THE EFFECT OF SEMANTIC STRUCTURE OF ARITHMETIC WORD PROBLEMS ON STUDENTS: A CASE OF KAKAMEGA MUNICIPALITY PRIMARY SCHOOLS, KENYA.

BY

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NOVEMBER, 2009

DECLARATION

DECLARATION BY THE CANDIDATE

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DEDICATION

This thesis is dedicated to the Creator, the almighty God, who gave me the physical and mental strength to undertake and accomplish this project.

ABSTRACT

Poor performance in mathematics word problems continue to cause concern to educators and the general Kenyan public. Although some interventions have been undertaken, little has changed. It was against that background that the need for this study was envisaged. The study was undertaken in kakamega municipality. Using stratified random sampling; six schools were selected from public and private schools. Sixteen grade 4, 5 and 6 mathematics teachers from sampled schools were interviewed. The teachers selected were all trained teachers who had taught for more than three years. Simple random sampling was used to select 30 percent of the students in each grade (primary 4, 5 and 6) from the sampled schools. They were required to fill 22 close- ended questions in a questionnaire. Expost-facto research design was adopted. The Study examined four independent variables namely: Semantic structure, grade level, type of school and gender. On the other hand the dependent variable was: ability to identify correct operation. Data obtained was analyzed using both descriptive and inferential statistics.

The findings of the study indicated that students related better to additive word problems than to multiplicative word problems and that they solved problems that did not involve relational statements better. The study also showed that the student's ability to solve word problems increases with grade level, but the relative difficulty of each problem type is grade independent. Thirdly, the study found that the type of school attended by the students significantly influence the ability to identify the correct operation required to solve arithmetic word problems. Finally, the study revealed that the students' gender does not significantly influence the ability to identify the correct operation required to solve arithmetic word problems.

From the findings it was recommended that mathematics instructors should help students to comprehend the relations embedded in arithmetic word problem and hence deduce the solution operation that correspond to their semantic structure. Besides, mathematics instructors and teachers should formulate arithmetic word problems representing the whole range of semantic structure. Thirdly, Kenya institute of education (K.I.E) should make revisions in mathematics curriculum based on a continuum of difficulty as predicted by semantic structures and other task variables. Fourthly ministry of education should mount regular in-service training (INSET) to update teachers on new instructional techniques and philosophy of arithmetic word problems of various semantic structures.

TABLE OF CONTENTS

DECLARATION ii
DEDICATION iii
ABSTRACT iv
TABLE OF CONTENTS v
ACKNOWLEDGEMENT viii
LIST OF TABLES ix
LIST OF FIGURES x
LIST OF ACRONYMS xi
CHAPTER ONE 1
INTRODUCTION 1
1.0Introduction 1
1.1 Background of the study 1
1.2 Statement of the problem 7
1.3 Purpose of the study 10
1.4 Research Questions 10
1.5 Research Hypotheses 11
1.6Assumptions of the study 11
1.7.Significance of the study 12
1.8.Scope of the study 13
1.9.Limitations of the study 13
1.10.Variables of the study 14
1.11.Theoretical Framework 14
1.12 Definition of Terms 16
1.13 Summary 17
CHAPTER TWO 19
REVIEW OF RELATED LITERATURE 19
2.0 Introduction 19
2.1 The Development of Semantic Categories of Word Problems 19
2.2 Effect of Semantic Structure of Problems Solving processes 26
2.3 Comprehending Arithmetic Word Problems 28

2.4 School Differences in Mathematics Performances 30

2.5 Cognitive Developmental Levels.. 32

2.6 Gender Differences in Mathematics Performances 36

2.5 SUMMARY.. 38

CHAPTER THREE 40

RESEARCH METHODOLOGY 40

3.0 Introduction 40

3.1 The Area of Study.. 40

3.2 The Study Sample 40

3.3 Sampling Procedure 43

3.4 Mitigating Factors.. 43

3.5 Research Design... 44

3.6 Data Collection Procedure... 45

3.7 Data Collection Instruments 45

3.7.1 Student Test 45

3.7.2 Teachers' Interview Schedule 46

3.8 Pilot Study 47

3.9 Reliability and Validity of Research Instruments...................................... 47

3.10 Data Analysis Technique... 49

3.11 Interpretation of T-test and Anova in the Study 49

3.12 Phase of Data Analysis... 50

3.13 Interpretation of Analyzed Data.. 51

3.14 Summary.. 52

CHAPTER FOUR 53

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA 53

4.0 Introduction 53

4.1 Word Categories and ability to Identify Correct Operation 54

4.2 Grade level and ability to Identify Correct Operation 61

4.3 Type of School and ability to Identify the Correct Operation..................... 68

4.4 Gender and ability to Identify the Correct Operation 73

4.5 The Teachers' View 78

4.6 SUMMARY OF FINDINGS.. 80

CHAPTER FIVE 82
DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS 82
5.0 INTRODUCTION 82
5.1 DISCUSSION.. 83
5.2 CONCLUSION.. 87
5.3 RECOMMENDATIONS 88
5.4 SUGESTIONS OF FURTHER RESEARCH... 89
REFERENCES 90
APPENDIX A 97
TEACHERS’ INTERVIEW SCHEDULE.. 101
APPENDIX C.. 102
RESEARCH PERMIT 102
APPENDIX D 103
MAP OF KAKAMEGA DISTRICT 103

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LIST OF TABLES

Table 1: KCPE 2004 Mathematics Performance…………………………………………...8

Table 2: The three semantic categories of addition and subtraction word problems..20

Table 3:Different types of addition and subtraction word problems (Riley et al, 1963) ………………………………………………………………………………..23

Table 4: Levels of Development…………………………………………………………..33

Table 5: Levels of Cognitive Development……………………………………………....35

Table 6: Summary of Selectd Schools…………………………………...………..41

Table 7: Distribution of Students by School Grade…………………………………….42

Table 8: The facility ratio by semantic structure and by specific problem…………..56

Table 9: ANOVA of students overall scores on word category problems………..…57

Table 10:A paired t-test between additive and multiplicative word problems……..…58

Table 11: Problems solved by more than 50% of students in each class…………….62

Table 12: Percentage of students in each school group by achievement class……..…64

Table 13:ANOVA for difference in grade means……………………………………65

Table 14: Means and standard deviations of scores by school ……………………....69

Table 15: ANOVA for difference in school means…………………………………..70

Table 16: Means and standard deviation of schools and overall performance……....74

Table 17: ANOVA for gender differences………………..…………………………75

LIST OF FIGURES

Figure 1 Student success on word categories…………………………………..60
Figure 2 Average performances in school grade……………………………….67
Figure 3 Average performance per school……………………………………..72
Figure 4 Gender performance per school……………………………………….77

LIST OF ACRONYMS

ANOVA	-	Analysis of variance
DQAS	-	Directorate of quality assurance and Standards
INSET	-	In-service Training
KCPE	-	Kenya Certificate of Primary Education
KIE	-	Kenya Institute of education
KNEC	-	Kenya National Examination Council
MOE	-	Ministry of Education
NCTM	-	National Council of Teachers of Mathematics
SMASSE	-	Strengthening Mathematics and Science Subjects in Secondary Schools
TIS	-	Teachers' Interview Schedule

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter examines the background information to the problem, a statement of the research problem, purpose of the study, the research questions, hypothesis, assumptions, significance, scope, limitations, variables, theoretical framework and definition of key terms used in the study.

1.1 Background of the study

Word problems remain to be the most ubiquitous kinds of problem solved in learning institutions. They pervade science and mathematics curricula from pre-primary to undergraduate schools. From simple combine problems to complex problems in thermodynamics, word problems are the most common kind of problems found in formal education. Their role dates back to antiquity as Decorte and Verschaffel (1993:117) aptly put it thus:

> **One can find verbal problems in the 400-years-old Egyptian papyri. They also feature in Greek and Roman manuscripts as well as in arithmetic textbook from the early days of printing.**

Word problems represent a quantitative word solution problem embedded within a shallow story context. According to Briar and Larkin (1984) word problems are the primary context in which children are asked to apply mathematical knowledge in useful situations, rather than to simply execute algorithms. Thus solving word problems may be an important precursor to the ability to construct mathematical representation of more complex situations, a critical skill for many kinds of "real" problem solving. To this end (NCTM, 2000:2) observes:

> **Problem solving is an integral part of all mathematic learning. In everyday life and in the workplace, being able to solve problems can lead to great advantages**.

Students tend to deem word problems as one of the most distasteful and anxiety-inducing tasks in Mathematics classroom. They perform poorly in solving word problems (Kouba , V.L., Brown, C.A., Carpenter, T.P., Lindquist, M.M., Silver ,E.A., and Swafford, J.O.((1988). It is well documented that students, who have little or no difficulty with various mathematical computations, may be unable to solve word problems in which appropriate operation is not specified. Carpenter, Corbitt, Kepner, Lindquist and Reys (1980) reported that 9- and 13 year olds constantly perform 10% to 30% worse on word problems than on comparative direct computations. This view is supported by many studies that have reported that students who are proficient in arithmetical computations may not necessarily solve arithmetic word problems with the same proficiency (Lyons,1994; Nesher,1976). From the foregoing, it seems that in addition to computational ability another skill which facilitates the extraction of correct operation from the given information is required. Despite the fact that a lot of work has been done in this field to alleviate students' poor performance on this part of the curriculum, the phenomenon remains a pedagogical puzzle.

Several explanations have been provided as to why students find arithmetic word problems very difficult to solve. Ineffective instruction has been among these explanations (Cardelle-Elawar, 1992; Carpenter and Moser, 1984; Decorte and Verschaffel, 1987; Essen and Hamaker, 1990) reported. Dellarosa, D., Kintsh, W., and Weiner,R. (1988) contended that pupil's failure on arithmetic word problems is due to lack of linguistic knowledge. The situation is even more problematic when the problems are expressed in learner's second language. (Abedi and Lord, 2001; Bernardo, 2001; Cuevas, 1984; Maro 1994). Kintsch and Greeno (1985), Dellarosa et al (1988) found that internal constructs such as the processing skills, pre-requisite knowledge and cognitive ability hinder word problem solving. Other explanations relate to less influential factors like: Context (Hiscock, 1993; Lopez, 1992), binary steps involved in the problems (Huinter, 1990) and superfluous information in the problems (Dunbar, 1995). Some researchers used attitudes and motivation (Wenger, 1992) and gender (Zambo, 1990) to explain why pupils find word problems very difficult.

Most older studies of the effect of task variables on students' arithmetic word problems solving concentrated on the surface characteristics and on the mathematical structure of those problems. For instance, the variables examined include the number of words in the problem, the place of the question, the presence of a cue or key words and so on (Decorte and Verschaffel, 1985). In most recent work, the focus has shifted from mathematical and surface aspects towards the semantic structure of the problem. Research evidence shows that the semantic structure is a major factor determining problem solution, hence significantly affecting students' performance and strategies with respect to verbal problems.

The effects of semantic structure of problems on solving processes have been reported by several researchers. Shalin (1987), Lopez(1992), Nesher and Hershkovitz (1994) found that pupils interact differently to problems of deferent additive structures. For instance, it has been shown that young children's strategies for subtraction problems are strongly influenced by the semantic structure underlying the problems (Carpenter and Moser, 1984). Decorte and Verschaffel (1987) reported similar findings relating to students strategies for addition problems. It has been demonstrated that problems involving relational statements (the compare problems) are more difficult than problems that do not contain such statements (Kintsch and Greeno, 1985). In multiplicative structure problems, situations that could be conceived as repeated addition were easier than others (Bell et al, 1984). They found that partition-type problems were the most favoured division-type problems and fractional-quotation problems were among the least popular among pupils. Greer (1992) pointed out that equal groups problems are more difficult. In contrast, Christou and Philipou (1999) reported that rate problems were the hardest multiplicative problems.

Research on early problem solving shows that kindergarten children and first graders, before learning arithmetic at school can solve simple addition and subtraction word problems but fail in some of them. (Carpenter et al., 1981; Lindvall and Ibarra, 1979; Lindvall, 1980; Riley et al., 1981; Tamburino, 1980). These findings leads to the need to treat the growth of a child's knowledge-structure in a way that identifies distinct main components (that is empirical, the logical and mathematical components). Riley et al (1981) investigated development levels of one-step word problem-solving ability that relate to growth in empirical, mathematical and logical knowledge structures. They hypothesized four developmental levels characterized by several components representing different aspects of knowledge. Hence, they claimed that their hypothesis concerning the developmental levels explains which kinds of problems can be solved by a student of a given level. Christou and Philippou (1998) expanded the theory of developmental levels in students' ability to solve one-step word problems by considering additive and multiplicative structures simultaneously. They reported that the ability to solve difficult problems increased with age, but the inherent difficulty of each problem remains stable for various grades and depends on the schemas and operations involved in each problem.

Gender differences in mathematics achievement in elementary level have reported divergent findings. For instance some investigations (Burton, 1979; Fennema and Sherma, 1978) have found no differences in mathematics performance at different levels of elementary school or at the elementary school level as a whole. A few studies have, however, revealed differences in favour of either boys or girls. According to some scholars (Fennema, 1974; Marshall 1984) girls were better than boys in solving computations items whereas boys were better than girls in solving higher-cognitive problems such as applications items and word problems. Some researchers (Geary, 1996; Johnson, 1984) have asserted that the boy advantage in solving mathematical word problems might be mediated, in part, by their advantage in spatial cognition. More specifically, it appears that males are better in generating spatial representations or diagrams, of the relational information conveyed in word problems. In Kenya, studies by

Mwangi (1985), Eshiwani (1987) and Kiragu (1986, 1988) reported gender differences in mathematics performance at high school. However, there is hardly any evidence that indicates whether gender differences in mathematics first appear in high school or at elementary school level. Since most of the studies in sex differences in mathematics achievement have not revealed consistent differences, there is need to investigate gender differences at elementary level in relation to choice of operation required to solve arithmetic word problems of various semantic structures.

Contemporary approaches to word problem solving have emphasized the conceptual understanding of the word problem before any solution attempts. Unfortunately most students employ key word or a procedural approach to their solution, directly translating story values into solvable algorithm (Jonassen, 2003). While the direct translation approach may lead to success to narrowly structured problems, it is not applicable in all problems. Good problem solvers tend to look beneath the surface information at the underlying problem model (Hegarty, Mayer and Monk, 1995). It is not surprising, then, that a student who has been taught a key word or a strictly procedural approach struggles with word problems that are more complex or semantically inconsistent with what they have learnt. (Nesher and Teubal, 1975; Fuson, Caroll and Landis, 1996). Jonassen (2003:1) asserts that:

> **Solving story problems requires that learners construct a conceptual model of the problem that integrates the (story) situational content with an understanding of the semantic structure of the problem based on the principles of mathematics being practiced in the problem.**

From the foregoing, it seems that the traditional approach to word-problem solving instruction do not support conceptual understanding of the problem structures particularly semantic structures. It was against this background that the study was set to investigate the effect of semantic structures of arithmetic word problem on students' choice of correct operation. The researcher was also prompted to undertake this study because of the fact that there are no known studies on semantical aspects of mathematics in Kenya.

1.2 Statement of the problem

Each year the Kenya National Examination Council (KNEC) prepares reports on how each subject examined was performed. Such reports usually analyze how each aspect of the syllabus was performed and candidates' performance in set areas. The KNEC has noted that "candidates continue to register poor performance in most aspects of the syllabus, in particular, application to number problems" (KNEC report, 2004:52).

Table 1 shows that student's weakness is majorly in applied arithmetic which basically is arithmetic word problem solving. This is an indication that some areas of the syllabus are either ignored or not taught well and is reflected by the perpetual poor performance in those areas.

Table 1: KCPE 2004 Mathematics Performance

Type of Question	% of candidates scoring correctly			
	2001	2002	2003	2004
Arithmetic (a) Mechanical	61.87	42.04	54.01	55.57
(b) Applied	41.45	47.86	42.66	29.39
(c) Data from tables	59.84	38.17	56.00	43.68

Source: KNEC Report 2004

The difficulty in teaching students how to solve word problems in mathematics is well known to teachers. Students, who have little or no difficulty with various mathematical computations, may be unable to solve arithmetic word problems in which an appropriate operation is not specified. What makes word problems difficult is not their formal properties, but the way the problems are expressed. Hence, students face semantic challenges when presented with arithmetic word problems to solve and the question of which operation to use becomes a rather instantaneous reaction. It seems that students are unable to comprehend the relations embedded in word problems and hence deduce the solution that respond to their semantic structure.

From the foregoing, it seems that semantic aspects may be influencing students' proficiency in solving arithmetic word problems. As of now, knowledge of how semantic structure relates to students proficiency in solving arithmetic word problems is not quite clear. There is need to establish the effect of the semantic structure of arithmetic word problems on students ability to identify the correct operation required to solve them with a view of improving students' proficiency.

Specifically this study sought to investigate how well primary schools students in municipality division can identify the correct operation required to solve arithmetic word Problems of various semantic structures and compare those abilities among students of different schools. It also sought to identify whether there is a developmental pattern in student's ability to identify correct operations required to solve an arithmetic word problem of various semantic structure. Finally, this study sought to establish whether students' gender had any influence on their ability to identify correct operations required to solve arithmetic word problems of various semantic structure.

1.3 Purpose of the study

The of this study was to ascertain how well primary school students could identity the correct operation required to solve arithmetic word problems of various semantic structures and compare such abilities among students of different school categories. It also sought to determine whether there is a development pattern in students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures. Finally, this study sought to determine whether students' gender influence their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

1.4 Research Questions

The following are the research questions that guided the study:

1. Do semantic structures of arithmetic word problems influence the student's ability to identify the correct operations required to solve them?
2. Is there any relationship between grade level and students' ability to identify the correct operations required to solve arithmetic word problems of various semantic structures?
3. Does the type of school attended by students influence their ability to identify the correct operations required to solve arithmetic word problems of various semantic structures?
4. Is there any gender differences in student's ability to identify the correct operations required to solve arithmetic word problems of various semantic structures?

1.5 Research Hypotheses

The following were the hypotheses of the research study stated in the null form and tested at 0.05 significance level.

HO_1 : There is no significant difference between semantic structure of arithmetic word problems and student's ability to identify the correct operation required to solve them.

HO_2 : There is no significant difference between student's grade level and their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

HO_3 : There is no significant difference between the type of school attended by students and their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

HO_4 : There is no significant difference between student's gender and their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

1.6 Assumptions of the study

The study was based on the following assumptions:

1. There are semantic structures of arithmetic word problems which determine the operation required to solve them and their difficulty level.
2. The students find difficulty in identifying the correct operation required to solve arithmetic word problems of various semantic structures.
3. There is gender differences in student's ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

4. The type of school attended by the students influences their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.
5. There is development levels in student's ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

1.7 Significance of the study

Since mathematics is the core subject in the curriculum and an important requirement for secondary and most of post-secondary school training, concern on the need to improve its performance is very significant. The study findings will shed some light on the effects of semantic structure in solving arithmetic word problems in primary schools in Kenya. The study will be useful to Kenya institute of education (K.I.E.) and directorate of quality assurance and standards (D.Q.A.S.) Which are responsible for curriculum development, interpretation and implementation. These findings will also be useful to the teacher trainers in teacher training colleges and universities. This will go a long way to assist them to reorganize their units in educational technology so that appropriate instructional skills for solving word problems are instilled in the teacher trainees. The study may be of benefit to the authors of mathematics text books and other mathematics instructional materials in presenting the contents in a way that facilitates conceptual understanding of word problems. The study is expected to form a basis for the continuing search into semantic aspects of mathematics that were not covered by the study.

1.8 Scope of the study

The study was carried out in selected primary schools of municipality division, Kakamega District, Kenya. The respondents of the study were primary 4, 5 and 6 students plus all the mathematics teachers of the selected school. Grade 4 students were used because one-step word problems are covered up to the first four years of primary mathematics. Some studies for example, Zambo and Fullman,(1994) have noticed that the upper elementary grades (particularly grade six) are critical, for it is about this time that gender-related difference occurs. The reason for focusing on the fifth grade and sixth graders was thus to ascertain whether this is the case in the Kenyan context. The conclusions made in the study are based on the responses of the sample population. It is hoped that the findings of the study may be applied to other districts in Kenya.

1.9 Limitations of the study

The study was beset by a number of limitations:

Absence of previous research on semantic structure of word problems in schools in Kenya limited the scope of the literature review. However, studies in the western countries were reviewed. The instrument (questionnaire) used was not a standardized one. However, efforts were made to develop a valid reliable tool as explained in the methodology section of this study. The cause-effect relationship could not to be established between independent variables and student’s ability to identify correct operation due to none manipulation of the variables in this study. There was also anticipated limitation of teachers declining to give information but this was reduced by assuring them of confidential treatment of the information they would give and establishing a rapport with them.

1.10 Variables of the study

In the study the independent variables were: semantic structure, grade level, type of school and gender. On the other hand the dependent variable was: ability to identify correct operation.

1.11 Theoretical Framework

The study was based on schema theory advanced by Marshall (1995). The notion of schema has its roots in Plato and Aristotle, and has played a central role in many influential philosophical and psychological investigations. The theory asserts that the critical element in solving problems lies in its structure. It is based on the assumptions that the external representations used to describe the structure of a problem can serve in constructing a mental model which can be retrieved and used in solving analogous problems with similar structure. Thus, attention should be paid to the selection of the correct schema which mirrors the structure of the problem.

Marshal(op.cit.) says: Schemas are problem solving vehicles, since they provide access to similar problems that have been encountered in the past, [… and] the means of reformulating or simplifying a problem. Nesher and Hershkovitz (1994) support that schemes constitute the bridge between the verbal formulation of a problem and its mathematical structure. Thus, a problem, schema functions as the means to describe and classify the elements of word problems and hence to conceptualize the relations and connections among them. For this reason schemas are regarded of primary importance with respect to cognitive processes involved in solving word problems, since they constitute a vehicle for comprehension of the semantic relations underlying a given text and it's mathematical structure, and they serve as generalized frames for action in a given situations (Christou and Philippou, 1999), Therefore, to solve word problems successfully learners must demonstrate conceptual understanding of the problem types by constructing problem schemas.

Brunner's theory of structure of discipline supports the use of scheme in solving word problems. Brunner argued that facts and concepts should be related to generalizations and that they should be used in problem solving. Nesher and Hershkovitz (1994) support that schemes serve as generalized habit for action in a given situation. Thus, in a simple word problem, both in additive and multiplicative structures, is a three component relation R (a, b c.), where a, b and c are the elements of the problem. For instance in problem A6(appendix A),the components of the triple R(a,b,c) are a="6 red marbles", b="8 blue marbles", and c="the marbles they have altogether". The student's mental interpretation of this abstract three-place relation, and the action associated with an additive and multiplicative relation comprises the schema of the situation. Mental schemes enable the student to interpret situations and to see both connections among components and the component's role. On the basis of a repertoire of familiar themes, students can envision and comprehend the relations embedded in a word problem and hence deduce the solution operation that corresponds to a scheme. Theoretical rationale in a scheme lies in their ability to help students to construct deep understanding of mathematical problems, clarify their thinking and justify their ideas.

1.12 Definition of Terms

Additive structure: - This refers to structures that yield either addition or subtraction operations depending on the incomplete component.

Algorithm: - Is a step by step procedure, applicable in a particular mathematical task, which, if followed correctly is guaranteed to give a solution for the task.

Arithmetic: - This refers to a branch of mathematics that deals with numbers and their Operations.

Canonical equation:-is arithmetic sentence of the form a+b=x, where a and b are known.

Conceptual field: - This refers to a set of situations, the mastering of which requires mastery of several concepts of different natures (Vergnand, 1987).

Conceptual understanding:-refers to the hierarchical network of knowledge and its corresponding relationships.

Facility ratio: - This is the proportion of the correct answers to the total numbers considered either for a specific problem or for all problems.

Modeling:-is the application of mathematics to solve problem situations in real world.

Multiplicative structure: - This refers to structures that yield either multiplication or division operations depending on the incomplete component.

Non-canonical equation:-is arithmetic sentence of the form x+a=b or a+x=b, where a and b are known.

Problem: - This refers to a mathematical task for which there is no readily accessible algorithm which determines completely the method of solution.

Problem Schema/Conceptual Model: - Refers to mental representations of the pattern of information that is represented in the problem.

Problem solving: - The process of moving towards a solution of the mathematical tasks when the path to a solution is not shown or partially shown.

Schema: - Refers to an organized structure consisting of some elements and relations which are related to a situation and it can be used to understanding incoming information (Mayer, 1992). A scheme serves a generalized habit for action in a given situation.

Semantic: - This is an interpretation of a arithmetic sentence in language that identifies the relevant reference, in the realm of objects and relations,

Spatial ability:-is the ability to perceive relations in space and visualize objects.

Structure: - This refers to a 3-place relation (a, b c) where a, b and c are three components (proportions) in the text of the problem.

1.13 Summary

In this chapter, the background of the study, the statement of the problem, research questions, justification and significance of the study have been addressed. In the background of the study, it was noted that performance in word problems continues to be poor in spite of various inputs especially resources and ideas. Research studies indicate that semantic structure plays a major role in affecting the difficulty levels of word problems. But a close scrutiny of these research studies does not reveal the effect of semantic structures on students’ proficiency in solving word arithmetic problems.

It was against this background that this study was undertaken. The study was based on the conceptual framework that semantic structure of arithmetic word problems influence students ability to identify correct operation required to solve them.

The chapter has outlined the effect of the semantic structure, grade level, type of school and gender in solving word problems. Perpetual poor results in applied arithmetic as shown by KNEC (1994) are well documented and continue to raise a lot of concern.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

The chapter reviews and critiques the pertinent literature related to the investigation. The review is divided into the following categories:

1. The development of semantic categories of word problems.
2. The effect of semantic structure of problem solving processes.
3. Comprehending arithmetic word problems.
4. School differences in mathematics performance.
5. Cognitive development levels.
6. Gender differences in mathematics performances.

2.1 The Development of Semantic Categories of Word Problems

The semantic categories for addition were initially established by Heller and Greeno (1979), and since then a large number of studies have separated arithmetic problems into two conceptual fields: Those that are additive and those that are multiplicative in their structures. A problem belongs to the additive field when the solution operation is either addition or subtraction and it belongs to the multiplicative field when the solution operation is either multiplication or division (Christou and Philippou, 1998).

A general description of each of these categories is given in table 2, along with examples and previous titles used in the past for some categories.

Table 2: The three semantic categories of addition and subtraction word problems

Current name of the category	**Characteristics**	**Example**	**Previous research and titles for the same category**
1. Combine	Involves static relationships between sets. Asking about the union set or about one of the two disjoint subsets.	There are three girls and four girls. How many children are they altogether?	COMBINE: Green (1980 a, b), Heller and Greeno (1978); Riley (1979) Riley et al (1981). PART-PART-WHOLE: Carpenter and Moser (1981); Carpenter et al (1981) STATIC: Nesher (1978, 1981) COMPOSITION OF TWOMEASUES: Vergnaud and Durand (1976), Vergnaud (1981)
2. Change	Describes increase or decrease of some initial state to produce a final product	John has six marbles. He lost two of them. How many marbles does John now have?	CHANGE: Greeno (1980 a, b) JOINING AND SEPARATING: Carpenter and Moser (1981); Carpenter et al (1981) DYNAMIC: Nesher and Katriel (1978), Nesher (1981) TRANSFORMATION LINKING TWO MEASURES: Vergnaud and Durand (1976), Vergnaud (1981)
3. Compare	Involves static comparisons between sets. Asking about the different set or about one of the sets where the difference set is given,	Tom has six marbles and John has four. How may marbles does Tom have more than John	COMPARE: Greeno(19980a,b),Carpenter and Nesher(1981),Carpenter et al(19981),Nesher and Katriel (1978), Nesher (1981) A STATIC RELATIONSHIP LINKING TWO MEASURES: Vergnaud and Durand (1976), Vergnaud (1981)

Source: Nesher et al.,(1982)

Romberg and Collins (1987) classified additive structures to include the following problem situations: change, combine, compare and equalize. In change-join problems the implied action increases a given initial quantity while in change-separate problems the action implies removing a subset from the initial set. Within each category there are three distinct types of problems according to the place of the unknown element (see A10). Combine problems involve static situations of two types. In combine-join problems, the unknown is a cardinal number of the union of two disjoint sets, and in combine-separate the required is a cardinal number of one set, given the cardinality of the union and the cardinality number of the other set;(A)=n(AUB)-n(B). Compare problems involve static relationships, where the task is to compare a referent set to a compared set and find their difference. (seeA13). Six different types of compare problems can be constructed by the relative position of the three entities (different, referent and compare set can be unknown). Equalize problems may be viewed as a combination of change and compare problems since there is an involved action as in change problems, and two disjoint sets that are considered in the same way as in compare problems. Depending on whether the action is to be performed on the smaller or the larger of the two sets, it becomes either an equalize-join or an equalize-separate problem respectively.

Riley et al(1981) classified addition and subtraction word problems into three categories: Change, combine and compare. They found that in each of the above categories, different problems can be formed by varying which item is to be unknown. In change problems for example three forms of information are found if the other two are given, yield three different cases. The unknown may be the initial, change or final set. Furthermore, the direction of change can increase or decrease so there is a total of six different kinds of change problems. A similar set of variation exists for compare problems. In combine problems there are fewer variations, the unknown is either the super/union set or one of the subsets. Thus Riley and associates distinguished fourteen types of elementary addition and subtraction word problems as shown in Table 3.

Marshall (1995) expanded categorization of additive word problems to include change, group, compare, restate and vary problems. Change problems present a quantity that change over time. In group problems small groups are combined to larger groups. Compare problems contrasts two things to determine which one is larger and which his smaller. Restate problems link things in relational terms (twice as big, three more than). and then restate the relationship in terms of numerical values. Finally, vary problems state a relationship between two things and then generalize that relationship to new situations. The problem typologies of Riley et al (op. cit) and of Marshall (op. cit) are both concerned with location of the unknown problem

Table 3: Different types of addition and subtraction word problems.

TYPE	**SCHEMA**	**DIRECTION**	**UNKNOWN**
Combine	Combine	-	Superset
Combine	Combine	-	Superset
Change	Change	Increase	Final/Result set
Change	Change	Decrease	Final/Result set
Change	Change	Increase	Change set
Change	Change	Decrease	Change set
Change	Change	Increase	Initial/Start set
Change	Change	Decrease	Initial/Start set
Compare	Compare	More	Difference set
Compare	Compare	Less	Difference set
Compare	Compare	More	Compared set
Compare	Compare	Less	Compared set
Compare	Compare	More	Reference set
Compare	Compare	Less	Reference set

Source: Riley et al., (1981)

The most important situations involving multiplication and division of integers include: Equal groups, rates comparisons, Cartesian product, and rectangular area. (Greer, 1992; Schmidt and Weiser, 1995). Equal group problems involve natural replications and repetitions of a sequence and can involve either multiplication or division (partittive or quotitive) depending on what is unknown. Compare problems are situations frequently expressed by a phrase such as "twice as much as" or "the n^{th} multiple of ". Rate problems are those with proportional structure; they call for finding the unknown among the four measures. Cartesian-product problems can be solved through an application of the set identity n (A X B) = n (A) n (B). Rectangular-area problems are those in which the factors are measures of sides of a rectangle and the product is the measure of the area.

Among the elements contained in the one-step word problems there are certain structures and relationships including three quantities which represent numerical information; two of them are supplied and the third one is required. The given statements are "complete element" because they contain both the description of the quantified objects and the numerical value, while the unknown element is an "incomplete element" is missing (Nesher and Hershkovitz, 1994). Christou and Philippou (1988) observed that the solution operation depended solely on the role played by the incomplete element. Exchanging this role solution changes from addition to subtraction or from multiplication to division and vice versa.

For example:

> There are 13 boys and 16 girls in the group. How many children are there in the group?

Three components of the above components are:

1. 13 boys in the group [Complete component]
2. 16 girl in the group [Complete component]
3. How many children are there in the group? [Incomplete component]

Each complete component has two basic parts; the number and the description of the quantified objects. In the first component the number is 13 and the description is 'boys in the group'. In the incomplete component we are missing the number (which is the target of the problem) but we know its description- 'children in the group'. The identical solution (29 children composed of 13 boys and 16 girls, in this case) can yield three different problems, depending on the incomplete complete component, and whether we are asking about the boys or girls or the children. Even when asking about one of the subsets (e.g. Boys) we do not care whether it is solved by subtraction (which is the operation in the canonical form: 29 – 16=?) or by addition (a missing addend 16 +? = 29). Should the two complete components be followed by a third, incomplete component of 'How many more girls are there in the group than boys?' (Instead of how many children are in the group), the problem would become totally different (Comparison rather than combine and subtraction rather than addition). Thus, a simple word problem, both in additive and multiplicative structures, is a three component R (a, b, c) where a, b and c are the elements of the problem.

The students' mental interpretation of this abstract three-place relation, and the actions associated with an additive or multiplicative relations comprise the schema of the situation. From the foregoing, it seems that for the students to successfully generalize valuable problem-solving strategies they must develop a mechanism for thinking about classes of word problems rather than attacking each problem as a separate and distinct task.

2.2 Effect of Semantic Structure of Problems Solving processes

A number of studies (Carey, 1991; Carpenter et al, 1981; Carpenter and Moser, 1984) have paid attention to the effect of semantics structure on arithmetic word problems on the students' solution and thought processes, particularly for addition and subtraction. Wilson (1967) pioneered a study relating a structure of verbal problems to performance and presented arguments as to why students should be made to understand structures underlying word problems. The teaching implications of Wilson's (1987) argument are that word problems should be taught meaningfully and systematically thus ensuring that the different components (structures) are given sufficient consideration during instructions. Lopez (1992), Nesher and Hershkovitz (1994) and Shalin (1987) have advocated that the semantic structures of the problems influence the solution processes. In other words, students interact differently to problems with different semantic structures. For instance, it has been established over the years that additive structures are more popular among students than multiplicative structures (Christou and Philippou, 1998). It has been demonstrated that problems involving relational statements (the compare problems) are more difficult for young children in solving than problems that do not contain such statements (Kintsch and Greeno, 1985).

Carpenter and Moser (1984) showed that young children's strategies for subtraction problems are strongly influenced by the semantic structures underlying the problems. Those children operating at the material and verbal levels tended to solve each subtraction problem with the strategy that closely models its semantic structure. A similar finding relating to the students' strategies for addition was reported by Decorte and Vershaffel (1987). As children's conceptual knowledge changes with growth, they become more flexible in their choice of solution (Carey, 1991). Decorte and Vershaffel (1987) observed that the students' strategy for word problems also depends on the sequence in which known quantities are introduced in the text.

Effects of multiplicative semantic structure on performance were reported in Bell, Fischbein and Greer (1984) and in Christou and Philippou (1998). Bell et al (1984) noted that situations that could be conceived as repeated addition were easier than others.
They found out that partition- type problems were found to be the most favoured division-type problems, and fractional-type problems were among the least popular among the students. Christou and Philippou (1998) observed that rate problems were the hardest multiplicative problems. Investigation on how young children formed and developed intuitive models of multiplication and how this models and how this model are related to the semantic structure of word problems was reported by Mulligan and Mitchelmore (1997). They conducted a longitudinal study on a group of girls as they progressed from grade 2 to grade 3. The students were interviewed in the beginning and at the end of each school year. At the first interview they were not exposed to multiplication.

The problems used in the study involved familiar contexts and all of them involved whole number data and answers. Analysis conducted on the correct responses showed three initiative models emerging from multiplication problems (direct counting, repeated addition, multiplication operation) and four from division problems (direct counting, repeated addition, repeated subtraction, multiplicative operation). The results also showed great variation in the use of models and consistent progression of solutions from grade 2 to grade 3 (Mulligan and Mitchelmore, 1997). This provided tentative but valid evidence of how young children's initiative understanding of whole number multiplication and division develop.

2.3 Comprehending Arithmetic Word Problems

Students normally employ a more tactical, problem avoidance to solving word problems. Sherill (1983) found that students demonstrate one pervasive problem-solving strategy:

1) Search for key words
2) Select algorithm (formula) based on key words
3) Apply the algorithm.

Because students normally make no effort to construct any kind of conceptual model of the problem, the commit errors and are unable to transfer any correct problem solutions to similar problems. When problem solvers attempt to directly translate the key propositions in the problem statement into a set of computations (direct translation strategy), they frequently commit errors (Jonassen, 2003).

Sheril (op.cit) found that students frequently: select either the wrong algorithm or wrong sequence of algorithm; select the proper algorithm, but use the wrong numbers; select the proper algorithm, apply the algorithm properly, and stop, not realizing that it was a multi-step problem; do not check their answers; and make little use of heuristics. Solving word problems requires more than the transformation of values into formulas. Jonassen (op. cit.) cites. (Hayes and Simon, 1976) for asserting that successful problems solvers need to construct a conceptual model of the problem and base their solution plans on their models.

Those conceptional models are also known as problem schemas, are mental representations of the pattern of information that is represented in the problem (Riley and Greeno, 1988).

Several problem solving models have been developed and reported by Briar and Larkin (1984), Fuson (1992), Hegarty, Mayer and Monk (1995) and Kintsch and Greeno (1985). The model presented by Hegarty et al (1995) assumes that the solver uses two distinct paths in comprehending a text; the direct translation approach and a problem model approach. The text is processed in increment. At each increment the solver reads a statement containing information about one of the variables. In constructing a text base the solver represents the prepositional content of his statement and integrates it with other statement, and integrates it with other information his or her current representation. At the second stage of comprehension the solver is guided by the goal of solving a mathematical problem and constructs a presentation that is refereed to as the mathematics-specific representation. It is at this stage the solvers using the two approaches differ. At the third stage, once the problem solver has represented the information that he or she is ready to plan the arithmetic computations necessary in solving the problems. A solver who used a direct translational approach bases his or her solution on key words while the one who uses the problem based model has a richer representation on which to base the solution plan.

The task of comprehending word problems is the most critical and represents the threshold of successful solutions regardless of the path taken by the solver.

The mental representation of the problem is formed from comprehending the different relationships of quantities and sets in the problem and is the basis of choice operation (Kintsch and Greeno, 1985). The process of constructing a problem representation involves mapping the verbal statement on an existing schema.

Thus, the schema comprises the vehicle for the comprehension of the semantic relations underlying a given text and its mathematical structure and its acts as a generalized frame for action in a given context. Ultimately, differences in difficulty between arithmetic word problems of various semantic structures may be accounted for by differences in the complexity of the available schema (Nesher and Hershkovitz, 1994).

2.4 School Differences in Mathematics Performances

A large number of studies in the developing countries have consistently shown that availability of instructional materials positively influences learner achievement; the levels of infrastructure seem to have a close correlation with learner achievement and availability of textbooks and instructional materials has consistently positive effect on learner achievement in developing countries (Heyremanm Fernel and Sepulueda

Stuando,1991).Similarly, Lockheed and Verspoor,(1991) found that school-based interventions raise student achievement. The levels of infrastructure seem to have a close correlation with learner achievement as one moves from least facility school (Govinda and Varghese, 1993).

Singh and saxena(1995) found that school-level factors of academic climate(test and feedback, homework and so on) and teacher quality,(teachers' pay, teaching experience, and so on) are the prominent contributors to learning achievement as compared to those of school resources(educational and physical facilities).Gupta and Gupta(1995) conducted a study to see the effect of state interventions on students' achievement and found that the operation Blackboard(OB) scheme, supply of free textbooks, scholarship for regular attendance, and midday meals have indicated a positive and significant impact on students, achievement in mathematics.

Among the school context variables, mean Socio-economic status (SES) has shown a positive association with school mean achievement. Teacher qualification,inservice training, and longer teaching experience lower the school mean achievement and play a negative role in student achievement in mathematics.Similarly,the school academic climate, teacher frequently taking tests and providing feedback, teacher assigning and correcting home-work and solving problems in the class have a positive relation with the school mean achievement in mathematics(Padhi and Jadhoo,1997).

General studies have been conducted to determine possible causes of the low achievement in mathematics in Kenya. For instance, Eshiwani (1983) and kiragu (1986, 1994) found at both primary and secondary levels, the availability of textbooks had a positive relationship to performance. Mwangi (1985) established two variables significantly correlating with achievement: the availability of teaching materials and graph paper for teaching concepts such as co-ordinate geometry. It seems that within-school factors play a significant role in determining and predicting learners' achievement. There is need to establish the influence of type of school attended on students' ability to solve arithmetic word problems of various semantic structure.

2.5 Cognitive Developmental Levels

Nesher,P., Greeno,J.G., and Riley,M.S.(1982) investigated developmental levels of one-step word problem-solving ability and hypothesized four developmental levels which explained which kind of problems can be solved by a student of a given level as shown in Table4.

Table 4: Levels of development

Type of Problem	Level 1	Level 2	Level 3	Level 4
Combine 1	X			
Combine 2			X	
Change 1	X			
Change 2	X			
Change 3		X		
Change 4		X		
Change 5			X	
Change 6			X	
Compare 1			X	
Compare 2			X	
Compare 3			X	
Compare 4			X	
Compare 5				X
Compare 6				X

Key: X Problems solved at given level

Source: Nesher et al. (1982)

At level 1, students are able to solve change problem 1, 2 and combine 1 problem. At level 2, students are able to solve change 3 and 4 problems. At level 3, students can solve compare 3 and 4 but fail in compare 5 and 6 problems. At level 4, students are able solve compare 5 and 6 problems.

Concerning the order of difficulty of additive structure problems, Bergeron and Herscovics (1990) identified four developmental levels. At the first level, students are able to solve simple change problems, in which the unknown is at the end of the story problem. At second level, students relate a change that occurred in the initial set to the relevant action in a more causal manner and hence they are able to solve complex change problems of the type a+x=b,where a and b are known. At the third level, children can solve all combine and change problems, and finally, at the fourth level (around the age of 9or 10), they can solve all kinds of compare problems of two distinct sets.

Christou and phillipou(1999) expanded the theory of developmental levels in students' ability to solve one-step word problems by considering additive and multiplicative structures simultaneously. Table 5 summarizes the hypothetical levels and the major characteristics of each developmental level. At first level, students are able to solve equal-group multiplication problems using the concept of multiplication as repeated as addition. At level 2, students seem unable to consider all parts of a problem concurrently and to reorder the elements if required. At level 3, students develop the ability to handle multiplicative structures that require division, and there is evidence that the intuitive model for division is quotation. Student at level 4 are able, for the first time, to solve rate problems but are still unable to master combination structures.

Table 5: Levels of Cognitive Development

Levels	**Abilities related to one-step word problems**
1	• Use key words (or cues) in solving problems. • Interpret the script in straight forward manner; understand the context of equalize-separate problems, when (a) they can be directly be modeled, (b) the unknown is the result in the canonical equation for the problem, and (c) the solution requires a canonical equation. • Solve equal-groups multiplication problems using the concept of multiplication as repeated addition.
2	• Compare two sets simultaneously and solve additive compare problems. • Solve combine and change problems, even if the solution isnoncanonical (except change-join when the unknown is the starting amount). • Understand problems of multiplicative structure(simple equal-group multiplication and division problems).
3	• Solve all additive structure problems. • Ignore the temporal order of ht events described in the text. • Find relationship in the text. • Solve compare multiplication and equal-groups division problems when the dividend is an extensive quantity and the divisor is an intensive quantity. • Understand the arithmetic operation that is needed for finding a missing part in nonstatic situations.
4	• Develop the ability to understand proportion structures, although they cannot grasp proportions that require division. • Solve simple rate problems, although they lack the ability to construct combination structures and thus are unable to solve Cartesian problems.

In general the hypothesized developmental levels have reported divergent findings. For instance Christou and phillipou(op.cit) reaffirmed the theory of primitive of models by Fischbein,Deri, Nero, and Marino(1985),indicating that repeated addition is an “ implicit, unconscious, and primitive intuitive models for multiplication”.

However, they contrasted Fischbein's ideas about the intuitive models of addition because the majority of the students at level 1 could not solve addition problems. Research findings vary concerning students' abilities to solve change problems in level 1.Carpenter (1985) found that students in level 1 could solve change and compare problems, although in Belgium, De Corte and Verschaffel (1993) found change problems to be difficult for second graders while in Greek, Christou and Phillipou(op.cit) found that the ability to solve change problems is a characteristic of level 2.Therefore there is need to conduct this study to confirm or negate these findings in Kenyan context.

2.6 Gender Differences in Mathematics Performances

A number of studies (Burton, 1979; Fennema and Sherma, 1978) have disclosed no gender differences in mathematical achievement at different levels of elementary school or at the elementary school level as a whole. Fewer, have however, revealed differences in favour of either boys or girls. For instance, according to some scholars (Fennema, 1974, Marshall, 1984), girls were better than boys in solving computation items, whereas boys were better than girls in solving higher–level cognitive problems such as application items and word problems. In contrast a longitudinal study (Marshall and Smith, 1987) has reported significance differences in favor of girls in almost every mathematics area evaluated in the third grade although the differences converged by the time the students reached the sixth grade. In Kenya however, relatively a few studies have dealt with mathematics achievement at elementary level. Studies by Mwangi (1985), Eshiwani (1987) and Kiragu (1986, 1988) reported differences in mathematics achievement favouring males generally occur during high school years.

Within the broad domain of mathematics, gender differences favouring boys are often found for the speed and accuracy with which word problems can be solved (Benbow, 1988; Casey, Nutall, Perazis and Benbow, 1995; Geary, 1996; Johnson, 1984; Marshall and Smith 1987). The boy advantage in solving mathematics problem is found as early as in the first grade and for children, adolescents and young adults in the United States, China, Japan and a host of European nations. (Harnisch, Steinkamp, Tsai and Walberg, 1986; Lummis and Stevenson, 1990; Stevenson et al., 1990). Some researchers (Geary, 1996; Johnson 1984) have asserted that the boy advantage in solving mathematics word problems might be mediated in part by their advantage in spatial cognition.More specifically male appear to be better at generating spatial representations or diagrams of the relational information conveyed in word problems In sharp contrast other investigators (Royer et al, 1999) argue that the male advantage in mathematics is not related to spatial cognition at all, but rather in speed or retrieving arithmetic facts from long-term memory.

In general, studies of gender different in mathematics achievement at the elementary school level have reported divergent findings. For instance some researchers (Zambo and Fallman, 1994) have reported that girl superiority in problem solving at the sixth grade level in the United States. Furthermore, though computation is assumed to be a mathematical skill in which girls outperform boys, some investigations (Lummis and Stevenson, 1990) have shown in three cultures (United states, Taiwan and Japan) that this was not so. More specifically girls were found to perform as well as boys. Lummis and Stevenson (op. cit.) further noted in their cross-cultural study that boys were superior in problem solving as early as the first grade. In sharp contrast other researchers (Hyde, Fennema and Lamon, 1990) who conducted a meta-analysis of 100 studies concluded that there were no significant differences in problem solving in the elementary grades while there was slight female superiority in computations. Overall most of the studies in gender differences in mathematics achievement have revealed no consistent differences in favour of either sex at the elementary school level. There was therefore need to conduct this study to negate or confirm these findings particularly in relation to ability identify the correct operation required in solving arithmetic word problems of various semantic structures.

2.5 SUMMARY

In this study a number of research studies that have analyzed the structure of arithmetic word problems have been analyzed and grouped into two great categories of semantic structure corresponding to the additive and multiplicative conceptual fields.

For the students to successfully generalize valuable problem-solving strategies they develop a mechanism for thinking about classes of problems rather than attacking each problem as a separate and distinct task

Most of the studies reviewed showed that the semantic structure of arithmetic word problems influence students thought and solution processes. It is also evident from the studies that students interact differently to problems of different semantic structures. In additive structure problems students solve problems better if they do not involve relational statements while in multiplicative structure problems, situations that could be conceived as repeated addition are easier than others.

Contemporary approaches to word problem solving have emphasized the conceptual understanding of the word problem before any solution attempts. Thus the task of comprehending word problems is the most critical and represents a threshold of successful solutions regardless of the path taken by the solver. A number of studies have disclosed no gender differences in mathematics at different levels of elementary school or at elementary level as a whole. However, some studies have revealed difference in favour of either boys or girls.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents an in-depth procedure of how this study was undertaken. It consists of a description of the study area, study sample, research design, sampling procedure and methods of data collection, analysis and interpretation.

3.1 The Area of Study

The study was carried out among students and mathematics teachers of primary schools in municipality division, Kakamega district of western province, Kenya. Municipality division was chosen for three main reasons: First the performance of mathematics has been below average in the last five years. Secondly the division enrolls students from a wide social and cultural background. Thirdly, the researcher had worked in the area and was, therefore, familiar with the schools and the head teachers.

3.2 The Study Sample

The study was a survey involving school grade 4, 5 and 6 students and mathematics teachers of selected primary schools in municipality division. Simple random sampling was used to select six (30%) out of twenty schools on the basis of whether they were public or private schools as reflected in table 6. All the mathematics teachers found in the six schools during the time of the study were involved. In total, the study involved 300 students and 16 teachers. Out of the 300 students, 150 were boys while 150 were girls. There were 4 female teachers and 12 male teachers making a total of 16. In each school, primary 4, primary 5 and primary 6 grade levels was selected. The resulting sample was primary 4 (N=112), primary 5 (N=90) and primary 6 (N=98) as shown in table 7.

Table 6: Summary of Selected Schools

School Type	**Total Number of Schools**	**Number of Sampled schools**	**Percent**	**Cummulative Percent**
Public	11	3	55	55
Private	9	3	45	100
TOTAL	**20**	**6**	**100**	

Table 7: Distribution of students by school grade

School grade	Total Number of students	Number of Sampled schools
Primary 4	375	112
Primary 5	302	90
Primary 6	328	98
Total	**1005**	**300**

3.3 Sampling Procedure

The target population of this research study was primary 4,5 and 6 students and mathematics teachers. They were all drawn from Kakamega municipality. For the purpose of sampling, schools in the municipality were categorized into two namely, public and private. It is on that basis, therefore, that stratified random sampling was used to select schools, which participated in the study. In this case, the municipality had two strata from which to select. From each stratum (category) 30 percent of the schools and students in each grade (primary 4, 5 and 6) were randomly selected with equal gender composition. After sorting out the different types of schools (public and private), each school was given a number which was written on a piece of paper, folded and then placed in the box. It was then thoroughly shuffled before picking the required numbers randomly. In situations where, there was more than one stream in the school, students were randomly picked from each stream. This was done to ensure that there was uniform representation among different types of schools, grades (primary4, 5 and 6) and streams.

3.4 Mitigating Factors

The earlier encounter with school administration was to prove very useful to the researcher for it was less difficult to persuade mathematics teachers to participate in the study. Although that familiarity could have been viewed as having an effect on the results of the study, the comparative advantage of interviewing a willing participant who was more relaxed and spontaneous in response proved quite useful to the study. This was quite apparent during the research study as teachers familiar with the researcher, were more co-operative in all aspects of the research study than those where not. They were generally at ease and less bothered by the researcher's interview. That was in sharp contrast with teachers whose encounter with the researcher was first. They were generally reluctant to participate in the study and needed more persuasion, prodding and assurance that nothing would be used against them before accepting to be interviewed.

3.5 Research Design

The research design of this study was Ex-post-Facto. This is a study design in which the study variables are not exposed to direct manipulation or intervention on the part of the researcher. However, the researcher provides as much control as possible under the existing conditions. In this research the only control provided was limiting the response to specific category of primary 4, 5 and 6 students in the selected schools.

Kerlinger (1983:379) defined as ex-post-facto design as:

> **Systematic empirical enquiry in which the scientist does not have direct control on the independent variables because their manipulation has already occurred or they are inherently not manipulable. Inferences about relations are made without direct intervention and dependent variables.**

In ex-post-facto research it is not possible to establish the cause- effect relationship of the variables investigated. The only inference we can draw in reference to the variables is that they appear related. However, Kerlinger (1983: 391-392) emphasizes that:

> **Despite its weakness much ex-post-facto research must be done in Psychology, sociology and education simply because many research problems in the social sciences and education do not lend themselves to experimental inquiry.**

3.6 Data Collection Procedure

Before embarking on data collection, authority was first sought from the ministry of science and technology through the school of education Moi University and from the District Commissioner's office. Head teachers of the selected schools were then contacted so as to explain the purpose of the study and obtain their consent. Arrangements were made between the head teachers and the researcher on the administration of the research instruments. Face to face interview of mathematics teachers was conducted, a total of 16 teachers (12 male and 4 female) were interviewed. The tests were administered to schools under examination conditions. All the three grades within a particular group had the test administered at the same time but at separate rooms. The task in the test required the students to read the scenario in the stem and select from the four solution models the one which will give them the answer to the problem. Selection of the correct solution model would mean identification of the correct operation in solving the problem.

3.7 Data Collection Instruments

Data was collected from the sample through the use of students' test and teachers' interview.

3.7.1 Student Test

The Test consisted of 22 one-step word problems, 14 additive structure and 8 multiplicative structure problems (See Appendix A).The additive structure problems were similar to those used by Nesher, Greeno and Riley (1982) but, slightly adapted to suit the language and cultural environment in Kenya. Six of the additive structure problems were change problems (three change-join and three compare-separate). The multiplicative structure problems were similar to those found in Greer (1992). Four of them were equal groups problems (two multiplicative and two division structure problems), two were rate problems and two were compare problems. The numbers used were whole numbers not exceeding 99 presented in familiar context. This was done to reduce cognitive loads such as linguistic, and computation on the problems. Moreover, when writing up the distractors care was taken to avoid hints or tricks in the answers. For example, when the solution model involved operation of division or subtraction, it was ensured that the bigger number was written first. Otherwise, the case would appear unusual to the student at this age so they might automatically reject the distractors even if they could not solve the problems. Each of the items consisted of a stem and distractors. The distractors were made up of one of the four basic operations and the numbers mentioned in the stem. Each correct answer was marked as 1 and each wrong answer as 0.The solutions were assessed as correct if the correct solution model was selected.

3.7.2 Teachers' Interview Schedule

Face to face interview of 16 teachers selected randomly were conducted using the teacher's interview schedule (see appendix B). The aim of the second instrument was to gather information about teachers' experience regarding the effect of semantic structures on students ability to solve arithmetic word problems with a view of improving their proficiency. The interview schedule contained open type problems which required the respondent to explain his/her own views about the stated issue. Since standardized questionnaires for the study are not available the researcher designed the questionnaire on the basis of the objectives, research questions and research hypotheses. The researcher administered the interview personally. He engaged the participants in a general discussion about the teaching of mathematics before administering the interview schedule.

3.8 Pilot Study

A pilot study was undertaken to ascertain the reliability of the two research instruments and also familiarize with the research situation. Two schools in fringe parts of Kakamega municipality that did not form part of the sampled schools for the actual study were randomly selected and used for the pilot study. They were selected from public and private school categories. The researcher approached the respective head teachers and sought permission to undertake the pilot study. After permission had been secured in the two schools, arrangements concerning the dates were thoroughly discussed and mutually agreed. Both the researcher and the assistant researcher conducted the pilot study. The students' tests were administered and collected the same day interview was carried out in that school. A total of 60 primary 4, 5 and 6 students took the tests. The interview of mathematics teachers was also conducted soon after tests had been done. The researcher jotted down skeleton notes as the interviewee fielded questions, but as soon as the interview was over, the information was quickly entered into the book. On average, the interview session lasted twenty minutes with each teacher.

3.9 Reliability and Validity of Research Instruments

To determine the reliability of the test items, it was pilot tested before being used in this study. Split-half technique was used to obtain X and Y scores. X distribution took odd positioned items and Y distribution took even positioned items. Pearson product moment formula was used to calculate the reliability coefficient of correlation. The formula is shown below:

$$\mathbf{r = N\sum XY - \sum X \sum Y \div (N\sum X^2 \sum Y^2)^{1/2}}$$

Where:

r = Coefficient of reliability

N = Total number of subjects

X = Rated values of one half

Y = Rated values of one half

∑= Summation

The coefficient obtained was then converted into an appropriate correlation for the entire test using Spearman-Brown prophesy formula.

The formula is:

$$\mathbf{r_{xx} = 2r_{nn} \div (1 + r_{nn})}$$

Where

r_{xx} = Reliability coefficient of the original test.

r_{nn} = Split-half reliability coefficient.

According to kerlinger (op.cit) a positive correlation coefficient(r) of 0.50 and above is a strong one and hence the instrument is deemed reliable. Computation using the formula yielded a reliability coefficient of 0.51 for primary grade four, 0.67 for primary grade five and 0.85 for primary grade six, which were judged as good measure of reliability for the students' tests.

To determine the content validity of the test and interview items, two experts in the department of curriculum instruction and educational media, Moi University examined them. Suggestions and advice offered were used to modify the research items and make them more adaptable in the study.

3.10 Data Analysis Technique

Data collected for his study was analyzed using descriptive and inferential statistics. Respondents to questions in the test and interview schedule were tallied, totaled and grouped accordingly. The groups responses were then expressed as a facility ratio, mean, standard deviation and then tabulated. Analysis of variance was then used to determine whether there are any significant differences in the means of different categories of word problems. The t-test was used to determine whether there are any differences in the means of different categories of word problems. Analysis of variance was then used to determine whether there are any significant differences in students' performance attending different schools. Analysis of variance was also used to determine whether there are any significant differences between boys and girls performance in solving word arithmetic problems.

3.11 Interpretation of T-test and Anova in the Study

In interpreting the results of the selected variables subject to ANOVA and t-test, the probability value, the degree of freedom (df), and significant levels of coefficients were used. On the basis of these determinants the following interpretations of the ANOVA and t-test were made:

1. If the probability value (p) is greater than the level of significance, the hypothesis is accepted and retained. It is then concluded that there is no significant difference at 0.05 level of significance.

2. If the probability value (p) is less than the level of significance, the hypothesis is rejected. It is then concluded that there is a significant difference at 0.05 level of significance.

3.12 Phase of Data Analysis

Data collected for this study was analyzed in nine phases:

1. The performance of students in various word categories was determined. This was done by scoring students responses to items and facility ratio, the proportion of students who responded correctly to each item were noted. A mean facility ratio of each category of word problems was worked out.
2. To determine whether the difference of word problems of different categories was significant, ANOVA for single within-subject independent variable (repeated measures) conducted on students overall scores on the categories of word problems was computed and significance of the results assessed.
3. To determine students’ performance in additive and multiplicative word problems. A paired t-test was computed and the significance of the results assessed

4. Latent class analysis was used to determine whether there was any association between class membership and success in problem type.
5. To determine if improvement in school grade performance were significant, ANOVA for the difference in grade performance was computed and significance of the results assessed.
6. To compare school performance in solving arithmetic word problems, means and standard deviations of scores by school was computed.
7. To determine if the difference in school performance was significant, ANOVA for difference in school performance was computed and significance of the results assessed
8. To determine gender difference in overall performance, means and standard deviations were computed. ANOVA for overall performance for boys and girls was computed and significance of the results assessed.
9. Data collected from interviews were summarized and reported.

3.13 Interpretation of Analyzed Data

Data was interpreted using the following methods:

1. Observation of the facility ratio for specific problem and word category and drawing inferences from them.
2. Observation of the association between class membership and success in problem type.
3. Observation of means and standard deviation of schools overall performance gender wise and drawing inferences from them.

4. Observing the significance of the f- and t- values obtained at various degrees of freedom (df) and at 0.05 level of confidence and the nature of relationships existing between variables.

3.14 Summary

The chapter has dealt with all aspects relating to how the study was undertaken. This section (methodology), being the heart of this study, was given due attention to ensure that data obtained represent accurate observation. The sampling procedure has been explained well to ensure that the sample selected was not biased. The instrument was piloted to establish its reliability whereas supervisors in the department of curriculum instruction and educational media of Moi University verified the validity. Data analysis technique and their interpretation have been explained.The chapter has dwelt relatively well with nearly all the issues pertaining to methodology.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

4.0 Introduction

This chapter presents analyzes and interprets the data gathered from the respondents. This study was designed to answer the major questions:

1. Do the semantic structures of arithmetic problems influence students' ability to identify the correct operation required to solve them?

2. Is there any relationship between grade level and students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structure?

3. Does the type of school attended by students influence their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures?

4. Is there any gender differences in students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures?

The presentation, analysis and interpretation of data were grouped into four main sections. The first section analyzed findings related to the students' ability to identify the correct operation required to solving arithmetic word problems of various semantic structures. The second section sought to ascertain whether there is relationship between students' grade level and their ability to identify the correct operation required to solve arithmetic word problems of various semantic structure. The third section compared students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures in different types of schools. The fourth section sought to ascertain whether there are gender differences in students' ability to identify the correct operation required in solving arithmetic word problems of various semantic structures. Data collected from interviews were summarized and directly reported. In sections one, two, three and four facility ratios, frequencies, percentages, mean, standard deviation, a paired t-test and ANOVA were employed in the analysis.

4.1 Word Categories and ability to Identify Correct Operation

The effect of semantic structure on arithmetic word problems on students' solution and thought processes have been discussed by many educators. It has been found that students interact differently to problems with different semantic structure. This study sought to establish the influence of semantic structure of arithmetic word problems on students' ability to identify the correct operation required to solve them.

Combine problems involve static relationships between sets. In combine-join problems, the unknown is the cardinal number of the union of the two disjoint sets, and in combine separate the required is a cardinal number of one set, given the cardinality of the union and the cardinality number of each other set. Change problem describes increase or decrease of some initial state to produce a final product. In change-join problems the implied action increases a given initial given quantity while in change-separate problems the action implies removing a subject from the initial set. Compare additive problems involves static comparisons between sets, where the task is to compare a referent set to a compared set and find their difference. Equal group problems involve natural replications and repetitions of sequence and can involve either multiplication or division depending on what is unknown. Compare multiplicative problems are situations frequently expressed by a phrase such as “twice as much” or “the n^{th} multiple of.” Rate problems are those with proportional structure; they call for finding the unknown among the measures

Table 8 summarizes the facility ratio by specific problem and by problem type, which is the proportion of correct answers to the total number considered for specific or for all problems with a word category.

Data in table 8 shows that combine problems are the easiest (0.686) among the additive problems followed by change problems (0.606). However, rate problems are the hardest (0.307) among multiplicative problems while compare problems (0.354) and equal group problems (0.508) were quite difficult for all subjects. Data from table 8 also reveals that additive structure problems (0.686, 0.606 and 0.541) were easier than multiplicative structure problems (0.508, 0.354 and 0.307). The above trend of performance is replicated at all three school grade levels as revealed by consistent decline in facility ratio across word problem categories.

TABLE 8: The facility Ratio by semantic structure and specific problem

Semantic structure	Specific problem	Facility ratio by grade			Facility ratio by semantic structure
		4	5	6	
Combine problems	A_6: C/J	0.396	0.544	0.596	0.686
	A_3: C/S	0.811	0.879	0.922	
Change problems	A_4: CH/S	0.369	0.433	0.525	0.606
	A_9: CH/J	0.306	0.600	0.606	
	A_{14}: CH/J	0.378	0.544	0.657	
	A_5: CH/J	0.595	0.711	0.778	
	A_{11}: CH/S	0.649	0.944	0.778	
	A_{10}: CH/S	0.694	0.800	0.838	
Compare problems (additive)	A_{15}: CO/S	0.441	0.389	0.374	0.541
	A_{16}: CO/S	0.414	0.422	0.515	
	A_{13}: CO/J	0.333	0.628	0.636	
	A_7: CO/J	0.387	0.644	0.717	
	A_2: CO/S	0.532	0.678	0.717	
	A_{12}: CO/S	0.577	0.656	0.778	
Equal groups	M_9 : EQ/D	0.250	0.382	0.596	0.508
	M_4 : EQ/D	0.378	0.456	0.616	
	M_2 : EQ/M	0.378	0.644	0.707	
	M_1 : EQ/M	0.477	0.633	0.646	
Compare problems. (multiplicative)	M_{13}: CO/D	0.171	0.167	0.263	0.354
	M_7: CO/M	0.387	0.544	0.606	
Rate	M_6: R	0.180	0.278	0.394	0.307
	M_8: R	0.252	0.389	0.374	

KEY

A = Problems are additive; M = Problems are multiplicative; CH = Change;
C = Combine; CO = Compare; J = Join; S = Separate; EQ = Equal groups; R= Rate;
M = Multiplication; D = Division

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This result shows that students seem to relate best to problems belonging to combine and change structures as they do to problems of other structures. When word problems are presented to the students it is very much likely that they would solve the combine or the change problems but may ask for the operation they would need to solve the problems of semantic structure compare, equal groups and rates categories.

To find out whether differences in the facility ratio noted in the semantic structures was significant or due to chance, the data was tested using one-way analysis of variance for single within-subject independent variable (repeated measures) on the student overall scores on semantic structure. The hypothesis was: Ho_1 : there is no significant difference between the semantic structure of arithmetic word problems and the students' ability to identify the correct operation required to solve them. The details of the findings are represented in table 9.

TABLE 9: ANOVA of students' Overall scores on Word problems

	Sum of squares	**d.f**	**Mean squares**	**F**	**Sig**
Word categories	181.713	5	36.343	40.865	0.000

Table 9 shows that the results of the inferential test undertaken, and the value of 0.000 obtained was significant, at 0.05 significance level. This means that there were significant differences between the semantic structure of arithmetic word problems and the students' ability to identify the correct operation required to solve them. Therefore the hypothesis was rejected. The conclusion was that the students' ability to identify the correct operation required to solve arithmetic word problems is dependent on their semantic structure.

To find out whether the difference in means noted in additive and multiplicative word problems were significant or due to chance, the data was tested using a paired sample t-test. The details of the findings are shown in table 10.

TABLE 10: A paired t-test between additive and multiplicative word problems.

	Paired differences					**t**	**d.f**	**Sig (2 tailed)**
	Mean	**Standard deviation**	**Standard Error Mean**	**95% confidence level of the difference**				
				Lower	**Upper**			
Additive structure Multiplicative structure	4.88	2.50	0.14	4.60	5.17	33.831	299	0.000

Table 10 shows that the results of the inferential test undertaken and it indicates that the differences are significant, at 0.05 level.

$t_{(0.05,\ 299)} = 33.83$, $P<0.000$

This means that there are significant differences in students' ability to identify the correct operation required to solve additive and multiplicative word problems. The conclusion is that students relate better to additive than multiplicative word problems.

Figure 1 depicts students' success on different word categories by school grade. As shown, the students' success ranged from 22% to 74% depending on the problem category. The students' success was lowest in rate problem (category 6) and highest in combined problems (Category 1) for all school grades (4, 5 and 6).

Generally, fourth graders were least successful in all types of word categories but success increases in the fifth and sixth grades. This may be attributed to an increase in students' conceptual knowledge as they move to higher grades hence they become more flexible in their choice of solution.

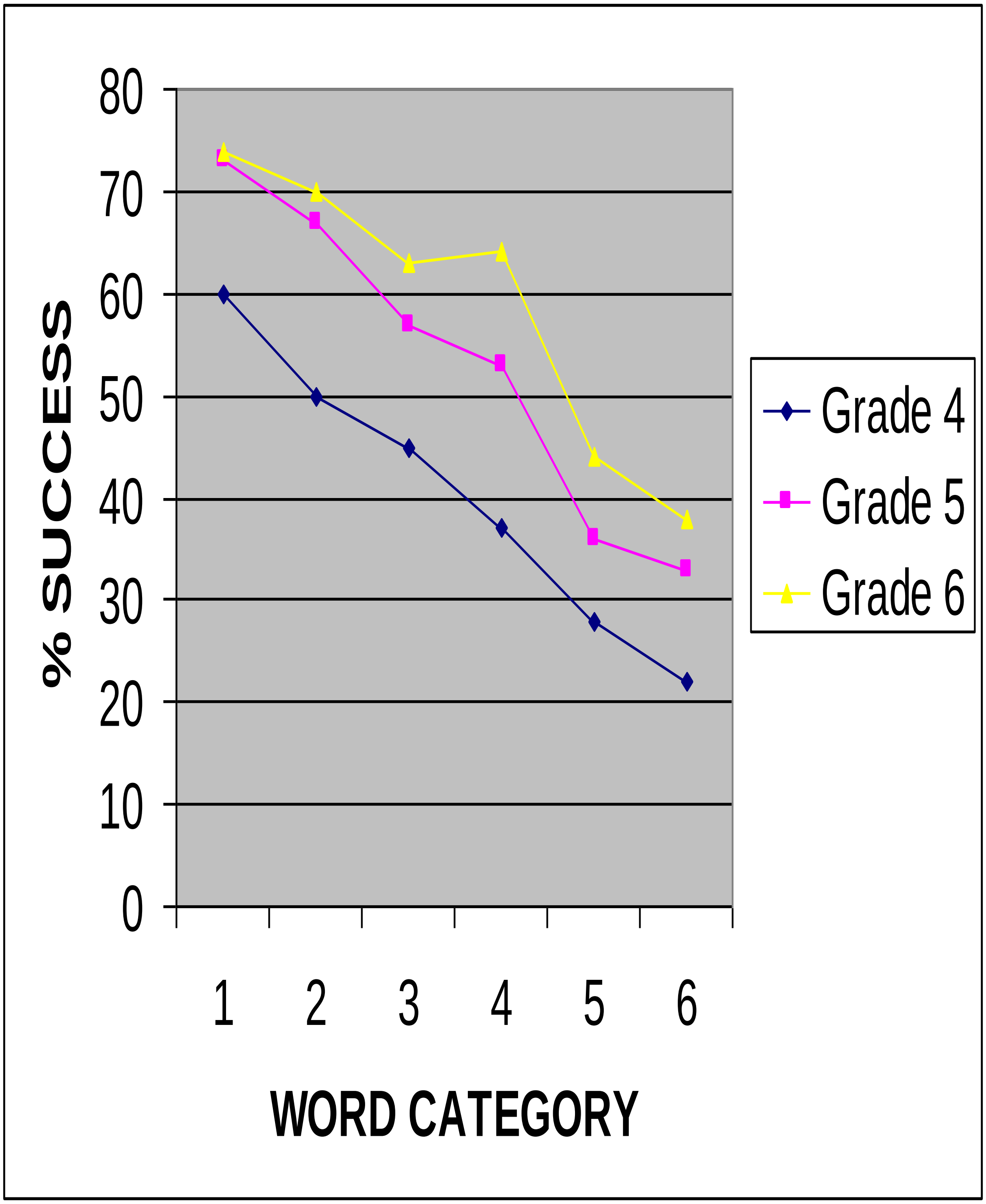

Fig. 1 Student success on Word problems

4.2 Grade level and ability to Identify Correct Operation

The second variable investigated was grade level which represents the developmental pattern in students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures. In order to search for possible developmental patterns of the problem types and the associated students' ability to solve them, data was analyzed using latent class analysis. The subjects were ranked according to success in the present study, and four classes of students were defined using the frequency quartiles: class 1(Lower achievers; N=47), class 2(below average; N=86), Class 3 (above average; N=98) and finally Class 4(High achievers; N=67).The classes essentially define the cognitive development level of the tasks relative to the subjects of the study. Latent class analysis was used to determine whether there was any association between class membership and success in problem type.

Table 11 presents word problems solved by more than 50% (the success criterion selected by the researcher) of the students achievement in each class. This study sought to determine whether there is a developmental pattern in the students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

TABLE 11: Problems Solved by More than 50% of Students in each class.

Problem Type	Class 1	Class 2	Class 3	Class 4
A_3	●	●	●	●
A_6			●	●
A_5		●	●	●
A_{10}		●	●	●
A_9				●
A_{11}		●	●	●
A_{14}			●	●
A_4				●
A_7			●	●
A_{12}			●	●
A_{16}				●
A_2		●	●	●
A_{13}			●	●
A_{15}				●
M_2			●	●
M_4			●	●
M_6				●
M_7			●	●
M_1			●	●
M_{13}				
M_8				
M_9				●

Key ● Over 50% success for all

Data in Table 11 showed that the lower achievers could solve (more than 50% of the students) problem A_3. However class 2 was able to solve problems A_3, $A_{2,}$ $A_{5,}$ A_{10} and A_{11}. Data from the table also reveals that any problem solved by the subjects in any one of the lower three classes was also solved successfully by the members of all subsequent class. For instance, problems A_3, $A_{2,}$ $A_{5,}$ A_{10} and A_{11} which were successfully solved in class 2 were also successfully solved by class 3 and 4.Similarly problems A6,A7, A12, A14, M1, M2, M4 and M7, which were successfully solved in class 3 were also successfully solved by class 4. It is also evident from the data that there are problems, such as M_6 and M_9, which were solved primarily by students in the top class, whereas two problem M_8 could not be solved (by more than 50%) even by the high achievers.

This results show that on average students were unable to solve higher level problems, unless they could solve problems of the immediately preceding level. The fact that on average students were unable to solve higher level problems, unless they could solve problems of the immediately preceding level, seems to provide compelling evidence that the identified levels might develop a hierarchy of thinking.

Table 12 shows percentage of students in each school grade by achievement class. It reveals a relation between school grade and latent classes' membership. Latent class analysis was used to determine whether there was any association between class membership and success in problem type.

TABLE 12: Percentage of students in each school group by achievement class.

	CLASS 1 (N = 47)		CLASS 2 (N = 86)		CLASS 3 (N = 98)		CLASS 4 (N = 67)		TOTAL (N = 300)	
	N	%	N	%	N	%	N	%	N	%
GRADE 4	25	22.3	53	47.3	25	22.3	9	8	112	100
GRADE 5	13	14.6	20	22.5	29	32.3	27	30.3	89	100
GRADE 6	9	9.1	13	13.1	44	44.4	33	33.3	99	100

In a post hoc examination of the relationship between school grade and latent classes' membership, it was found that there was across affiliation in the latent classes. Table 12 revealed that the percentage of fourth graders is decreasing as we move to higher classes, becoming 8% in achievement class 4 while the proportion of the fifth and sixth grade students increases. Specifically, majority of the law achievers are second graders(43.3%) while proportions of fifth and sixth graders belonging to class 1 are quite low (14.6% and 9.1% respectively). On the other hand 62.2% and 77.7% of the fifth and sixth graders belonged to the upper two classes.

To find out whether differences in grade means were significant or due to chance, the data was tested using one way analysis of variance. The hypothesis was: HO_2: there is no significant difference between students' grade level and their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures. The details of the findings are presented in table 13.

TABLE13:ANOVA for difference in grade means.

	Sum of squares	d.f	F	Sig
Between groups	1028.265	2	28.121	0.000
Within groups	5429.922	297		
Total	6458.187	299		

Table 13 shows that the result of the inferential statistics undertaken, and the value of 0.00 obtained between groups is very significant, at 0.05 significance level. This means that there are significant differences between students' school grade and their ability to identify the correct operation required to solve word arithmetic problems of various semantic structures. It was concluded that the student ability to identify the correct operation required to solve arithmetic problems of various semantic structures is dependent on their grade level but the relative inherent difficulty of each problem type is grade independent.

Figure 2 depicts students' average performance by school grade. As shown the students mean score ranged from 33% to 78% depending on the grade and the school. Students' average performance in solving word arithmetic problems improves with school grade in all schools. However within each school there are varied performances in school grade level scores. This is because students' conceptual knowledge changes with growth and also due to individual differences among students.

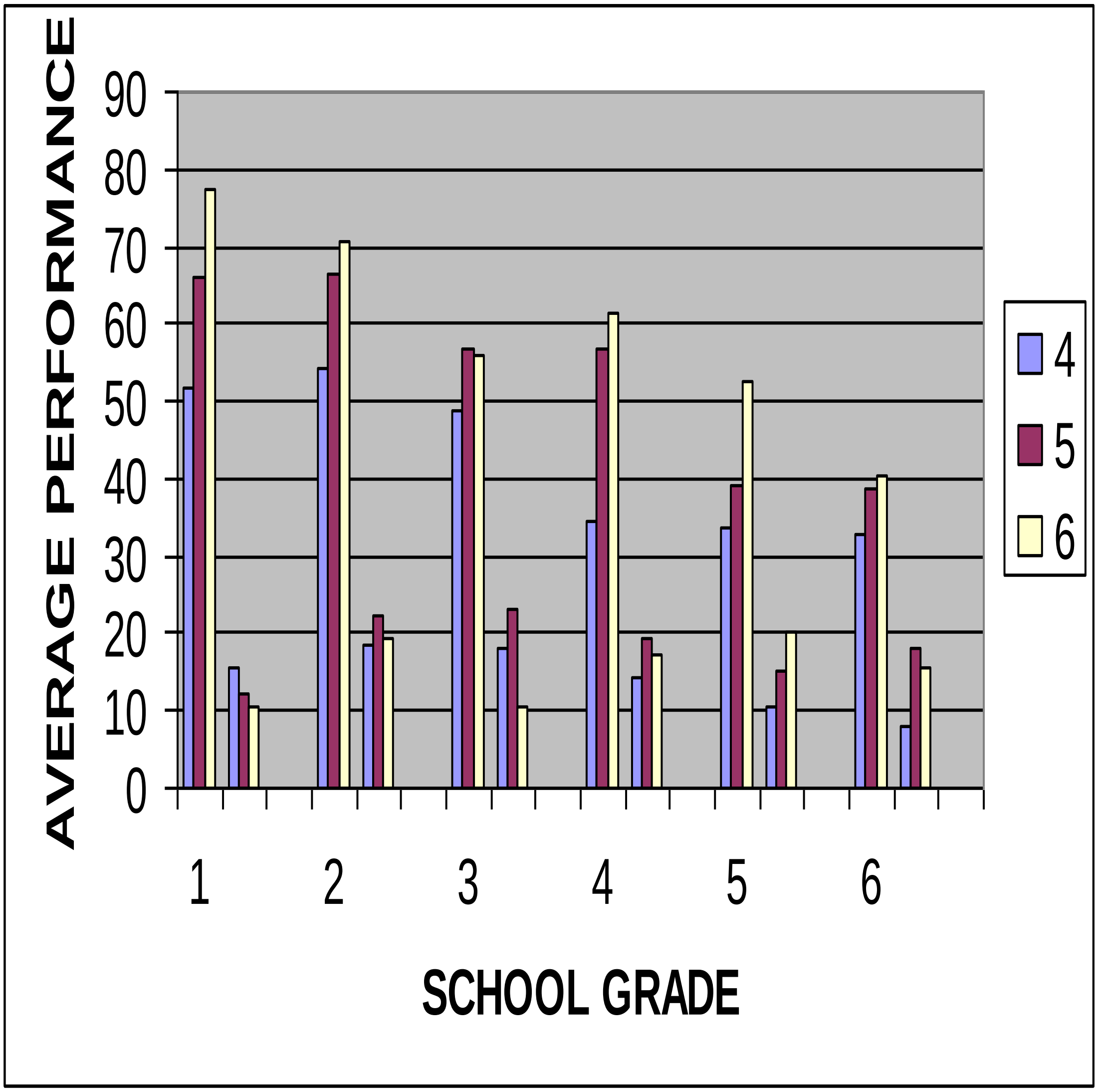

Figure 2: Average performance in school grade

4.3 Type of School and ability to Identify the Correct Operation

School variables that affect school quality and students learning cover broad range of factors comprising the inputs, the resources and the process variables. School- level factors of academic climate, teacher quality and school resources are prominent contributors to learning achievement. It seems that within- school factors play a significant role in determining and predicting learners' achievement in mathematics. It was in that regard that it was considered important variable in the study with view to establish students ability among schools to identify the correct operation required to solve arithmetic word problem of various semantic structures.

Table 14 shows means and standard deviation of different schools. The study sought to establish how the school influences the student's performance in solving arithmetic word problems of various semantic structures. Data in table 14 shows that school 1(mean score=65.0) and school 2 (mean score=63.8) had above average performance. However school 3(mean score=53.9) and school 4(mean score=51.0) had average performance. Below average performance was exhibited in school 5(mean score=41.8) and school 6(mean score 37.2). Data also reveals that private schools (1, 2 and 3) performed better than public schools (4, 5 and 6).

TABLE 14: Means and standard deviation of scores by school

SCHOOL	NUMBER	MEAN SCORE	STANDARD DEVIATION
1	58	65.0	16.7
2	60	63.9	20.9
3	32	53.1	19.0
4	64	48.6	20.6
5	52	41.9	17.4
6	34	37.2	14.2
TOTAL	**300**	**52.8**	**21.1**

These results reveal that private schools performed better than public schools in solving arithmetic word problems. The poor performance of public schools can be attributed to large grade size which has negative effects on teaching-learning and thus on students' performance. Secondly, private schools have better remuneration and working conditions which enhances teachers' motivation and commitment to the profession hence positive effects on teaching-learning and on students' performance.

To find out whether the differences in school performance in solving arithmetic word problems were significant or due to chance, the data was tested using one-way analysis of Variance (ANOVA). The hypothesis was: Ho_3: there is no significant difference between school attended and students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structure. The details of the findings are presented in table 15.

TABLE 15: ANOVA for differences in school means.

	Sum of squares	**d.f**	**F**	**Sig**
Between groups	1534.197	2	18.321	0.000
Within groups	4923.990	294		
Total	**6458.187**	**299**		

Table 15 shows that the results of the inferential test undertaken, and the value, and the value of 0.00 obtained between groups is very significant, at 0.05 significance level. This means that there are significant differences between school attended and students' ability to identify correct operation required to solve arithmetic word problems of various semantic structures. Therefore the hypothesis was rejected.

Further analysis to determine school contribution to score variation was done using Eta-square (η^2). Calculation of Eta-square (η^2) between schools and the overall scores, show that 23.8% of the variation in scores is accounted for by the difference in the schools. It was thus concluded that students' ability to identify correct operation required to solve arithmetic word problems of various semantic structures is dependent on school attended.

Figure 3 depicts students' average performance by school. As shown, the mean score range from 37% to 65%. Generally all private schools (1, 2 and 3) performed above average and all public schools (4, 5 and 6) performed below average. However within each school category there were variations in performance which may be attributed to school related factors such as teaching models and grade size among others which affect teaching-learning hence students' performance.

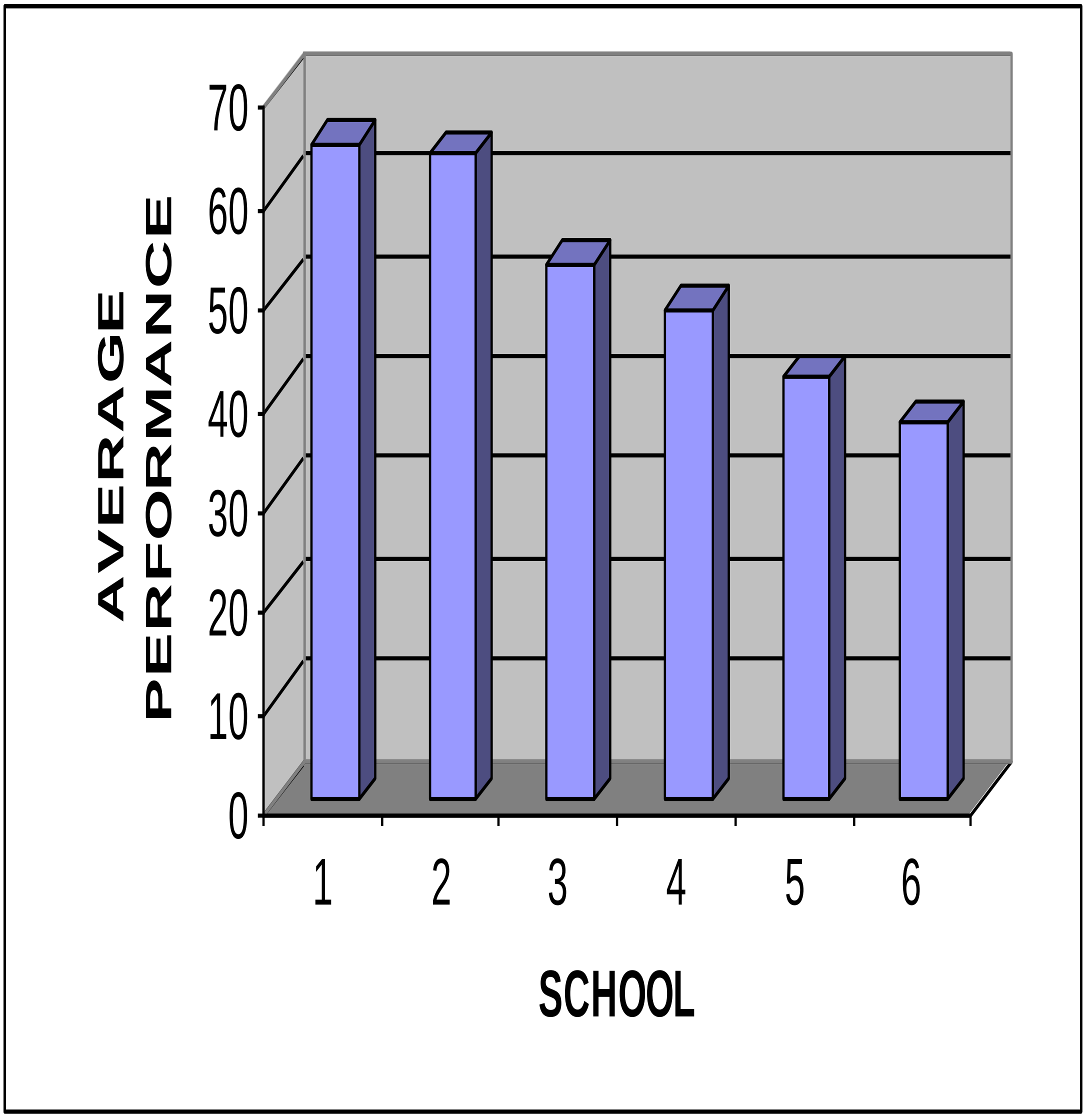

Fig. 3: Average performance per school

4.4 Gender and ability to Identify the Correct Operation

A great deal of research has been carried out with the aim of revealing the nature of differences between the sexes. Studies of gender differences in Mathematics achievement at elementary school level have reported divergent findings. The reason for focusing on fourth, fifth and sixth graders in this study was to find out at what grade level do gender-related differences first appear in Kenyan context. Generally, gender differences in mathematics achievement have revealed no consistent differences in favor of either sex at the elementary school level. This study sought to determine whether students' gender influences their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

Table 16 shows means and standard deviations of individual and overall schools' performance. The study sought to establish how students' gender influences performance in solving arithmetic word problems. Data in table 16 shows that girls performed better than boys in school 1 (girls' mean =97.9, boys' mean =62.1) and school 2 (girls' mean =66.5, boys' mean =61.4). The boys performed better than girls in school 4 (boys' mean =49.4, girls' mean =47.4), School 5 (boys' mean =44.1, girls' mean =39.7,) and school 6 (boys' mean =38.2, girls' mean =36.1,). The performance was same for boys and girls in school 3 (mean =53.1). Data also showed that there was very little difference in the overall performance between boys (mean score =52) and girls (mean Score=53.7).

TABLE 16: Means and standard deviations of schools and overall performance

SCHOOL	GENDER	NUMBER	MEAN	STANDARD DEVIATION
1	Male	29	62.1	18.3
	Female	29	97.9	14.6
	Total	58	65.0	16.7
2	Male	30	61.4	24.3
	Female	30	66.5	16.8
	Total	60	63.9	20.9
3	Male	16	53.1	21.1
	Female	16	53.1	17.2
	Total	32	53.1	19.0
4	Male	32	47.4	15.4
	Female	32	49.4	25.0
	Total	64	48.6	20.6
5	Male	26	44.1	17.7
	Female	26	39.7	17.2
	Total	52	41.9	17.4
6	Male	17	38.2	15.9
	Female	17	36.1	12.7
	Total	34	37.2	14.2
OVERALL	Male	**150**	**52.0**	**20.7**
	Female	**150**	**53.7**	**21.6**
	Total	**300**	**52.8**	**21.1**

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These results reveal that even though there are slight differences in gender performance among students in various schools, the holistic view indicates that there are no gender differences in students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structure.

To find out whether gender differences in student performance were significant or due to chance, the data was tested using one-way analysis of variance. The hypothesis was: Ho_4: there is no significant difference between gender and students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures. The details of the findings are presented in table 17.

TABLE 17: ANOVA for gender differences

	Sum of squares	**d.f**	**Mean square**	**F**	**Sig**
Between groups	200.826	2	200.826	0.449	0.503
Within groups	133,232.8	289	447.090		
Total	**133,433.6**	**299**			

Table 17 shows that the results of the inferential tests undertaken, and the value of 0.503 obtained between groups is not significant, at 0.05 significance level. This means that there are no significant differences between students' gender and their ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.

Further analysis to determine the gender contribution to score variations was done using the Eta-square (η^2). Calculation of Eta-square (η^2) between gender and overall scores shows only 0.2% of the variations in scores is accounted for by the differences in gender. It was thus concluded that the ability to identify the correct operation required to solve arithmetic word problems of various semantic structures is independent of the students' gender.

Figure 4 depicts students' average gender performance by school. As shown, the mean score for females range from 38.2% to 62.1% and for males range from 36.1% to 67.9%. Generally there is negligible gender difference (schools 2,4,5 and 6) or no gender differences (school 3) in performance. In sum, the hypothesis that there is no gender difference in identifying the correct operation required to solve arithmetic word problems of various semantic structure is confirmed.

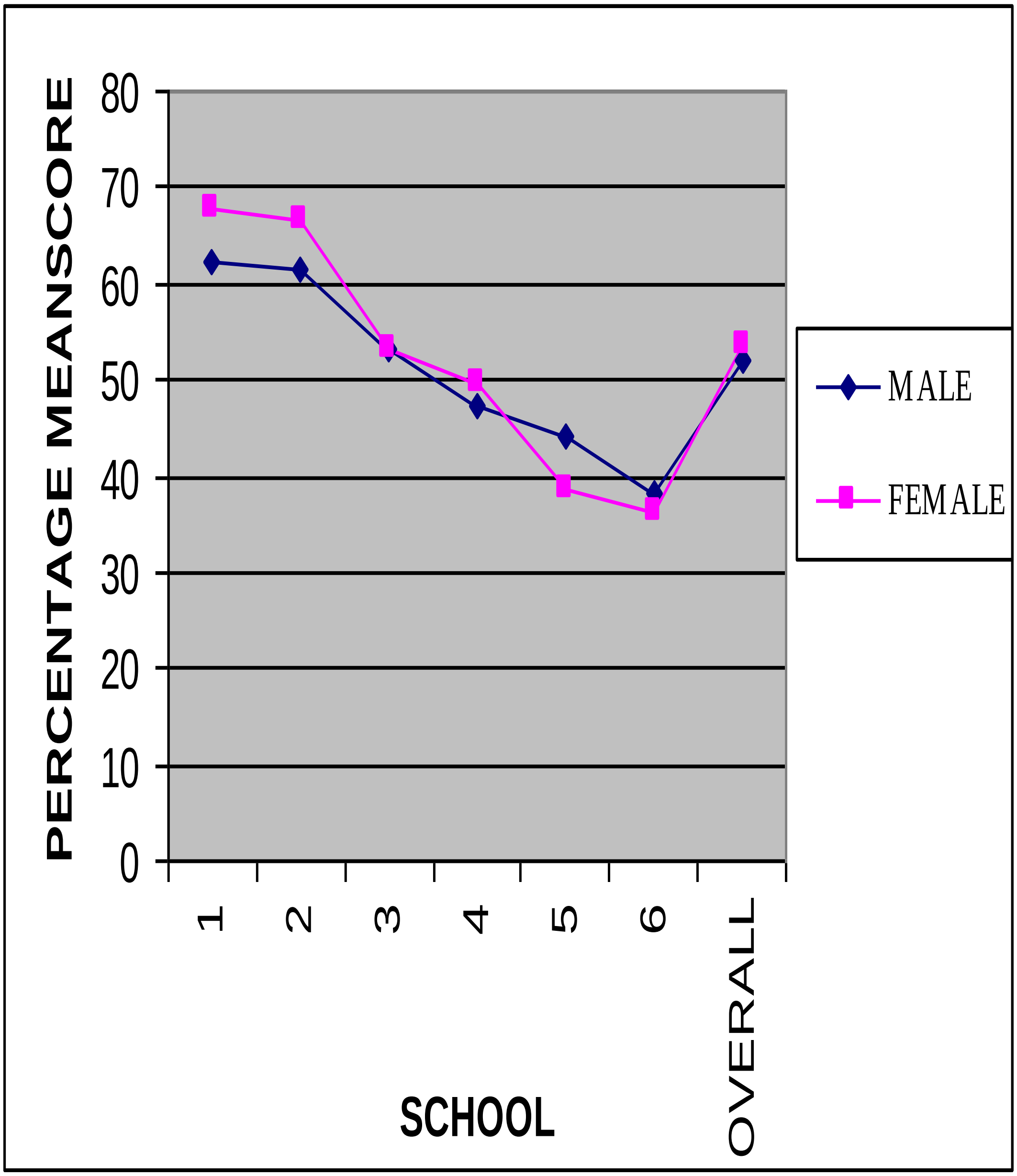

Figure 4: Gender performance per school

4.5 The Teachers' View

The researcher conducted interview with teachers using the interview schedule (TIS) appearing in appendix B. The main reason for interviewing the mathematics teachers was to establish their understanding of the effect of semantic structure on students' ability to solve arithmetic word problems. Specifically the interview sought to establish whether students find difficulty in identifying the correct operation required to solve arithmetic word problems of various semantic structure, possible causes of the difficulty in identifying the correct operation, whether the semantic structures influences operation required to solve arithmetic word problems, students proficiency in one-step word problems at different grade levels, and remedies that could be taken to alleviate students weak performance in arithmetic word problems.

On identifying the correct operation required in solving arithmetic word problems by students in the selected schools, 14 teachers (87.5%) asserted that their students had difficulty, while 2 (12.5%) asserted that there students had no difficulty. As to why students find it difficult to identify the correct operation, teachers suggested several reasons. These included: Lack of comprehension, Lack of linguistic knowledge, poor interpretation, absence of verbal cues, order of events and unnecessary numerical information required to reach a solution. From the foregoing it appears that the structure of word problems, may influence students' ability to solve arithmetic word problems. The implication here is that mathematics teachers need to undergo some form of in-service training on how to effectively teach word problem solving.

Question 3 of the interview was used to establish how the students interact with additive and multiplicative arithmetic word problems in terms of proficiency. Teachers were nearly unanimous as significant number (90%) concurred that students related better to additive than multiplicative word problems. Ten (62.5%) teachers argued that students performed better in additive problems because they appeared more often in the student's environment at this age. Some teachers asserted that additive problems quantities are represented directly and thus pupils can easily map problems representation into appropriate arithmetic operation.

Question 5 of the interview was used to establish the developmental trend in ability to identify correct operation required to solve arithmetic word problems of various semantic structures. Three quarters of the teachers agreed that higher grades performed better than lower grades. However a few students in lower grades out performed those in higher grades. This they argued was due to differences in learners' capacity probably due to variations in their physical and mental experiences.

On what should be done to alleviate students weak performance in arithmetic word problems, five teachers proposed that teachers should emphasize the use of worked examples to teach arithmetic word problems. This involves presenting students with a thorough demonstration of the working through specific word problems. Three teachers suggested re-skilling of teachers through in-service training, seminars, workshops and symposia. These findings suggest a possible fault in pedagogical expertise in arithmetic word problems. Some teachers suggested continuous assessment in word problem solving. They argued that this would improve transfer of learning. Three teachers suggested use of diagrams and drawings to help students better identify the problem type, gain and retain word problem solving skills. Two teachers suggested that text book authors and KNEC examiners should pay attention to appropriate formulation of arithmetic word problems based on a whole range of semantic structures. More practical efforts to improve the performance in the subject like the Japanese strengthening mathematics and science subjects in secondary schools (SMASSE) should be initiated in primary schools. That, in the view of most teachers interviewed could reverse the continued poor performance in mathematics word problems in the long run.

4.6 SUMMARY OF FINDINGS

In this chapter, the semantic structures of word problems and specific problem in each category have been analysed.The depended variable (ability to identify correct operation) was tested against the independent variables namely; semantics structure, grade level, school and gender. The chapter has also analyzed teachers' view on students' weak performance in arithmetic word problems and ways of alleviating it.

From the data presented and analyzed in this chapter it is clear that Kakamega municipality primary school students' ability to identify the correct operation required to solve arithmetic word problems were significantly related to their semantic structure. It was established that students' ability to identify the correct operation required to solve arithmetic word problems was significantly related to their grade level and the type of school attended. Further it was established that students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structure is independent of their gender.

Suggested remedies for alleviating students' weak performance in arithmetic word problems include: use of worked examples, reskilling of teachers, continuous assessment, use of diagrams and drawings and appropriate formulation of work problems based on semantic structures.

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.0 INTRODUCTION

The purpose of the study was to investigate the role of semantic structure of arithmetic word problems on students' ability to identify the correct operation among students of municipality division, Kakamega District, Kenya. The need to investigate students' proficiency in one-step word problems to discuss the effect of semantic structure on their ability to identify the correct operation required in solving them arose from the concern of the research findings that difficulty in solving word problems exists. The study was designed in form of survey involving three hundred selected middle upper primary schools and sixteen mathematics teachers from six schools in municipality division, Kakamega District. Using students' tests and teachers' interview schedules the researcher collected data from the students and teachers. The data was then analyzed manually and/or using the Statistical Package for Social Sciences (SPSS). Frequencies, percentages and facility ratio were computed and assessed to highlight the important aspects of the trend of data observed. The statistical tests employed were ANOVA and t-tests. The hypotheses tested were accepted or rejected at 0.05 level of confidence. This chapter focuses on the discussion of the study findings, conclusions, recommendations and suggestions for further research.

5.1 DISCUSSION

The discussion in this chapter follows the order of the hypotheses being tested. The major findings of the study will be highlighted, discussed and pegged to earlier studies or reports on arithmetic word solving. The similarities and differences of this study with those of other studies will be highlighted and explanations offered.

The first hypothesis was:

HO_1 : There is no significant difference between semantic structure of arithmetic word problems and student's ability to identify the correct operation required to solve them.

The results obtained showed a significant difference in the means of different categories of word problems. It found that students seem to relate best to problems belonging to combine and change structure as they do to other structures. This finding is in support of Kintsch and Greeno (1985).To Kintsch and Greeno problems that involve relational statements (the compare problems) are the most difficult for young children to solve than problems that do not involve such statements. It was also found out that students related better to additive problems than multiplicative problems. This difference is most significant in grade four than other grades levels because grade four students have had very little exposure to such types of word problems than at grade six level. The additive problems were better solved than multiplicative problems because they appeared more often in the students' environment at this age. Secondly, addition and subtraction word problems given to students' involve only extensive quantities only, quantities that can be directly represented.

Multiplication and division problems involve both extensive and intensive quantities, quantities that are derived from other quantities such as bottles per crate. Thus, problem schemata for multiplication and division problem would have to be more complex than those of addition and subtraction (Carpenter et al., 1993). On the strength of these findings the null hypothesis was rejected (See tables 8 and 9). Two conclusions were then made: The first was that students' ability to identify the correct operation required to solve arithmetic word problems is dependent on their semantic structure. The second one was that students' related better on additive problems than multiplicative problems. These findings seem to agree with those of Nesher et al., (1982), Decorte and Vershaffel (1987) and Christou and Philippou (1999).

The second hypothesis was:

HO_2: There is no significant difference between students' grade level and their ability to identify the correct operations required to solve arithmetic word problems of various semantic structures.

```Results show that problems solved by low achievers are evidently solved with greater facility ratio by students in higher achievement classes, whereas there were some problems that were only solved by high achievers. The fact that on average students were unable to solve higher level problems, unless they could solve the problems of the immediately preceding level, seems to provide compelling evidence that there is a developmental pattern in students' ability to identify the correct operation required to solve arithmetic word problems of various semantic structures.
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It was also found out that students competency in solving problems increased with school grade however each type of problem maintains their relative difficulty. The variance in school grade is due to developmental level of students which follow predictable and qualitatively distinct stages. Two conclusions were then made: the first one was that students were unable to solve a higher level problem, unless they could solve the problems of the immediately preceding level. The second one was that the ability of students to solve arithmetic word problems increases with school grade but the inherent difficulty in each problem depends on its semantic structure. These findings lend support to those of Nesher and Hershkovitz (1994), and Christou and Philippou (1999).

The third hypothesis was:

HO_3: There is no significant difference between the type of school attended by students and their ability to identify the correct operations required to solve arithmetic word problems of various semantic structures.

The findings showed that there are significant differences between the type of school attended by student and their ability to identify the correct operations required to solve arithmetic word problems of various semantic structures. This led to the rejection of the null hypothesis. It was then concluded that students' ability to identify the correct operations required to solve arithmetic word problems of various semantic structures is influenced by the type of school the learner attends. According to Padhi and Jadho(1997) school climate, teacher frequently taking tests and providing feedback, teacher assigning and correcting homework and solving problems in class have a positive relation with school mean achievement in mathematics. The question that needs to be addressed is why some schools performed better in arithmetic word problems. One important factor within the general school variable is whether it is private or public.

Private schools revealed a statistically significant difference in their favour ($t = 33.831$, $d.f = 299$, $p < 0.05$).One problem that is observed in public schools is large grade size. This problem has been aggravated with the advent of free primary education in 2003. Large class size has an obvious negative effect on the teaching-learning process and thus on students' performance. Subjects like mathematics require students should to do assignments daily. The teacher should also correct these assignments frequently to give immediate feedback to students. But when the grade size is large, the teachers cannot appraise the students' performance periodically. Consequently, he/she cannot give immediate feedback to the students. In such an environment where guidance of the teacher is minimal, if students feel that they are performing adequately, they will continue in the same way even if they are not on the right track and one can imagine what performance of these students on mathematics tests would look like. A more comprehensive study is therefore required to verify how teachers in primary schools handle the teaching of arithmetic word problems. Secondly, case studies could be devised in better performing schools to determine whether some of the good teaching models could be adopted.

The fourth hypothesis was:

HO_4: There is no significant difference between student's gender and their ability to identify the correct operations required to solve arithmetic word problems of various semantic structures.

The results obtained showed that there is no gender difference in mathematics achievement at elementary school level at least in Kenyan context.

It was found that there is no significant difference in a student's ability to identify the correct operation required to solve arithmetic word problems of various semantic structure. On the strength of these findings, the null hypothesis was accepted (see table 15). It was then concluded that student's ability to identify the correct operations required to solve arithmetic word problems of various semantic structures is independent of their gender. This finding is in line with some investigators (Hyde et al., 1990) who conducted a meta-analysis of 100 studies and conclude that there was no significant difference in problem solving in elementary grades. However, the findings contradict those of Marshall (1984) who reported that boys were better than girls in solving higher level cognitive problems such as word problems. These differences in findings could be due to time lapse, geographical, social, physical and cultural differences.

5.2 CONCLUSION

The following conclusions were made on the basis of the research findings:

1. Students related better to additive problems than multiplicative problems. More so they solve problems that do not involve relational statements better.

2. There is an overall increase in performance in solving arithmetic word problems with age but the relative difficulty of each problem type is grade independent.
3. The schools attended by students significantly influence their ability to solve arithmetic word problems of various semantic structures.
4. There is no significant difference in solving arithmetic word problems of various semantic structures among boys and girls of primary schools in municipality division, Kakamega District.

5.3 RECOMMENDATIONS

On the basis of its findings, this study concludes that difficulty in identifying the correct operation required to solve arithmetic word problems of various semantic structures exists among primary school students of municipality division, Kakamega District. Based on this conclusion, the following recommendations are made:

1. Mathematics instructors should help students to comprehend the relations embedded in arithmetic word problems and hence deduce the solution operation that corresponds to their semantic structure.
2. Mathematics teachers and KNEC examiners should pay more attention to appropriate formulation of arithmetic word problems based on a whole range of semantic structures.
3. The KIE should make relevant revisions in mathematics curriculum based on a continuum of difficulty as predicted by semantic structure and other task variables.

4. The government through MOE should mount regular INSET to update teachers on new instructional techniques and philosophy of arithmetic word problems of various semantic structures.

5.4 SUGESTIONS OF FURTHER RESEARCH

To bring more light onto the issues investigated in this study, it is suggested that the following studies be conducted:

1. A broader study covering more topics in mathematics.
2. A similar study but involving other factors not covered in this study such as misconceptions, linguistic knowledge and superfluous information. The influence of these factors on students' ability to solve arithmetic word problems needs to be investigated.
3. Since the present study was limited to learners, a similar study but based on mathematics teacher's competency in teaching arithmetic word problems and how it influences student's ability to solve arithmetic word problems..
4. The effect of use of English as a second language on learning arithmetic word problems.
5. A similar study should be carried out on other districts in Kenya.

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APPENDIX A

STUDENTS TEST

NAME ……………………………….. SCHOOL ……………………………………….

CLASS ………………………………. SEX ………………………………. (Boy or Girl)

AGE …………………………….

INSTRUCTIONS

Answer all questions by shading the working that will give answer

A_6:C/5	Joe has 3 sweets and Tom has 5 sweets. How many sweets do they have altogether?				
	A 5 X 3	O	B 5 – 3	O	
	C 3 +5	O	D 3 ÷ 5	O	
A5:CH/J	Joe had 2 books, then Tom gave him six more books. How many books does Joe have?				
	A 6 – 2	O	B 2 + 6	O	
	C 2 X 6	O	D 6 ÷ 2	O	
A7:CO/J	Joe has 8 pens. Tom has 5 pens. How many pens does Joe have more than tom?				
	A 8 – 5	O	B 5 ÷ 8	O	
	C 3 X 8	O	D 8 ÷ 5	O	
A3:C/5	Joe and Tom have 15 sweets altogether. Joe has 3 sweets. How many sweets does tom have?				
	A 15 ÷ 3	O	B 3 X 15	O	
	C 3 +5	O	D 15 - 3	O	

A10:CH/S	Joe has 12 bags, then he gave 9 bags to Tom. How many bags does Joe now have?			
	A 9 X 12	O	B12 – 9	O
	C 12 ÷ 9	O	D 9 + 12	O
A12:CO/5	Joe has 20 toys. Tom has 13 toys. How many toys does Tom have less than Joe?			
	A 20 ÷ 13	O	B 13 X 20	O
	C 13 + 20	O	D 20 – 13	O
A9:CH/J	Joe has 4 sweets. Then tom gave some more sweets, now Joe has 11 sweets. How many sweets did Tom give him?			
	A 4 X 11	O	B 11 ÷ 4	O
	C 11 - 54	O	D 4 + 11	O
A16:CO/J	Joe has 21 books. Tom has 9 more books than Joe. How many books does Tom have?			
	A 9 + 21	O	B 21 ÷ 9	O
	C 21 - 9	O	D 9 X 12	O
A11:CH/S	Joe had 25 bags, he then gave some bags to Tom. Now Joe has 10 bags. How many bags did he give to Tom?			
	A 25 ÷ 10	O	B 10 X 25	O
	C 10 X 25	O	D 25 - 10	O
A2:CO/S	Joe has 13 pens. Tom has 4 pens less than Joe. How many pens does Tom have?			
	A 4 ÷ 13	O	B 13 ÷ 4	O
	C 13 - 4	O	D 4 X 13	O
A14:CH/J	Joe had some books. Tom gave him 5 more books, now Joe has 22 books. How many books did Joe have in the beginning?			
	A 22 - 5	O	B 5 + 2	O
	C 5 X 22	O	D 22 ÷ 5	O

A13:CO/J	Joe had 14 bags. He had 6 more bags than tom. How many bags does tom have?			
	A 14 ÷ 6	O	B 6 + 14	O
	C 6 X 14	O	D 14 - 6	O
A4:CH/S	Joe has some pens, he then gave 8 pens to Tom, now Joe has 2 pens. How many pens did Joe have in the beginning?			
	A 8 – 2	O	B 2 X 8	O
	C 2 + 8	O	D 8 ÷ 2	O
A15:CO/S	Joe has 3 books, he has 5 books less than tom. How many books does Tom have?			
	A 3 + 5	O	B 5 ÷ 3	O
	C 5 – 3	O	D 3 X 5	O
M2:EQ/M	A farmer has 9 cows each produces 5 liters per day. How much milk does he collect in a day?			
	A 9 ÷ 5	O	B 5 X 9	O
	C 5 + 9	O	D 9 – 5	O
M4:EQ/D	Twenty four people were carried in cars, each car could carry 4 people. How many cars were used?			
	A 24 - 4	O	B 4 X 24	O
	C 4 + 24	O	D 24 ÷ 4	O
M6:R	Bob's friend lives 80 KM away from his house. He visits his friend by car traveling at 40 KM per hour. How long does it take Bob to reach his friend's place?			
	A 40 X 80	O	B 80 ÷ 40	O
	C 80 ÷ 40	O	D 40 + 80	O
M7:CO/M	A mother has 99 shillings and the father has 3 times as much money as the mother. How much money does the father have?			
	A 99 ÷ 3	O	B 3 X 99	O
	C 3 + 99	O	D 99 - 3	O

M1:EQ/M	A family buys 30 packets of milk every month. How many packets of milk does the family buy in a year?			
	A 12 X 30	O	B 30 ÷ 12	O
	C 30 - 12	O	D 12 + 30	O
M13:CO/D	John has 56 shillings and he has 8 times as much money as Ben. How much money does Ben have?			
	A 56 - 8	O	B 8 + 56	O
	C 8 X 56	O	D 56 ÷ 8	O
M8:R	In a classroom there are three boys for every girl. If there are 13 girls in the class, how many boys are there?			
	A 13 ÷ 3	O	B 3 X 13	O
	C 3 +13	O	D 13 - 3	O
M9:EQ/D	A tray can hold 6 eggs, Jack has 96 eggs, how many trays did he fill?			
	A 6 + 96	O	B 96 ÷ 6	O
	C 96 - 6	O	D 6 X 96	O

KEY

A = Problems are additive M = Problems are multiplicative.

CH = Change; C = Combine; Co = Compare; J = Join;

S = Separate; EQ = Equal groups; R = rate;

M = Multiplication; D = Division.

APPENDIX B:

TEACHERS' INTERVIEW SCHEDULE

Respond to questionnaire by ticking (√) in the brackets provided or writing in the spaces provided.

PART 1

Name of school: ………………………………………………………………………….

Category: ……………………………………………………………………………………

Sex: ……………………………………………………………………… (Public/Private)

PART 2

1. Do pupils in your class find difficulty in identifying the correct operation required in solving arithmetic word problems of various semantic structures?

2. In your opinion, why do your pupils find difficulty in identifying the correct operation required in solving arithmetic word problems of various semantic structures?

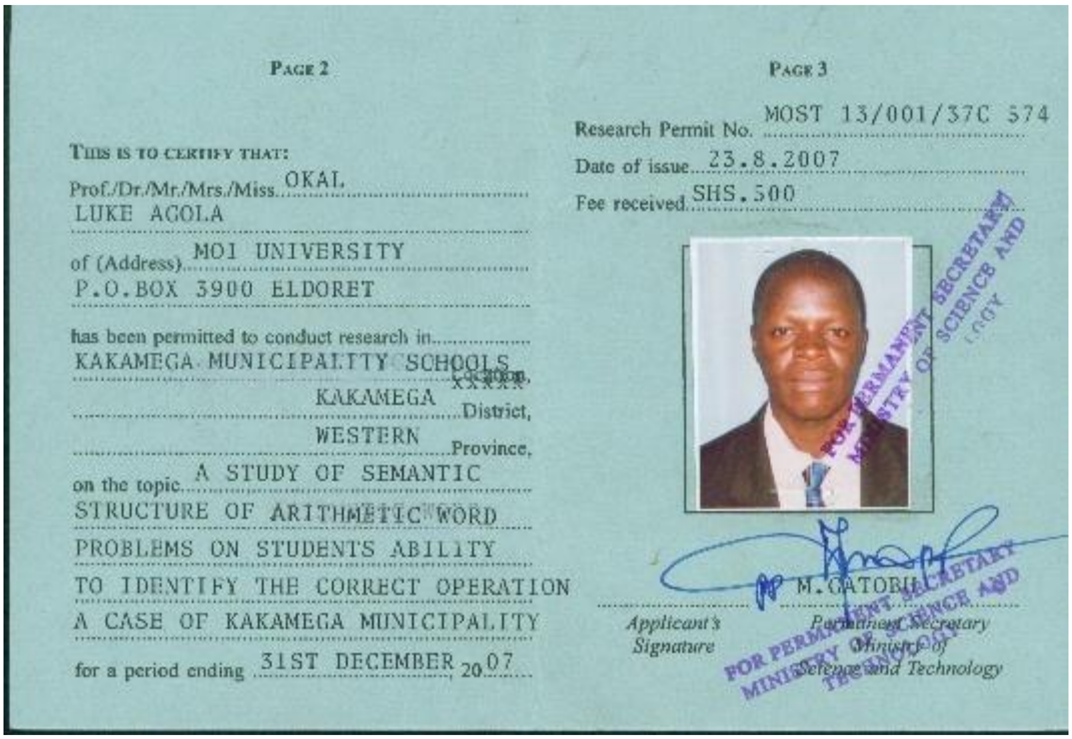
3. How well do pupils in your class perform in additive and multiplicative word problems?

4. What are the possible causes of differences in performance?
5. How do pupils in different class levels (4, 5 and 6) compare in terms of performance in arithmetic word problems of various semantic structures?

6. What are the possible remedies to alleviating pupils' weak performance in arithmetic word problems?

APPENDIX C

RESEARCH PERMIT



PAGE 2

THIS IS TO CERTIFY THAT:

Prof./Dr./Mr./Mrs./Miss. OKAL LUKE AGOLA

of (Address) MOI UNIVERSITY P.O.BOX 3900 ELDORET

has been permitted to conduct research in KAKAMEGA MUNICIPALITY SCHOOLS XXXXX Location, KAKAMEGA District, WESTERN Province,

on the topic A STUDY OF SEMANTIC STRUCTURE OF ARITHMETIC WORD PROBLEMS ON STUDENTS ABILITY TO IDENTIFY THE CORRECT OPERATION A CASE OF KAKAMEGA MUNICIPALITY

for a period ending 31ST DECEMBER 20 07

PAGE 3

Research Permit No. MOST 13/001/37C 574

Date of issue 23.8.2007

Fee received SHS.500

M.GATOBU

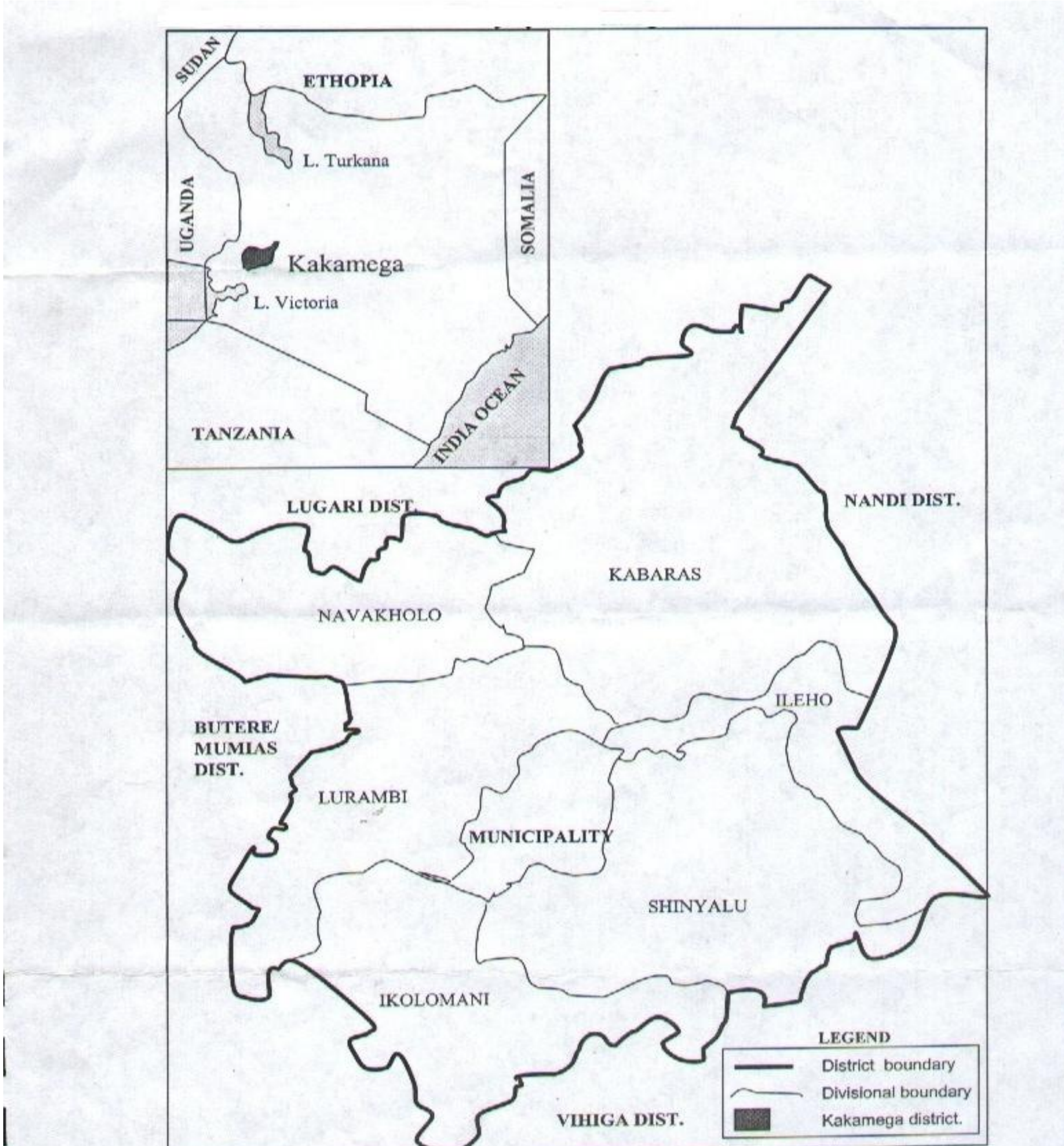
Applicant's Signature

Permanent Secretary Ministry of Science and Technology

FOR PERMANENT SECRETARY MINISTRY OF SCIENCE AND TECHNOLOGY

APPENDIX D

MAP OF KAKAMEGA DISTRICT



Kakamega District Development Plan 2002-2008