mathematical vocabulary and gender differences in Mathematics achievement.

2.1 Mathematical Vocabulary

According to Pimm (1987), Mathematical language has its own vocabulary, which can be roughly divided into three groups. The first group covers the technical terms specific to Mathematics for example, multiplicand, and quadrilateral among others. The next group comprises the technical terms used in Mathematics that also have unrelated everyday meanings with terms such as *volume, product* and *difference.* The last group is the Mathematical use of words adapted from similar everyday meanings. In this category are words such as *similar, face* and area. Mathematical English has several other dimensions, including a specialized syntax, for example the use of words like *and, a,* or *if*; use of symbols (e.g., 3-D); ways of talking and writing (e.g., word problems, writing a solution, giving an explanation; and social factors (e.g., the use of ‘we’ to refer to people who do Mathematics, as in “We call that a pentagon.” (Secada, 1991 & 1992).

Adams, Thangata and King (2005) have reported on research highlighting the complexity of working with words used in Mathematics that have multiple meaning. Mathematical language includes many words that sounds the same as words with other meanings (for homophone), and many words that have the same spelling as everyday words but have different meanings as mathematical terms. Table 2.0 provides examples of some of these words.

Table 2.0 Mathematical words and Homophonic Partner

Mathematical term	Homophonic Partner
Arc	Ark
Chord	Cord
Mode	Moved
Pi	Pie
Plane	Plain
Serial	Cereal
Fine	Sign
Sum	Some

Source: Adapted from Adams, Thangata & King (2005)

Another complication is the multiple of different words used for one operation. Taking *subtraction* as an example, the common words used include minus, *take* *away* and *subtract*. But there are others like *difference between, less, reduce, remove, decrease, discount, take off* and various other phrases that call for the use of subtraction (Pimm, 1997).

Mathematics uses many words in the English language that are already familiar to students in their everyday lives. Words such as ‘change’ have a specific mathematical meaning, but also have an everyday meaning. When used in mathematics classrooms they are often ambiguous. Some other examples are provided in Table 2.1. Students need to be taught new meanings for these already similar words.

Table 2.1 Mathematical Words and their Everyday Usage

Mathematical term	Everyday usage
Angle	Point of view
Concrete	Hard substance used in paving
Figure	Shape of an object
Odd	Strange
Order	Place a request
Rational	Same
Volume	Sound level

Source: Adapted from Adams, Thangata & King (2005)

Marzano (2001) notes that there are three main types of questions associated with mathematical word problems. The first types of questions are the *change* *questions* in which there is an event that alters the value of a quantity. The second types of questions are the *combine questions* which relate to static situations where there are two amounts. These are considered either as separate entities or in relation to each other. The last types of questions are the *comparison questions*. These questions involve the comparison of two amounts and the difference between them. The problem with these types of questions is their semantic structure. This study assumed that the difficulties in these types of questions are likely to affect students' understanding of mathematical concepts and eventually their achievement in Mathematics.

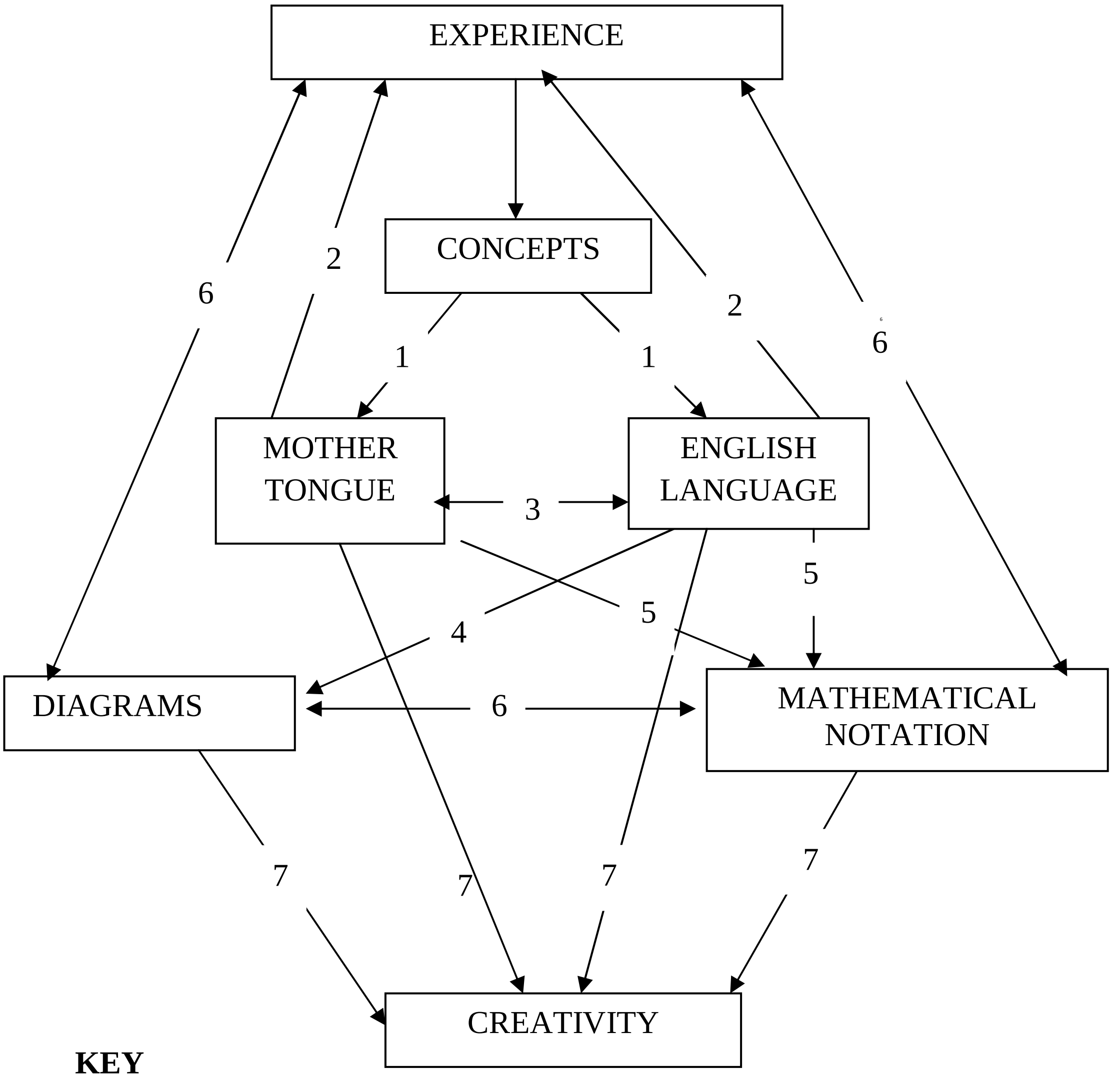
2.2 The Role of Mathematical Vocabulary in the Learning of Mathematics

Perhaps more than any other subject, teaching and learning Mathematics depends on language. Mathematics is about relationships: relationships between numbers, between categories, between geometric forms and between variables. In general, these relationships are abstract in nature and can only be brought into being through language. Even Mathematical symbols must be interpreted linguistically. Thus, while Mathematics is often seen as language free, in many ways learning Mathematics fundamentally depends on language. For students still developing their proficiency in the language of the classroom, the challenge is considerable. Indeed research has shown that, while many ESL students are quickly able to quickly develop a basic level of "conversational" English, it takes several years to develop more specialized "academic" English to the same level as a native speaker. If the learners of ESL are to succeed in

Mathematics, they need to become proficient in all dimensions of Mathematical English, since to some extent the structure of Mathematics is reflected in the structure of its language.

The interest in the relationship between language and learning in general is not new. Some theorists (e.g., Whorf, 1956) have suggested that language determines and defines thought. Others (e.g., Piaget, 1952; Vygotsky, 1962) have tended to accept only a limited effect of language on thought, stressing the role of prior cognitive learning in language development and the shifting meanings of words as concepts continue to develop. Although researchers have long recognized the vital role that language plays in Mathematics performance (Aiken, 1972), they have not always acknowledged its role equally important in the process of acquiring mathematical concepts and skills.

Linguists use the term language register to refer to the meanings that serve a particular function in the language, as well as the words and structures that convey those meanings. A Mathematics register, therefore, can be defined as the meanings belonging to the natural language used in Mathematics. A Mathematics register is more precise than the natural language itself because the meanings of the terms are much narrower in scope. Mathematical terms give rise to "an almost totally non-redundant and relatively unambiguous language" (Brunner, 1976, p. 209). Halliday (1975) suggested that a Mathematics register comprises of four components. The first component is one where the natural language words are re–interpreted in the context of Mathematics, *such as set, point, field, column, sum, even (number) and random*. The second component consists of technical terms such as *square on the hypotenuse* and *least common multiple*. The third component involves the terms created from combinations of natural language words, such as *feedback* and *output*. The final component consists of the terms formed from combining elements of Greek and Latin words, such as *parabola, denominator, coefficient,* and *asymptotic.* In addition to vocabulary, a Mathematics register also includes styles of meaning and ways of presenting arguments within the context of Mathematics. These processes require new structures, which are most often borrowed from specialized forms in the natural language. Examples of expressions adapted from English include: "*the area under the given curve",* "*the sum of the first terms of the sequence".* Clark (1975) proposed a model (Figure 2.1) for representing the different roles that language might play in the teaching and learning of Mathematics.



KEY

1. Representation, definition, creation 2. Discussion, instruction 3. Translation

4. Description, discussion 5. Verbalization 6. Representation 7.Validation

Figure 2.1: A Model for Considering the Role of Mathematical vocabulary in Mathematical Activity

Source: Adopted from"Some Aspects of Psycholinguistics" by R. Clark (1975). In E. Jacobsen (Ed.), Interactions between Linguistics and Mathematical Education: Final Report of the Symposium Sponsored by UNESCO, CEDO and ICMI, Nairobi, Kenya, September 1 -1 1, 1974 (UNESCO Report No. ED-74/CONF.808), p. 80.

In the above model, concepts are viewed as a result of the learner's experience, with language facilitating the learners conceptual development thought discussion and instruction. These activities might take place in the learner's mother tongue or in a second language like English. Language is also applied to the content of mathematics in the representation of experience graphically through diagrams and by means of Mathematical notation (symbols).

The diagrams might be given a description or discussion, and the notation might yield a verbalization. In the model, Clark (1975, p.81) includes creative processes (inspiration) that may or may not make use of verbal, spatial or notational imagery. The model suggests a variety of the roles language plays in Mathematics instruction. Language, then, has a number of different uses in Mathematics. It represents concepts, describes experiences, describes and discusses diagrams, verbalizes mathematical notation, defines new concepts for the learner, creates through logical deduction, concepts which are new to everybody and checks validity of creative intuitions. Different linguistic activities serve different purposes when mathematical concepts and skills are being acquired. Students require considerable proficiency in both their first and second languages if they are to cope with the range of linguistic activities required for Mathematics.

2.3. Methods of Teaching Mathematical Vocabulary

According to Chall (1987), there are two general methods for teaching vocabulary: Direct teaching and Meaningful Context. Direct teaching of selected vocabulary has been advocated for many years (Readence & Rickelman, 1989; Klein, 1988; Vacca & Vacca, 1996). Direct teaching of vocabulary guides students to assign deeper meaning to words. The method commonly used by teachers who teach vocabulary directly is the definition-only method (Naggy, 1988). In this instruction, students typically look up the word in the dictionary or are told its definition, write meaning of the word, and memorize it. According to Irvin (1990), this method is ineffective because it leads to minimal understanding. In contrast to the definition-only method, which leads to surface understanding only, some direct methods can be effective in helping students assign deeper meaning to words. According to Moore & Readance (1984) and Dunston (1992), the graphic organizer may be one of the more promising approaches. A graphic organizer represents concepts and their relationships visually. Meaningful contexts involve providing children with a foundation of meaningful experiences from which they can negotiate understanding of words from contexts (Chall, 1987). Children learn words in a school setting by observing how the words are used in intelligible contexts. Mathematics instruction that encourages appropriate teacher and student communication provide contexts for learning the language of Mathematics (NCTM, 1990). As helpful as the use of context can be in developing Mathematical vocabulary, it is usually not sufficient. Students may not be able to select and organize the information needed to develop meaning or the context may not be rich enough to provide the necessary information (Naggy, 1988).

Neither context nor direct teaching alone is sufficient for developing meaningful Mathematical vocabulary, but, when combined, the two can be complementary. Monroe & Pendergrass (1997) carried a study on the combined approach. In a learning context emphasized student construction of meaning, the teacher provided opportunities for learners to learn to represent, discuss, read, write and listen to Mathematics. Once students had some experiences with a concept, the teacher taught vocabulary directly using graphic organizer to help access and organize newly acquired knowledge. The graphic organizer also provided a structure for guiding students to extend relationships among concepts. In conclusion, approaches that combine meaningful context and direct teaching through the use of graphic organizer were used in the current study in teaching mathematical vocabulary. The method employed was the Frayer Model with ICT integration.

2.4 The Frayer Model

The Frayer model was designed by Dorothy Frayer (1969) and her colleagues at the University of Wisconsin USA. The Frayer model, also known as a *word map*, is a strategy designed to help students understand relationships and similarities between concepts (Clark, 2007). This strategy uses a graphic organizer to help students understand a concept and recognize similarities and differences between that concept and other concepts being discussed. The framework of Frayer model consists of; the concept word, its definition, characteristics word, the examples and non-examples of concept word. This strategy provides students with the opportunity to understand what a concept is and what it is not in the context within which it is presented. It gives students an opportunity to demonstrate their understanding and to construct meaning by providing examples and non-examples from the text or even from their own lives and experiences (Doty, Cameron & Barton, 2003).

The Frayer model is a graphic organizer used for concept development and vocabulary building. This model requires students to think about a concept and describe it. The model is designed to have students analyze a concept, synthesize the concept, and apply the information. Using the Frayer model is an extremely valuable tool for helping students grasp the meaning and truly understand a new concept. Concept development is the key for understanding the content material (Russell, Waters & Turnet, 2013). The Frayer model provides a graphic organizer that asks students to organize their thinking about a term in four ways; definition, characteristics, examples and non-examples. The definition goes in the top left square, characteristics in the top right square, examples in the bottom left square and non-examples in the bottom right square. The definition should be one the student develops rather than something copied from a dictionary or glossary. The characteristics of the term should be things that are essential. The examples and non-examples help push students' thinking about the term. The structure and thinking processes incorporated in this strategy provides an opportunity for students to build a deep understanding of the term (Roe & Smith, 2012).

The Frayer model is especially useful for teaching vocabularies that describes complex concepts or vocabulary that describes concepts students may already know but cannot yet clearly define. A template of the Frayer model is displayed in Figure 2.2.

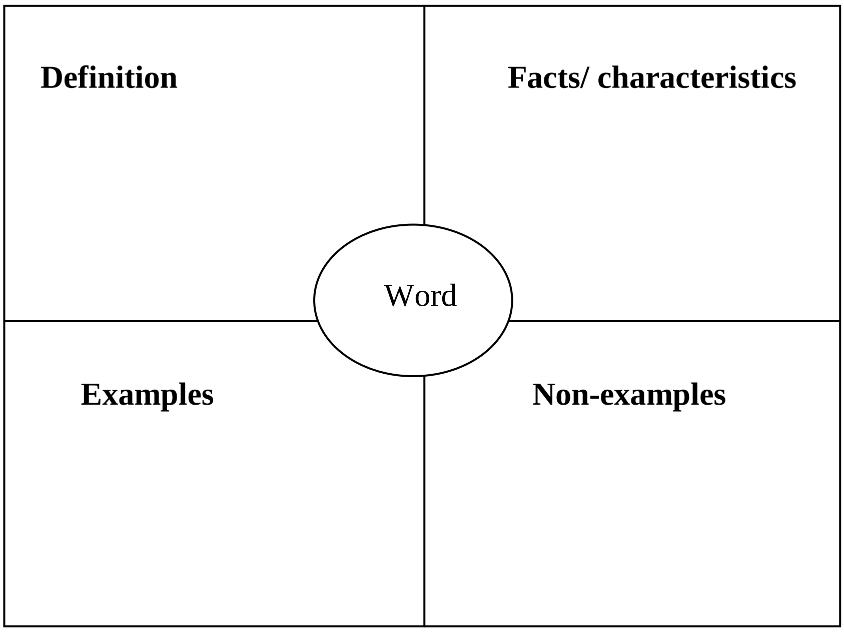


Figure 2.2 A Template of The Frayer Model

Source: Frayer, D., Frederick, W. C., and Klausmeier, H. J. (1969). *A Schema for Testing the Level of Cognitive Mastery*. Madison, WI: Wisconsin Center for Education Research.

It is recommended that when introducing a concept, the teacher should ask questions that require brainstorming, such as "what is a polygon?" or "what is a matrix?" (Marzano, 2001) Students should be actively involved in generating examples and brainstorming in small cooperative groups. This is in line with 21st century pedagogical skills. Students should also be asked to identify key characteristics and examples, as well as non-essential characteristic and non-examples. Naturally, the teacher begins by modeling, using an overhead transparency or by recording suggested concept words or example in the white board. By encouraging student inquiry and by being responsive to student questions, a variety of questions will emerge.

Clark (2007) describes the procedure of using Frayer model in classroom by saying that teacher should first distribute copies of Frayer model graphic organizer. Then, the students would begin by writing the concept at the center. This may be a concept phrase or a single word, depending on the needs of the students and the lesson objective. First, as a class, determine the definition of the concept. Students can use their textbooks or a variety of resources to develop a definition that is clear, concise and easy to understand. Secondly, help students determine the characteristics or attributes of this concept. Finally, determine as a class what the concept is and what it is not. Encourage students to generate their own examples and allow time for students to discuss their findings with the class. Once students are comfortable using this strategy, they can work in small groups, in pairs, or independently to research different concepts relating to the material. Furthermore, Frayer and her colleagues (Greenwood, 2010) originally outlined seven step procedure. These are as follows:

1. Define the new concept, discriminating the attributes relevant to all instances of the concept.
2. Discriminate the relevant from irrelevant properties of the concept.
3. Provide an example of the concept
4. Provide a non-example of the concept
5. Relate the concept to a subordinate concept
6. Relate the concept to a super ordinate concept
7. Relate the concept to a coordinate term

Another version of the procedure in using the Frayer Model to teach vocabulary is by giving each student Frayer Model student page. Explain that Frayer model is a way to help them understand the meaning of concept. In addition, have student formulate a definition in their own words in the top left box of the Frayer model student page. Then have students write some characteristics of inferences in the top right box. Moreover, have students work in pairs to come up with examples and non-examples from their own lives. Encourage them to use their previous experiences as a basis for their examples and non-examples. Finally, the students can present and explain their models to other groups. As they present to each other, informally asses their understanding of the concept and clarify as necessary. In addition, Urquhart &

Frazee (2012) gave another input on how to use Frayer model, the steps are:

1. Assign the concept of word from the text to be studied
2. Explain all of the attributes of Frayer model to be completed.
3. Model for students using the Frayer model with an easy word or concept from a familiar text.
4. Have students work in pairs and complete their model diagram using the assigned concept or word.
5. Once the diagram is completed, have students share their work with other students.

At its simplest, the teacher's explanation in the classroom when teaching vocabulary involves pointing out to the students where the text uses and defines particular terms. Teacher’s definitions might point out pictures, maps, and charts in the text that illustrate the concept involved in particular terms. For some words, actual objects can be used from which students might get term-related multisensory experiences. Though it is the most efficient way to introduce vocabulary, direct teaching might not be an effective method. Students will not always feel the need to listen or look, particularly if the routine of the explanations becomes too tedious and regular. When the teacher uses this approach, presentations of words and definitions need to be varied, exciting, and with reinforced student involvement. This way of teaching vocabulary should be interspersed with other approaches to vocabulary development (Russell, Waters & Turner, 2013). One advantage of this strategy is that, students are active learners and are noticeably highly motivated. Students learn best through active involvement in learning new words (Roe & Smith, 2012). Consequently, students exposed to the Frayer model tend to go far beyond learning mere definitions of words; instead, they develop a far deeper understanding of concepts. As a result the use of the Frayer model increases the students' understanding of new vocabulary, and they show a deeper and more complex understanding of concepts (Cohen & Cowen, 2008). The process of stating a definition, describing characteristics and articulating examples and non-examples helps students develop a deeper understanding of a word than they might achieve from only a definition (Greenwood, 2010).

In a study, Monroe and Pendergrass compared the Frayer model to the definition only model in teaching Mathematics vocabulary. The definition only model involved having students write the definition of a new word after an oral review of the word. The Frayer model outperformed the control group after two weeks of instruction, and led Monroe and Pendergrass to declare that the model is an effective model of teaching vocabulary (Gore, 2004).

2.5 Gender and students achievement in Mathematical vocabulary and Mathematics

Gender is a social construction, it concerns the differing qualities culturally attributed to women and men. The use of the word “gender” not only denotes an emphasis on the social (as opposed to biological) attributes of women and men, but also indicates recognition of the relationship between masculinity and femininity (Hyde, Fennema and Lamon, 1990). In this study, gender was considered in relation to those differences that might be observed or perceived between boys and girls in relation to achievement in Mathematics.

Girls tend to perform better overall in school than boys, but they perform less well than boys in Mathematics. This observation could be interpreted as an issue about girls and Mathematics. In national tests in England taken in year 6 (10-11 years) in 2006, the girls outperformed boys in all subjects except Mathematics (www.dfes.gov.uk). In a meta-analysis of gender differences in Mathematics performance, 51% of the studies showed males scoring higher, 6% showed exactly no difference between males and females, and 43% showed females scoring higher (Hyde, Fennema and Lamon, 1990).

Joffe and Foxman (1986) gave questionnaires to 11-15-year-olds and found interesting gender differences concerning attitudes towards Mathematics. Girls tended to be less confident about their mathematical performance and they underrated themselves, while boys tended to express greater expectations of success. It is expected that, because of their general academic success in school, girls would be more self-confident about their academic abilities and have higher academic self-esteem. On the contrary, girls are more likely to be overly critical in evaluating their own academic performance, whereas boys tend to overestimate their own academic abilities and accomplishments

(Pomerantz *et al*, 2002). Haylock (1984) found that among higher-attaining pupils aged 11 to 12 years, the girls tended to show greater anxiety and a lower self-concept in Mathematics than the boys. High anxiety and low self-concept correlated significantly with lower scores in tests of mathematical creativity. Pound (2006) raises the issue of confidence in relation to younger children learning Mathematics and reports that bright girls may be less resilient learners than boys; in other words, girls may be more inclined to give up in the face of difficulties.

Hyde, Fennema & Lamon (1990), carried out a major meta-analysis of studies on gender differences in Mathematics performance. The analysis found that the effect size of gender differences in Mathematics performance ranged between 0.03 and 0.26 across large samples. Haylock (1984) also found that the girls in his sample were less inclined to take reasonable risks in unfamiliar Mathematics tasks, tended to think in narrower categories and showed more rigidity in their thinking. Some writers note gender differences in Mathematics and stereotypical behaviour appearing in boys and girls in the early years of schooling. Pound (2006: 132), discussing younger children learning Mathematics, claims that 'girls, in particular, may enjoy keeping busy, doing unchallenging but safe activities, which frequently result in praise and rows of ticks.

It appears then that there is some evidence of gender-related differences in relation to achievement in Mathematics, attitudes towards Mathematics and behaviour in mathematical activities. What is not clear is the source of such differences. Young children will pick up views about Mathematics and everything else that happens in school from their parents and from society generally. It may be the case that adults perpetuate an association between Mathematics and those activities perceived as male, or the message is sent out that it is not important whether or not girls are good at Mathematics. It is certainly the case that negative attitudes to Mathematics can be passed on from one generation to another within families (Burnett and Wichman, 1997). Males perform better in problem solving than girls (Neyland, 1994). Perhaps the best explanation for this gender difference is that it is a result of gender difference in course choice. Boys chose careers in engineering and physical science where problem solving is essential to their success. There is also a danger that teachers will treat boys and girls differently in Mathematics classes. This may be done unconsciously because they actually believe that they are innately different or because the teachers themselves are influenced by the norms of the society. Soro (2002) reported that teachers in Finland showed strong beliefs that girls tend to rely on rote learning of routine procedures in Mathematics while boys demand and get more teacher attention. This perception reinforces and sustains these differences in their teaching. Teachers, particularly male teachers, are sometimes observed to be more protective towards girls in the way they deal with pupils' problems and errors in Mathematics. Such behaviour by the teacher could serve to reinforce a non-risk-taking approach to problem solving in girls, while giving the boys the advantages of more opportunities to sort things out for themselves and thereby to construct their own meaning more securely. From the foregoing it can be concluded that the differences between male and female achievement in Mathematics are insignificant (Hyde, Fennema and Lamon, 1990). These differences vary among countries. The differences become more pronounced at high school age. Problem solving is the main area where boys achieve better results than girls. It was a concern of the study to establish the effects of mathematical vocabulary instruction of students' achievement in Mathematics among the gender. In addition the study also explored the differences in the students' performance in Mathematics between boys and girls.

2.6 Critical Review of Related Studies

Sanders (2007) carried out a study on embedded strategies in Mathematics vocabulary instruction. The study focused on the use of keyword mnemonics in Mathematics vocabulary instruction. The study tested for significant differences between groups on a vocabulary assessment and conducted a repeated measures analysis of variance on two levels of instruction; direct instruction versus keyword mnemonic instruction and across three measures of pretest, posttest, and follow-up. Although both groups did show significant improvements, the students who participated in the keyword mnemonic classes outperformed the students in the direct instruction classes as measured on both the posttest and the follow-up test of the vocabulary assessment.

Kranda (2008) carried out an action study to investigate the relationship between fifth grade students' understanding of precise Mathematics vocabulary and student achievement in Mathematics. The study focused on students' understanding of written Mathematics problems and on their ability to use precise Mathematical language in their written solutions of critical thinking problems. It was found out that, with teaching, modeling and ample opportunities to use the language of Mathematics, students understanding and use of specific Mathematical vocabulary increased. However, it was also found out that students' resisted using precise Mathematics vocabulary in writing Mathematical solutions.

Wolf (2013) carried out a study on the effects of elaborative vocabulary instruction on the vocabulary, written explanations, and knowledge structures on 104 sixth grade students of an urban middle school. The study was a two-group quasi-experimental design. The study involved three randomly assigned three experimental treatment groups. These groups were taught 13 target words over a four-week period. The results showed that the elaborative vocabulary instruction had statistically significant effects on the concept map scores favouring the experimental group, but generally showed no significant differences in vocabulary, explanatory writing, and self-efficacy and attitudes.

The findings of the study supported the need for continued investigations in quality vocabulary instruction that impact writing. Specifically, teacher training and support in the area of vocabulary instruction to impact explanatory writing outcomes. McConnel (2008) carried out a study on the influence of vocabulary instruction on 8^{th} grade students' understanding of mathematical concepts. The study found out that knowing the meaning of the vocabulary played a major role in the students' understanding of the daily lessons and their ability to take tests. Understanding the vocabulary and the concepts allowed the students to be successful on their daily assignments, chapter tests and standardized achievement tests. Laurie (2011) carried out a study to explore the effect of direct instruction in Mathematics and science vocabulary instruction on students' achievement. The participants were 114 5^{th} grade public school students in two different mathematics and science classes. Fifty-eight students were in the experimental group while fifty-six were in the control group. The experimental group received direct instruction with mathematics and science vocabulary terms.

Georgious (2003) carried out a study on the impact of direct vocabulary instruction on communication and achievement of 6^{th} grade mathematics students'. The study was carried out over a four-month time period. The study found out the majority of the students improved their overall understanding of mathematical concepts and eventually their achievement in Mathematics. In addition, students were more exact in their communication after receiving vocabulary instruction. Gifford & Gore (2005) carried out a study the effects of focused academic vocabulary instruction on 15 underperforming Mathematics students. The study was carried out in a Tennessee school with 6^{th} grade classes. The study found out the students' Normal Curve Equivalent scores experienced a 93 percent increase above adequate yearly progress.

Another critical study related to the current one was carried out by Monroe & Pendergrass (1997) compare the effects of two models of vocabulary instruction—the integrated graphic organizer and the definition only model on the mathematical vocabulary use of fourth grade students. Two classes of forth graders (N = 58) were selected for the study. Each of the 59 students was randomly assigned to one of the two groups: one group using the definition only model and the other the CD-Frayer model. Knowledge of measurement concepts was assessed through mathematical writing before and after two weeks of instruction. The length of the study was 10 school days. There was a 60- minute period available to teach a lesson, with about 10 minutes lesson of the period allocated for journal writing. A statistically difference was found for the number of concepts with measurement concept between the two groups. The CD-Frayer model class (M = 12.857, SD = 10.543) performed better that the definition only class (M = 8.444, SD =5.989), $\rho < .041$. The difference indicated that the vocabulary instruction using the CD-Frayer model was more effective in increasing student use of mathematical vocabulary. The study also reported that the students receiving the definition-only vocabulary instruction did not enjoy writing definitions or seeing them on the board. Those students taught mathematical vocabulary using the integrated CD-Frayer model appeared to welcome mathematical vocabulary and actively participated in the group discussions. Holding the attention of the class seemed easier when vocabulary discussions were taking place. As Moore & Readence (1984) notes, the teachers who use the graphical organizer to teach content during instruction are likely to feel better prepared and more organized.

In the Kenyan context, the method commonly used by teachers who teach vocabulary is the definition-only method. In this instruction, students typically look up the word in the dictionary or are given its definition, write meaning of the word, and memorize it. This method is ineffective because it leads to minimal or surface understanding only. However, no study has been carried out at least in Murang’a County, Kenya to determine the effects of Mathematical vocabulary on student’s achievement in Mathematics. This formed the basis of the current study. The study used a combined approach of direct and meaningful contexts in the teaching of Mathematical vocabulary and explored its effects on students’ achievement in Mathematics.

2.7 Chapter Summary and Gap Identification

The chapter reviewed literature on mathematical vocabulary, the role of Mathematics vocabulary in learning of Mathematics, methods of teaching mathematical vocabulary and gender differences in achievement in

Mathematics. The complete details of the methodology to be used are fully discussed in next chapter. From the literature reviewed a number of generalizations can be made. First, students are likely to encounter difficulties in the learning of Mathematics if they do not understand the meanings of mathematical vocabulary. Secondly, direct vocabulary instruction has an impressive track record of improving student's backgrounds knowledge and the comprehension of academic content (Marzano, 2001). Direct instruction on words that are critical to new content produces the most powerful learning.

According to Marzano (2001) students should be able to define, pronounce, draw, give examples, use in writing and verbally express mathematical vocabulary. He further points out that systematic vocabulary instruction is one of the most important interventions of enhancing understanding of mathematical words. However, systematic vocabulary instruction is rare in US schools. Direct instruction of Mathematics vocabulary was also identified as the best strategy for enhancing students understanding of mathematical concepts. It was reported that students' achievement would increase by 33 percentile points when vocabulary instruction focus on specific words that are important to what students are learning (Stall and Fairbanks, 1986). The review further identified Frayer model as a suitable strategy for Mathematics vocabulary instruction. This is because the Frayer model is a strategy that helps students understands mathematical vocabulary. It allows students to see what a mathematical word concept is and what it is not. Students also demonstrate their understanding by providing examples and non-examples. This strategy focuses on a graphic organizer that students use in order to understand the meaning of a concept they are learning and distinguish that concept from others they may know or are learning. In the use of this strategy, Marzano (2001) suggests that the vocabulary list should be limited to focus on 5-7 key words for a 3-week topic. The current study adapted this strategy and used only 10 words within the 10 week period of the study.

In an important study, Monroe and Pendergrass (1997) compared the Frayer model to the definition only model in teaching Mathematics vocabulary. The definition only model involved having students write the definition of the new word after an oral review of the word. The Frayer model outperformed the control group after two weeks of instruction, and led Monroe and Pendergrass to declare that the model is an effective model of teaching vocabulary (Gore, 2004). This study was carried out in Britain. The conditions in Britain and Kenya are different. The study used primary school students who use English as their First language. In Kenya, the students learn English as a second language. This is likely to yield different results. The current study was carried out in Kenyan secondary schools. The review did not identify any study carried in Murang'a County or at least in the Kenyan context on the effect of Mathematical vocabulary instruction on students' achievement in Mathematics. It is in the quest to fill this gap that the current study was designed to establish the effects of mathematical vocabulary instruction on students' achievement in Mathematics in secondary schools of Murang'a County, Kenya.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter describes the methodology that was employed in the fulfilment of the research objectives. To this end, the following seven issues are discussed: Research Design, Location of the study, Target Population, Variables, Sample Size and Sampling Techniques, Research Instruments, Data Analysis and Ethical considerations.

3.2 Research Design

A research design refers to the specific methods and procedures applied in a research study to answer a research question (Privitera, 2014). The study used a nonequivalent control group pretest-posttest quasi-experimental design. According to Wiersma & Jurs (2005), a nonequivalent control group pretest-posttest quasi-experimental design is suitable when intact groups of participants are used in an experiment rather than assigning participants at random to experiments treatments. The design involves the use of methods and procedures to make observations in a study that is structured similar to experiments, but the conditions and experiences of participants lack some control because the study lacks random assignment and includes a pre-existing factor. The design was found to be suitable because as Mugenda (2008) notes the administrators in educational institutions do not allow dismantling of the intact classes so as to allow for random assignment.

The study used the intact classes as they were without random assignment. The purpose of this type of study as noted by Goodwin (2005) is to evaluate the effectiveness of some treatment. The study was designed to evaluate the effectiveness of the Frayer Model with ICT integration and definition-only strategies for teaching mathematical vocabulary. According to Privitera (2014), the design is chosen when one want to compare scores before and after treatment in a group that receives treatment and that does not receive the treatment. The study compared the students' scores in Mathematics achievement tests before and after treatment in both the experimental and control groups. The choice of the study was also informed by other studies in the same area. Other researchers who have carried out studies on effectiveness of mathematical vocabulary instructional strategies used this design (Sanders, 2007; Wolf, 2013; Iwankovitsch, 2013). The notational paradigm of the design can be summarized as shown below:

Experimental Group	O_1	X	O_3
....			
Control Group	O_2	(x)	O_4

Key: O_1 and O_2 represent the pre-test observations, X-Treatment, (x) -No treatment, O_3 and O_4 represent post-test observations for the experimental and control groups respectively. The dashed line separating the parallel rows indicates that the experimental and control groups have not been equated by randomization.

Source: **Cohen, Manion and Morrison (2011, p. 323).**

Several reasons informed the choice of the quasi-experimental design. First, it was not possible to assign individual participants to groups randomly. Secondly, to receive permission to include the students of the two county schools in the study, the researcher agreed to keep existing classrooms intact. Third, the entire classrooms, not individual students, were assigned the treatments. Since random assignment was not possible, the studies choose the quasi-experimental design. To minimize the threats of internal validity, every effort was made to include the groups that are as equivalent as possible. In addition, possible effects from the reactive arrangements were minimized (Gay, Mills and Airasian, 2009).

3.2.1 Variables

The main independent variables were the mathematical vocabulary teaching strategies while The Students' performance in Mathematics formed the dependent variables. The main teaching strategies were the Frayer Model with ICT integration for the experimental group while the definition-only for the control group. Specifically, the following were considered the main variables of the study.

a) Student-Related Variables

The students' independent variables included scores in pre-test and post-test Students Mathematical Vocabulary Tests (PRESMVT and POSMVT), Students Mathematics Attitudes Questionnaire (SMAQ) while the pre-test and post-test Students Mathematics Achievement Test (PRESMAT and POSMAT) scores formed the dependent variable.

b) Teacher-Related Variables

The teacher-related variables included gender, training background, qualification (professional and academic) and experience. Others included their ability to help students with Mathematics Vocabulary and various strategies of Mathematics vocabulary instruction.

c) Control Variables

Mathematics performance could be a function of factors such as resources (personnel and teaching aids), school ethos, learners and teachers' attitudes towards the subject, Mathematical vocabulary, English Language proficiency and Mathematical language among others. Since this study intended to establish the effects of mathematical vocabulary instruction on students' Mathematics performance, certain factors were controlled. These factors included teacher's qualifications and Mathematics text books. In order to take care of these factors, only qualified teachers in Mathematics education were involved in the study.

3.2.2 Research Methodology

The study was a quantitative research. This methodology was chosen because the study aimed at determining the relationships between a particular mathematical vocabulary instruction strategy and students' performance in

Mathematics (Cohen, Manion & Morrison, 2011). In addition, the study was guided by null hypotheses to establish the relationship between the variables. The study chose the quantitative methodology because the study used achievement test to measure the performance of learners as a result of the instruction. It was also deductive in nature and aimed at making generalizations (Mugenda, 2003). The study used achievement tests and a questionnaire to collect quantitative data.

3.2.3. Treatment and Control Procedures

The study had two experimental and the control groups, one in each school with a total of 216 students. Before the treatment, all the students in the four groups filled the Students Mathematics Attitude Questionnaire (SMAQ). They then sat for the Pre-test Students Mathematical Vocabulary Test (PRESMVT).

The study involved teaching the control and experimental groups mathematical vocabulary using different strategies. The presentation rate was one word per lesson to a total of ten items for the study similar to the one employed by other research implementation studies (Mastropieri, Sweda and Scruggs, 2000; Sander, 2007).

The two control groups were taught the 10 Mathematics vocabulary words for a period of ten weeks between May and July 2013 using the definition-only strategy (Definition-only method). The other two experimental groups were taught 10 Mathematics vocabulary words for the same period but using the

Frayer Model with ICT integration strategy. The students from all the groups were given The Mathematics Vocabulary Dictionary (SMVD) during the lesson and collected after. Guiding notes for the lesson planning for teaching Mathematical vocabulary were developed by the researcher with collaboration of experts in Mathematical Education from Kenyatta University and CEMASTEA. The lessons for the experimental group were taught in the Computer Laboratory and students were allowed to access the site: http:// www.amathsdictionaryforkids.com in the course of the lesson. The control group was also taught one lesson per week in the computer laboratory but did not access the site. One vocabulary was taught by the trained teachers per lesson per week. The ten (10) vocabularies were taught for 10 weeks. The full schedule is presented in Appendix H.

After the 10 weeks, all the four groups filled the Students Mathematics Attitude Questionnaire (SMAQ). They also sat for the post-test Mathematical Vocabulary Test, POSMVT and the post- test Mathematics achievement test, POSMAT.

3.3 Location of the Study

The study was carried out in two Secondary Schools in Kahuro District, Kiharu Constituency of Murang'a County, Kenya (Appendix N). Kahuro District is among the seven Districts of Murang'a County, Kenya. The schools were purposively chosen. The choice of the two schools was informed by the fact that they are in the same administrative Location, get students from the same catchment area, score almost equal Mean Standard Scores in KCSE, have similar facilities and are accessible in terms of communication. In addition, no similar study has been conducted in the schools regarding effects of Mathematics instruction on students' performance in Mathematics. Moreover, the schools were equipped with ultra-modern computer laboratories where students' of the experimental group could access the maths dictionary by Jenny Eather at www.amathsdictionaryforkids.com.

3.4 Target Population

The target population for the study consisted of all the 98,200 students from all the 257 public secondary schools in Murang'a County (Statistics from County Education Office, Murang'a, 2013). Of the 257 public secondary schools in Murang'a County, 2 were of National Status, 21 County schools and 234 District schools.

3.5 Sampling Techniques and Sample Size

3.5.1 Sampling Techniques

Sampling is the process of selecting a number of individuals in a study in such a way that the individuals selected represent the large group from which they were selected (Mugenda & Mugenda, 2003). The purpose of sampling is to secure a representative group which will enable the researcher to gain information about a population. From the target population, a number of samples were drawn for use in the study. Different sampling techniques were used to select a sample from each.

a) The School Sample

Purposive sampling was used to select the two County secondary schools in Murang'a County, Kahuro District. According to Mugenda (2008, p. 96), purposive sampling is a sampling technique that allows a researcher to use cases that have the required information with respect to the objectives of his/her study. Cases are therefore handpicked because they are informative or possess the required characteristics (Orodho, 2009, p.147). The study was a quasi-experimental design and needed to involve schools with similar demographics; admitted students with the same KCPE marks, had almost the same M.S.S in Mathematics in KCSE for the last five years, drew students from the same catchment area and was equipped with computers with internet connectivity. The researcher consulted the County Director office-Murang'a in 2012. The County schools were purposively chosen since they met the set criteria. The two County schools had a total of two thousand and six (2006) students. The table 3.1 summarizes the demographics of the two schools.

Table 3.1 Participating Schools' Demographics

School	Distribution of school population					KCSE MSS for Mathematics 2008-2012				
	F 1	F2	F 3	F4	Total	2008	2009	2010	2011	2012
Boys	236	216	215	189	856	6.41	6.81	6.85	7.43	7.96
Girls	325	273	278	274	1150	6.27	6.83	6.77	7.21	7.84
Total	**561**	**489**	**493**	**463**	**2006**					

Source: County Director Office, Murang'a, 2013

b) The Students Sample

Simple random sampling technique was used to select two out of the four (4) Form Two (II) classes in the boys' school. Similarly, two out of the five (5) Form Two (II) classes in the girls' school were randomly selected. The names of the various Form Two classes were written down on pieces of paper and two randomly picked without replacement. Census was used in the selection of the participating students. All the fifty four (54) students from each of the classes were involved in the study. A sample of 108 Form Two (II) students from each school was selected for the study giving a total of Two Hundred and Sixteen (216).

Form One (I), Three (III) and Four (IV) students were omitted for various reasons. Form Ones (I) were considered as not adequately exposed to the secondary school Mathematics and English curricula. Four (IV) students were considered to be busy preparing for KCSE examinations and therefore were excluded from the study. The Form Three (III) class was not involved in the study as the administrators in the two participating schools felt that there were potential candidates and were equally preparing for KCSE.

c) The Teachers Sample

Purposive sampling technique was used to select the six (6) participating teachers. They were purposively selected as they were handling the Form Two (II) classes. This method is acceptable in empirical research (Rukangu, 2000). This was because they were regarded as having the required information with respect to the objectives of the study (Mugenda, 2008). They knew the Form Two (II) students in terms of their Mathematics proficiency. In addition, introducing new teachers would have created curiosity and brought the Hawthorne effect (Cohen, Manion and Morrison, 2011). Out of the fifteen (15) Mathematics teachers in the schools, six (6) Mathematics teachers were chosen for the study.

3.5.2 Sample Size

Following the above sampling techniques, a sample size of 216 Form Two (2) students from the two County schools was chosen for the study. The sampling frame is presented in Table 3.1

Table 3.2 Sampling Frame

School Type	Total Number of F2 students	Experimental group	Control group	Total sample
Boys	216	54	54	108
Girls	273	54	54	108
Total	**489**	**108**	**108**	**216**

3.6 Research Instruments

The study employed seven (7) instruments namely: Students Mathematics Attitudes Questionnaire (SMAQ), Pre-test Students' Mathematics Vocabulary Test (PRESMVT), Posttest Students' Mathematics Vocabulary Test (POSMVT), Students' Mathematical Vocabulary Dictionary (SMVD), Pretest Students Mathematics Achievement Test (PRESMAT), Posttest Students Mathematics Achievement Test (POSMAT) and Mathematics Teachers Questionnaire (MTQ) to collect both qualitative and quantitative data.

a) Students Mathematics Attitudes Questionnaire (SMAQ) (APPENDIX A)

The students' Mathematics Attitudes Questionnaire (SMAQ) was adapted from the widely used Mathematics attitudes survey, *the Attitudes towards Mathematics Inventory* (ATMI) by Tapia (1996). It consisted of 40-items assessing student's (1) self- confidence, (2) value, (3) motivation (4) enjoyment as related to Mathematics. The students answered using a five-point Likert

Scale: 1-Strongly disagree, 2- Disagree, 3- Neither agree nor disagree, 4 -Agree, and 5-Strongly agree. This instrument was used to assess the students' attitudes towards Mathematics since as Cote and Levine (2000) noted factors such as motivation and attitude impact on students' achievement. It was used as a pre-test and post-test survey on students' attitude towards Mathematics.

b) Pre-test Students' Mathematics Vocabulary Test (PRESMVT) (APPENDIX B)

It constituted five (5) Mathematical words drawn from Form One Mathematics syllabus. The rigorous procedure outlined below was used to select the five words for the PRESMVT.

In May 2012, each participating teacher received an email explaining the research and requesting assistance in choosing the target vocabulary terms. The teachers were asked to choose problematic words from the 8.4.4 Form One syllabus. The initial suggestions were combined and mailed out again, this time with a rating scale. Teachers rated the difficulty level of each word on a scale of 1-5.

1. Not a problem
2. A small problem
3. Sometimes a problem when used in certain contexts
4. Always a problem
5. and a major difficulty to most of the learners

The teachers also rated the words according to their impact on test success. (1) No impact on test scores (2) small impact on test success (3) some impact on test success (4) big impact on test success (5) a major impact on test success. This depended on their perception of word would influence success rate of a student to get a question right if the word appeared in a question.

The scores from each of these categories were averaged and then both averages were added together to form a composite score. The list for the initial vocabulary is presented in Appendix O. The total score for each word was calculated and the words rank ordered. The teachers then received another email asking for their final input. The most top-scoring words on the final list were removed and others were also removed due to the difficulty in representing in a picture or diagram. The final selection lists of 15 vocabulary terms were emailed to the teachers. They included (1) Product (2) Factors (3) chord (4) polygon (5) degree (6) scale (7) power (8) area (9) integer (10) multiple (11) perimeter (12) capacity (13) ratio (14) angle (15) percentage.

Five were used for the pre-test survey while ten (10) were used for the post-test survey. This included perimeter, percentage, capacity, ration and angle. Students were required to define the word, use the word in a sentence and draw a picture or diagram that visually represents the meaning of the word. Each attracted one mark totaling to fifteen (15) marks.

c) Post-test Students' Mathematical Vocabulary Test (POSMVT) (APPENDIX C)

It constituted ten (10) Mathematical words also drawn from Form One Mathematics syllabus. Students were required to define the word, use the word in a sentence and draw a picture or diagram that visually represents the meaning of the word. Each attracted one mark totaling to thirty (30) marks. It was administered in a staggered manner, each at the end of the day after the lesson for the ten (10) weeks.

d) Pre-test Students' Mathematics Achievement Test (PRESMAT) (APPENDIX D)

The Pre-test Students' Mathematics Achievement Test (PRESMAT) was an achievement test. It aimed at determining students' application of Mathematical vocabulary in answering Mathematical questions. It was newly constructed with some items adapted from KNEC (2008, 2009 & 2010). It consisted of five (5) Mathematical problems applying the five (5) Mathematical Vocabularies of the PRESMVT. A table specification was drawn and the item written following Bloom's levels of cognitive taxonomy. The five questions were from each of the five levels. Each question scored three (3) marks totalling to 15 marks.

e) Post-test Students Mathematics Achievement Test (POSMAT) (APPENDIX E)

The Post-test Students' Mathematics Achievement Test (PRESMAT) was an achievement test. It aimed at determining students' application of

Mathematical vocabulary in answering Mathematical questions. It was newly constructed with some items adapted from KNEC (2008, 2009 & 2010). It consisted of ten (10) Mathematical problems applying the ten (10) Mathematical Vocabularies of the PRESMVT. A table specification was drawn and the item written following Bloom's levels of cognitive taxonomy. There were two questions from each of the five levels. Each question scored three (3) marks totalling to 30 marks. It was administered to the students in a staggered manner, each at the end of the day after the lesson for the ten (10) weeks. Scores of the ten (10) tests were compiled for each student at the end of the 10 (ten) weeks.

f) Mathematics Teachers Questionnaire (MTQ) (APPENDIX F)

This instrument was used to find out the perception of Mathematics teachers as to the relationship between mathematical vocabulary, Mathematics teaching, learning, communication and achievement. It was newly constructed with some items adapted from Rukangu (2000) and Njoroge (2003). This instrument was also used to provide more information about the teachers and curriculum characteristics in relation to mathematical vocabulary instruction and Mathematics achievement. The questionnaires were issued by the researcher after the teachers' training on the study. The ccompleted questionnaires were then collected later at the agreed date and time by the researcher during the monitoring sessions.

g) Mathematical Vocabulary Dictionary (SVD) (APPENDIX G)

It constituted definitions of ten (10) mathematical vocabulary terms that were covered within the entire teaching period of mathematical vocabulary instruction. They were adapted from a Mathematics dictionary by Jenny Eather at www.amathsdictionaryforkids.com. The students referred to the dictionary for the definitions of the ten (10) Mathematics vocabulary words used in the study.

3.6 Pre-testing/ Pilot Study

Piloting was done in order to refine the instruments. The process of refinement was necessary so as to determine the difficulty level of the items in the instruments, check the difficulty of the language used, estimating the time allocation for items and to enhance the validity and reliability of the items.

The drafted instruments were piloted in one County school in the neighbouring Kirinyaga County. They were piloted with twenty (20) randomly selected Form Two students. This number is sufficient in order to discover the major flaws in the questionnaires (Sudman, 1976). The five instruments namely SMAQ, PRESMVT, PRESMAT, POSTSMVT and POSMAT were administered to them Two Form Two (II) Mathematics teachers filled the MTQ. The data collected at that stage were analysed and the results used for appropriate amendment of the instruments. The time to be allocated for the four tests PRESMVT, PRESMAT, POSMVT and POSMAT was also determined. The items in the instruments which did not have any flaws were retained while others were modified.

3.6.1 Validity

Content and construct validity of the research tools were initiated at the design stage. Some of the items used in the study were adapted from Rukangu (2000), Njoroge (2003), KNEC (2008, 2009 & 2010). These strengthened both content and construct validity. This stage was followed by the pilot study whose main purposes were to check the appropriateness of the language used in the tools and to conceptualise them for predictability and reliability. The PRESMVT, POSMVT, PRESMAT and POSMAT were developed with the assistance of an Expert in Educational Psychology at Kenyatta University and the KNEC Mathematics Examiners in 233/1-paper one.

3.6.2 Reliability

Since the Students' Mathematics vocabulary Test (SMVT) and Students' Mathematics Achievement Test (SMAT) items had dichotomous scores with varied levels of difficulty. Their reliability coefficient was determined using Kuder-Richardson (KR-Formula 20) estimates. KR- Formula 20, as an estimate of reliability was appropriate because it required less time than any other method of estimating reliability since it was administered once and it provided the mean of all possible split half coefficients (Gay, 1992:167, Wiersma & Jurs, 2005). The KR-formula 20 used was adapted from Sattler (1988:27)

Thus,

$$r_{tt} = \left[\frac{n}{n-1}\right]\left[\frac{s^2 - \sum pq}{s^2}\right]$$

Where, r_{tt}= reliability estimate

n = number of items on the test

s_t^2=Variance of the total test

p = proportion of the respondents getting an item correct.

q = proportion of the respondents getting an item incorrect

$\sum$pq =sum of the product of p and q for each item.

A reliability coefficient of 0.83 and 0.89 for PRESMVT and PRESMAT respectively were obtained. They were accepted as they were above the recommended 0.8 (Mugenda and Mugenda, 2003). The Students' Mathematics Attitudes Questionnaire (SMAQ) was adopted from and reliability of this instrument was recorded as 0.96 (Tapia and Marsh, 2004).

The reliability of the non-dichotomous score tool, MTQ was determined using the Cronbach coefficient formula adapted from Sattler (1988, p, 27): $r_{tt} = \left[\frac{n}{n-1}\right]\left[\frac{s^2 - \sum pq}{s^2}\right]$ Where, n and s_t^2 are as defined above, r_{tt} = coefficient alpha reliability estimate and $\sum s_i^2$ = Sum of variance of individual items. The MTQ had a reliability of 0.81 and was also accepted. In order to ensure the appropriateness of the MTQ questionnaire, pre-testing was done in one County School in Kirinyaga County. One Mathematics teacher was given the MTQ to complete in order to discover the major flaws. The revised instruments were then administered to the sample respondents in the main study.

3.7 Training of Participating Teachers

All participating teachers attended a training session at their schools. This session which lasted approximately an hour took place during their planning time or after school hours. All teachers received the same information on the importance of mathematics vocabulary in relation to student's achievement in Mathematics along a packet of all project materials. The teachers received an explanation of the project materials. The materials included the PRESMVT, PRESMAT, SMVD, SMAQ, POSMVT, POSMVT, manila papers, felt pens, lesson plan books and consent forms. Also included was a detailed project schedule to ensure all teachers presented the words and assessment on the same day. The teachers of the control group returned to their classroom while the teachers in the experimental group received explanation on how to do the lesson plan on the vocabularies, how to use graphic organizers and how to access the Mathematics dictionary at http://www.amathsdisctionaryforkids.com in their computers and use it.

3.8 Data Collection Procedures

Piloting of the instruments was done immediately after authority was granted by the Board of Post-Graduate Studies of Kenyatta University. This helped to carry out Actual administration of the experiment which took the following steps.

Step 1: It involved the Administration of the Students Mathematics Attitude Questionnaire (SMAQ) to the 216 Form Two (II) students. This was followed by the pre-testing of the 216 Form Two (II) students on understanding of Form Two (II) Mathematics vocabulary words derived from Form one syllabus. It involved administration of PRESMVT. This was carried out by the teachers.

Step 2: It involved the teaching of Mathematics vocabulary by the teachers using the Frayer Model with ICT integration to the experimental group for a period of ten (10) weeks. The Mathematics Vocabulary Dictionary (SMVD) was availed to the students during the lesson and collected after. Guiding notes for the Lesson planning for teaching Mathematical vocabulary were developed by the teachers of the Experimental groups. The notes were developed by the researcher in collaboration with experts in Mathematical Education from Kenyatta University and CEMASTEA. The lessons for the experimental group were taught in the Computer Laboratory and students were allowed to access the site: http:// www.amathsdictionaryforkids.com in the course of the lesson. The control group was also taught one lesson per week in the computer laboratory but did not access the site. One vocabulary word was taught by the trained teachers per lesson per week. The ten (10) vocabulary words were taught for 10 weeks. The full schedule is presented in Appendix H.

Step 3: It involved Post-testing students on knowledge of Form One (I) Mathematics vocabulary words and their associated application. The POSMVT and POSMAT for the vocabulary were administered for 5 minutes after 4.30pm on the material day the experimental group was taught.

Step 4: It involved the administration of the Students' Mathematics Attitudes Questionnaire (SMAQ) again to both Control and Experimental groups.

Step5: On completion of the study, the researcher debriefed the participants. The participants were thanked for their participation and cooperation. The purpose of the study was explained again. The researcher also answered questions that the participants raised. Finally, the participants were told that the results of the study would be available by February 2015 at Kenyatta University Post modern library, Nairobi-Kenya.

3.9 Methods of Data Analysis

The data collected underwent various stages of preparation before the analysis using the Statistical Package for Social Sciences (SPSS) computer software. First, the data were edited and coded. A code book was then used to prepare computer code sheet, which was later used to synthesize the data. Upon completion of data entry, the data was cleaned to detect and remove any errors committed during data entry. Simple frequency analyses on the variables were run and random cross-tabulation done to clean the data.

Data germane to the study was both quantitative and qualitative. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) Version 21.0. Quantitative analysis involved presentation of statistical data in form of frequency distribution tables whose explanation was mainly descriptive and inferential statistics. The statistical significance of the results was then examined at $\alpha = 0.05$ statistical confidence level. Quantitative data was analyzed using Pearson product moment correlation coefficient, independent t-test, paired-t-test and 2-way ANOVA.

Pearson product moment correlation coefficient was used to determine the relationship between student's scores in Mathematics vocabulary test and Mathematics achievement test. Student's t-test was used to compare significantly the means in student's performance of both the students'. Mathematical vocabulary test (SMVT) and the students Mathematical achievement test (SMAT). It was used to compare whether there is any significant difference in the means obtained in the scores of the PRESMVT and PRESMAT in both control and experimental groups. It was also used to compare students mean score in the pre-SMVT control and experimental groups, pre-SMAT for control and experimental groups, post SMVT for control and experimental groups and post-SMAT for control and experimental groups. It was also used to compare the students' mean scores between the English Language Proficient group and Non-English Language Proficient groups. Paired t-test was used to establish if there were any significant differences in students' change towards Mathematics due to Mathematical vocabulary instruction using the Frayer Model.

Effect sizes (*r*) were calculated using the following formulas adapted from Rosnow & Rosenthal (1996).

$$r = \sqrt{\frac{F\ (1, -)}{F\ (1, -) + d_f}}$$

F (1, _) = ratio for the effect

$$r = \sqrt{\frac{t^2}{t^2 + d_f}}$$

t = *t* value,

df= degrees of freedom

Qualitative analysis considered the inferences that were made from the opinion of the respondents. This analysis was presented in narrative form and where possible tabular form. The lesson plans used by teachers of the experimental groups in the Mathematical vocabulary instruction were analysed and a prototype for teaching Mathematical vocabulary was developed.

3.10 Logistical and Ethical Considerations

A permit was sought from National Council of Science Technology and Innovation (NACOSTI) (Appendix M) after approval to carry out research was authorised by the Board of Post Graduate Studies and the Ethics Board of Kenyatta University. The County Director of Education and the County Commissioner in Murang'a County were also informed about the study and granted permission to visit the study sites. Permission was also sought from the principal before involving students and teachers. The consent of the respondents was also sought before participating in the study. The participants in the study were assured that the information they gave would be treated with outermost confidentiality and only for the purposes of the study. A number of measures were undertaken to ensure both the experimental and control were not disadvantaged. First, the experimental group was exposed to the treatment during the last lesson once every Wednesday for 12 weeks. Secondly, the administration of the achievement tests was done after the classes at 4.00Pm. Finally, the teachers agreed to expose the control group to the treatment in subsequent term after the study.

3.11 Chapter Summary

This chapter described the research design, locale, sample and sample techniques, construction of research instruments, procedures for materials development and administration of the instruments. It also described the reliability and validity of the research instruments and the ethical consideration for the study. The next chapter describes the methods of data analysis, presentation, interpretation and discussion of research findings.

CHAPTER FOUR

PRESENTATION OF FINDINGS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This study focused on the effect of Mathematical vocabulary instruction on students' achievement in Mathematics in secondary schools in Murang'a County, Kenya. This chapter presents, interprets and discusses the findings generated from this study and from other related studies. The study was guided by four research objectives. The first objective was to determine the extent to which mathematical vocabulary instruction influence students' performance in Mathematics. The second objective was to establish the strategies used that influence students' mastery of Mathematical vocabulary. The third objective was to develop a prototype lesson plan for Mathematical vocabulary based instruction. The last objective was to establish the influence of Mathematical vocabulary instruction on students' attitude change towards Mathematics.

In order to achieve the above objectives, the study was guided by five hypotheses. The first hypothesis was that there was no association between mathematical vocabulary instruction and students' performance in Mathematics. The second hypothesis was that there was no significant difference between means scores on vocabulary assessments for students taught Mathematics vocabulary using the Frayer Model and those taught Mathematical vocabulary using the definition-only method. Next was that there was there was no significant difference between students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer Model and those taught mathematical vocabulary using the definition-only method. The fourth hypothesis was that there was no significant difference between students' performance in Mathematics for students English Language proficient group and non-English Language proficient group. Finally, the last hypothesis was that there was no significance difference in the students' attitudes toward Mathematics between students taught Mathematics vocabulary using the Frayer Model and those taught mathematical vocabulary using the definition-only method.

For systematic presentation of the findings, the chapter presents them in the following order:- extent to which mathematical vocabulary influence students' performance in mathematics; strategies used that influence students' mastery of mathematical vocabulary; Development of a prototype lesson for mathematics vocabulary instruction; Influence of mathematical vocabulary instruction on students' attitude change towards mathematics; discussion of results and chapter summary.

4.2 Extent to which Mathematical vocabulary influence students' performance in Mathematics

The first objective of the study was to determine the extent to which mathematical vocabulary influence students' performance in Mathematics. To this end, this section presents the analysis of data obtained from the student mathematical vocabulary tests both in the pre-test (PRESMVT) and post–test (POSMVT) and the students' performance in Mathematics achievement in pre-test (PRESMAT) and post-test (POSMAT).

4.2.1 Students' performance in Mathematics Vocabulary Test before Intervention

In order to address the issues of internal validity in terms of Mathematical ability of the student and teacher knowledge, a pre-test of PRESMVT was administered to 216 students, 108 boys and 108 girls. The result are presented in Table 4.1

Table 4.1 Students' Performance in the Pre-test, PRESMVT by Gender

Gender	n	*M*	*S. D*	S.E of Mean
Boys	108	7.45	3.634	0.350
Girls	108	8.50	2.943	0.283

Table 4.1 shows that the girls performed better (*M* = 8.50, *S.D* = 2.943) than the boys (*M* = 7.45, *S.D* = 3.634) in the pre-test Mathematics vocabulary test.

In order to test whether there was a statistically significant difference between the students' gender and performance in Mathematics vocabulary for the pre-test Vocabulary test, PRESMVT, a *t* test was computed using SPSS Program. The results are presented in Table 4.2

Table 4.2 Comparison of the students' performance in the Pre-test Mathematics Vocabulary test (PRESMVT) between gender

	Levene's test for equality of variance		*t* test for equality of means					95% confidence interval of the difference	
	F	**Sig.**	***t***	**df**	**Sig (2-tailed)**	**S.E Difference**	**Mean Difference**	**Lower**	**Upper**
Equal variance assumed	7.638	.006	-2.325	214	.021	.450	-1.046	-1.933	-.159
Equal variances not assumed			-2.325	205.15	.021	.450	-1.046	-1.933	-.159

Table 4.2 shows that the Levene's test revealed that the variances of the groups are unequal, F = 7.638, *p* = .006. An equal variance not assumed *t* test revealed a statistically reliable difference in the mean score of PRESMVT between girls (*M* = 8.50, *S.D* = 2.943) and boys (*M* = 7.45, *S.D* = 3.634), absolute *t* (205.157) = 2.325, *p* =.021, α =.05. Thus the study concluded that there was significant difference between gender of student and performance in Mathematics terminology. The girls performed significantly higher than the boys. This could

be attributed to the fact that girls have greater brain activity in comparison to boys when completing word meaning tasks (Berninger *et al* 2008). These results agree with those obtained by Njoroge (2003). This implies that boys should be taught in simplified and appropriate mathematical vocabulary in order to post better results in Mathematics examinations. The study was also interested in establishing the performance of students in the pre-test mathematical vocabulary test between the control and experimental groups. The results are presented in Table 4.3.

Table 4.3 Students' performance in the pre-test mathematical vocabulary test, PRESMVT between experimental and control groups

Group	**n**	***M***	***SD***	**Std error**	**95% confidence interval for mean**	
					Lower Bound	**Upper Bound**
Boys Control	54	7.83	3.479	.473	6.88	8.78
Boys Experimental	54	7.07	3.776	.514	6.04	8.10
Girls Control	54	8.48	3.243	.441	7.60	9.37
Girls Experimental	54	8.52	3.640	.359	7.80	9.24
Total	**216**	**7.98**	**3.340**	**.227**	**7.53**	**8.42**

From Table 4.3, it can be noted that the boys control group performed better (*M* = 7.83, *S.D* = 3.479) that the boys' experimental group (*M* = 7.07, SD = 3.776). The table also shows that the girls' experimental group (*M* = 8.52, *S.D*=2.640) performed better than the girls' experimental group (*M* = 8.48, *S.D* = 3.243). In order to test whether there were any significant difference between the control and experimental groups, ANOVA was computed using SPSS program. The results are presented in Table 4.4

Table 4.4 Comparison of the students' performance in the pre-test Vocabulary test, PRESMVT between the Control and Experimental Groups

Source	SS	df	M.S	F	Sig.
Between groups	74.718	3	24.906	.081	10.963
Within groups	2324.167	212	2.272		
Total	**2398.884**	**215**			

Table 4.4 shows there was no any statistically significant mean difference in performance of PRESMVT between the control and the experimental groups, F (3,212) = 2.272, ρ = .081, α = .05. The study thus concluded that the experimental and control groups were homogenous in terms of performance in mathematical Vocabulary. This helped to address the question of internal validity; both groups were of similar ability at the beginning of the study.

4.2.2 Students' performance in Mathematics Achievement test before Intervention

The pre-test students' Mathematical achievement test, PRESMAT was administered to 216 students, 108 girls and 108 boys. The results are tabulated in Table 4.5

Table 4.5 Students performance in the PRESMAT by Gender

Gender	**n**	***M***	***S.D***	**Std Error Mean**
Boys	108	5.65	3.166	.291
Girls	108	5.79	2.316	.223

Table 4.5 shows that the girls performed better (*M* = 5.79, *S.D* = 2.316) than the boys (*M* = 5.65, *S.D* = 3.166) in the PRESMAT. In order to test whether there was a statistically significant difference between the students' gender and performance in pre-test Mathematics achievement test, PRESMAT, a *t* test was computed using SPSS Program. The results are presented in Table 4.6.

Table 4.6 Comparison of Students' performance in the pre-test Students Mathematics Achievement Test (PRESMAT) by gender

	Levene's test for equality of variances		*t* test for equality of means					95% confidence interval for mean	
	F	**Sig.**	**n**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**S.E Difference**	**Lower**	**Upper**
Equal variances assumed	15.196	.000	-.379	214	.705	-.139	.366	-.861	.583
Equal variances not assumed			-.379	200.49	.705	-.139	.366	-.861	.583

From Table 4.6, the Levene's test shows that variances between the two groups is unequal, F = 15.196, p < .0005. An equal variance not assumed *t* test failed to reveal a statistically significant difference in the mean scores of PRESMAT for the control groups between girls *(M* = 5.79, *S.D* = 2.316) and boys (*M* = 5.65, *S.D* = 3.166), absolute *t* (200.491) = .379, ρ = .705, α = .05. It was therefore concluded that there was no significant mean difference in the performance of Mathematics between the boys and girls in the pre-test Students Mathematics achievement test. This indeed confirmed the homogeneity of the groups before the study.

The study was also interested in determining the homogeneity of the control and experimental groups in their performance of the PRESMAT. Table 4.7 shows the mean scores in the PRESMAT by groups.

Table 4.7 Means Scores in the PRESMAT by Groups

Group	n	*M*	*S.D*	Std error	95% confidence interval for mean	
					Lower Bound	Upper Bound
Boys Control	54	6.02	2.789	.381	5.25	6.78
Boys Experimental	54	5.28	3.212	.437	4.40	6.46
Girls Control	54	5.78	2.508	.341	5.09	6.15
Girls Experimental	54	5.80	2.131	.290	5.21	6.38
Total	**216**	**5.72**	**2.687**	**.536**	**5.36**	**6.08**

From Table 4.7, it can be observed that the Boys' control group (*M* = 6.02, *S.D* = 2.789) performed better than the boys' experimental group (*M* = 5.28, *S.D* = 3.212). The table also shows that, girls' experimental group performed better (*M* = 5.80, *S.D* = 2.131) than the girls' experimental group (*M* = 5.78, *S.D* = 2.508).

In order to test whether there was any significant difference between the control and experimental groups; ANOVA was computed using the SPSS program. The results are presented in Table 4.8

Table 4.8 ANOVA of Performance in PRESMAT

Source	SS	df	M.S	F	Sig.
Between groups	15.866	3	5.289	.730	.535
Within groups	1535.907	212	7.245		
Total	**1551.773**	**215**			

Table 4.8 shows that there was no statistically significant mean difference in the student performance in the PRESMAT between the control and experimental groups, F (3,212) = .730, p = .535, α = .05. The study thus concluded that the experimental and control groups were homogenous in terms of performance in Mathematics test, PRESMAT. This helped to address the question of internal validity; both groups were of similar ability at the beginning of the study.

4.2.3 Correlation between Students' Level of Mathematics Vocabulary and Level of Mathematics achievement Before Intervention

The study was also set to establish the relationship between Mathematics vocabulary and students' achievement in Mathematics. The students' scores in the PRESMVT and the PRESMAT were correlated. The results are tabulated in table 4.9

Table 4.9 Correlation between pre-test Mathematics Vocabulary test, PRESMVT and pre-test Mathematics Achievement test, PRESMAT

		Pre-SMVT	Pre-SMAT
Pre-SMVT	Pearson correlation	1	.373**
	Sig.		.000
	n	216	216
Pre-SMAT	Pearson correlation	.373**	1
	Sig.	.000	
	n	216	216

***Correlation is significant at the 0.01 level (2= tailed)**

Table 4.9 shows a weak positive relationship, r (216) = 0.373, $\rho = .0005$, between scores of mathematical vocabulary and student's performance in Mathematics. This value agrees with that obtained by Njoroge (2003), r = 0.3608, $\rho < .0005$ between mathematical vocabulary and performance in Mathematics. Since r = 0.373, then $r^2 = 0.139129$. This implies that 13.9% of the total variation of Mathematics performance is accounted for by mathematical vocabulary. This implies mathematical terminologies are a requisite for one to perform well in Mathematics examinations.

4.2.4 Students' Level of Performance in Mathematics Vocabulary after Intervention

The study sought to establish the students' performance in the post test Mathematics achievement test, POSMAT between gender. The results are shown in table 4.10

Table 4.10 Students' Performance in POSMVT between Gender

Gender	n	*M*	*S.D*	Std Error
Boys	108	17.57	8.831	.850
Girls	108	13.22	5.024	.483

Table 4.11, it can be observed that the boys performed better (*M* = 17.57, *S.D* = 8.831) than the girls (*M* = 13.22, *S.D* = 5.024) in the POSMVT. In order to test whether there was any significance difference between mean scores in vocabulary assessment between gender, independent sample *t* test was computed using the SPSS program. The results are presented in Table 4.11

Table 4.11 Independent sample test on Students' performance in the post-test Students' Mathematics Vocabulary Test (POSMVT) between Gender

	Levene's test for equality of		*t* test for equality of means					95% confidence interval for	
	F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	S.E Difference	Lower	Upper
Equal variances assumed	73.422	.000	4.451	214	.000	4.352	.978	2.425	6.279
Equal variances not assumed			4.451	214	.000	4.352	.978	2.425	6.282

Table 4.11 shows that, the Levene's test revealed that the variance between the boys and girls are unequal. An equal variance not assumed *t* test revealed a

statistically significant difference in the mean scores of POSMVT between boys (*M* = 17.57, *S.D* = 8.831) and girls *(M* = 13.22, *S.D* = 5.024), *t* (214) = 4.451, $p < .0005$, $\alpha = .05$. Although girls had performed better in the PRESMVT than the boys (table 4.1), the boys performed better than the girls in the POSMVT. This shows that with proper intervention the boys' performance can equal that of the girls in mathematical vocabulary tests.

The study was also designed to seek whether *there was a statistically significance difference between students' performance in Mathematics vocabulary between the English Language proficient (ELP) group and non-English Language proficient group (NELP).* The results of the students' performance in the POSMAT of the two groups are presented in Table 4.12

Table 4.12 Students' Performance in POSMAT between ELP and NELP

Gender	n	*M*	*S.D*	Std Error Mean
ELP	93	16.34	6.406	.664
NELP	123	19.91	8.210	.740

Key: ELP- English Language Proficient, NELP- Non- English Language proficient

Table 4.12, the English Language proficient group performed better (*M* = 6.04, *S.D* = 6.406) than the non-English Language proficient group (*M* = 14.91, *S.D* = 8.210) in the POSMVT. In order to test whether there was statistically significant mean difference between the two groups, independent sample t-test was computed and the results are presented in Table 4.13

Table 4.13 Independent Sample t Test

	Levene's test for equality of variances		*t* test for equality of means					95% confidence interval for mean	
	F	Sig.	*t*	df	Sig. (2-tailed)	MD	S.E. D	Lower	Upper
Equal variances assumed	12.79	.000	.101	214	.272	1.132	1.029	-.896	3.161
Equal variances not assumed			1.139	213.773	.256	1.132	.995	-.896	3.093

Table 4.13 the Levene's test revealed that the variability in the two groups is unequal, F = 12.797, p < .0005. An equal variances not assumed *t* test failed to reveal any statistically significant difference in the mean scores of the ELP (*M* = 6.04, *S.D* = 6.406) and NELP (*M* = 14.91, *S.D* = 8.210), *t* (214) = 1.139, ρ =.272, α = .05.

The study also sought to establish the students' performance in POSMVT between the experimental and control groups. The results are presented in Table 4.14.

Table 4.14 Students' Performance in the POSMVT between the Experimental and Control Groups

Group	n	*M*	*S.D*	Std error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Boys Control	54	9.98	4.346	.591	8.80	11.17
Girls Control	54	12.63	5.790	.7888	11.05	14.21
Boys Experimental	54	25.17	4.592	.625	23.91	26.42
Girls Experimental	54	13.81	4.089	.556	12.70	14.93
Total	**216**	**15.40**	**7.492**	**.510**	**14.39**	**16.40**

Table 4.14 shows that the boys' experimental group that was taught mathematical vocabulary using the Frayer Model with ICT integration (*M* = 25.17, *S.D* = 4.592) performed better than the control group (*M* = 9.98, *S.D* = 4.346), which was taught using the definition–only method. The table further shows that the girls' experimental group (*M* = 13.81, *S.D* = 5.790) performed better than the girls' control group (*M* = 12.63, *S.D* = 4.346). In order to test whether *there was a significant difference between means scores in mathematical vocabulary assessment for students taught mathematical vocabulary using the Frayer Model and those taught vocabulary using the definition-only method,* ANOVA was computed. The results are shown in Table 4.15.

Table 4.15 ANOVA for Vocabulary assessment test between the experimental and control groups

Source	SS	df	M.S	F	Sig.
Between groups	7286.537	3	2428.846	107.695	.000
Within groups	4781.222	212	22.553		
Total	**12067.759**	**215**			

Table 4.15 shows that the ANOVA revealed statistically that there was a significant reliable difference in the vocabulary assessment means scores of the experimental (*M* = 19.49*, S.D* = 7.158) and the control groups (*M* = 11.31, *S.D* = 5.266), F (3,212) = 107.695, ρ < .0005, α = .05. Therefore the null hypothesis H_0 2< 0 was rejected and the alternative H_2 > 1 was accepted. Thus, the study concluded that *there was a statistically significant difference between the mean scores in Mathematics vocabulary assessment for students taught Mathematical vocabulary using the Frayer Model and those taught through the definition-only method.* This implies that if strategies are employed to teach mathematical vocabulary, students understanding would be enhanced and perhaps better performance in Mathematics would result. The effect size (r) was computed using the formula adapted from Rosenthal and Rosnow (1996). The value (r) obtained was 0.547. This indicated a medium effect size.

Further tests were done using Tukey's H*SD* test. The results of the multiple comparisons in the mean scores of the four groups were as presented in Table 4.16.

Table 4.16 Tukey's HSD Multiple Comparison test in the Mean Scores of the Control and Experimental Groups

(I) Four groups	(J) Four groups	Mean differences (I-J)	SE	Sig.	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Boys Control	Girls control	-2.648*	.914	.021	-5.01	-.28
	Boys Experimental	-15.815*	.914	.000	-17.55	-12.82
	Girls Experimental	-3.833*	.914	.000	-6.20	-1.47
Girls Control	Boys control	2.468*	.914	.021	.28	5.01
	Boys Experimental	-12.537*	.914	.000	-14.90	-10.17
	Girls Experimental	-1.185	.914	.556	-3.55	1.18
Boys Experimental	Boys control	15.185*	.914	.000	12.82	17.55
	Girls control	12.537*	.914	.000	10.17	14.90
	Girls Experimental	11.352*	.914	.000	8.99	13.72
Girls Experimental	Boys control	3.833 *	.914	.000	1.47	6.20
	Girls control	1.815	.914	.566	-1.18	3.55
	Boys Experimental	-11.352*	.914	.000	-13.72	-8.99

***The mean difference is significant at the .05 level**

A Tukey's H*SD* post hoc test revealed that there was a statistically significant mean difference between the mean scores of the POSMVT between the girls control and the boys control groups (ρ =.001), and also between the boys experimental and boys control groups (ρ < .0005). It also revealed that there was a statistically significant mean difference between the girls experimental and the boy's control (ρ < .0005), and also between the boys experimental and girls control and (ρ < .0005). It also revealed that there was a statistically significant mean difference between the boys experimental and girl's experimental groups (ρ < .0005). In addition, it revealed that there was no statistically significant mean difference between the girls control and girls experimental (ρ = .566).

4.2.5 Students' Level of Mathematics Achievement after Intervention

The Post-test Mathematics achievement test had 10 items and each was awarded a maximum of 3 marks totaling to 30 marks. The 216 scripts were marked by two experienced KNEC examiners of KCSE 121/1. The two scores of each student from each examiner were correlated and value of .987 was obtained. This value was high enough and it enhanced the reliability of the scores. Average score was then used in the data analysis. The study was interested in establishing students' Mathematics performance in the POSMAT between gender. The results were as presented in Table 4.17.

Table 4.17 Students' Mathematics Performance in the POSMAT by Gender

Gender	n	*M*	*S.D*	Std Error
Boys	108	8.18	4.795	.461
Girls	108	7.68	3.001	.289

Table 4.17 shows that the boys performed better (*M* = 8.18, *S.D* = 4.795) than the girls (*M* = 7.68, *S.D* = 3.001) in the post-test Mathematics test (POSMVT). In order to test whether there was any statistically significant difference in the mean scores between boys and girls, an independent sample *t*-test was computed and the results are presented in Table 4.18

Table 4.18 Independent Sample t-Test of POSMVT on Gender

	Levene's Test for Equality of Variances		*t* Test For Equality of Means					95% Confidence Interval for Mean	
	F	Sig.	*t*	df	Sig. (2-Tailed	M. D	S.E D	Lower	Upper
Equal variances assumed	15.962	.000	.919	214	.359	.500	.544	-.573	1.573
Equal variances not assumed			.919	179.685	.360	.500	.544	-.574	1.574

Table 4.18 shows that the Levene's revealed that the variances of the two groups are unequal, F= 15.962, $p < .0005$. An equal variances not assumed t-test failed to reveal any statistically significant difference in the mean scores of boys (*M* = 8.18, *S.D* = 4.795) and girls (*M* = 7.68, *S.D* = 3.001), t (179.685) = .919, ρ =.359, α =.05.

The study also sought to establish whether there was any significant difference in the mean scores of the boys and girls control and experimental groups in the performance of the post-test POSMAT. The mean scores of the groups were computed and the results are presented in table 4.19.

Table 4.19 Comparison of the students' performance in the post-test Mathematics Achievement test, POSMAT between the control and experimental groups

Group	**n**	***M***	***S.D***
Boys Control	54	6.78	2.912
Boys Experimental	54	9.57	5.826
Girls Control	54	6.65	2.283
Girls Experimental	54	8.70	3.298
Total	**216**	**7.93**	**3.998**

Table 4.19 shows that the boys' experimental group (*M* = 9.57, *S.D* = 5.826) performed better than the boys control group (*M* = 6.78, *S.D* = 2.912) in the post-test POSMAT. On the other hand, the girls' experimental group with a

mean score (*M* = 8.70, *S.D* = 3.298) performed better than the girls control group (*M* = 6.76, *S.D* = 2.283) in the post-test, POSMAT. The overall mean score, (*M* = 7.87, *S.D* = 3.998), from the maximum score of 30, represents 26.43%. This percentage score is similar to the national trend in KCSE examinations (KNEC, 2010).

This study also sought to establish whether there is any significance difference between students' performance in Mathematics for taught mathematics vocabulary using the Frayer Model with ICT integration (experimental group) and those taught mathematical vocabulary using the definition-only method (control group). An analysis of variance, ANOVA was done for the four groups and the results are presented in table 4.20.

Table 4.20 ANOVA Students' performance in the post-test students Mathematics Achievement test, POSMAT between the control and experimental groups

Source	Sum of squares	df	Mean square	F	Sig.
Between groups	338.704	3	112.901	7.7626	.001
Within groups	3098.111	212	14.614		
Total	**3436.815**	**215**			

Table 4.20 shows that there was a statistically significant difference between the four groups as determined by one-way ANOVA, $F(3,212) = 7.726$, $\rho < .0005$. Since this result was statistically significant, further follow up tests were

performed using Tukey's H*SD* post-hoc test and the results presented in table 4.21.

Table 4.21 Tukey's HSD multiple comparison test of the mean differences between the control and experimental groups

(I) Four groups	(J) Four groups	Mean differences (I-J)	SE	Sig.
Boys control	Girls control	.130	.736	.998
	Boys Experimental	-2.796*	.736	.001
	Girls Experimental	-1.926*	.736	.046
Girls Control	Boys control	-1.30	.736	.998
	Boys Experimental	-2.926*	.736	.001
	Girls Experimental	-2.056*	.736	.029
Boys Experimental	Boys control	2.796*	.736	.001
	Girls control	2.926*	.736	.001
	Girls Experimental	.870	.736	.638
Girls Experimental	Boys control	1.926*	.736	.046
	Girls control	2.056*	.736	.029
	Boys Experimental	-.870	.736	.638

***The mean difference is significant at the .05 level**

A Tukey's H*SD* post hoc test revealed that there was a statistically significant difference between the mean scores of the POSMAT between the boys control and the boys experimental groups (ρ = .001) and also between the girls control and the experimental groups (ρ =.001). It also revealed that there was a statistically significant differences between the boys control and girls experimental groups (ρ = .046) and between girls control and girls experimental groups (ρ = .029) in the performance of POSMAT. In addition, it revealed that there was no statistically significant difference between the boys control and girls control (ρ = .998) and between boys experimental and girls experimental (ρ = .638) groups in the performance of POSMAT.

The findings revealed that the experimental groups outperformed the control groups in the post-test students' mathematics achievement test, POSMAT. The boys' experimental group (*M* = 9.57, *S.D* = 5.826) performed better than the boys control group (*M* = 6.78, *S.D* = 2.912) in POSMAT. A Tukey's H*SD* post hoc test revealed that there was a statistically significant mean difference between the mean scores of the POSMAT between the boys control and the boys experimental groups (ρ = .001). On the other hand, the girls' experimental group (*M* = 8.70, *S.D* = 3.298) outperformed the girls control group (*M* = 6.76, *S.D* = 2.283) in the POSMAT. A Tukey's H*SD* post hoc test revealed that there was a statistically significant mean difference between the mean scores of the POSMAT between the girls control and the experimental groups (ρ =.001). The third hypothesis, H_03, that *there is no significant difference between students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer model and those taught Mathematical vocabulary using the definition-only method* was rejected. The alternative hypothesis, H_3 was accepted. Thus, the study concluded that there was a statistically significance difference between the students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the definition only method. The effect size, r = 0.1875 obtained indicated a small effect size. The study also sought to find out the students' performance in the POSMAT between the ELP and NELP. The result are presented in table 4.22

Table 4.22 Students' English Language Proficiency and their Performance in post-test Mathematics Achievement test, POSMAT

Gender	n	*M*	*S.D*	Std Error Mean
ELP	93	8.80	3.699	.384
NELP	123	7.27	4.103	.370

Key : ELP- English Language proficient, NELP= Non-English Language Proficient

Table 4.22 shows that the English Language proficient group performed better (*M* = 8.80, *S.D* = 3.699) in the POSMAT than the non-English Language proficient group (*M* = 7.27, *S.D* = 4.103). Further test using independent sample t-test were done to establish if there is any significant difference in the student's Mathematics for the English language proficient group and the non-English language proficient group. The results are presented in Table 4.23.

Table 4.23 Independent samples test of POSTMAT on ELP and NELP

	Levene's Test for Equality of Variances		*t*-test For Equality of Means					95% Confidence Interval for Mean	
	F	**Sig.**	***t***	**df**	**Sig. (2-Tailed**	**MD**	**S.E.D**	**Lower**	**Upper**
Equal variances assumed	.405	.525	2.825	214	.005	1.527	.541	.462	2.593
Equal variances not assumed			2.866	207.420	.005	1.527	.533	.477	2.578

Table 4.23 shows that the Levene's test revealed that the variability of the two groups is equal, F = .405, ρ = .525. An equal variances assumed *t* test shows that there was a statistically reliable significant mean difference between ELP and NELP in the performance of POSMAT, t (214) = 2.825, ρ = .005 at α = 0.05. Therefore, the null hypothesis H_0 4 = 0, that *there was no significant difference in the students' Mathematics performance between the English Language proficient group and the non-English language proficient group* was rejected and the alternative accepted. The study therefore concluded that there was a statistically significant mean difference in the students' performance between the English Language proficient Group and the Non-English Language proficient group. The difference can be accounted by the fact that the rubric and items of the post-test Mathematics test, POSMAT needed the proper

comprehension of the English language used. The items were written on English language and the English language proficient groups understood the demands of the items perhaps then enhancing their overall performance in the test. The effect size, $r = .1895$ indicated a small effect size.

4.2.6 Relationship between Students' Level of Mathematics Vocabulary and Level of Mathematics Achievement after Intervention

The study was also designed to establish the relationship between the students' level of Mathematics and Mathematics Achievement after the intervention. In order to achieve this, the students' scores of the Mathematics Vocabulary test, POSMVT and Mathematics Achievement test, POSMAT were correlated. The results are tabulated in Table 4.10

Table 4.24 Correlation between students' scores in Post-test Mathematics Vocabulary Test, POSMVT and Post-test Mathematics Achievement Test, POSMAT

		POSMVT	**POSMAT**
POSMVT	Pearson correlation	1	.457**
	Sign(2-tailed)		.000
	n	216	216
POSMAT	Pearson correlation	.457**	1
	Sig.(2-tailed)	.000	
	n	216	216

***Correlation is significant at the 0.000 (2-tailed**)

From the Table 4.24, it can be observed that Pearson product correlation coefficient r (216) = 0.457, $\rho < 0.0005$, $\alpha = .05$ shows a positive relationship between students' scores in terminologies test and performance in Mathematics test. The value r = 0.457 was found to be significant at $\alpha = 0.05$. Hence the null hypothesis, H_O1, $r < 0$, that *there is no relationship between students' level of mathematical vocabulary and level of mathematics achievement* was rejected and the alternative hypothesis H_1, $r > 0$ was accepted. Thus, it was concluded that there was a positive relationship between students' level of mathematical vocabulary and level of Mathematics achievement. Since r = 0.457, then $r^2 = 0.208849$. This implies that 20.9% of the total variation of students' performance in mathematics can be accounted for by their understanding of mathematical vocabulary. Since there is a positive relationship between students' level of mathematical vocabulary and level of mathematics achievement, Mathematics students should be taught mathematical vocabulary using appropriate strategies. This way, students would be able to read Mathematics texts better, learn and communicate mathematical concepts, understand comprehension questions in assessment and eventually perform better in Mathematics examination. This would help them achieve the secondary school Mathematics objectives as outlined by KIE (2002). They will be able to develop a positive attitude towards learning of Mathematics and communicate Mathematical ideas. Ultimately students would become more informed citizens and more of them would join Mathematics and science related careers. This would in turn lead to research and development, innovation and industrialization as envisaged in Kenya's Vision 2030.

4.2.7 Teachers' Opinions on Effects of Mathematical Vocabulary Instruction on Students' Achievement in Mathematics

A total of six (6) graduate teachers filled the Mathematics Teacher's Questionnaire (MTQ). Two-thirds (67%) of these teachers were males. This can be attributed to the belief some years ago, that Mathematics was viewed as a male domain and girls were encouraged to study and pursue art-related subjects. Thus, only a few girls ended up in Mathematics related careers such as Mathematics teaching. In addition, they were teachers who were professionally trained in Mathematics Education. The participating teachers (n = 6) held varied opinions on the effects of Mathematical vocabulary instruction on students' achievement in Mathematics. The complete results are presented in Table 4.25.

Table 4.25 Teachers' opinions on the effects of Mathematical vocabulary instruction on students' achievement in Mathematics

Statement	Response	n	Percentage
Mathematics vocabulary instruction has effects on Students achievement in Mathematics.	YES	5	83.33
	NO	1	16.67
	Total	**6**	**100**

Table 4.25 shows that, more than ¾ (83%) of the teachers were of the opinion that mathematical Vocabulary instruction had some effects on students' achievement in Mathematics. These instructors were aware that Mathematics learning begins with language, proceeds with language is used in expressing the Mathematical statements and is examined in the same language which contains these words. Therefore Mathematics learning cannot be divorced from understanding of Mathematics vocabulary. Mathematics concepts are communicated and learnt in words.

4.2.8. Learning difficulties in Mathematics posed by lack of mathematical vocabulary

The six (6) participating teachers in the study cited the learning difficulties that the lack of Mathematics vocabulary proficiency may pose to the teaching, learning and students' performance in Mathematics. The results are presented in Table 4.26

Table 4.26 Learning difficulties in Mathematics posed by lack of mathematical vocabulary

	Learning difficulty in Mathematics	n	%
1	Students will not be able to understand Mathematical word problems	6	100
2	Students will fail to verbally express Mathematical concepts	5	83.33
3	Students may not understand what the teacher is teaching class	6	100
4	Students may not achieve Mathematics proficiency	4	66.67
5	Students will not able to read Mathematics textbooks	6	100
6	Students may not be able to understand Mathematics Questions in exams	6	100

Table 4.26 shows that, all the 6 (100%) teachers agreed that the lack of proficiency in mathematical vocabulary instruction may lead to students not been able to understand Mathematics word problems. This will in turn lead to poor performance in the subject. Also, more than ¾ (83%) of the teachers felt that students fail to verbally express Mathematical concepts due to lack of proficiency in Mathematics vocabulary. The world of work today demands presentation of financial reports to various stakeholders. It is therefore imperative to equip learners with the necessary skills to able to learn mathematical vocabulary so they can understand Mathematical concepts and also prepare them for the world of work. All the teachers felt that lack of

proficiency in Mathematical vocabulary may hamper students from reading Mathematics textbooks. This is quite detrimental since Mathematics students need adequate practice to be able to comprehend Mathematical concepts. They also felt that students may not be able to understand Mathematics questions in exams leading to poor performance. The implication here is that students should be equipped with appropriate Mathematical vocabulary. This would enhance their understanding of Mathematical concepts and hence mathematical word problems. It would also improve their readability of Mathematics textbooks and eventually their performance in Mathematics.

4.3 Strategies Used that Influence Students' Mastery of Mathematical Vocabulary

The third objective of the study was to establish the strategies used and how they influence students' mastery of mathematical vocabulary.

4.3.5 Practices involving Mathematics Vocabulary

The six (6) teachers who participated in the study were also required to rate the extent to which the practices, involving Mathematics vocabulary were done. The responses were follows: A – to a very large extent, B– to a large extent, C– not sure, D–to a small extent and E-not all respectively. The results are presented in Table 4.27.

Table 4.27 Teachers' Opinions on Practices that Influence Mastery of Mathematical Vocabulary

	Statement	n	Responses				
			A	B	C	D	E
1	I always determine the Mathematical vocabulary proficiency of my	6	1 16.7%	0 0%	0 0%	4 66.7%	1 16.7%
2	I always teach Mathematical vocabulary by definition only method	6	5 16.7%	1 83.3%	0 0%	0 0%	0 0%
3	I always teach Mathematical vocabulary by both Direct teaching and Meaningful Context methods.	6	0 0%	1 16.7%	0 0%	1 16.7%	4 66.7%
4	I always consider the Mathematical vocabulary proficiency of my learners during the setting of Mathematics items	6	0 0%	1 16.7%	1 16.7%	2 33.3%	2 33.3%
5	Writers of Mathematics textbooks consider Mathematical vocabulary proficiency of learners during writing of books	6	1 16.7%	1 16.7%	2 33.3%	1 16.7%	1 16.7%

Table 4.27 shows that ⅔ (67%) of the teachers only determine to a small extent the Mathematical vocabulary proficiency of their learners before they teach

them. The practice in the Kenyan context is that the teachers do not pre-test their students to determine the level of vocabulary proficiency. Probably this trend should be reversed to enable them enhance vocabulary understanding. This would in turn enhance students understanding of Mathematical concepts. Also, more than ¾ (83%) teach Mathematical vocabulary by definition method. This is only appeals to the surface (Instructional) understanding only which is soon forgotten. Deeper and understanding can be achieved through strategies such as the graphical organizer based on Frayer Model approach.

It can also be observed from Table 4.27 that ⅔ (67%) of the teachers do not at all use a combination of direct teaching and Meaningful Context methods to teach vocabulary. This is because they use the definition method. Also, a small percent $^1/_6$ (17%) of the teachers used the combination method to a large extent. From the same table, it can be noted that $^1/_6$ (17%) did consider to a large extent the mathematical proficiency of their learners when setting examinations. The examinations questions are loaded with Mathematical terminologies that students must understand before solving them. It is imperative to consider the mathematical vocabulary for the learners so that they can be able to read and understand the items in an exam and eventually good performance will result. Further, it can be noted from the table 4.27 that majority $^1/_3$ (33%) of the teachers were not sure whether the Mathematics textbook writers consider the Mathematical Vocabulary proficiency of the readers. The textbooks treats vocabulary casually and do not spare time to give them thorough definitions. In conclusion, the classroom practices aimed at enhancing Mathematical vocabulary are only done to a small extent or not all. Perhaps then if the practices are done the students' poor performance in the subject will be a thing of the past.

4.3.2. Strategies Used that Influence Students' Mastery of Mathematical Vocabulary

The study also sought to establish the strategies that can be used to enhance the mastery of Mathematics vocabulary in the classroom. The six teachers involved in the study enumerated a number of strategies as tabulated in Table 4.28.

Table 4.28 Strategies Used That Influence Mastery of Mathematics Vocabulary

	Strategy	**n**	**%**
1	Using synonyms for simple words	6	100
2	Integrate the four language modes: Listening, speaking, reading, writing into Mathematics classroom	4	66.67
3	Using illustrations, discussions, arguing and reasoning	3	50
4	Breaking difficult words into more understandable segments	4	66.67
5	Teaching mathematical vocabulary and language structures daily	6	100
6	Teach students strategies to learn and study new vocabulary	6	100
7	Use technology in the teaching and learning of Mathematics Vocabulary	6	100
8	Talk aloud while solving problems on the chalkboard	3	50
9	Simplify speech in the classroom	6	100
10	Demonstrating whenever possible in ways that supplement spoken or written instructions	6	100
11	Using graphic organizers based on Frayer Model	6	100

Table 4.28 shows that teachers are aware of effective strategies for the teaching and learning of mathematical vocabulary. All the six teachers (100%) cited the use of synonyms for important words as a good strategy. For example the word difference can have synonyms such as *less than, reduce or decreased.* It can be represented in a graphical organizer as shown in Figure 4.1

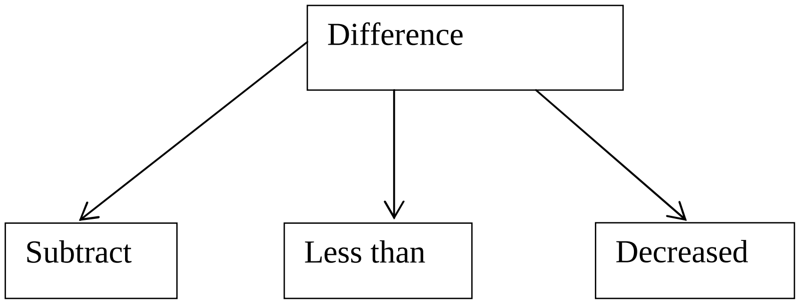


Figure 4.1 Synonyms for the Word "Difference" in Mathematics

Table 4.28 also shows that 6 (100%) of the teachers agreed that on integration the four language modes: Listening, speaking, reading, writing into Mathematics classroom. During the classroom discourse, the four language skills should be utilized so as to enhance understanding the deep meaning of a mathematical vocabulary. In addition, they also cited the use of illustrations, discussions, arguing and reasoning as another strategy. Illustrations or drawings to represent the word help to internalize the word (Irujo, 2007). Also, $^{2}/_{3}$ (67%) of suggested the breaking difficult words into more understandable segments as another strategy. Collier (2007) recommends that vocabulary should be taught through context cues and word parts. For example triangle = 3 angles can be related to tripod= 3 legs. All the six teachers (100%) identified the teaching of mathematical vocabulary and language structures daily as another strategy. When students enter the Mathematics classroom or period, the teacher should have 3 to 5 of the essential vocabulary words written in a contextual sentence. The students can then write the word and through a cloze procedure define the word using synonyms. The class can then discuss the vocabulary words and possible definitions, clarifying any misunderstandings.

This can enhance retention as well as understanding of the term. The teachers also agreed that another method that can be used to teach Mathematical vocabulary is to teach students strategies to learn and study new vocabulary.

The various strategies that can be used include completing word scrambles, crosswords and other prepared game sheets. A website that teachers can utilize to create these sheets is http://www.puzzlemaker.com. Students are required to create vocabulary section in their Mathematics notebooks, write journals, class word walls, student-dictionaries and flashcards with definition, examples, word used in a sentence, picture, diagram or word written a native language translation (Secada, 2001).

Table 4.28 shows that all the six teachers (100%) cited technology use as an important strategy in the mastery of Mathematical vocabulary. In addition, it can be noted that half (50%) of the students felt that talking aloud while solving problems on the chalkboard to will show the students thinking process and common errors. This way they felt they would enhance the mastery of the language. This strategy is teacher centered and so probably the reverse should be done. The learners can be used to solve problems on the chalkboard and talk aloud.

Table 4.28 also shows that all six teachers (100%) who participated in the study also thought that simplifying speech in the classroom would be another strategy. The teacher can do so through the use of active voice and present tense, and provide objects, pictures and manipulative. The teacher can modify the questions according to their linguistic complexity in a certain order. This could enhance the understanding of concepts taught as the language is simple and to the level of the learners. Also all the teachers agreed that demonstrating whenever possible can be another strategy to enhance mastery of the mathematical vocabulary. Demonstration in ways that supplement spoken or written instructions can go a long way to aid in the internalization of the vocabulary word.

Finally, it can be seen from table 4.28 that all the six teachers (100%) cited the use of graphical organizers based on the Frayer model as the best strategy for the mastery of the mathematical vocabulary. According to Marzano (2004), the Frayer model represents one of the best strategies for teaching vocabulary because it is student centered. It involves students creating a four square and placing a vocabulary word in the middle. The dictionary definition of the word is placed on the top left square. In the top right square, the students rewrite the definition in their own words or the characteristics of the word. In the bottom left the students write the synonyms of the vocabulary or the examples. On the bottom right students create a drawing that will help them to identify the word in the future. They can also write the non-examples of the word. Kensella (2005) has assembled a variety of the vocabulary templates. Examples of graphic organizers can be available at: http://www.scoe.org/context.php & http://www.eduplace.com/graphic organizers. It is useful to note that the above strategies cannot be used in isolation but integrated together. Effective lesson planning and delivery must also be integrated. This is discussed in the next section.

4.4. Development of a prototype lesson for Mathematics Vocabulary Instruction

The participating teachers developed their own lesson plans based on ASEI-PDSI approach. The ten (10) Mathematical Vocabularies were taught to the experimental group for a period of 10 weeks. The strategies used in teaching were the use of Vocabulary Graphic Organizers based on the Frayer Model (Frayer, Fredrick and Klausmeier, 1969). The Frayer Model was used as follows:

i. The concept was introduced and the definition was done
ii. The teacher then explained the Frayer Model diagram
iii. The teacher explained how the students were to fill out the diagram
iv. The students were given time to practice the assigned vocabulary
v. Once the diagram was complete, the students were allowed to share their work with other students.
vi. The students wrote the foldable
vii. The class logged into http://www.amathsdictionaryforkids.com by Eather for five minutes to see the illustrations for the definition of the terminologies.
viii. The students the presented their in groups

ix. The teacher harmonized the results and made conclusions

The lesson plans were observed and lesson study was done. Areas of improvements were suggested. The teachers of the experimental groups of the two schools and the researcher then met and deliberated on the model of lesson for Mathematical Vocabulary Instruction. They agreed that the lesson must have the three parts: Introduction, development and conclusion. The development must have activities based on Students experimentation, Improvisation of locally available resource materials. The lesson must also integrate the use of ICT. The student activity must make use of graphic organizers based on the Frayer Model.

The Frayer model is a graphical organizer used for word analysis and vocabulary building. The strategy stresses the understanding words within the larger context of the reading selection by requiring students, first, to analyse the items (definition and characteristics) and second, to synthesize or apply the information by thinking examples and non-examples.

To this end a prototype lesson plan was developed. A sample lesson plan from one of the treatment group teachers was used. The full details are outlined in Figure 4.3.

Name of school**: X School** Teacher's Name: **Mr**. **Kamau**

Form: **2** Class: **WEST** Topic: **Integers**

Date: **17/7/2013** Time**: 2.40-3.20pm** Duration: **40 minutes**

Objectives:

By the end of the lesson, the learner should be able to:

i. Define the term integer

ii. Graphically represent the term integers on a Frayer model diagram and the number line

References

i. KLB. (2003). Secondary Mathematics Students' Book One. Nairobi: Author. Pg 28-35

ii. Explore Mathematics book 1. Nairobi Longman Publishers Ltd.

iii. Frayer mode

Pre-requisite Knowledge

i. Number line

ii. Natural numbers

Materials

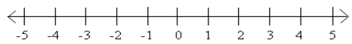
Pencils, Markers, Graphic organizers, white and red wooden "1 x1" tiles, foldable, ruler, computers connected to the internet

Figure 4.2 A prototype of a lesson plan for Mathematics Vocabulary based instruction

Teaching-learning activities (TLAs)	**Teaching-learning Points (Core points)**	**Evaluation/ Remarks**
Introduction (5mins) • Introduction of the Mathematics Vocabulary word - integers **Definition** • The teacher tells the students that they will do certain activities to help them understand the vocabulary, distributes the materials and worksheets • The teacher explains how the Frayer Model diagram works and how to fill it.	**Definition of the vocabulary.** • An integer is a number that can be written without a fractional or a decimal component • Integers are a set of whole that include the following:- -3, -2, -1, 0,1,2,3, • They are positive whole numbers , negative whole number and zero • The name derives from the Latin *integer* meaning literally "untouched" hence "whole".	What do you understand by the term integers?

Development : (30minutes)	Characteristics of the term	What are the
Activity II(5mins) **Characteristics of the term** Class discussion of the facts or characteristics about the term and fill in the area "facts and characteristics" Give "examples and non-examples"	• Integers include the whole numbers and their additive inverses • Form a sub-set of the rational numbers • Represents the difference between two objects in a set • Successive integers differ by one	Characteristics of the term integers?
Activity II (6mins) Log into http:// www.amathsdictionary.com .Provision of the SMVD	**Examples of the word** -30, -4/2, 0,1 **Non-examples of the word** -3.75, - 2/3 , 0.6, 3 ½ ,$\sqrt{2}$	What are some examples of the word? What are some non-examples of the word?

Activity III (5mins) **Students complete the Frayer Model**	**The Frayer model** **Definition:** They are positive whole numbers, negative whole number and zero **Characteristics**: Include the Whole numbers and their additive inverses **Examples**: -30, -4/2, 0, 1, 3 **Non- Examples:** - 3.75, - 2/3, 0.6, 3 ½,	How can the word be represented in a Frayer Model diagram?
Activity IV (10mins) a) Students create a foldable about the definition of the term b) they will complete each section of the foldable in class with a step by step procedure	**Foldable** **Integers:** -3,-2,-1, 0,1,2,3 **Whole number** **Zero** **Positive or natural** 1, 2, 3, 4……	How can one represent integers in a foldable?

Activity V (5mins) Harmonization of the results from the various groups. **Conclusion (5mins)** Review of the meaning word, characteristics, examples and non-examples.	• Representation of integers on the numbers line  • Integers are usually represented on a number line at equal intervals	How can integers be represented in a number line? Classify the following as integers:- -20,-6,0.8,10,0,0.67, ½ , 2/3, 7/8 , 2.75

4.5. Influence of Mathematical vocabulary instruction on students' attitude change Towards Mathematics.

The second objective was to establish the influence of Mathematical vocabulary instruction on students' attitude change towards Mathematics. In order, to address this objective, a students' attitude towards Mathematics survey was done. It consisted of 40 items covering various components concerning Mathematics. The students answered using a five-point Likert scale with lower answers indicating a more negative attitude towards Mathematics and high answers a more positive one. A paired *t*-test was performed on the mean of the pre-and post –survey and result are as shown in table 4.29.

Table 4.29 Comparison between the pre- and post – Mathematics Attitude Survey

Group	Pre-test survey				Post-test survey				*t*-test		
	n	***M***	***S.D***	**S.E**	**n**	***M***	***S.D***	**S.E**	***t***	**df**	**Sig.**
Boys Control	54	125.19	9.658	1.314	54	125.50	10.09	1.373	-.163	53	.871
Girls Control	54	124.92	4.790	.652	54	125.16	7.815	1.063	6.30	53	.532
Boys Experimental	54	124.52	7.100	.966	54	130.52	6.598	.898	4.462	53	.000
Girls Experimental	54	124.37	5.22	.817	54	129.74	7.481	1.018	-3.194	53	.002

Table 4.29 shows that the paired t-test performed on the totals of the pre- and post-test survey indicates that there was no significant differences between the control groups of both boys and girls, absolute t (53)= .163, ρ = .871 for the boys and t (53) = 6.30, ρ = .532. However there was a statistically significant difference in the attitude towards Mathematics for the experimental groups, t (53) = 4.462, ρ <.0005, α = 0.05 for the boys and absolute t (53) = 3.194, ρ = .002, α = .005 for the girls respectively. The null hypothesis, $H_0 5 < 0$, that *there was no statistically significant difference in students' attitudes toward Mathematics between students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the direct instruction method* was therefore rejected and the alternative

accepted. The study concluded that there was a statistically significant difference in the students' attitudes toward Mathematics between the Pre-survey and post-survey. This attitudinal change could be attributed to the intervention.

The effect size for the control group, r =.0223 indicated a small effect size while that of the experimental group, r = .522 indicated a medium effect. The relationship is stronger for the experimental group than that for the control group. Perhaps this could be attributed to the intervention, that is, Mathematical vocabulary instruction. The study then analysed the post survey Mathematics attitude survey. Table 4.30 shows the mean scores for the four groups.

Table 4.30 Analysis of the Post-Survey Mathematics Attitude

Group	n	*M*	*S.D*	Std error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Boys Control	54	125.50	10.092	1.373	122.75	128.25
Girls Control	54	125.16	6.598	.898	122.22	126.32
Boys Experimental	54	130.52	7.815	1.063	127.92	132.19
Girls Experimental	54	129.74	7.418	1.018	127.70	131.78
Total	**216**	**127.45**	**8.416**	**.573**	**126.33**	**128.58**

Table 4.30 shows that the boys' experimental group had a higher mean attitude score (*M* = 130.52, *S.D* = 7.815) than the boys control group (*M* = 125.50, *S.D* = 10.092). Also the girls' experimental group had a higher mean attitude score (*M* = 129.74, *S.D* = 7.418) than the girls control group (*M* = 125.16, *S.D* = 6.598). In order to test whether there was a statistically significant mean difference among the groups ANOVA was computed and the results are presented in Table 4.31

Table 4.31 ANOVA of Attitude between Groups

Source	**SS**	**df**	**F**	**Sig.**
Between groups	1319.352	3	6.704	.000
Within groups	13908.185	212		
Total	**15227.537**	**215**		

Table 4.31 shows that ANOVA revealed that there was a statistically reliable mean difference among the groups, $F (3,212) = 6.704$, $\rho < .0005$, $\alpha = 0.05$. Further tests were carried out using Tukey's H*SD* Post Hoc comparison test and the results presented as shown in Table 4.32

Table 4.32 Tukey's HSD Comparison Test

(I) Four groups	(J) Four groups	M.D (I-J)	S.E	Sig.	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Boys control	Girls control	.034	1.359	.922	-3.06	5.02
	Boys Experimental	-5.02*	1.359	.020	-8.59	-.52
	Girls	-	1.359	.035	-8.28	-.20
Girls control	Boys control	-.034	1.359	.922	-5.02	3.06
	Boys Experimental	-5.360*	1.359	.003	-9.57	-1.50
	Girls	-4.58*	1.359	.005	-9.26	-1.19
Boys Experimental	Boys control	5.02*	1.359	.020	.52	8.59
	Girls control	5.360*	1.359	.003	1.50	9.57
	Girls	.780	1.359	.997	-3.72	4.35
Girls Experimental	Boys control	4.240*	1.359	.035	.20	8.28
	Girls control	4.580*	1.359	.005	-1.19	9.26
	Boys Experimental	-.730	1.359	.997	-4.35	3.72

***The mean difference is significant at the .05 level**

A Tukey's *HSD* test shows that there was no statistically significant mean difference in attitude scores between the boys control group and the girls control groups. (ρ = .922). This implies that the control groups were homogenous enhancing internal validity of the study. It also showed that there was no any statistically significant mean attitude difference between the boys' experimental group and the girls' experimental groups. (ρ = .977). This finding is a clear suggestion that the Mathematics vocabulary instruction had similar effects towards the experimental groups.

However, a significant differential effect was noted between the boys experimental and the boys control groups (ρ = .020) and the girls experimental and girls control groups (ρ = .005). In addition there was a significant differential effect between the boys experimental and girls control group (ρ = .003) and girls experimental and boys control groups (ρ = .035). The significant difference observed in favour of the experimental groups is probably due to exposure to the mathematical vocabulary instruction.

4.5 Discussion of the Results

The first hypothesis, $H_0 1$ was that *there is no association between Mathematical vocabulary assessment and students' performance in Mathematics*. This null hypothesis failed and the alternative, H_1 was accepted. The study found out that there was a weak positive relationship between students' scores in vocabulary test and performance in the Mathematics test, r = 0.457, ρ = 0.01,α = 0.05. The results are similar to those obtained by Njoroge (2003), r = 0.3608, ρ = 0.01, α = 0.05, between mathematical vocabulary and performance in Mathematics. Mathematical vocabulary refers to words that label Mathematical concepts. Without the understanding the terminologies used in Mathematics, Mathematical concepts cannot be understood. This will eventually lead to students' poor performance in Mathematics assessments.

The second hypothesis H_O2 was that *there is no statistically significant difference between mean scores on vocabulary assessments for students' taught Mathematics vocabulary using the Frayer Model and those taught Mathematical vocabulary using the definition-only method*. The t-test revealed statistically that there was a significant difference in the Mathematics vocabulary assessment mean scores of the experimental *(M* = 19.49, *S.D* = 7.158) and the control groups (*M* = 11.31, *S.D* = 5.266), t (214) = 9.572, $\rho < .0005$, $\alpha = .05$. This implies that the experimental group taught mathematical vocabulary through the Frayer Model with ICT integration performed better than the control group taught through definition-only method. The findings of the study concur with those of Monroe & Pendergrass (1997) who compared the effects of two models of vocabulary instruction—the integrated CD-Frayer model and the definition only model on the mathematical vocabulary use of fourth grade students. The CD-Frayer model class (*M* = 12.857, *S.D* = 10.543) performed better that the definition-only class (*M* = 8.444, *S.D* =5.989), $\rho <$ .041.in the mathematical vocabulary used in writing their journal. The difference indicated that the vocabulary instruction using the CD-Frayer model was more effective in increasing student use of mathematical vocabulary. The current study also found out the students receiving the definition-only vocabulary instruction did not enjoy writing definitions or seeing them on the board. Those students taught mathematical vocabulary using the integrated Frayer model with ICT integration appeared to welcome mathematical vocabulary and actively participated in the group discussions. Holding the attention of the class seemed easier when vocabulary discussions were taking place. As Moore & Readence (1984) notes, the teachers who use the graphical organizer to teach mathematical vocabulary is likely to feel better prepared and more organized.

A similar study carried out by Sanders (2007) who tested the significant differences in performance of mathematical vocabulary assessments between groups exposed two different mathematical vocabulary instruction strategies—keyword mnemonics and direct instruction. Although both groups did show significant improvements, the students who participated in the keyword mnemonics classes (M = 33.65) outperformed the students in the direct instruction classes (M = 30.53) as measured on the posttest and follow up test of the mathematical vocabulary assessment, $F(1,206) = 13.196$, $p < .0005$. The study reported an effect size (r) = .2453 which was considered a small effect size. However, the current study found an effect size (r) = .547 which indicated a medium effect size. This implies that the all factors held constant, the Frayer Model with ICT integration strategy is a better intervention for Mathematics vocabulary instruction than the key mnemonics strategy. Roe & Smith (2012) rightly observed that the structure and thought processes incorporated in the Frayer model strategy provide an opportunity for students to build a deep understanding of mathematical vocabulary. Thus, the study concluded that the Frayer Model with ICT integration is good a intervention for Mathematical vocabulary instruction.

The third hypothesis, H_O3, was that *there is no significant difference between students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer model and those taught Mathematical vocabulary using the definition-only method*. The findings revealed that the experimental groups outperformed the control groups in the post-test students' achievement test, POSMAT. The boys' experimental group (*M* = 9.57, *S.D* = 5.826) performed better than the boys control group (*M* = 6.78, *S.D* = 2.912) in the POSMAT. A Tukey's H*SD* post hoc test revealed that there was a statistically significant mean difference between the mean scores of the POSMAT between the boys control and the boys experimental groups (ρ = .001). On the other hand, the girls' experimental group (*M* = 8.70, *S.D* = 3.298) outperformed the girls control group (*M* = 6.76, *S.D* = 2.283) in the POSMAT. A Tukey's H*SD* post hoc test revealed that there was a statistically significant mean difference between the mean scores of the POSMAT between the girls control and the experimental groups (ρ = .001). Thus, the third hypothesis of the study was rejected. The alternative hypothesis, H_3 was accepted. Thus, the study concluded that there was a statistically significance difference between the students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught mathematical vocabulary using the definition only method. The effect size, r = 0.1875 obtained indicated a small effect size.

The above findings also concur with those obtained by Marzano (2004) who found that teaching academic vocabulary positively influenced students' performance in standardized test scores by as much as 33%. In yet another similar study, Glifford and Gore (2008) showed that underperforming Mathematics students who received vocabulary instruction showed standardized test gains as high as 93%.

In his book, 'classroom instruction that works: research based strategies for increasing student achievement', Marzano (2001) reported that graphical organizers like the Frayer model when used during vocabulary instruction yield a 22 percentile gain. The findings of the current study differ with those of Monroe and Pendergrass (1997) who found out the students taught mathematical vocabulary using the CD-Frayer model had a lower mean score in the number of mathematical applications after the instruction (*M* = .179, *S.D* =. 390) compared to those taught using definition-only model (*M* = .444, *S.D* = 1.219). However, the differences in the mean were not significant, $\rho < .390$. Since the mathematics applications for both groups were minimal, the results were considered irrelevant.

One advantage of the Frayer model strategy is that, students are active learners and are noticeably highly motivated. This is in line 21^{st} century skills that advocates for constructivism and problem solving in Mathematics learning. Students learn best through active involvement in learning new words (Roe & Smith, 2012). Consequently, students exposed to the Frayer model tend to go far beyond learning mere definitions of words; instead, they develop a far deeper understanding of concepts. As a result the use of the Frayer model increases the students' understanding of new vocabulary, and they show a deeper and more complex understanding of concepts (Cohen & Cowen, 2008). The process of stating a definition, describing characteristics and articulating examples and non-examples helps students develop a deeper understanding of a word than they might achieve from only a definition (Greenwood, 2010).

The implication of the above findings is that Mathematics teachers should design mathematical vocabulary instruction using graphic organizers based on Frayer Model with ICT integration. This is because the strategy was found to be more effective than the definition-only method. This strategy is learner centered hence it applies the 21^{st} century pedagogy skills. The onus of learning is solely that of the learner. The teacher is only a facilitator who must design rich mathematical activities. The learners are able to construct knowledge in a community of learners. This embraces constructivism and small group cooperative learning. This calls for change on the pedagogy in our Mathematics classrooms. Traditionally, the mathematics teacher is viewed as the source of knowledge and the learners as passive recipients. The learners should be allowed to work cooperatively in small groups with well-defined roles to construct definitions of mathematical vocabulary. This would lead to deeper understanding of mathematical vocabulary which in turn would lead to better understanding of Mathematical concepts.

The fourth hypothesis H_O4 was that *there is no significant difference between students' performance in Mathematics for students' English Language proficient group and non-English Language proficient group*. The English Language proficient group performed better (*M* = 8.80, *S.D* = 3.699) in the POSMAT than the non-English Language proficient group (*M* = 7.27, *S.D* = 4.103). On computing the t-test, the t-value obtained, t (214) = 2.825, $\rho = .005$ was also found to be significant at $\alpha = 0.05$. Therefore the null hypothesis was rejected and the alternative hypothesis, H_4 was accepted. The study concluded that there was a significant difference in the students' performance between the English Language proficient Group and the Non-English Language proficient group. The difference can be accounted by the fact that the rubric and items of the post-test Mathematics test, POSMAT needed the proper comprehension of the English language used. The items were written in English language and the English language proficient groups understood the demands of the items perhaps then enhancing their overall performance in the test. The obtained effect size, r = .02 indicated a small effect size. Similar findings have been found out in other subjects. In a study by Aina, Ogundele & Olanipekun (2013) to establish the relationship between students' proficiency in English Language and Academic performance in science and technical education, the findings revealed that there was a strong positive correlation between students' score in English Language and performance in the both science, r (30) = .553, and technical education, r (30) = .643. Several studies agree with the current findings. For example, Hinkelman (1956) found positive correlations of 0.78 (grade 2), 0.71 (grade 5), and 0.77 (grade 7) between reading scores and arithmetic marks. In secondary schools, Pitts (1952) found a correlation of 0.53 between mathematical competence and reading level among black girls.

Johnson (1944) found that teaching mathematical vocabulary improved mathematics achievement. Proficiency in English, measured by students' ability to effectively communicate to a certain extent, may have an influence on their ability to master the mathematics where English is the medium of instruction (AlHaddad, *et al*, 2004). Chamot & O'Malley (1994) contends that English language learners may find mathematics challenging because they must filter their mathematics knowledge-a language on its own–through a second language, English. So, in this case, mathematics becomes the "third" language. Students face an extra challenge, then, as they attempt to learn cognitively demanding, highly abstract mathematical concepts while they are still learning English.

The implication of the above findings is that the Non-English language proficient students in should be identified and given extra instruction on mathematical vocabulary to enable them achieve in Mathematics like their English language proficient counterparts. In addition there should be the integration the four language modes: Listening, speaking, reading, writing into Mathematics classroom. During the classroom discourse, the four language skills should be utilized so as enhance deep learning of mathematical vocabulary.

Finally the fifth hypothesis, H_O5 was that there *is no significant difference in the students' attitudes toward Mathematics between students taught Mathematics vocabulary using the Frayer model and those taught Mathematical vocabulary using the definition-only* method. A paired *t* test performed on the totals of the pre- and post-test survey on Students' Mathematics Attitude Questionnaire, SMAQ indicated that there was no significant difference between the control and experimental groups on either the pre-survey, t absolute (107) = .119, $\alpha = .906$ and the post-survey, *t* absolute (107) = 2.267, $\alpha = .053$. The null hypothesis $HO_5 < 0$ was there accepted. Thus there was no any significant difference in the students' attitudes toward Mathematics between students taught mathematical vocabulary using the Frayer Model and those taught mathematical vocabulary using the definition-only method. The effect size was then computed for both groups. The value for the control group was r = 0.011 indicated a small effect size while that of the experimental group was r= 0.21 also indicated a small effect size but the relationship is stronger for the experimental group than that for the control group. Perhaps this could be attributed to the intervention-mathematical vocabulary instruction. Similar results were obtained by Sanders (2007) who found no significant difference between the group taught mathematical vocabulary through the Keyword mnemonics and definition-only strategy on either pre-survey, t (42) = .232, α = .817 or the post-survey t (40) = .99, α = .921. Fennema *et al* (1990) and Cockcroft Report (1982) also stated that attitudes are related to achievement in Mathematics. The implication here is that mathematical vocabulary instruction using the Frayer model using the ICT integration strategy should be enhanced as it does not only lead to improved students' performance in Mathematics but also leads to positive attitude towards the subject.

The second objective was to establish the strategies that can be used to enhance the mastery of Mathematical vocabulary. The six Mathematics teachers involved in the study gave the 11 strategies. They included using synonyms for simple words, integrating the four language modes: listening, speaking, reading, writing in the Mathematics classroom, using illustrations, discussions, arguing and reasoning, breaking difficult words into more understandable segments, teaching Mathematical vocabulary and language structures daily, teaching students strategies to learn and study new vocabulary and teaching students strategies to learn and study new vocabulary. They also included using technology in the teaching and learning of Mathematics vocabulary, talking aloud while solving problems on the chalkboard, simplifying speech in the classroom, demonstrating whenever possible in ways that supplement spoken or written instructions and using graphic organizers based on Frayer Model. Similar strategies have been advocated by researchers in the area of mathematics vocabulary (Marzano, 2004: Irujo, 2007: Molina, 2010: Gifford & Gore, 2010). The study concluded that the most effective method is the use of graphical organizers based on the Frayer model because it is learner centered. The method enhances deeper understanding of the Mathematics vocabulary. The study also concluded that integration of the method with others together with ICT would the most effective strategy that can be employed to enhance mastery of mathematical vocabulary.

The last objective was to develop a prototype lesson plan for Mathematics Vocabulary based instruction. The ASEI-PDSI approach using the graphical organizer based on the Frayer model with ICT integration was developed. According to Onchong'a (2013), ASEI is relevant in ICT integration. The teaching approach is activities, student-centered teaching, Experiments, and improvisation (ASEI) and cyclic instructional processes of Plan-Do-See-Improve (PDSI) are critical aspects of engaging learner's meaningfully in instruction (Njuguna, 1999). According to Frayer *et al* (1969) and Marzano (2004), there are several benefits to the students associated with the Frayer model. Key ones include: The students are able to (1) develop understanding of key concepts and vocabulary (2) draw on prior knowledge to make connections among concepts (3) compare attributes and examples (4) think critically to find relationships between concepts and to develop deeper understanding and (5) make visual connections and personal associations. Informed by the aforementioned benefits the study recommends adoption of the Frayer Model with ICT integration for Mathematics vocabulary based instruction.

4.6 Chapter Summary

This chapter has presented the research findings, their interpretation and discussed them in relation to other studies concerning mathematical vocabulary instruction and students achievement in Mathematics. It also presents and discusses a prototype of a lesson plan for Mathematics Vocabulary based instruction The next chapter contains the summary of the research findings conclusions and recommendations for further study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the findings of the study. In addition, conclusions and recommendations from the findings are presented. Additional research areas have also been given. The implications of the study at various levels have been outlined.

5.2. Summary of the Study Findings

This study was conducted for the purpose establishing the effects of mathematical vocabulary instruction on students' Mathematics achievement. The study was a non equivalent control group pretest-posttest quasi-experimental design. It was conducted in the two purposively selected secondary schools in Kahuro District in Murang'a County, Kenya. The study sample involved two hundred and sixteen (216) Form Two students in the two schools and six (6) Mathematics teachers. Both the experimental group and the control group consisted of fifty four (54) students from each school. The experimental groups in both schools were taught mathematical vocabulary using the Graphical Organizer based on the Frayer Model with ICT integration instructional approach for ten (10) weeks during the second term in the school year 2013. The control group was taught mathematical vocabulary using the definition-only method for the same period. Data was collected using four achievement tests, one attitude inventory and one questionnaire. The main unit of analysis was the students. The study was guided by the following four (4) objectives (1) To determine the extent to which mathematical vocabulary instruction influence students' performance in Mathematics. (2) To establish the attitudinal change towards Mathematics due to Mathematical Vocabulary Instruction. (3)To establish the strategies that can be used to enhance the mastery of Mathematical Vocabulary. (4) To develop a prototype for a lesson plan for Mathematics vocabulary based instruction.

The first two objectives were addressed by five (5) null hypotheses. The first hypothesis, H_O1 was that *there was no relationship between mathematical vocabulary assessment and students' performance in Mathematics*. The study found out that there was a weak positive relationship between students' scores in vocabulary test (*M* = 7.93, *S.D* =3.988) and Students' performance in the Mathematics test (*M* = 15.40, *S.D* = 7.492), r (216) = 0.457, $p < .0005$, $\alpha = .05$. Since r = 0.457, then $r^2 = 0.208849$. This implies that 20.9% of the total variation of students' performance in mathematics can be accounted for by their understanding of mathematical vocabulary.

The second hypothesis H_O2 was that *there was no statistically significant difference between means scores on vocabulary assessments for students taught Mathematics vocabulary using the Frayer Model and those taught using* *definition-only method*. The study established that the boys' experimental group that was taught mathematical vocabulary using the Frayer Model with ICT integration (*M* = 25.17, *S.D* = 4.592) performed better than the control group (*M* = 9.98, *S.D* = 4.346), which was taught using the definition–only method. The study also found the girls' experimental group (*M* = 13.81, *S.D* = 5.790) performed better than the girls' control group (*M* = 12.63, *S.D* = 4.346). A t-test revealed statistically that there was a significant difference in the Mathematics vocabulary assessment means scores of the experimental (*M* = 19.49, *S.D* = 7.158) and the control groups (*M* = 11.31, *S.D* = 5.266), t (214) = 9.572, $\rho = < .0005$, $\alpha = .05$. The effect size r obtained was 0.547. This indicated a medium effect size.

The third hypothesis, H_O3 was that *there was no significant difference between students' performance in Mathematics for students taught Mathematics vocabulary using the Frayer model with ICT integration and those taught using definition-only method.* The boys' experimental group (*M* = 9.57, *S.D* = 5.826) performed better than the boys control group (*M* = 6.78, *S.D* = 2.912) in the post-test Mathematics achievement test. On the other hand, the girls' experimental group (*M* = 8.70, *S.D* = 3.298) performed better than the girls control group (*M* = 6.76, *S.D* = 2.283) in the post-test Mathematics achievement test. The study established that there was a statistically significant difference between the students' performance in Mathematics for the students' taught Mathematics vocabulary using the Frayer Model with ICT integration and those taught vocabulary using the definition-only method. The value of effect size, (r) = .1875 indicated a small effect size.

The fourth hypothesis H_O4 was that *there was no significant difference between students' performance in Mathematics for the English Language proficient group and non-English Language proficient group.* The English Language proficient group (*M* = 8.80, *S.D* = 3.699) performed better than the Non-English Language proficient group (*M* = 7.27, *S.D* = 4.103) in the Post-test mathematics test. A t-test revealed that there was a significant difference in the students' performance in Mathematics between the English Language proficient group and the Non-English Language proficient group, $t\ (214) = 2.825$, $\rho = .005$, $\alpha = .05$.

Finally the fifth hypothesis, H_O5 was that *there was no significance difference in the students' attitudes toward Mathematics between students taught Mathematics vocabulary using the Frayer Model and those taught through definition-only method.* A paired t-test performed on the totals of the pre- and post-test survey, Students' Mathematics Attitude Questionnaire, SMAQ, indicates that there was no significant differences between the control groups of both boys and girls, absolute $t\ (53) = .163$, $\rho = .871$ for the boys and $t\ (53) = 6.30$, $\rho = .532$. However there was a statistically significant difference in the attitude towards Mathematics for the experimental groups, $t\ (53) = 4.462$, $\rho < .0005$, $\alpha = 0.05$ for the boys and absolute $t\ (53) = 3.194$, $\rho = .002$, $\alpha = 0.05$ for the girls respectively. The study established that there was there was a statistically significant difference in the students' attitudes toward Mathematics between the Pre-survey and post-survey for the students taught mathematics vocabulary using the Frayer Model. The effect size for the control group, *r* = .0223 indicated a small effect size while that of the experimental group, r = .522 indicated a medium effect. This attitudinal change could be attributed to the intervention. A post hoc comparisons using the Tukey's *HSD* test indicated that a significant differential effect was noted between the boys experimental and the boys control groups (ρ = .020) and the girls experimental and girls control groups (ρ = .005). In addition there was a significant differential effect between the boys experimental and girls control group (ρ = .003) and girls experimental and boys control groups (ρ = .035). The significant difference observed in favour of the experimental groups was probably due to exposure to the mathematical vocabulary instruction based on the Frayer model with ICT integration.

In general the following is a summary of the main research findings:

i) There was a positive relationship between students' mathematical vocabulary assessment and students' performance in Mathematics.

ii) The students exposed to the Mathematics vocabulary instruction using the Frayer model with ICT integration performed better than those taught using the definition-only method in Mathematics vocabulary assessment.

iii) The students taught Mathematics vocabulary instruction using the Frayer Model with ICT integration performed better in Mathematics tests than those taught mathematical vocabulary using the definition only method.

iv) The English Language proficient group performed better than the Non-English Language proficient group in the post-test mathematics achievement test

v) There was a significant change in the students' attitude towards mathematics after the intervention for the groups taught mathematical vocabulary using the Frayer model with ICT than those taught using the definition-only method.

vi) The most effective strategy for Mathematical vocabulary instruction was established to be the use of Graphical Organizers based on the Frayer Model with ICT integration because it is learner centered.

Additional Findings

i. The study found out that the girls performed significantly higher than the boys in Mathematics terminology test. The difference was statistically significant.

ii. Boys performed better in the Mathematics tests than the girls. However, difference was not statistically significant.

iii. The study found out that the abstract nature of Mathematics terms, difficulty of the English Language itself, ambiguity, total isolation of Mathematics from the English language, lack of vocabulary learning as part of the learning in the lesson and rare use of mathematical terms outside the classroom were some of the factors that contribute to language being problematic in Mathematics.

iv. The teachers cited a number of problems that are caused the lack of proficiency in Mathematical vocabulary cause to the teaching and learning of Mathematics. First, students would not be able to understand mathematical word problems. Secondly, they would not be able to verbally express mathematical concepts. Thirdly, they may not participate fully in the classroom discourse. In addition, students may not achieve Mathematics proficiency. They would also not be able to read Mathematics textbooks and eventually would not be able to understand word problems in Mathematics exams.

5.3 Conclusions

Following the above findings, the study logically made eight (8) conclusions. First, the study concluded that there is a positive association between terminologies used in Mathematics and students' performance in Mathematics.

Secondly, the study concluded that a well-developed and executed Mathematics Vocabulary Instruction can effectively improve students' achievement in Mathematics.

Third, an effective mathematical vocabulary instruction can be used to promote students' attitude toward the Mathematics.

Fourth, the English language proficient students are likely to perform better in Mathematics than non-English Language proficient students.

Fifth, the use of graphical organizers based on the Frayer model with ICT integration is an effective method for Mathematics vocabulary instruction.The lesson follows the ASEI-PDSI approach. The method is a cognitively guided instructional strategy. It involves three broad steps. The first step is the *Introduction stage*. Here, the presents the mathematical vocabulary that might be confusing because of its relational qualities or one to be encountered in a topic. The teacher then divides the class into groups, provides materials and worksheets. The teacher then explains the Frayer model diagram to the learners. The second step is the *Development stage*. The learners find the examples, non-examples, facts and characteristics of the vocabulary to complete the diagram. They also use textbooks, login in the internet and other supplementary materials to aid in the exercise. They then makes foldable of the word. Once their diagrams are complete, the various groups make their presentations. The teacher harmonizes the results from the groups. The last stage is the *Conclusion stage*. It is the closure stage. In this step, the review of the lesson is done. Exercises for further activities are also given.

The sixth conclusion was that the prototype lesson plan for vocabulary instruction can be used to enhance relational understanding of the vocabulary. This is because it is learner centred and involves the learner deeper.

The seventh conclusion is that there are many problems that face Mathematics students who are not proficient in mathematical vocabulary. These include not being able to understand mathematical word problems, inability to verbally express mathematical concepts and to understand what the teacher is teaching in class. In addition, students may not achieve Mathematics proficiency, may not able to read Mathematics textbooks and eventually may not be able to understand word problems in Mathematics exams.

The last conclusion is that the theoretical model of the cognitively guided instruction anchored the study appropriately. The Frayer model with ICT integration strategy to Mathematics vocabulary instruction embraced the constructs of CGI and was found to be effective.

The thesis of the study was that Mathematics vocabulary is a significant factor in Mathematics comprehension. Students often have trouble remembering the definitions of difficult Mathematics terms, causing them to miss problems that are dependent upon these terms. The Frayer Model with ICT integration was shown by this study to be an effective way to teach Mathematics vocabulary to secondary school students.

5.4. Recommendations

From the conclusions of the study, policy recommendations were made to a number of key stakeholders. In addition, areas of further study were suggested.

5.4.1. Policy Recommendations

The study made a number of recommendations to the following stake holders:

a) Mathematics Teachers

The Mathematics teachers should be sensitized on the effects of Mathematics Vocabulary on students' performance in Mathematics. Since there was a positive relationship between students' scores in mathematical vocabulary and students' performance in Mathematics, simple and appropriate mathematical language should be used in the teaching, learning and assessment of Mathematics.

b) Mathematics Textbook Writers

Mathematics textbook writers control the commercial curriculum. Therefore, they should be sensitized on the effects of Mathematics vocabulary on students learning of Mathematics. They should lay emphasis on the exposition of mathematical vocabulary in their textbooks before their use in mathematical text and questions. They should use the Frayer model in explaining the terminologies that learners would encounter in every section of their textbook. This would enhance students' understanding of Mathematics.

c) The Kenya National Examination Council

The Kenya National Examination Council and other examination bodies should take into account the issues of mathematical language in setting Mathematics items.

d) The Kenya Institute of Curriculum Development (KICD)

The Kenya Institute of Curriculum of Development, the body charged with curriculum development in Kenya should design Mathematics materials with simplified appropriate language to enhance learner readability leading to improved students' Mathematics performance. The KICD should pilot the developed prototype lesson for mathematical vocabulary instruction in a number of schools in different counties and thereafter it could adopted in all schools.

e) Mathematics teachers' educators

Mathematics teachers' educators should also be sensitized on the need to train Mathematics teachers on the strategies that can be used to enhance students' mastery of Mathematics vocabulary instruction. The Frayer model with ICT integration is the best method since it learner centred, it would enhance deep understanding of the mathematical vocabulary and lead to relational understanding of mathematical concepts.

f) Mathematics Education Researchers

The study recommends further study in the area of mathematical vocabulary instruction.

5.4.2. Recommendations for Further Research

The study recommends further study on the following:

i. The effects of social language (motivation) on students' performance in Mathematics.
ii. Impact of teacher qualifications, attitude and school factors on students' performance in Mathematics.
iii. Effects of English language proficiencies on students' performance in Mathematics.
iv. The effectiveness of the prototype lesson plan

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APPENDICES

Appendix A: Students Mathematics Attitudes Questionnaire (SMAQ)

Instructions

As you read the statement, you will know whether to agree or disagree. If you strongly agree, write **A** next to Number 1. If you agree, but not so strongly, or you only 'sort of agree', write **B**. If you disagree with the statement very much, write **E** for strongly disagree, but not so strongly, write **D**. If you are not sure about the sentence or you cannot answer it, write **C**. Do this for the rest of the statements. Take time in each statement, but be sure to answer every statement. There is no "right" or "wrong" answer. The only correct responses are those are true for you.

	Statements	**Response**
1	Mathematics is a very worthwhile and necessary subject.	
2	I want to develop my mathematical skills.	
3	I get a great deal of satisfaction out of solving a Mathematics problem.	
4.	Mathematics helps develop the mind and teaches a person to think.	
5.	Mathematics is important in everyday life.	
6	Mathematics is one of the most important subjects for people to study.	
7	High school math courses would be very helpful no matter what I decide to study.	
8	I can think of many ways that I use math outside of	

	school.	
9	Mathematics is one of my most dreaded subjects.	
10	My mind goes blank and I am unable to think clearly when working with Mathematics.	
11	Studying Mathematics makes me feel nervous.	
12	Mathematics makes me feel uncomfortable.	
13	I am always under a terrible strain in a math class.	
14	When I hear the word Mathematics, I have a feeling of dislike.	
15	It makes me nervous to even think about having to do a Mathematics problem.	
16	Mathematics does not scare me at all.	
17	I have a lot of self-confidence when it comes to Mathematics.	
18	I am able to solve Mathematics problems without too much difficulty.	
19	I expect to do fairly well in any math class I take.	
20	I am always confused in my Mathematics class.	
21	I feel a sense of insecurity when attempting Mathematics.	
22	I learn Mathematics easily.	
23	I am confident that I could learn advanced Mathematics.	
24	I have usually enjoyed studying Mathematics in school.	
25	Mathematics is dull and boring.	
26	I like to solve new problems in Mathematics.	
27	I would prefer to do an assignment in math than to write an essay.	

28	I would like to avoid using Mathematics in college.	
29	I really like Mathematics.	
30	I am happier in a math class than in any other class.	
31	Mathematics is a very interesting subject.	
32	I am willing to take more than the required amount of Mathematics.	
33	I plan to take as much Mathematics as I can during my education.	
34	The challenge of math appeals to me.	
35	I think studying advanced Mathematics is useful.	
36	I believe studying math helps me with problem solving in other areas.	
37	I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	
38	I am comfortable answering questions in math class.	
39	A strong math background could help me in my professional life.	
40	I believe I am good at solving math problems.	

Appendix B: Pre-Test Students Mathematics Vocabulary Test (PRESMVT)

This is a test on Mathematics whose main purpose is exploring the effects of Mathematical vocabulary instruction on students' Mathematics achievement. Answer all the questions carefully and honestly as much as possible. Your answers to the questions will be used in improving the learning and teaching of Mathematics in secondary schools, as well as confirming your great mathematical ability.

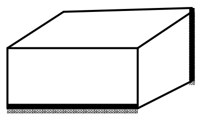
Part I: Students Personal Information

Students' Characteristics

Class: _____

Part II: Mathematics Vocabulary Test

Complete the following table (15mks)

	Word	Definition	Use the word in a sentence	Draw a picture or diagram that visually represent the meaning of the word
	Volume	Is the amount of space occupied by an	A cube of 1cm occupies a volume of $1cm^3$	 1cm
1	Perimeter			
2	Percentage			
3	Capacity			
4	Ratio			
5	Angle			

Appendix C: Post-test Students' Mathematical Vocabulary Test (POSMVT)

This is a test on Mathematics whose main purpose is exploring the effects of Mathematical vocabulary instruction on students' Mathematics achievement. Answer all the questions carefully and honestly as much as possible. Your answers to the questions will be used in improving the learning and teaching of Mathematics in secondary schools, as well as confirming your great Mathematical ability.

Part I: Students Personal Information

Students' Characteristics

Class: _____ b) ___________years

Part II: Mathematics Vocabulary Test Complete the following table (30mks)

	Word	Definition	Use the word in a sentence	Draw a picture or diagram that visually represent the meaning of the word
	Volume	Is the amount of space occupied by an object	A cube of 1cm occupies a volume of $1cm^3$	
1	Product			

2	Factors			
3	Chord			
4	Polygon			
5	Degree			
6	Scale			
7	Power			
8	Area			
9	Integer			
10	Multiple			

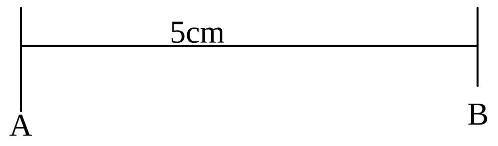
Appendix D: Pre-test Students Mathematics Achievement Test (PRESMAT)

Total: 15 Marks) Time: 15 minutes

This is a test on Mathematics whose main purpose is exploring the effects of mathematical vocabulary instruction on students' Mathematics achievement. Answer all the questions carefully and honestly as much as possible. Your answers to the questions will be used in improving the learning and teaching of Mathematics in secondary schools, as well as confirming your great mathematical ability.

1. The perimeter a semi-circular protractor is 14.28cm. Find its radius. (3mks)
2. A man invested sh.36000 in two companies P and Q.P pays a dividend of $11\frac{1}{4}$% while Q pays a dividend of $10\frac{1}{2}$ %. If from his total investment, he obtained a return of $10\frac{3}{4}$ %, how much money did he invest in each company?
3. A farmer has three containers of capacity 12 *l*, 15*l* and 21 *l*. calculate the capacity of the largest container that can fill each of them an exact number of times. (3mks)
4. A development committee is selected in such a way that the ratio of men to women is 7:5 while the ratio of youth to women is 3:4, find the ratio of youth to men (3mks)

5. Line AB given below is one side of triangle ABC. Using a ruler and a pair of compasses only:



Complete the triangle ABC such that BC= 5cm and < ABC=45^0 (1mk)

On the same diagram construct a circle touching sides AC, BA produced and BC //produced. (2mks)

Appendix E: Post-test Students Mathematics Achievement Test (POSMAT)

This is a test on Mathematics whose main purpose is exploring the effects of Mathematical vocabulary instruction on students' Mathematics achievement. Answer all the questions carefully and honestly as much as possible. Your answers to the questions will be used in improving the learning and teaching of Mathematics in secondary schools, as well as confirming your great Mathematical ability.

1. The size of an interior angle of a polygon is 156°. Find the number of sides of the polygon. (3mks)
2. Express the numbers 1470 and 7056 as a product of its prime factors. Hence evaluate, leaving the answer in prime factor form (3mks)
3. A chord AB of length 13cm subtends an angle of 67° at the circumstance of a circle centre O. Find the radius of the circle (3mks)
4. The boundaries PQ, QR, RS and SP of a ranch straight lines such that: Q is 16 km on a bearing of 040° from P; R is directly south of Q and East of P and S is 12km on a bearing of 120° from R. Using a scale of 1 cm to represent 2km, show the above information a scale drawing (3mks)
5. Find the greatest common factor of x^3y^2 and $4xy^4$. Hence factorize completely the expression $x^3y^2-4xy^4$ (3mks)

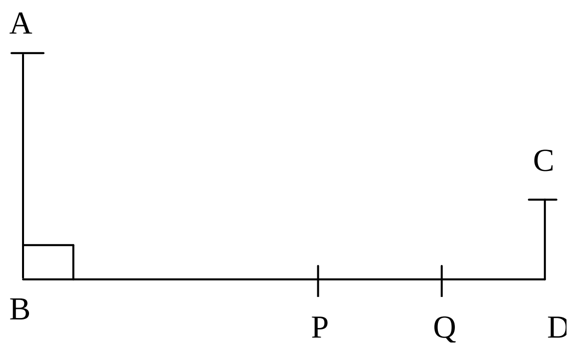
6. The sum of three consecutive odd integers is greater than 219. Determine the first three such integers. (3mks)

7. A model of a tent consists of a cube and a pyramid on a square base. See the figure below. Draw accurately the net of the model and use it to calculate the total surface area of the model (3mks)

8. Solve the equation, leaving your answer in power form. (3mks)

$3^{(2y-1)} + 2\,x^{3^{(y-1)}} = 1$

9. The diagram below represents two vertical watch towers AB and CD on a level ground. P and Q are two points on a straight road BD. The height of the tower AB is 20m and road is 200m. Given that QC= 50.9m and the ratio of BQ: QD is 3:1, calculate the angle of elevation of A from C to the nearest degree. (3mks)



10. List the first six multiples of 6, 8 and 12. Hence find the length of the shortest piece of pipe that can be cut into equal lengths of each 6cm or 8cm or 12cm (3mks)

Appendix F: Mathematics Teachers' Questionnaire (MTQ)

Students' performance in Mathematics is a major concern world-wide. This study is designed to explore the effects of Mathematical vocabulary instruction on students' Mathematics achievement. The results of the study will go a long way in improving students' poor performance in Mathematics. The information you provide will be accepted unanimously and treated with strict confidentiality. It will be used for the purposes of the study and in no way against you. You are required to answer the following questions honestly.

Instructions: Tick (√) or complete where appropriate.

Teacher self-Information

I: Teachers Characteristics

1. Gender: Male: [ ] Female: [ ]
2. Academic qualifications:

   Graduate [ ]

   Non Graduate [ ]
3. Type of qualification

   B.Ed [ ]

   Dip Ed [ ]

   BSc [ ]

   BA [ ]

Others (specify) _____________

II: Teaching Information

1. Subject (s) trained/ studied

   (i)

   (ii)

2. Subject (s) now teaching

   i)

   ii)

3. Total Teaching years' experience:_________________________

4. Teaching information regarding the effects of Mathematical vocabulary instruction on Mathematics achievement

5. a) In your opinion do you think there are effects of Mathematical vocabulary instruction on students' achievement in Mathematics?

   Yes [ ] No [ ]

b) If yes, I) State three (3) Factors that contribute to language being problematic in Mathematics

   II) State three (3) problems that you think lack of Mathematical vocabulary proficiency cause to the teaching, learning and performance of Mathematics.

   i)

   ii)

   iii)

6. In your experience, what strategies could be used to enhance the mastery of mathematical vocabulary?

    i)

    ii)

    iii)

7. The following are statements about practices involving Mathematics vocabulary. Read each item carefully and enter the letter that most closely corresponds to the extent to which you carry them out or are carried out. Please answer every question.

USE THE THESE RESPONSE CODES:

A – To a very large extent, B – to a large extent, C – Not sure, D –to a small extent and E –not all

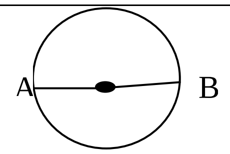
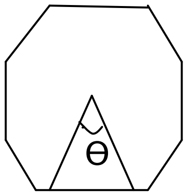
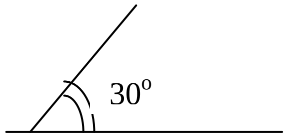
	Statement	Response
1	I always determine the Mathematical vocabulary proficiency of my learners before I teach them.	
2	I always teach Mathematical vocabulary by definition only method	
3	I always teach Mathematical vocabulary by both Direct teaching and Meaningful Context methods.	
4	I always consider the Mathematical vocabulary proficiency of my learners during the setting of Mathematics items	
5	Writers of Mathematics textbooks consider Mathematical vocabulary proficiency of learners during writing of books	
6	Mathematical vocabulary instruction should be introduced to help in improving students' achievement in Mathematics	

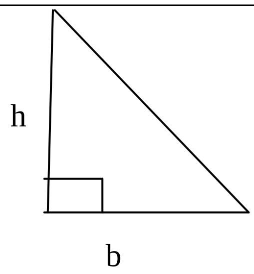
THANK YOU FOR YOUR TIME AND COOPERATION

Appendix G: Students' Mathematical Vocabulary Dictionary (SMVD)

NB: Adapted from a maths Dictionary for Kids by Jenny Eather.

NO	WORD	DEFINITION	USE THE WORD IN SENTENCE	DIAGRAM
1	Product	Product is the result in the result of multiplying or an expression that identifies factors to be multiplied	The product of 2 and 3 is six (6)	$2\ x\ 3 = 6$ $x - means\ Multiply$
2	Factors	Factors are numbers you can multiply together to get another number. A factor is a whole number which divide exactly into a whole number leaving no remainder	2 and 4 are factors of 8	2 x 4 = 8

3	Chord	A line segment that joins two points on the circumference of a circle	The diameter is the longest chord in any given circle	 AB – Chord
4	Polygon	A polygon is a two dimensional shaped plane figure with straight lines	Triangles, rectangles, squares and pentagon are examples of polygon. 7 sided polygon is called a heptagon	 8 – octagon
5	Degree	A degree is a measure of angles	There are 360^o in a full rotation	 Rotation of 30^o
6	Scale	Scale is the ratio of the length of drawing to the length of the real thing	A scale of a graph is a series of numbers placed at fixed or equal distances	1:200,00

7	Power	The power of a number shows how many times to use the number in a multiplication	The other word for power is exponent	$2^3 = 8$
8	Area	Area is size of a surface	Areas is a scalar quantity Area of a triangle is given by $A = \frac{1}{2}bh$	 $A = \frac{1}{2}bh$
9	Integer	An integer is a number with no fractional part	Integer is a mathematical term to define the set of whole numbers both negative and positive	{0,1,2,3,…………} Are set of integers

10	Multiple	The multiple of a number is what you get when you multiply that number by some other number of e.g. multiply 3 by 5 = 15 , so 15 is a multiple of 3	The first few multiples of 3 are 3,6,9,15,18,21	The multiples of 7 are 0,7,14,21,28,35,49 7 x 0 = 0 7 x 1 = 7 7 x 2 = 14 $7x3 = 21$ *etc*

Appendix H: Instructional Sequence

No	WEEK	ACTIVITY
1	WEEK 1	The teachers administered the Pre-test SMVT, SMAQ, Pre-test SMAT
2	WEEK II	Day 3: Instruction on the word**' Product'** 4.00pm: Administration of post-test 1 on product to both control and experimental groups
3	Week III	Day 3: Instruction on the word '**Factors'** 4.00pm: Administration of post-test 2 on factor to both control and experimental groups
4	Week IV	Day 3: Instruction on the word 'chord' 4.00pm: Administration of post-test 3 on chord to both control and experimental groups
5	Week V	Day 3: Instruction on the word Polygon 4.00pm: Administration of post-test 4 on Polygon to both control and experimental groups
6	Week VI	Day 3: Instruction on the word Degree 4.00pm: Administration of post-test 5 on Degree to both control and experimental groups
7	Week VII	Day 3: Instruction on the word scale 4.00pm: Administration of post-test 6 on Scale to both control and experimental groups

8	Week VIII	Day 3: Instruction on the word Power 4.00pm: Administration of post-test 7on Power to both control and experimental groups
9	Week IX	Mid –term break
10	Week X	Day 3: Instruction on the word Area 4.00pm: Administration of post-test 8 on Area to both control and experimental groups
11	Week XI	Day 3: Instruction on the word Integer 4.00pm: Administration of post-test 9 on Integer to both control and experimental groups
12	Week XII	Day 3: Instruction on the word Multiple 4.00pm: Administration of post-test 10 on Multiple to both control and experimental groups
13	Week XIII	Day 3: Administration of SMAQ

Appendix I: Marking Scheme for the PRESMVT and PRESMAT

Marking scheme for the PRESMVT

1. Perimeter of a figure is the total length of its boundaries
2. Capacity is the ability of a container to hold fluids
3. Percentage – (%) is a fraction whose denomination is 100 e.g. 27% means ${}^{27}/_{100}$
4. Ratio- is a way of comparing two similar quantities
5. Angle – is a figure formed by 2 rays called the side of the angle sharing a common end called vertex of the angle

Marking SCHEME for the PRESMAT

1. $\frac{1}{2}\pi D + D$

$$14.28 = \frac{1}{2}X\frac{22}{7}x2r + 2r$$

$$= \frac{22r}{7} + \frac{2r}{1}$$

$$14.28 = \frac{22r}{7} + 14r$$

$$36r = 14.28x7$$

$$r = \frac{99.96}{36} = 2.7766cm$$

2. $11\frac{1}{4}x + 10\frac{1}{2}(36000 - x) = 10\frac{3}{4}(36000)$

$11.25x + 10.5\ (36000 - x)$ = $10.75\ (36000)$

$11.25x + 378000 - 10.5x = 387{,}000$

$0.75x = 9000$ Thus X= 12,000

$P \rightarrow X$ = 12,000 and $Q = 24{,}000$

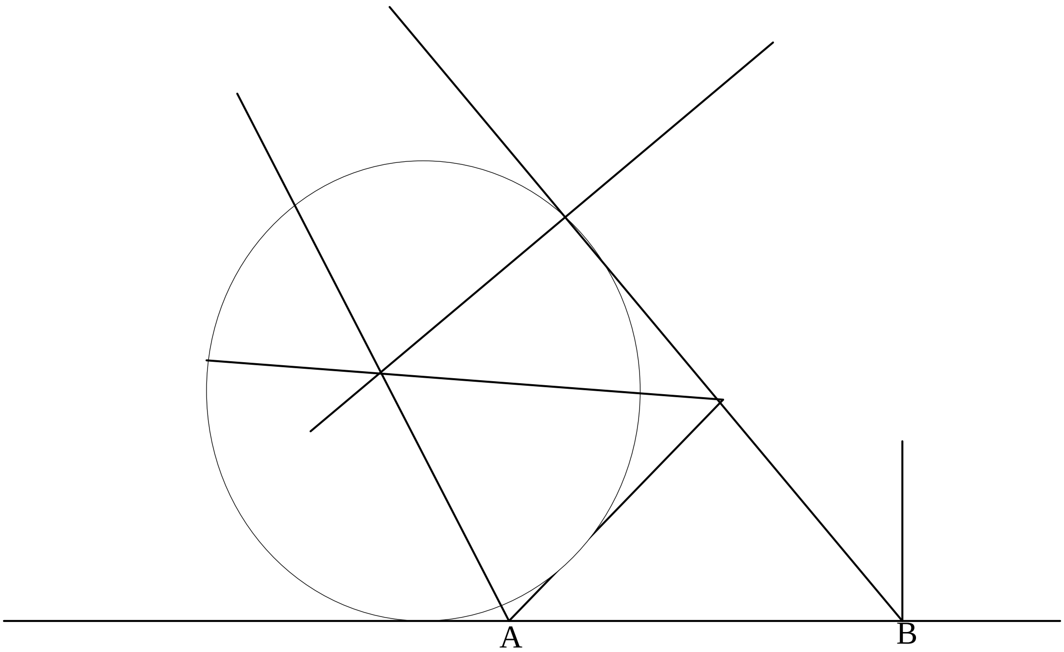
3.

3	12	15	21
	4	5	7

4.

Men	:	Women		
7	:	5 ………………..x 4		
Women	:	youth		
4	:	3 …………………...x 5		
Men	:	Women	:	youth
28	:	20	:	15
Men	:	Youth		
28	:	15		

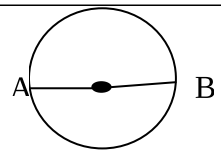
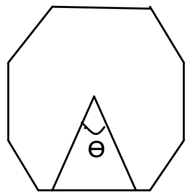
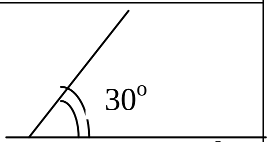
5. Complete the triangle ABC such that BC = 5cm and <ABC = 45^O.

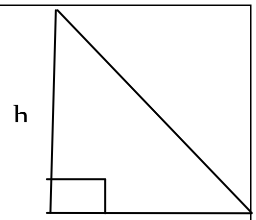


Appendix J: Marking Scheme for POSVMT

(I mark each for definition, use and diagram- 10 x 3= 30 marks)

NO	WORD	DEFINITION	USE THE WORD IN SENTENCE	DIAGRAM
1	Product	Product is the result in the result of multiplying or an expression that identifies factors to be multiplied	The product of 2 and 3 is six (6)	$2x3 = 6$ $x - means\ multiply$
2	Factors	Factors are numbers you can multiply together to get another number. A factor is a whole number which divide exactly into a whole number leaving no remainder	2 and 4 are factors of 8	2 x 4 = 8

3	Chord	A line segment that joins two points on the circumference of a circle	The diameter is the longest chord in any given circle	 AB – Chord
4	Polygon	A polygon is a two dimensional shaped plane figure with straight lines	Triangles, rectangles, squares and pentagon are examples of polygon. 7 sided polygon is called a heptagon	 8 – octagon
5	Degree	A degree is a measure of angles	There are 360^o in a full rotation	 Rotation of 30^o
6	Scale	Scale is the ratio of the length of drawing to the length of the real thing	A scale of a graph is a series of numbers placed at fixed or equal distances	1:200,00
7	Power	The power of a number shows how many times to use the number in a multiplication	The other word for power is exponent	$2^3 = 8$

8	Area	Area is size of a surface	Areas is a scalar quantity Area of a triangle is given by $A = \frac{1}{2}bh$	 $A = \frac{1}{2}b\ \ b$
9	Integer	An integer is a number with no fractional part	Integer is a mathematical term to define the set of whole numbers both negative and positive	$\{0,12,3, \dots \dots \dots ..\}$ Are set of integers
10	Multiple	The multiple of a number is what you get when you multiply that number by some other number of e.g. multiply 3 by 5 = 15 , so 15 is a multiple of 3	The first few multiples of 3 are 3,6,9,15,18,21	The multiples of 7 are 0,7,14,21,28,35,49 $7x0 = 0$ $7x1 = 7$ $7x2 = 14$ $7x3 = 21\ \ etc$

Appendix K: Marking Scheme for POSMAT

1. $156°/24°$ sum of the exterior angles of a polygon ass upto 360° $\therefore \frac{360}{24} = 15\ sides$

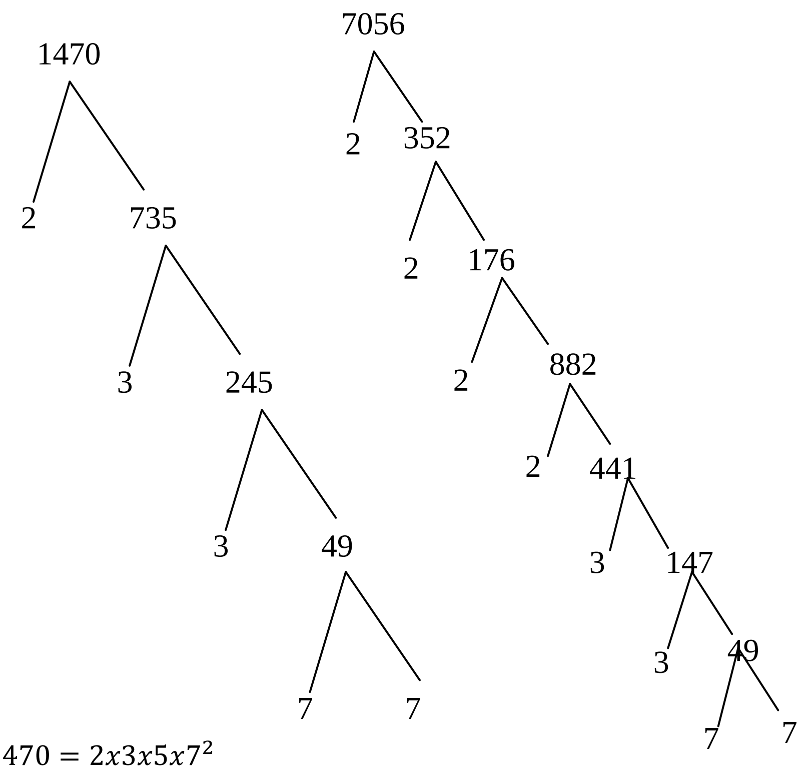
   Or sum of the interior angles (2n-4) 90 where n is a No. of sides

   $156n = (2n - 4)90$ or $\frac{2n-4)90}{n} = 150$

   $156 - 180n - 360$ $180n - 360 = 156n$

   $24n = 360$ $24n = 360$

   $n = \frac{360}{24} = 15sides$ $n = 15sides$

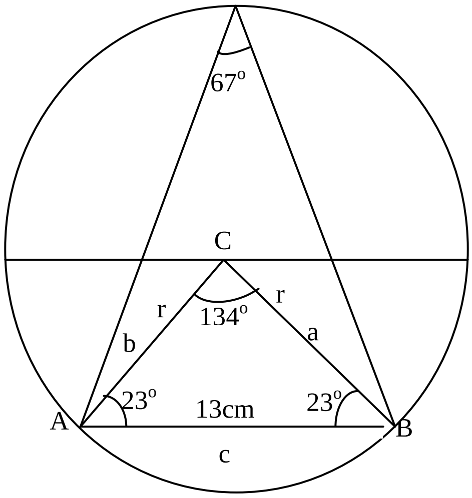
2. 

   $1470 = 2x3x5x7^2$

   $7056 = 2^4x3^2x7^2$

   b) $1470x7056 = (2x3x5x7^2\ (2^4x3^2x7^2 = 2^5x3^3x5x7^4$

3.



$$\frac{r}{\sin A} = \frac{C}{\sin C}$$

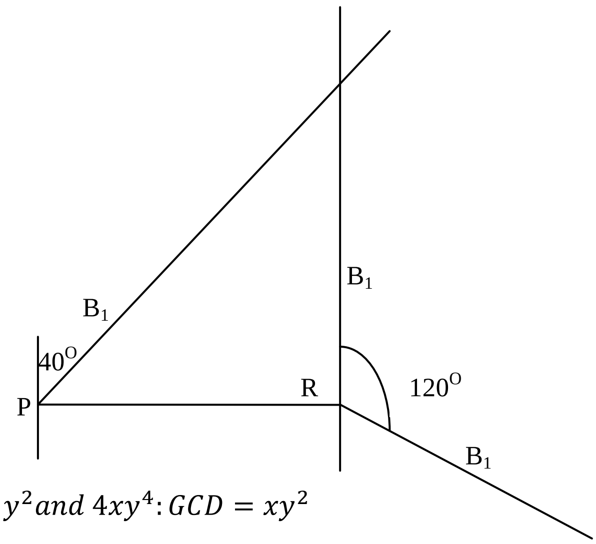
$$\frac{r}{\sin 23} = \frac{13}{\sin 134}$$

$$\frac{r}{0.390} = \frac{13}{0.719}$$

$$r = 0.390x13$$

$$= 7.06cm$$

4.



5. $x^3y^2 and\ 4xy^4 : GCD = xy^2$

$x^3y^2 - \ 4xy^4$

$xy^2(x^2 - 4y^2)$

6. $n + 1,\ n + 3, n + 5, n + 7 > 219$

$n + 1, n + 3, n + 5, > 219$

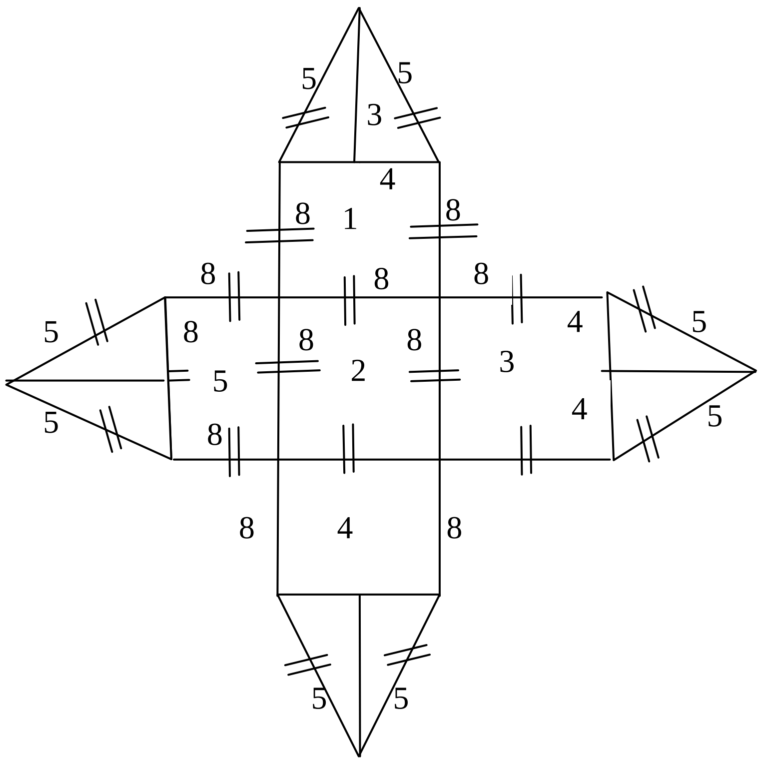
$3n = 219 - 9$

$3n = 210\ 3n = 70$

The integers are 71,73,75,77

Three integers whose sum > than 219 are 73, 75, 77

7.



$$S.A\ Squares = 5\ x\ 8\ x\ 8 = 320cm^2$$

$$S.A\ Triangles = 4\ x \frac{1}{2}\ x\ 8\ x\ 3 = 48cm^2$$

$$= 368cm^2$$

8. $3^{(2y-1)} + 2\ x\ 3^{(y-1)} = 1$

$3^{2y} \div 3^1 + 2\ x\ 3^y \div 3^1 = 1$

let $3^y = x$

$\frac{x^2}{3} + \frac{2x}{3} = 1$

$x^2 + 2x = 3$

$x^2 + 2x - 3 = 0$

$x^2 + 3x - x - 3 = 0$

$x(x+3) - 1(x+3) =$

0

$x - 1 = 0\ or\ x + 3 = 0$

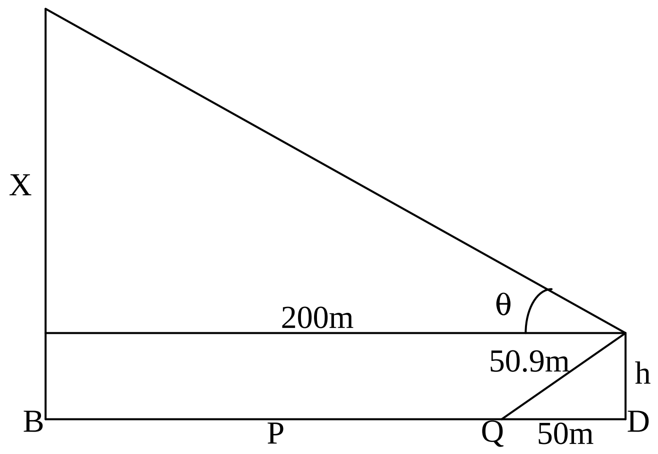
$x = +1\ x = -3$

$but\ 3^y = x$

$3^y = 1 \rightarrow y = 0$

$or\ 3^y = -3$

9.



$$h = \sqrt{(50.9^2) - (50)^2}$$

$$= 9.529$$

$$x = 20.0 - 9.52943$$

$$= 10.47057$$

$$\tan\theta = \frac{x}{200}$$

$$\tan\theta = \frac{10.47057}{200}$$

$$= 2.996° \approx 3°$$

10 6 = 6,12,18,24,30,36

8 = 8, 16, 24,32,40,48

12 = 12, 24, 36,48,60,72

2	8	12	6
2	4	6	3
2	2	3	3
3	1	3	3
	1	1	1

LCM $= 2x2x2x3 = 24cm$. Therefore the shortest pipe = 24cm

Appendix L: Student Consent Form

I willingly give my informed consent to take part in the research study indicated below.

Topic: **Effects of mathematical vocabulary instruction on students' achievement in Mathematics in secondary schools of Murang'a County, Kenya**

By: **Benson Njoroge Wanjiru**

Department: **Educational Communication and Technology, Kenyatta University**

Taking part in this study is on voluntary basis and it is taken as noble undertaking which will lead to generating of information and yield knowledge in the research field

Participants name: …………………………………………………………...

Signature: ………………………………… Date: ………………………….

Thank you

Appendix M: Research Permit

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/14/013/1109**

Date: **27th June 2013**

Benson Njoroge Wanjiru
Kenyatta University
P.O Box 43844-00100
Nairobi.

RE: RESEARCH AUTHORIZATION

Following your application dated **14th June, 2013** for authority to carry out research on ***"Effects of Mathematical Vocabulary instruction on Secondary schools students' achievement in Mathematics in Murang'a County, Kenya."*** I am pleased to inform you that you have been authorized to undertake research in **Kahuro District** for a period ending **30th June, 2015.**

You are advised to report to **the District commissioner and District Education Officer, Kahuro 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.

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The District Commissioner
The District Education Officer
Kahuro District.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development".

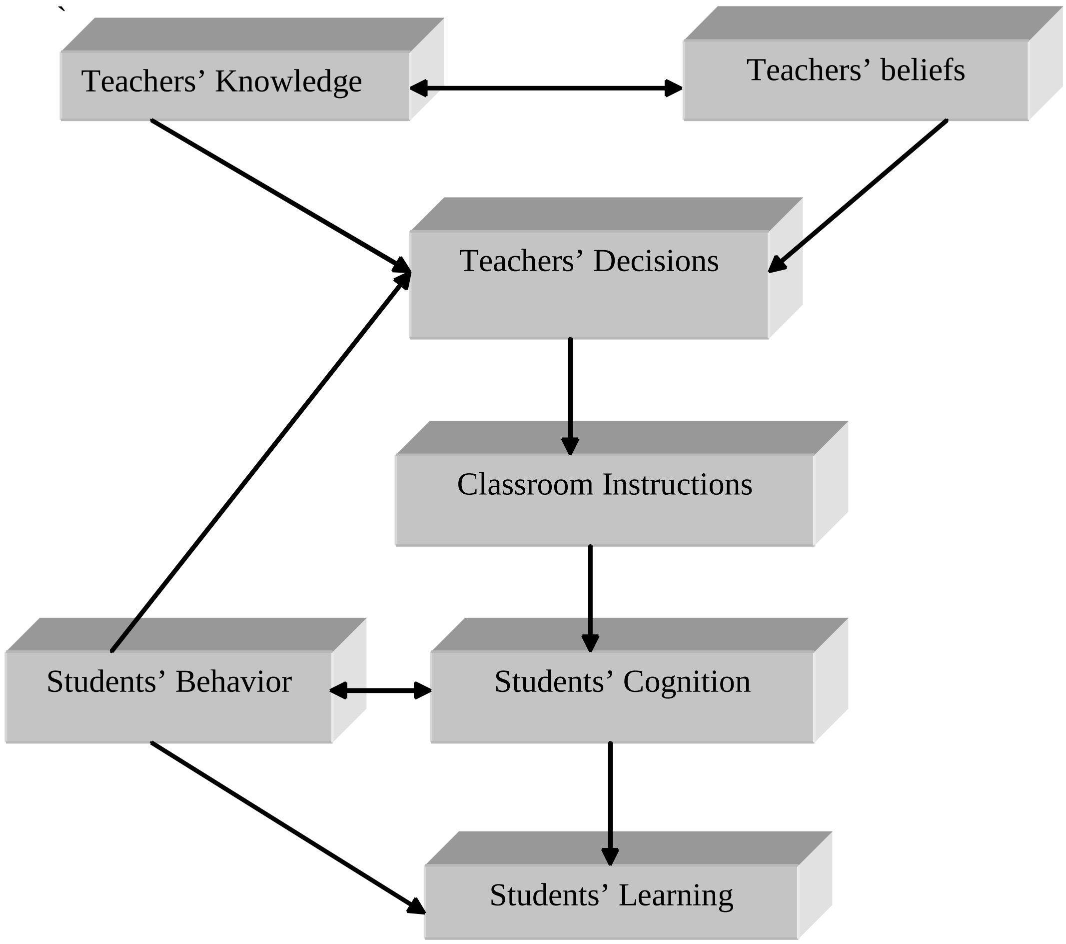
Appendix N: Map of Kiharu Constituency

Appendix O: Initial Vocabulary List

No.	TOPIC	VOCABULARY TERM	COMPOSITE SCORE ($^x/_{100}$)
1	**Natural Numbers**	Place value	8.90
		Divided	8.17
2	**Factors**	Factor	8.33
		Prime number	8.00
		Product	8.50
		Multiple	7.7
3	**Divisibility test**	Divisible	6.1
4	**Greatest common divisor**	G.C.D	8.00
5	**Least common**	Multiple L.C.M	8.33
6	**Integers**	Number line	6.00
		Integer	6.21
7	**Fraction**	Denominator	8.17
		Numerator	8.50
		Improper function	8.50
		Equivalent fractions	6.71
8	**Decimals**	Decimal	8.67
		Recurring decimals	7.67
		Decimal places	7.83
		Standard form	8.50
9	**Square and square root**	Square	8.33
		Square root	8.3
		Factorization	7.83
10	**Algebraic expression**	Algebraic fraction	8.50
11	**Rate, ratio, proportion and percentage**	Rate	8.21
		Ratio	6.62
		Proportion	8.13
		Percentage	6.14
12	**Length**	Significant figures	6.83
		Perimeter	6.67

		Arc chord	6.00
13	**Area**	Area	8.17
		Sector	8.00
		Cylinder	8.50
14	**Volume and capacity**	Volume	8.67
		Capacity	6.00
15	**Mass, weight, density**	Mass	6.50
16	**Time**	24hrs system	8.00
17	**Linear equation**	Simultaneous equation	8.64
18	**Commercial Arithmetic**	Exchange rate	8.50
		Discount	867
19	**Co-ordinates and graphs**	Coordinates	8.50
20	**Angles and plane figure**	Angle	7.67
		Degree	6.23
		Polygon	7.83
21	**Geometrical construction**	Perpendicular bisector	8.67
22	**Scale drawing**	Scale	7.50
		Angle of elevation	6.00
		Angle of depression	6.00
		Bearing	6.21
23	**Common solid**	Solid	8.50
		Net	6.50

Appendix P: A Model for Cognitively Guided Instruction



Source: Adapted from Fennema, Carpenter & Lamon (1991)