EFFECTS OF THE PROBLEM-SOLVING TEACHING APPROACH ON STUDENTS' MATHEMATICS ACHIEVEMENT, SELF-CONCEPT AND PERCEPTION OF THE CLASSROOM ENVIRONMENT IN VIHIGA DISTRICT, KENYA

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RECOMMENDATION

This thesis has been submitted for examination with our approval as University Supervisors.

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Dr. B. N. Githua — Date

Signature _____ 28/7/06

Prof. M. I. Okere — Date

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DEDICATION

This thesis is dedicated to my humble grandfather Fanuel Mutange.

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ABSTRACT

The general performance in mathematics by secondary school students in Kenya has over the years been poor. There is evidence that students have problems in understanding and applying the concepts they learn in mathematics, which to some extent is attributed to learning/teaching approaches teachers use. The purpose of this study was to determine the effects of using Mathematical Problem-Solving teaching approach on students' mathematics achievement, self-concept and perception of the mathematics classroom environment. The null hypotheses tested include; establishing whether the use of MPS teaching approach has any statistically significant effect on students' mathematics achievement, self-concept, perception of the classroom environment and whether there is any significant gender difference in achievement of students taught through the MPS teaching approach. A random sample of 40 district co-educational day schools was drawn from district schools in Vihiga District. Simple random sampling was used to draw four schools from the 40 schools. A total of 146 Form Three students drawn from the four schools participated in the study. The quasi-experimental Solomon Four-Group design was used in this study. Five different instruments namely; Mathematics Achievement Tests, Mathematics Classroom Environment Questionnaire, Mathematics Self-Concept Questionnaire and Classroom Observation Schedule were used to collect data from the 146 students. These students were randomly assigned in their intact classes to four groups namely; experimental groups 1 and 3 and control groups 2 and 4. All the groups were taught the same content of the topic Commercial Arithmetic in mathematics. However, groups 1 and 3 were taught by the MPS teaching approach while groups 2 and 4 were taught through the convectional teaching approach. Groups 1 and 2 were pre-tested prior to the implementation of the MPS treatment. At the end of the topic, all the four groups were post-tested using three dependent measures: MAT2, MSCQ and MCEQ. Both qualitative and quantitative data were generated and hence both descriptive statistics (means, standard deviations & percentages) and inferential statistics (t-test & Analysis of Variance) were used for data analysis and hypotheses testing at 0.05 α-level. The results show that increased students' learning, enhanced students' mathematics self-concept and better perception of the classroom environment occurred among students where MPS teaching approach was used, but gender had no significant influence on their achievement. The researcher concluded that MPS is an effective teaching approach. It is of uttermost importance to students in co-educational schools where girls' performance has been poorer than that of boys. In essence, the MPS teaching approach was helpful in enhancing the teaching and learning of mathematics, facilitated in making the subject easily understandable to students, raised their mathematics self-concept and improved the perception of their mathematics classroom environment and consequently their performance in the subject. Therefore, mathematics educators should encourage mathematics teachers to use it and teacher educators to make it part of the teacher-education curriculum.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANCOVA:	Analysis of Covariance
ANOVA:	Analysis of Variance
CBI:	Computer Based Instruction
CCA:	Conventional Classroom Approach
CCE:	Co-operative Class Experiment
CI:	Commercial Arithmetic
IPI:	Integrated Programmed Instruction
KCPE:	Kenya Certificate of Primary Education
KCSE:	Kenya Certificate of Secondary Education
KIE:	Kenya Institute of Education
KNEC:	Kenya National Examination Council
K-R 21:	Kuder Richardson Formula 21
MAT1:	Mathematics Achievement Test1
MAT2:	Mathematics Achievement Test2
MCEQ:	Mathematics Classroom Environment Questionnaire
MPS:	Mathematical Problem-Solving
MSCQ:	Mathematics Self-Concept Questionnaire
PI:	Programmed Instruction
SMASSE:	Strengthening of Mathematics and Sciences at Secondary Education
SML:	Socialised Mathematical Language
SPSS:	Statistical Package for Social Sciences

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Mathematics is one of the core subjects in the Kenya Secondary School Curriculum and it is an examinable subject for all students at that level of education (Republic of Kenya, 1999). A lot of importance is attached to the subject by the society. This could be because mathematics as a tool finds its application in our daily lives at home, in the office, science, engineering, commerce, technological development and research. Since it is an important utilitarian subject, good mastery of mathematics implies effective learning of other science disciplines (Cockroft, 1982; Mutunga & Breakel, 1992; Mondoh, 1995). Furthermore, Ndibwirwe, cited in Githua (2002) notes that the subject is both academically and vocationally important for both males and females while Costello (1991) argues that competence in mathematics is looked upon as a guarantee to career opportunities and good life.

Despite the aforementioned applications and importance of mathematics in everyday life, students have consistently performed poorly in the subject. This is evidenced through the mass failure at national examinations in the subject in the Kenya Certificate of Secondary Education (KCSE) examination results (Kenya National Examination Council [KNEC], 2005) as shown in Table 1.

Table 1

Summary of KCSE National Mean Scores from 1999 to 2004 in Mathematics

Year	Paper	Candidature	Marked out of	Mean Score	Standard Deviation
1999	1		100	13.46	13.85
	2		100	11.01	11.76
	Overall	172,879	200	24.45	24.94
2000	1		100	17.46	16.44
	2		100	15.05	16.06
	Overall	181,947	200	33.22	31.00
2001	1		100	18.83	18.45
	2		100	18.62	17.15
	Overall	193,702	200	37.43	34.00
2002	1		100	19.95	19.38
	2		100	19.51	19.25
	Overall	197,118	200	39.39	37.95
2003	1		100	17.17	16.31
	2		100	21.45	19.86
	Overall	205,232	200	38.62	36.17
2004	1		100	19.05	17.61
	2		100	22.71	19.76
	Overall	213,155	200	39.42	37.98

Source: Adapted from KNEC (2005) Report, p. 35

From the statistics shown in Table 1, the mean score figures indicate that there was significant improvement in the overall mean score in the year 2004 compared to the previous years. However, the general performance in the subject is still poor as depicted by the low mean scores.

To compound this problem of dismal performance, there is overwhelming evidence that the proportion of girls passing mathematics in KCSE is lower than that of boys (KNEC, 1999; 2000; 2001; 2002; 2003). The poor performance is attributed to various factors which include; shortage of well trained mathematics teachers, resources and textbooks, among others (Eshiwani, 1975; 1983; Githua, 2001; 2002; KNEC, 2000; 2001; 2002; 2003; 2004; 2005).

An analysis of the KCSE examination question papers (KNEC, 2000; 2001; 2002; 2003; 2004; 2005) indicates that questions on Commercial Arithmetic keep recurring year after year

yet no remarkable improvement has ever been realised in terms of student performance in the topic and hence the general poor performance in mathematics. This in a way suggests that students have a problem in this topic. It is however important that students perform well in this topic since Commercial Arithmetic gives useful information applied in our daily life at home, in science, accounts, commerce, geography, industry, technological development and research (KIE, 2001). Thus, Commercial Arithmetic is applicable in our daily life, studied in the Forms One and Three mathematics' syllabus and examined at the KCSE mathematics examinations (KIE, 2002).

There is evidence that there is an instructional problem in mathematics and therefore, students have problems in conceptualisation of the learned knowledge and skills in the topic Commercial Arithmetic (Eshiwani, 1984; SMASSE, 1999; Changeiywo, 2001). The poor performance depicted by students in this topic portrays inadequate understanding of concepts in it. This is due to the poor instructional approaches used in teaching mathematics (Eshiwani, 1975; Mondoh & Yadav, 1998).

Eshiwani (1975) reported that girls scored higher on achievement tests when taught by use of Programmed Instruction (PI) method and Integrated Programmed Instruction (IPI) method, as opposed to boys who scored higher on achievement tests when the method of instruction was the Conventional Classroom Approach (CCA). Programmed Instruction (PI) is a method where material to be learnt is carefully designed in a sequence of tiny units of work through which students work to achieve knowledge and understanding. Each unit is an effective stimulus and the correct response leads to the next unit. In this method, the teacher provides an effective sequence of activities for the students to reach the set objectives. The Integrated Programmed Instruction (IPI) is a method where the material to be learnt is carefully designed in a sequence of tiny units of work through which students are guided by the teacher to achieve knowledge and understanding. A teacher leads students to the next unit only after the previous one has been successfully covered and the objectives met. The Conventional Classroom Approach utilises teacher-centred methods that are commonly used in mathematics classrooms. A teacher prepares his/her work based on the schemes of work. The teacher explains the various concepts to be learnt through the use of different methods while the class listens and carries out the activities as directed. The class moves at the teacher's pace from topic to topic. Eshiwani (1975) concluded from his research findings that the

method of instruction is an important influence on achievement and retention. Moreover, students' values, interests and behaviour are affected by the way the teachers handle the teaching and learning process (Oloyende, 1996).

Problem solving instruction in schools does not emphasise techniques used by skilful mathematics problem solvers. In secondary school mathematics courses in Kenya, the emphasis is usually on problem-specific procedures and mathematical manipulations to help students get answers, rather than the application of meaningful heuristics and generalisable problem solving procedures that could be applied across a wide range of contexts. The lack of emphasis on qualitative reasoning and integration of conceptual knowledge within problem solving instruction encourages rote memorisation of procedures and formulaic approaches that do little to foster conceptual understanding. The mathematics problems that students solve illustrate a single path to a single answer; the notion that a problem may have multiple solutions or multiple paths to a solution is not stressed. Anderson and Roth (1989) observed that at the primary school level, the solutions to the "problems" that pupils are given usually require only single answers. In respect to this, pupils do not solve problems but rather answer questions. Moreover, students are not given open-ended problems that require to be broken into smaller sub-problems, to device mathematical methods for answering the sub-problems, or to summarise the knowledge learned from solving problems in a form that makes it conducive to apply it in novel contexts.

The problem solving approach has been widely accepted as the way to teach vocational agriculture. On effects of level of problem solving approach to teaching on students' achievement and retention, Boone (1990) found that students' level of achievement and retention was highest when problem solving approach to teach was used. In the same study, Boone found that for high level cognitive items, students taught by problem solving approach exhibited lower achievement loss than those taught by subject matter approach. In an earlier study, Boone (1988) found that high school agriculture students taught using problem solving teaching approach first in an instructional series had higher achievement scores than those taught first using a subject matter approach.

1.2 Statement of the Problem

Studies conducted in mathematics education reveal that the method of instruction is one of the major factors responsible for the students' poor performance in mathematics. There is a clear indication that students do learn the procedures to solve particular types of problems but they cannot solve related problems in Commercial Arithmetic in national examinations. This is due to lack of conceptual understanding and transfer of the learned knowledge and skills to solve mathematical problems in Commercial Arithmetic. Mathematical Problem-Solving (MPS) is one of the teaching approaches that can be used to teach Commercial Arithmetic in secondary schools. This learner-centred approach may be useful in improving students' performance in mathematics among secondary school students in Kenya, which has been poor for many years. However, its effects on students' mathematics achievement, self-concept and perception of the classroom environment has not been explored in Kenya. As such, the researcher found it essential to investigate the effects of Mathematical Problem-Solving (MPS) teaching approach on students' achievement in Commercial Arithmetic, mathematics self-concept and perception of their classroom environment.

1.3 Purpose of the Study

The purpose of this study was to investigate the effects of Mathematical Problem- Solving (MPS) teaching approach on Form Three students' achievement in Commercial Arithmetic, mathematics self-concept and perception of their classroom environment.

1.4 Objectives of the Study

The following specific objectives guided the study:

(i) To determine whether MPS teaching approach has any effect on students' achievement in Commercial Arithmetic in mathematics as compared to Conventional Teaching Approach.

(ii) To determine whether MPS teaching approach has any effect on students' Mathematics Self-Concept as compared to Conventional Teaching Approach.

(iii) To determine whether MPS teaching approach has any effect on students' perception of their mathematics classroom environment as compared to the Conventional Teaching Approach.

(iv) To determine whether there is any gender difference in achievement by students taught through MPS teaching approach.

1.5 Hypotheses of the Study

The following null hypotheses were statistically tested:

Ho1: There is no statistically significant difference between the achievement scores of students who are exposed to MPS teaching approach and those who are not exposed to it.

Ho2: There is no statistically significant difference between the mathematics self-concept scores of students who are exposed to MPS teaching approach and those who are not exposed to it.

Ho3: There is no statistically significant difference between the perception of the mathematics classroom environment scores of students who are exposed to MPS teaching approach and those who are not exposed to it.

Ho4: There is no statistically significant gender difference in achievement of students taught through MPS teaching approach.

1.6 Significance of the Study

Literature is replete with studies indicating that poor performance of students in mathematics examinations is due to the expository teaching methods adopted by teachers during the instructional process (Eshiwani, 1975; 1983; Ayot & Patel, 1987; Mondoh, 1997; Changeiywo, 2001; Githua, 2002). This implies that better teaching methods should be found and implemented in Kenya's secondary schools. This study has provided empirical data on the effectiveness of using the MPS teaching approach in enhancing students' mathematics self-concept, fostering the perception of their classroom environment and hence improving their achievement in mathematics. This information is essential in determining the best way of organising students for effective teaching that leads to meaningful learning.

Many secondary schools in Kenya are co-educational. However, it has been observed that girls in co-educational schools do not perform as well as boys in mathematics examinations (KNEC, 1999; 2000; 2001; 2002; 2003). The introduction of MPS teaching approach will enhance interaction among the students, which would narrow the performance gap between boys and girls. This will thus enable teachers and schools to eliminate gender difference in students' mathematics achievement.

The findings of this study will supplement Government's efforts directed towards improving the process of mathematics education in Kenya's secondary schools. The information obtained from this study may be helpful to:

(a) Curriculum developers at the Kenya Institute of Education (KIE) in their review of secondary school mathematics' syllabi and instructional objectives.

(b) Education inspectorate in the task of supervising classroom practices in the teaching of mathematics in Kenya's secondary schools.

(c) Teacher training colleges and Universities in Kenya in the task of producing effective mathematics' teachers.

(d) Heads of mathematics departments and mathematics teachers during the instructional process. These teachers are likely to teach in a stimulating and motivating manner, catering for both girls and boys fairly, thus producing better results among their students, regardless of gender.

Contrary to the previous studies that focused on gathering data on students' performance, perception of the learning environment in mathematics and/or sciences and the teaching of mathematics in a socialised mathematical language (Kiboss, 1997; Wasike, 2003; Wekesa, 2003), the current study has shown that the MPS teaching approach could become an integral part of instruction in Kenyan secondary schools mathematics classrooms. Hence, it is hoped that policy makers, teachers, students and all those concerned with mathematics education may find the approach useful in the instructional process. All the stakeholders are likely to benefit from the results of this study by using appropriate teaching approach that will make the instructional process easily understandable by teachers and Form Three students in secondary schools especially in Commercial Arithmetic. This might improve the instructional process and consequently the students' performance in mathematics in general and Commercial Arithmetic in particular at the secondary school level.

1.7 Scope of the Study

The study involved Form Three students selected randomly from secondary schools in Vihiga district. The district has provincial, district and private categories of schools. The district was selected because students' performance in mathematics has been poor. For example, the years 1998, 1999, 2000, 2001 and 2002 recorded low mean scores of 3.174, 3.026, 3.311,

3.402 and 3.513 respectively, as compared to the maximum aggregate score of twelve points (District Education Office Vihiga [DEOV], 2003).

The topic covered in the study was Commercial Arithmetic constituting simple interest, compound interest, loans, appreciation, depreciation, hire purchase and income tax as stipulated in the KIE syllabus and teachers' guide. This topic was selected because students' performance in this area has been poor in KCSE examinations (KNEC, 1999).

1.8 Limitations of the Study

The current study focussed on Form Three students drawn from four randomly selected co-educational secondary schools in Vihiga District. Generalisation of the results was therefore confined to the Form Three students enrolled in district co-educational schools in Vihiga district. In addition, this study was conducted within a specified time frame and resources of the researcher. Thus, only identified variables (achievement, self-concept & perception) and sampled schools were studied.

The topic covered was Commercial Arithmetic as presented in the approved KIE syllabus (KIE, 2002). The generalisation of the findings therefore was limited to the topic Commercial Arithmetic rather than to mathematics as a subject.

1.9 Assumptions of the Study

This study was carried out under the assumptions that the programme would not be interrupted by sudden closure of schools or absence of some students from schools, that the schools included in the study sample, provided common classroom environments for all students, that the students who participated in the study had similar characteristics and that they provided honest responses.

1.10 Definition of Terms

The following operational definitions were used in the study:

Achievement: Represents scores attained after administering the Mathematics Achievement Tests (MATs).

Conventional Teaching Approach: Refers to the teacher-centred traditional mode of instruction (to which control groups were exposed to) used in the mathematics classroom.

Gender: Refers to differences between male and female students as a group in a school set-up aspect rather than physical differences only.

Mathematics Classroom Environment: Refers to teacher and student activities, discussion, time, language and instructional materials used during mathematics lessons.

Mathematics Self-Concept: Refers to learners' attitudes, feelings and knowledge about their mathematical skills, abilities, enjoyment and interest in Commercial Arithmetic in mathematics as measured on a five point Likert scale.

Perception: Refers to learners' views and opinions about their classroom environment that was measured on a five point Likert scale.

Problem-Solving: It this study, it refers to the application of mathematical knowledge, concepts, principles, strategies and skills to solve mathematical problems in Commercial Arithmetic.

Self-concept: Refers to learners' attitudes, feelings and knowledge about their abilities and skills.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviews the importance, teaching and learning of mathematics in Kenyan secondary schools. Students' achievements in mathematics, their mathematics self-concept and perception of their mathematics classroom environment have featured in this discussion. Literature on teaching methods in general and problem-solving in mathematics curriculum in particular has been discussed. Finally, the theoretical framework of the study has been explained.

2.2 Importance of Mathematics

According to Borowski and Borwein (1989), mathematics is defined as a group of related subjects including algebra, geometry, trigonometry and calculus, concerned with the study of numbers, quantity, shape and space, and their interrelationship, applications, generalisations and abstraction. Mathematics is a fascinating mental activity that permits us to test and extend our intellect.

Mathematics plays an important role in scientific progress and technological development. Cockroft (1982) concurs with Mutunga and Breakel (1992) in stating that the fundamental role of mathematics lies in its everyday application in most social sciences and arts, government and business transactions. Cockroft (1982) further states that mathematics is increasingly being applied in the study of sciences and medicine, geography, economics, business and management studies, house chores, military and aerodynamic advancements. Scopes (1973) outlined four basic goals of teaching the subject as utilitarian, personal, economic and cultural goals. Moreover, Johnson and Rising (1972) note that as an art, mathematics has been applied in painting, music and beauty design. Further, Ashworth (1981) points out that mathematics is necessary in the study of the other science subjects. This was further crowned by Gardener, Glenn and Renton (1973) who commented that mathematics is the queen of the arts and handmaid of science. Thus, mathematics in our society is training in itself, where development of new techniques and concepts must have scientific, economic and sociological consequences akin to the development needs of the society.

Today, on realisation of the importance and impact of science and technology to the modern society, it is necessary as educators to take into account, not only the societal needs, but also the mathematical needs of the student. According to Johnson and Rising (1972), these mathematical needs are; to know that mathematics contributes to understanding of natural phenomena; also, to understand the use of mathematics to investigate, interpret and make decisions in human affairs; in addition, to understand how mathematics as a science and an art contribute to our cultural heritage; lastly, mathematics helps the students to develop his/her appreciation and enjoyment of the subject itself and realisation of its role in development of science and technology for civilisation.

Mathematical problem solving is a valuable study because it disciplines the mind and thereby enables the mathematician, because of his/her training in mathematics, to deal more successfully with problems outside mathematics than he/she would have been able to do without that training (Cockroft, 1982). By solving exercises the students learn to concentrate, to draw deductions, to think clearly, to express themselves precisely and to achieve in mathematical accuracy.

The world of work in the 21st century is less manual but more mental; less mechanical but more electronic. On this view, the United States National Research Council (1989) pointed out that there is a risk of becoming a nation divided both economically and racially by knowledge of mathematics. It is therefore important that the current century be approached, armed and equipped with mathematical skills that can be applied in mathematical problem solving, if there has to be hope of achieving any progress at personal and national levels.

2.3 Secondary School Mathematics in Kenya

2.3.1 Objectives of Teaching Mathematics in Secondary Schools

The main objective of teaching this subject at secondary school level is to assist in the process of producing a person who will be numerate, orderly, logical, accurate and precise in thought (KIE, 2002). The person should be competent in appraising and utilising the mathematical skills in playing a positive role in the development of a modern society. This implies that a person will make precise and logical use of mathematical knowledge and skills to concretise problems from everyday situations, comprehend, analyse, synthesise and evaluate a set of numerical data to both familiar and unfamiliar situations.

2.3.2 Teaching Mathematics in Secondary Schools

Teaching is a process where a teacher enables a learner to acquire concepts, skills, values and attitudes in order to cognitively develop his/her mind (Olela & Bennars, 1993). Mursel (1954) concurs with Okere (1986) in arguing that it is teaching that brings about effective learning. The determining factor in this case is not methods or procedures but results that could be applied in other areas. Thus, teaching involves teacher activities that are aimed at assisting the learner to learn. Effective teaching takes place if there is meaningful learning as an outcome.

However a suitable method of teaching in the hands of one teacher may be quite unsuitable for another. The methods adopted must be in line with students' cognitive and language abilities if they have to be effective. This means that the methods adopted depend on the teachers' interests and abilities, intelligence and interests of pupils and availability of facilities for effective and efficient teaching. Ayot and Patel (1987) indicate that the chalk-and-talk methods whose main player is the teacher are not very popular in mathematics because the learners tend to be passive listeners. Further, Gibbs (1988) on teaching and learning methods found that most teachers who use lecture method for instruction concentrated on talking and made very little use of chalkboard to qualify the concepts, give examples and summarise key points of a lesson. A similar finding was reported by Montgomery (1990) who contends that the expository method is not appropriate for teaching mathematics where conceptualisation is dependent upon practical activity. These findings were further supported by Changeiywo (2001) who observed that the teaching of science and mathematics in Kenyan schools is mainly theoretical and characterised by teachers who adopt a chalk-and-talk style that is heavily textbook oriented, thus failing to account for individual needs.

Lecture method is largely used because it is what most graduate teachers are familiar with. Therefore, a purely lecture method is not effective in the teaching of mathematics at secondary school level. What is required is a multimodal learner-oriented method that suits all learners. According to Hamachek (1995), subjects that have structured information and skills such as mathematics, languages and sciences require direct teaching that demand that the teacher reviews pre-requisites, state lesson objectives, give guided practice accompanied with feedback, allow supervised individual work and finally give review through a question

and answer session or problem solving. Besides, Mondoh and Yadav (1998) attribute learners' achievement in mathematics to effective usage of modern teaching techniques. Mondoh and Yadav recommend methods that emphasise a heuristic approach. It was out of this concern that this study sought to explore the instructional potential of using Mathematical Problem-Solving (MPS) teaching approach in teaching mathematics.

2.4 Students' Achievement in Mathematics

A steady decline in academic achievement scores of secondary school students in mathematics and sciences has caused deep concern in many countries (Ogunniyi, 1996). In Kenya, for instance, the KNEC examination reports (KNEC, 2000; 2001; 2002; 2003) indicate that the overall performance of students at KCSE mathematics has been on a downward trend. Table 2 shows the performance in KCSE mathematics for a period of seven years.

Table 2

Performance in KCSE Mathematics from 1996 to 2004

Year	Paper	Mean Score	Standard Deviation
1996	1	17.43	17.09
	2	19.09	16.59
	Overall	36.24	32.99
1997	1	17.44	16.69
	2	15.50	15.49
	Overall	32.62	31.59
1998	1	19.59	18.23
	2	15.64	15.25
	Overall	35.04	32.71
1999	1	13.46	13.85
	2	11.01	11.76
	Overall	24.45	24.94
2000	1	17.46	16.44
	2	15.05	16.06
	Overall	33.22	31.00
2001	1	18.83	18.45
	2	18.62	17.15
	Overall	37.43	34.00
2002	1	19.95	19.38
	2	19.51	19.25
	Overall	39.39	37.95
2003	1	17.17	16.31
	2	21.45	19.86
	Overall	38.62	36.17
2004	1	19.05	17.61
	2	22.71	19.76
	Overall	39.42	37.98

Source: Developed from KNEC (2000; 2001; 2002; 2003; 2004; 2005) Reports

As can be seen in Table 2, the mean score figures indicate a significant improvement in the overall mean score in the year 2004 compared to the previous years. However, the general performance in the subject is still poor as portrayed by the low mean scores. The results were particularly poor in 1999 KCSE examination. Besides, the achievement of both girls and boys over the nine-year period has been poor as is evident from the low mean scores and standard deviations. This poor performance has been the concern for many years, leading to many researches in an attempt to alleviate the problem.

Attempts by the Ministry of Education, Science and Technology to improve performance in mathematics have not been rewarding. The current complaint aired every time the results of the national examinations are released is that performance in mathematics and sciences has not shown any significant improvement (Aduda, 2003; 2004). Several factors including; shortage of well trained mathematics teachers, lack of appropriate mathematics textbooks, mathematical language problems, students' negative attitude towards mathematics, poor teaching methods and lack of mathematics laboratories, among others, have been found to affect performance in mathematics in Kenyan Secondary Schools (Eshiwani, 1984; Mondoh, 1997; SMASSE, 1999; Changeiywo, 2001).

A study by Kirts and Stewart (1983) among high school students revealed that those student teachers of vocational agriculture who used the problem solving teaching approach asked higher level cognitive questions than those teachers and student teachers not using the problem solving teaching approach. Similarly, while carrying out a study on the effects of the problem solving approach on achievement, retention and attitudes, Flowers (1986) discovered a significant difference between high school agriculture students taught by problem solving teaching approach and those taught by the subject matter approach. Boone (1990) noted in the study of effects of problem solving approach to teaching on student achievement and retention that few critics have expressed opposition to the effectiveness of the problem solving approach as a method of teaching on student achievement.

In Kenya, previous studies on performance in mathematics or science education concentrated on the direct effects of students' background factors and school environment, students' attitudes, mathematics classroom environment factors and the type of instruction (Eshiwani,

1975; Kirembu, 1991; Makau & Coombe, 1994). Mondoh (1995) identified teaching effectiveness as the most significant variable of students' achievement. Teaching effectiveness may be influenced by the instructional approach that a teacher uses. On the other hand, Kiboss (1997) dealt with the effects of Computer Based Instruction (CBI) on students' attitudes, motivation, understanding the topic of measurement in physics and their perception of the classroom environment. Kiboss mediated the effects of instruction upon achievement in secondary physics.

In the teaching of secondary chemistry in Kenyan schools, Wachanga (2002) found a significant difference between students taught by Co-operative Class Experiment (CCE) teaching method and those taught by the conventional teaching method. Students taught using CCE teaching method had higher achievement scores and a noticeable improvement in their motivation to learn chemistry.

Githua (2002) reveals that there exists a correlation between: schools' social set-up, students' mathematics self-concept, their perception of mathematics evaluation, teachers' feedback, instructional approaches, classroom physical conditions and students' motivation to learn mathematics. Githua found that various factors relate to the motivation to learn mathematics in Kenyan secondary schools, students' mathematics self-concept being among them. Further, Githua asserts that students' mathematics self-concept correlates with their achievement in mathematics. This implies that any intervention programmes designated to enhance students' mathematics self-concept will positively affect their learning and consequently their achievement in mathematics. Such mathematics self-concept enhancement programmes will help learners enhance motivation to learn mathematics, which correlates with their mathematics achievement. This will improve students' ability to sustain effort and persistence in handling mathematical tasks and hence raise their mathematics achievement level (Marsh, 1991).

Recently, Wasike (2003) studied the relative effect of a Socialised Mathematical Language (SML) on secondary school students' achievement in mathematics and their perception of the learning environment. Wasike attested to the positive effects of using a SML on students' perception of their mathematics classroom environment. However, Costello (1991) supports

Kiboss (1997) that students' perception of mathematics and the classroom environment in which it is learnt are negatively affected by the teacher's approach in presenting the subject matter.

According to Mondoh (2000), learners differ considerably in their potential for learning mathematics. Mondoh argues that significant differences in learning mathematics include knowledge of mathematical concepts, structures and special talents. Mondoh therefore suggests that for improvement in mathematics performance, the learning of mathematics should be based on building concepts, thinking with concepts and going on to manipulation skills.

Current researches findings in Kenya indicate that gender difference in mathematics achievement begin to appear at upper primary school level and increase in the secondary school (Makau, 1994). This gender difference in achievement is attributed to the interaction of factors outside the school system or the background factors of the students and factors within a school environment (Kirembu, 1991; Makau & Coombe, 1994). Farrel (1993) argues that students' achievement in developing countries is much influenced by factors within the school.

An analysis of KCSE results show that boys perform better in science and mathematics than girls. For instance, in the 2002 KCSE results, girls recorded a lower mathematics performance mean score of 16 per cent compared to 23 per cent for boys. Similarly, in the 2003 KCSE results, boys performed better in the sciences and mathematics than girls. However, the worst performed subject was mathematics with a mean score of 19.30 per cent (Aduda, 2003; 2004).

Mondoh (1997) concurs with Eshiwani (1975) that mathematics in our classrooms has been depicted as that masculine subject where the link between mathematics in class and its relevance outside is lacking. The teachers have been trained to handle it in a very masculine way, making girls to fear it. Additionally, Mondoh (1997) argues that it would have been better if an approach that was more flexible; catering for both girls and boys fairly was adopted. Further, Mondoh notes that girls seem to prefer a method, which is stimulating and motivating; a method that allows for individual attention, where the student moves at his/her

own pace. Furthermore, Mondoh argues that boys seem to prefer the Conventional Classroom Approach method - with all its masculinity: the truth being that although on average their performance is better than that of girls, it is not excellent; and therefore, it would do no harm to introduce a method (the MPS teaching approach) that would improve their performance too.

From the foregoing, it is clearly evident that the effects of Mathematical Problem-Solving (MPS) teaching approach on students' achievement in mathematics had not been explored. Thus, this study investigated on the effects of Mathematical Problem-Solving (MPS) teaching approach on students' achievement in mathematics in Vihiga secondary schools.

2.5 Students' Mathematics Self-Concept

Different scholars have different definitions of self-concept. According to Borg and Gall (1989), the set of cognitions and feelings possessed by one constitute the individual's self-concept. Similarly, Byrne (1984) emphasises that self-concept is the summation of the attitudes, feelings and knowledge about one's mathematical abilities and skills. Dembo (1994) indicates that self-concept can be equated to the amalgamation of the individuals' own perceptions. Besides, Dembo is of the opinion that for a student to arrive at a general perception of himself/herself, he/she must amass facts on which to base his/her perceptions in order to form his/her self-concept that is organised.

Several factors may lead to a change in self-concept in an individual: social situations, interactions with parents, peers, teachers and institutions such as home and schools. Self-concept is evaluative. According to Marsh (1990 & 1991), students' mathematics self-concept is one of the academic facets of self-concept. Marsh (1991) also argues that maximising self-concept of ability in an academic subject is recognised as a critical goal in itself. It is also a means of facilitating the attainment of other desirable outcomes in education, such as: effort and persistence in performing mathematical problem solving activities, attributions to failure or success, academic achievement, course work selection, completion of high school and the ultimate university attendance.

Githua (2002) proposed that an experimental study be carried out to study the effects of intervention programmes on students' mathematics self-concept. In response to this proposal, this study addressed itself to the effects of MPS teaching approach on students' mathematics self-concept in Kenyan secondary schools. Perhaps this approach could enhance students' conceptualisation of mathematical concepts and hence raise their mathematics self-concept.

2.6 Students' Perception of Mathematics Classroom Environment

Studies have shown that conducive classroom environment is an important determinant of students' achievement in mathematics and sciences (Kiboss, 1997; Wasike, 2003; Wekesa, 2003). Specifically, Wasike found that a condusive classroom environment is vital for good performance in mathematics. Further, Wasike argues that a conducive classroom environment should exist to foster social interactions. This involves reciprocal contacts between the teacher and the learner whose interchange leads to meaningful teaching and learning. The teacher acts as a mediator between the students and the body of knowledge and this may vary from one teacher to another depending on his/her knowledge, experience and attitude. Thus, it seems prudent that, an effective learning environment is one in which the teaching-learning process varies according to such factors as the role of the teacher, of the learner, and the nature of instructional activities (Kiboss, 1997). Kiboss further argues that student' perceptions about science and mathematics might be negatively affected by the way the teacher presents the subject matter. The arousal and maintenance of attention during instruction process may be achieved by embedding the proper perception of the lesson elements. Kiboss adds that attention is influenced by a variety of factors e.g. the level of student involvement, personal interests and prior knowledge, lesson complexity, novelty and familiarity and pacing.

Besides, Ndirangu (2000) asserts that teaching and learning materials are inadequate especially for science subjects. This has made teachers resort to theoretical approaches. These approaches have contributed to negative perceptions by learners who view some science subjects as irrelevant and strenuous to learn. As such, the knowledge and understanding of the psychological aspects of the learner in the classroom situation were important for this study.

2.7 Teaching Methods

Teaching is providing learning opportunities that enable students to learn. It is an interactive process where learners learn as they interact with one another, with the teacher and with the environment, as well as an intentional activity (Olela & Bennars, 1993). Given that teaching is an intentional activity concerned with student learning, it follows that it is sensible for the teacher to spend some time on thinking and articulating his/her intentions in teaching a particular topic to a group of students and on checking whether those intentions are realisable.

On the other hand, learning is an active process in which learners actively construct meaning of their own experience (Mursel, 1954; Driver & Bell, 1986). Mursel further argues that a good context for learning must be that in which the learners interact with each other, and concepts to be acquired are simplified. Mondoh (2000) notes that in the process of learning mathematics, learners should be actively involved so as to construct meaning from experiences provided in the mathematics lesson and in some cases lessons outside the classroom that are mathematical in nature.

There is no best teaching method, rather there is appropriate teaching method with respect to a given classroom situation. This is because what suits a group of students may not be best for another group. According to Shiundu and Omulando (1992), an appropriate teaching method is the one which:

a) Builds on the body of knowledge already possessed by the learners.
b) Enables students to be actively involved in the learning process rather than being mere recipient of ready-made information.
c) Enables students to make effective use of the relevant learning resources.
d) Helps to create a suitable learning environment in the classroom.
e) Takes into consideration suitable time-tested maxims of teaching.

Olela and Bennars (1993) observe that the goals of teaching are that the student may gain knowledge, skills, deepening of understanding, development of problem solving or changes in perceptions, attitudes, values and behaviour. For realisation of these teaching goals and depending on the subject matter to be taught, various teaching methods can be used. These

methods are grouped into three major categories, namely; learner centred, teacher centred and teacher-learner centred methods (Okere, 1996, Ayot & Patel, 1997).

a) Learner Centred Methods

These are methods that put the learner in the centre stage, whereby the learning process is essentially the task of the learner and can be accomplished only through the efforts of the learner. Teacher's control and participation is minimal. The teacher only makes suggestions; provide materials and tasks that enable learning to take place as well as providing an enabling environment that is conducive for learning. This means that the learners must do their own learning and develop their own understanding, skills and attitudes, while the teacher's job is not so much to impart knowledge but to guide and help students as they discover the meanings, practice the skills and undergo the experiences that will shape their learning. According to Ayot and Patel (1987) and Okere (1996), learner centred methods include:

(i) Question method
(ii) Case study method
(iii) Research project method
(iv) Group discussion method

b) Teacher Centred Methods

These are methods where the teacher transmits information to a somewhat passive student listener. The teacher controls the flow of information whereas students listen, observe and make notes (Ayot & Patel, 1997). The teacher centred methods include; lecture and demonstration methods, among others.

c) Teacher-Learner Centred Methods

These are methods in which the students study some phenomena or event by carrying out practical work in a particular lesson under the supervision of the teacher. These methods include; class experiment, whole-class discussion and project methods, among others.

2.7.1 Instructional Methods Used in Teaching Mathematics

A method of teaching entails a detailed description of teacher's and learner's activities as a given lesson is presented either in the classroom, laboratory or in the field (Ayot & Patel,

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1987). Mathematics teachers have wide variety of methods, which they can find useful for teaching. Mainly the topic, time and resources available, among others, will determine the appropriate method. Some of the methods commonly used, and are discussed thereafter, include:

a) Lectures
b) Group work
c) Question and answer method
d) Supervised practice
e) Teachers provision of feedback from tests and assignments
f) Revision work
g) Use of examples
h) Discussion
i) Mathematical Problem-Solving teaching method.

a) Lecture

In a lecture teaching approach, a teacher talks most of the time, uses audio-visual materials to illustrate mathematical concepts, works mathematical problems on chalkboard and finally summarises the main points of a lesson on chalkboard while students listens, take notes and have limited chances of asking questions (Knot & Mutunga, as cited in Githua, 2002).

In high school mathematics instructions, short lectures within a lesson are used to:

(i) Arouse students' interest
(ii) Review previous work
(iii) Introduce a new topic, especially if it is difficult and unfamiliar to students
(iv) Tell students the goal of a lesson
(v) Give supplementary explanations or present original concepts integrated from various sources
(vi) Provide a frame work of ideas which can then be developed in latter lessons
(vii) Summarise a lesson through consolidation of the key points covered.

Such short lectures could be interjected with group work, supervised practice or any other mathematical activity in order to give students an opportunity to participate in mathematical

problem solving activities. According to Good and Brophy (1995), lectures can be effective if the teacher is enthusiastic when teaching, uses proper communication skills and gives clear explanation of the subject matter. The teacher should have clear understanding of mathematical concepts, structures the mathematical activities, sequences, explains and present the right amount of content in a given time. There should also be convenient pacing and proper articulation of the mathematical content. Periodic internal summaries and major summary should be provided during mathematical activities. In addition, vague terms, halting speech and irrelevant digressions must be avoided. The teacher should also use gestures, facial expressions, appropriate movements and pointing, besides oral communication (Good & Brophy, 1995). Teachers' enthusiasm includes conveyance of sincere interest in the subject matter and involves proper modelling. In addition, it constitutes dynamic vigour in which teachers are alive, show surprise, joy and suspense and other emotions, which portrays the fact that they are interested in the subject matter they are teaching.

According to Okere (1996), the advantages of using the lecture method include:

(i) It is an economical way of transmitting information to a large number of students. This is because it does not need a lot of facilities.

(ii) It can readily be used for maximisation of information density i.e. through it, a lot of material can be passed within a short time.

(iii) It is useful for providing a framework and theories, which can be developed and considered in details subsequently.

(iv) It enables the teacher to present information in a logical and coherent order.

(v) It helps to develop in students the art of listening and skill of note taking.

On the other hand, the disadvantages of the lecture method are (Okere, 1996):

(i) It is less effective when used with less mature learners, in that it leads to boredom and inattention.

(ii) It does not provide feedback to the teacher as to the effectiveness of the learning.

(iii) It allows very little or no room for active student participation in the learning process. This leads to less effective learning when used with immature learners.

(iv) It gives no room for students to clarify their misunderstanding or misconception during the lesson.

(v) It leads to poor retention of information disseminated, unless the students are able to take notes systematically and try to follow later.

Further, Okere (1996) stresses that for the teacher to handle the lecture effectively for the students, then, the teacher must prepare well for the lesson. In particular, the teacher must:

(i) Organise the information to be presented to the students in a systematic way.

(ii) Scale down the material to conform to students' level of understanding (cognitive maturity).

(iii) Partition the material into groups of homogeneous ideas by giving sub-headings.

(iv) Limit the amount of material to the quantity, which students can take in the given time.

(v) Plan for the use of various learning resources (i.e. models, maps, realia etc) during the lecture.

(vi) Consider the pace of delivery of the material together with the necessary stimulus variation.

(vii) Set an assignment based on the material covered in the lecture. This helps the teacher to find out whatever the learners have grasped and any misconceptions formed.

b) Question and Answer Method

This Socratic method of teaching involves a teacher introducing a lesson by asking students probing questions while the students answer the questions. This can be done by asking logical questions, which must be prepared well in advance for reasonable questioning. According to Walkin (as cited in Githua, 2002), planned questions stimulate, encourage and consolidate learning as instruction progresses while verbal praise of students for correct responses motivates them to learn and hence excel in the subject. The questions should also be clear, purposeful, brief, asked in natural language, addressed to entire class in normal conversational tone and asked one at a time. The frequency of interaction and time spent waiting for students responses (wait time) and the time spent on interaction with students during classroom instruction have far reaching implications on learning and hence the students' achievement, self-concept and perception of the classroom environment (Good & Brophy, 1995). In using this method, the teacher should not impose his/her own notions on

the students, rather encourage them to develop their own conclusions and draw their own inferences. However, the teacher should have preconceived notions about what the final learning should be and carefully aim his/her questions so that the student should arrive at the conclusions desired. The teacher may give students cues leading to correct responses. Finally, the teacher summarises the main points of the lesson on the chalkboard.

In secondary school mathematics instruction, question and answer method within a lesson are used to:

a) Introduce a topic
b) Correct misconceptions in a given topic
c) Summarise a topic.

Question and answer method is advantageous in that:

(i) It helps the learner to have logical thinking skill, which leads to a conclusion and inferences.
(ii) Since the learning is individualised, then it is retained in the cognitive structures in the long run i.e. what is learned is not easily forgotten.

On the other hand, question and answer method is limited in the following ways:

a) It is not good for a classroom situation because if one student is involved in the questioning process, the others may be lost.
b) It is time consuming.

c) Supervised Practice from a Mathematics Textbook

According to (Jaji, 1993), the teaching method of supervised practice from a mathematics textbook, where a teacher asks learners to individually work out mathematical exercises from a mathematics textbook during class instruction and then goes round the class supervising as well as attending to individual difficulties, helps learners to have the following: a feeling of self-confidence, satisfaction, competence and self-worth due to the opportunities afforded to them. These opportunities are ability to apply mathematical skills, heuristics, algorithms and use of different cognitive strategies to solve mathematical problems.

d) Teachers' Feedback from Assignments and Tests

In this teaching method, teachers mark assignments and tests and give students verbal or written comments pinpointing errors, mistakes and mathematical misconceptions (Dean, 1982). The feedback given to students can either motivate or demotivate them to learn and excel in mathematics, enhance or lower their mathematics self-concept, better or worsen the perception of the classroom environment and consequently affect their effort and persistence at mathematical tasks (De Cecco & Crawford, 1988).

It is worth noting that feedback enriches learners' mental schema, besides providing emotional support. Hamachek (1995) emphasises that teachers' feedback offers the following advantages:

(i) It encourages repetition of skills at which a learner is successful.

(ii) It helps in creation and improvement of unsuccessful responses.

(iii) It provides incentive for accurate performance; and

(iv) It increases effort and helps in the realisation of proximal goals during learning.

e) Revision of Questions from Tests and Past Examinations

In this teaching method, teachers ask students to answer mathematical questions from past tests, mark them, gives students feedback then take time to go over the questions in a detailed and structured way. Besides explaining to students how to answer questions, teachers give them further practice (Scott, 1997). This enhances mastery of mathematical content and competence in the use of different strategies for solving mathematical problems.

f) Working in Small Groups

In this approach of teaching, students are given some work to do co-operatively in small groups (Marr & Helme, 1996). According to Johnson and Johnson (1995), students learn in groups by participating actively in a relaxed friendly atmosphere. Johnson and Johnson are of the agreement that the method is task oriented, gives learners an opportunity to be active, practice social skills, and exercise freedom and responsibility in a group.

According to Stasser, Kerr and Davis (as cited in Githua, 2002), groups are more able to recognise and adopt correct problem-solving strategies when suggested by a group member. Groups quickly detect errors of problem representation and reject them. Stasser, Kerr and Davis contend that groups are able to process more information collectively than individuals for problem-solving. Burden (1995) argues that groups can be based on students' ability, interest, skill, and activity or on integration. The objective of a lesson determines whether the group is a mixed ability one, a co-operative learning group or a peer tutoring group on some identified problem. In group classroom arrangement a teacher directs and supervises the activities of each group and finally obtains results from each group leader of a class discussion (Muneitsi, 1994). Indeed, studies have shown that using small groups of students to work on activities, problems and assignments increases students' achievement (Okere, 1996; Kiboss, 1997; Githua, 2002; Wachanga, 2002; Wasike, 2003; Wekesa, 2003). Consequently, when using small groups for mathematics instruction, teachers should (Kilpatrick, 1992):

(i) Choose tasks that deal with important mathematical concepts and ideas.

(ii) Select tasks that are appropriate for group work.

(iii) Consider having students initially work individually on a task and then follow with group work where students share and build on their individual ideas and work.

(iv) Give clear instructions to the groups and set clear expectancies for each (for each task or each group).

(v) Emphasise both group goals and individual accountability.

(vi) Choose tasks that students find interesting.

(vii) Ensure that there is closure to the group work, where key ideas and methods are brought to the surface either by the teacher or the students, or both.

In co-operative learning groups, students' self-esteem, self-efficiency, effort and regular attendances in class are enhanced. Students are also motivated to learn and excel in the subject, by being given an opportunity to praise others, receive help and praise from others, in addition to having opportunities to elaborate personal views during classroom instruction (Githua, 2002).

g) Worked Out Class Examples of Mathematical Problems

Teachers provide worked sample problems or use textbooks provided examples with the hope that students will determine the underlying principle or rule that govern the solution of the initial problem and transfer their learning to a new problem (Githua, 2002). According to Horn (1995), students face the obstacles of inability to understand why the underlying rule worked correctly in the given example and secondly, their inability to use the underlying rule to a new problem. Further, Horn proposed that mathematics teachers should use appropriate method of teaching worked examples as:

(i) More teacher involvement rather than the routine solution of problems.

(ii) Encouragements of students talk aloud.

(iii) Prompting students to overtly describe their understanding of worked examples.

(iv) Require their understanding and give summaries of their understanding.

These will help students to overcome the obstacle of understanding a worked example, besides being evidence that they have obtained independent knowledge.

To help students use worked examples in transfer of mathematical knowledge, Horn (1995) advises teachers to:

(i) Give adequate varied examples.

(ii) Reveal various complexities of the worked example.

(iii) Plan a series of worked examples each with a new feature; and

(iv) Require that students work out similar examples immediately.

This will enhance students' ability and transfer of learning to new mathematical problems. Mathematics teachers may sometime want students to solve a new problem by using what they already know about an analogous problem. To perform this effectively, students need to go through three processes:

(i) Identification or recognition of a rule that is applicable to the new problem.

(ii) Abstraction of some common elements in problems they know and in the new analogous problem; and

(iii) Application of known mathematical knowledge directly to the new analogous problems.

Additionally, Horn (1995) emphasises that to help students acquire abilities in these three processes, mathematics teachers should:

(i) Give hints and prompts.

(ii) Present more than one analogous example.

(iii) Point out similarities of a known problem and the new analogous example.

(iv) Use teaching aids, reviews and direct advice.

(v) Facilitate students' explicit practice.

(vi) Give immediate feedback.

(vii) Encourage inductive thought; and

(viii) Facilitate hands-on practice.

h) Discussion Method

In this approach of teaching, students talk together in order to share information, or exchange ideas and opinions about a mathematics topic or problem. Cantor, cited in Okere (1996), asserted that discussion is a non-directive teaching that removes the teacher from his/her usual role as information dispenser, confirmation provider and limit setter. The non-directive teacher's position is more akin to a group leader who is reluctant to lead. This means that the role of a teacher during discussion is that of a leader and not information provider as is usually the case during normal teaching lessons. Okere (1996) notes that there are two major forms of discussion, namely:

(i) Whole-class discussion

(ii) Group discussion.

i) Whole-Class Discussion

In this approach, the teacher leads an informal discussion involving all students in the class. The teacher may start at asking questions, which is targeted to generating a lively discussion. Students are then given time to present their ideas, views or opinions on the topic being discussed. The teacher, as the director of the discussion does activities such as:

- Asking questions.
- Clarifying students' comments.
- Making tentative summary to help students achieve understanding of the topic.

ii) Group Discussion

In this approach, students are divided into small groups, which can be called panel discussion groups. These groups should comprise between 3-8 students. Each group researches on a topic after which the group members;

- Organises themselves by choosing a group leader.
- Discusses their data.
- Consolidates the information.

Each group is given time to present their findings to the whole class and the other students ask questions. The role of the teacher during the presentations is to offer guidance with respect to the; validity of the information and any misconception should be corrected by the teacher.

Okere (1996) stresses that in planning for a discussion; the teacher must take into account the following:

- The topic to be discussed must be given to the learners well in advance. It should be clearly stated.
- Students must be given adequate time to collect information on the topic.
- The type of discussion to be used should be specified. In case of group discussion, students must be assigned to groups as early as possible.
- Time and venue for discussion should be specified as early as possible.
- Time to be taken by each group when presenting should be indicated early.

Further, Okere identifies the following as the advantages of using the discussion method:

(i) It gives the learners an opportunity to participate actively in the learning process.

(ii) It enables learners to work together as a team especially when collecting information and presenting.

(iii) It enables the learners to develop a sense of responsibility in making decisions.

(iv) It provides the students with opportunity to develop their skills and ability to organise information and formulate responses to questions.

(v) It encourages mental alertness on the part of the learner.

(vi) It encourages good listening, which brings about effective learning.

(vii) Learners learn the art of speaking.

In contrast to the aforementioned advantages, Okere (1996) is of the view that the discussion method is limited in the following ways:

(i) It is time consuming.

(ii) It is difficult to achieve maximum interactions when the group is large.

(iii) It requires the learner to have good communication skills in order to participate effectively.

(iv) If it is not well planned, it may end up or breakdown to meaningless pooling of ignorance.

(v) In this method, some students may not participate actively while a few may tend to dominate.

(vi) It is somehow difficult to evaluate the contribution of each student in the discussion.

It is worth noting that whole-class discussion following individual and group work improves students' achievement (Githua, 2002; Wachanga, 2002; Wasike, 2003; Wekesa, 2003). In that sense, it is important that whole-class discussion follows student work on mathematical problem-solving activities. The discussion should be a summary of individual work in which key ideas are brought to the surface. This can be accomplished through students presenting and discussing their individual solution methods or through other methods of achieving closure that are led by the teacher, the students, or both (Kilpatrick, 1992; Okere, 1996).

Further, Kilpatrick (1992) supports Okere (1996) that whole-class discussion can be an effective diagnosis tool for determining the depth of student understanding and identifying misconceptions. They are of the opinion that teachers can identify areas of difficulty for particular students, as well as ascertain areas of student success or progress.

2.8 Problem-Solving in Mathematics Curriculum

2.8.1 Meaning of Problem-Solving Approach

Mathematics teachers are advised to give specific consideration towards problem solving whilst planning and teaching a particular subject topic (Begle, 1979). The focus is on teaching mathematical topics through problem-solving contexts and inquiry-oriented

environments that are characterised by the teacher helping students construct a deep understanding of mathematical ideas and processes by engaging them in doing mathematics: creating, conjecturing, exploring, testing and verifying (Lister & Raymond, 1994). Specific characteristics of a problem-solving approach include:

a) Interaction between students/students and teacher/students (Van Zoest, Jones & Thornton, 1994).
b) Mathematical dialogue and consensus between students (Van Zoest et al., 1994).
c) Teachers providing just enough information to establish background/intent of the problem, and students clarifying, interpreting, and attempting to construct one or more solution processes (Cobb, Wood & Vackel, 1991).
d) Teachers accepting right/wrong answers in a non-evaluative way (Cobb et al., 1991).
e) Teachers guiding, coaching, asking insightful questions and sharing in the process of solving problems (Lister & Raymond, 1994).
f) Teachers should know when it is appropriate to intervene, and when to step back and let the students make their own way (Lister & Raymond, 1994).
g) Further, a problem-solving approach can be used to encourage students to make generalisations about rules and concepts, a process, which is central to mathematics (Evan & Lappin, 1994).

Schoenfeld (1994) notes that early problem-solving courses focused on problems amenable to solutions by Polya-type heuristics: draw a diagram, examine special cases or analogies, specialise, generalise, and so on. Over the years the courses evolved to the point where they focused less on heuristics per se and more on introducing students to fundamental ideas; the importance of mathematical reasoning and proof, for example, and of sustained mathematical investigations (whereby problems served as starting points for serious explorations, rather than tasks to be completed).

Schoenfeld (1994) suggested that a good problem should be one, which can be extended to lead to mathematical explorations and generalisations. In that sense, a good problem must satisfy the following criteria:

(i) It must be challenging.
(ii) It should cause students to respond.
(iii) It must not have an immediately available answer.

Further, Schoenfeld (1994) described three characteristics of mathematical thinking:

(i) Valuing the processes of mathematisation and abstraction and having the predilection to apply them.

(ii) Developing competence with the tools of the trade and using those tools in the service of the goal of understanding structure- mathematical sense-making.

(iii) Cobb *et al.* (1991) suggests that the purpose for engaging in problem solving is not just to solve specific problems, but also to encourage the interiolisation and reorganisation of the involved schemes as a result of the activity. Not only does this approach develop students' confidence in their own ability to think mathematically (Schifter & Fosnot, 1993), it is a vehicle through which students construct, evaluate and refine their own theories about mathematics and the theories of others (National Council of Teachers of Mathematics [NCTM], 1989).

In view of the foregoing, the current study intended to establish the effectiveness of Mathematical Problem-Solving (MPS) teaching approach in mathematics instruction.

2.8.2 Mathematical Problem-Solving Teaching Approaches

Mathematical problems are well structured in that they are clearly stated, have known solutions and are evaluated against well known undisputed criteria. Biehler and Snowman (1997) note that mathematical problems have given information, obstacles and a goal. Polya (1973) suggests the following four steps that can help a learner to successfully solve mathematical problems:

a) Understanding the problem

- Can state the problem in own words.
- Can identify what are given and what are asked for. This involves identifying the unknown and the known, sorting out the data given, the conditions to be satisfied, drawing a suitable figure and introducing suitable notation.

b) Planning a Solution

- Plans how to gather data necessary to solve the problem.
- Arranges data systematically and presents them concisely using tables, diagrams, graphs or charts.

- Formulates own procedures for answering questions. This involves finding the connection between the data and the unknown. The following questions are useful to consider before settling on the plan:
    (i) Have you seen this problem before or the same problem in a slightly different form?
    (ii) Do you know a related problem?
    (iii) Do you know a theorem that could be useful?

c) Carrying Out the Plan

- Explores as many different solutions as possible.
- Interprets result.
- Applies different problem solving strategies.
- Carry out the plan while checking the correctness of each step.

d) Looking Back

- Explains/justifies solutions of problems.
- Evaluate merits of different solutions.
- Formulates related problems.
- Explores other solutions to verify correctness of answers based on one's solutions.
- Verifies and interprets result in relation to the original problem.
- Acquires confidence in using mathematics meaningfully.
- Uses with increasing confidence, problem-solving approaches to investigate and understand mathematical content.

Much of the mathematics that students encounter in school can be introduced by posing interesting problems on which students can make legitimate progress. In this way, the content developed is motivating to the students. It reveals mathematics as sense making discipline rather than one in which rules for working exercises are given by the teacher to be memorised and used by students. Solving problems that have been strategically chosen and carefully sequenced is a fundamental vehicle for learning mathematical content. It has often been observed and rightly so, that problem solving is at the heart of mathematics and that problem solving must therefore be the focus of school mathematics (NCTM, 1989). Problem solving is often seen as something that can be done only in a learning cycle, and mathematical

concepts are developed or constructed along the way. Problem solving should therefore enable students to:

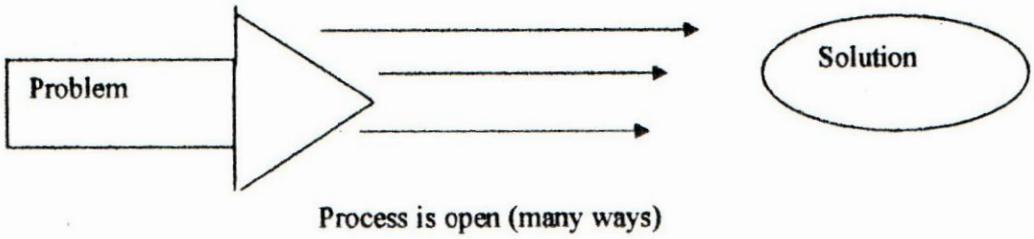
a) Build new mathematical knowledge.
b) Solve problems that arise in mathematics and other contexts.
c) Apply and adapt a variety of appropriate strategies to solve problems.
d) Monitor and reflect on the process of mathematical problem solving.

Zimmerman (1989) points out that the new philosophy is a shift from, teaching as treatment and learning as effect, to learners actively constructing mathematics in their learning processes. To know mathematics is to be able to do mathematics, which involves giving students opportunities to be involved in the processes of mathematics, such as:

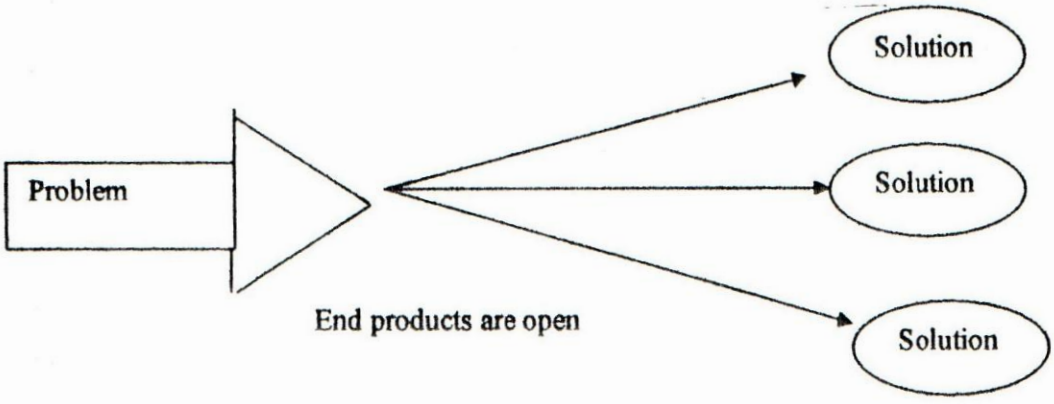
(i) Developing and using correct mathematical language,
(ii) Carrying out algorithms,
(iii) Making observations, looking for patterns and establishing relationships,
(iv) Making hypotheses and validating them,
(v) Constructing proofs,
(vi) Carrying out measurements of various kinds, geometrical constructions and developing an appreciation for accuracy,
(vii) Reasoning logically both inductively as well as deductively,
(viii) Collecting, organising, representing, analysing and interpreting data,
(ix) Modelling everyday problems into mathematical problems.

This will undoubtedly lead to the development of a mathematical culture. In order to achieve this, the teacher should try to develop an open approach to problem solving (Figure 1).

1st Stage

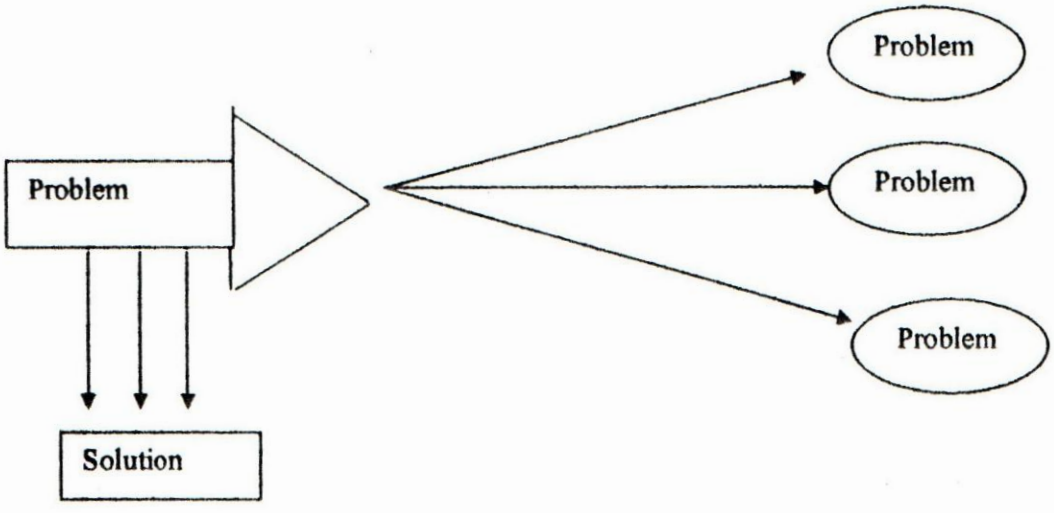


Process is open (many ways)



End products are open

2nd Stage



Source: Adapted from Mrasi (2004), p. 8

Fig 1: Open Approach to Problem Solving

In order to promote a mathematical culture, the teacher should include the following approaches; open ended problems or divergent problems, which is a type that does not have right answer or has many solution from different approaches and lead to generation of more problems (Figure 1).

Mathematics should therefore be represented as problem solving, communication and reasoning, making connections and making representations. Problem solving is therefore the most efficient way of setting up a flexible storage system for mathematical knowledge. The problem solving approach offers an excellent opportunity for learners to be actively involved in hands-on, minds-on and hearts-on activities in the development of their mathematical knowledge. In order to meet new challenges in work, school and life, students need to adapt and extend whatever mathematics they know. It is important to note that mathematics furnishes the language and concepts for description, analysis and modeling of various situations (Lesh, 1997).

According to Mrasi (2004), an effective teacher should know the students well, their strengths and weaknesses for proper planning in order to ensure equal access for all students. The teacher should be able to, not only explain things to the learners, but to listen to them closely with understanding and support their learning. The teacher should realise that knowing something for oneself, for communication to an expert, is not the same as knowing it for explanation to a student. This way the teacher is able to categorise the students according to their abilities during their planning sessions. The ability to perform these activities is an important indicator of progress in problem solving that is being made by students.

Teaching through problem solving requires planning problems that will give students an opportunity to learn and practice a wide variety of strategies. When teaching a more diverse range of students, the approach should be to let the mathematics arise from students' experiences and supporting the students' learning through developmental teaching (Carpenter, 1989).

Consequently, a problem solving approach to teaching is less threatening to students since it starts with daily occurrences. The approach starts off with a real-life problem situation

with which students are familiar. It provides students with opportunities to offer different approaches in solutions and verify these methods. It also requires them to select from previous experiences and knowledge as they try to solve the problem, thereby extending their mathematical knowledge. The solutions to the problem provide a good opportunity to link previously learned concepts, skills and knowledge to the new concept (Polya, 1973; Stacey & Groves, 1985; Boston & Suydam, 1987).

Good teaching in mathematics involves a careful consideration of the way teachers deliver lessons with the express aim of making mathematical knowledge equally hope to all students, thus allowing each learner to develop to their full potential. The basic components of good teaching focus on process that change behaviour and aims that specify directions and attainment (Rivard, 1996). The quality of a lesson cannot be judged by how much apparent activity there is in a class, but on the quality of carefully selected activities that promote learning. Meaningful learning occurs in a class that is mentally active, engagement in quality and focused activities and absorbed in what a skilful teacher is saying or doing. Teachers should not confuse activity learning with activity for its own sake. The practice has been too much activity, too much noise, and too much movement where students have lacked clear guidance, control and focus. There ought to be activity in the mind. Learning is more likely to take place when students are mentally engaged in the pursuit of knowledge than when they are merely passive recipients of it (Driscoll, 1994).

2.8.3 Teaching Mathematics through Problem Solving Approach

The main objective of learning mathematics is to use the knowledge gained in an adaptable way in dealing with standard as well as realistic problems, which are meaningful to the learners. Teachers often see themselves as providers of information: they should rather see themselves as stimulators of reflection, explanation and as mediators between knowledge and the learners. Students need to build new mathematical knowledge through problem solving activities. They also require solving problems from mathematics as well as questions from other contexts (Thompson, 1985; Confrey, 1987; Cooper & Robinson, 2002). It is important to explore a variety of appropriate strategies and skills for problem solving, as well as monitoring and reflecting on the process of mathematical problem solving. According to Becker, as cited in Mrasi (2004), there are

three key guiding questions that need to be asked before any problem solving activity is undertaken in any mathematics classroom in order to effectively plan one's work:

a) What do the students know before they come to the lesson?
b) What does the teacher want the students to know and be able to do when they leave the lesson?
c) What teaching techniques and resources can the teacher therefore use in order to achieve the objectives set?

A problem-solving disposition includes the confidence and willingness to take on new and difficult tasks. Successful problem solvers are resourceful, seeking out information to help solve problems and making effective use of what they know. If the first approach to a problem fails, they can consider a second or a third. If those approaches fail, they know how to reconsider the problem, break it down, and look at it from different perspectives. Part of being a good problem solver is being a good planner, but good problem solvers do not adhere blindly to plans (Harris & Graham, 1992).

Problems and problem solving play an essential role in students' learning of mathematical content and in helping students make connection across mathematical content areas. Much of the mathematics that students encounter in school can be introduced by posing interesting problems on which students can make legitimate progress. In this way the content developed is motivating to the students. It reveals mathematics as a sense making discipline, rather than one in which rules for working exercises are given by the teacher to be memorised and used by students. Solving problems that have been strategically chosen and carefully sequenced is a fundamental vehicle for learning mathematics and through problem solving must therefore be the focus of school mathematics. Learners should be assisted to learn mathematics in a meaningful way so as to appreciate its relevance in all aspects of our lives. Problem solving provides learners with the opportunity to not only acquire and extend their mathematical knowledge, but to engage in doing mathematics (Thompson, 1985).

Problem solving is the most effective way of developing conceptual understanding in the teaching and learning of mathematics. It is worthwhile to note that in the teaching of mathematics, know-how is much more important than mere possession of information. Know-how in mathematics is the ability to solve problems, not merely routine problems but

problems requiring some degree of independence, judgement, originality and creativity (Boston & Suydam, 1987). This would, undoubtedly represent a worthwhile goal of teaching mathematics. The teacher should promote what Skemp (1989) refers to as relational understanding that is the use of rules with understanding as opposed to instrumental understanding that is the use of rules without understanding. The teacher's role is to emphasise methodical work in problem solving i.e. emphasising the process of problem solving. The teacher should develop the students' know how, promote their ability to reason, and endeavour to recognise and encourage creative thinking in the learners (Confrey, 1987; Copper & Robinson, 2002).

According to National Council of Teachers of Mathematics (NCTM, 1989), problem solving can therefore be defined as a process of using previously acquired facts, skills, concepts, principles and strategies to solve problems and in the process acquire new knowledge. Solving a problem means finding a way out of a difficulty, a way around an obstacle, attaining an aim, which was not immediately attainable. This requires imitation and plenty of guided practice. Therefore, it should be recognised that the most efficient way of setting up a flexible storage system of mathematical knowledge in the learners is for them to learn the material in a problem solving way. Mrasi (2004) observes that in a class of forty or more, with students of a varied range of motivational state and ability, it is impossible to provide every single student with differentiated learning experiences that are just right for their development and ability. It is important for teachers to endeavour to carefully plan for and to include problems of varying levels of difficulty to cater for the wide ability range in their classes. There should be something for everyone. Students should not be denied involvement in their own teaching.

According to Horn (1995), teaching procedures should be designed to promote curiosity and problem solving attitudes. Students need to build new mathematical knowledge through solving activities. They also require solving problems from mathematics as well as problems from other contexts. It is important for the teacher to explore a variety of appropriate strategies and skills for problem solving, as well as monitoring and reflecting on the process of mathematical problem solving. A problem-solving disposition includes the confidence and willingness to try on new and difficult tasks.

Problem-solving strategies are key to enabling students to continue their learning far beyond the classroom, leading them to become autonomous problem-solvers. Successful problem-solvers draw on variety of strategies, use knowledge of patterns within their topic, make it certain that they understand a problem before attempting a solution, and use effective self-regulation during the process. Once they understand the problem, they develop an initial plan, carry it out, and reflect on the success of the solution (Polya, 1973).

In regard to mathematics specifically, a major problem in a section of the curricular is that algorithms are taught out of context. Lochhead and Zietsman (2001) argue that teaching must be done within the context in order to avoid students' perfunctory performance on algorithms alone. Lochhead and Zietsman further assert that much emphasis is laid on general-purpose strategies that can be applied across a range of mathematical contexts. Beyer (1988) supports Polya (1973) four-step sequence of introducing mathematical problem-solving. The teachers reinforce this strategy and elaborate upon it as student progress through the classes, using it as a framework for a variety of solution plans and formulae (Beyer, 2001). Kelly, Lang and Pagliaro (2003) identifies eight general problem-solving strategies including: identifying the target goal (what is to be solved), making a plan, identifying the key information, evaluating one's plan and solution, hypothesis generation and testing, estimation, trial-and-error and dividing a problem into sub-problems (two or more procedural operations).

Cook (2001) stresses tasks that engage students in problem-solving and mathematics reasoning and that quality rather than quantity should rule the day in problems that are thought-provoking, using problems that challenge students' curiosity. Cook further emphasises that students can gain from learning strategies such as: trial-and-error, drawing a diagram or model, process of elimination, looking for patterns, simplifying the problem, working backwards, organising information and then writing an equation. Moreover, Lochhead and Zietsman (2001) contend that good problem-solvers also not only have these strategies as part of their repertoire, but also have two other characteristics: a positive and determined attitude about problem-solving, and awareness in the sense of understanding *how* they solved the problems. Hence, this study considered the use of the different learning strategies and the characteristics of good problem-solvers during mathematics instruction.

Effective teaching of problem-solving process in mathematics involves encouragement of learners to generate their own explanations why worked examples of problems are correct, represent problems, explain inductively principles underlying worked examples, create conducive problem-solving environments, use group-work and facilitate the formation of positive attitudes toward problem solving and give clear and positive expectancies to students (Leder, 1987; Horn, 1995). This study established the essence of using such problem-solving strategies in mathematics instruction.

2.8.4 Teaching Mathematics through Problem Posing

During the 1980's problem solving received a lot of emphasis and its place in the teaching and learning of mathematics was firmly secured. The aspect of problem posing was not adequately highlighted, despite being an important ingredient in learning mathematics.

Mrasi (2004) indicates that at the end of every chapter in a mathematics textbook, there are usually standard (routine) problems often with one particular method of solution and one correct answer. This is, of course done at the end of the tell-and-show method where the teacher tells the students how it is done and shows them via an example. This promotes simple recall of facts, procedures, theorems and algorithms, which are usually learnt by rote. Students become mere recipients of knowledge. Such methods deny students the opportunity to engage in more important aspects of learning mathematics as this basically represents convergent thinking. The result is promotion of reproductive thinking whose end points are low cognitive abilities. Important aspects such as the ability to reason, synthesise, evaluate, develop conjectures, hypothesise (offering a probable solution or explanation), make inferences and stimulate thinking about different point of view are ignored (Lister & Raymond, 1994). Thus, teachers need to promote the practice of rephrasing problems, posing new problems in order to explore new ideas, make connections and deepen students' understanding of important mathematical content.

Baseline studies conducted by SMASSE in 1998 showed that most of what students learn comes directly from the teachers and/or textbooks and not enough attention is paid to students' perceptions (Mrasi, 2004). The teacher should build on these perceptions through

careful criticism, providing cues, praise and supporting students' mathematical thinking. Polya (1973) observes that students who pose their own problems are better motivated to solve them than if they are imposed from without through textbooks or teachers. Consequently, it is important to encourage problem posing in that, a problem well posed is a problem partly solved. Often the posing of new problems and their solutions is more interesting and challenging than the original problems posed by the teacher. Problem posing should be a continuous process, which takes place at the beginning, during and after solving a given problem. Students learn a lot when they reflect upon the nature of the problems they pose. This has the effect of inspiring and evaluating existing ideas held by the learners. It also provides learners with the opportunity to be actively involved in the learning process by engaging in generating and solving problems (NCTM, 1989).

Trismen, cited in Mrasi (2004) is of the opinion that students can develop their mathematical understanding well, if they are encouraged to ask and answer their own questions, such as how? Why? What if? What does that mean? Is there a better way? Does the order matter? Is it always true? Can the result be generalised? The role of the teacher is to promote the development of critical thinking skills. Students need to be encouraged to talk about what they are thinking and explain their working (Garfola & Lester, 1985). Finally, it is important to encourage students to work individually, in pairs, or in small groups where the teacher acts as resource person. This was reflected very well in Totally Integrated Quality Education and Training (TIQET) (Republic of Kenya, 1999) that science and mathematics teaching and examinations should be oriented to problem solving approaches. This is because of the realisation that the curriculum should lay emphasis on talent development, creative thinking and promotion of innovativeness and analytical thinking. These are the qualities required of an individual who will be functional in society for national development (TIQET):

a) Problem formulation for clarity and to support students' organisation of thinking processes and experiences relating to subordinated competences.
b) Problem solving strategies in order to support reasoning abilities and logical arrangement of work.
c) Validating answers in order to support learning.
d) Reviewing solutions in order to establish coherence of mathematical content and reasonableness of answers.

e) Encouraging extensions in order to challenge learners extend their learning and draw out creativity.

2.8.5 Instructional Language in Mathematical Problem-solving

According to Durkin and Shire (1995), mathematical knowledge is transmitted, explored and advanced via language. Students and teachers write, talk and listen mathematics. However, in the diverse contexts of mathematical communication and instruction, language can help the learners to gain insights, yet it can serve also to obscure and impede the learning process. Ramogoro and Kiboss (1997) argue that in cases where English has been used in science, teachers need to have a good command of the English language for meaningful learning to take place. In addition, Okere (1996) asserts that teaching is greatly facilitated by the media of language, which provides not only a means of communication but also a means of imposing order on our experiences. Moreover, Githua (2001) observes that the specialised language in mathematics tests and examinations is one of the factors that may contribute to poor performance. Consequently, fluency in English influences mathematical problem solving. Cresswell (1983) found that reading achievement influences mathematics problem solving. Besides, Dawe (1983) indicates that first language competence is important for reasoning mathematically in English. Thus, reading and understanding English is a prerequisite for higher mathematics achievement.

Furthermore, in teaching true problem solving strategies to deaf students, Kelly *et al.* (2003) found that mathematics teachers do not emphasise true problem solving as much as they should. This is because they feel that their deaf students are not strong in their written skills. They do not challenge their deaf students with higher level thinking skills while solving word problems. Lowered expectation result in their giving less homework with word problem solving and less class time is spent on teaching word problem solving. True problem solving includes specific content domain areas, skills such as problem representation, using analogies to solve word problems, posing new problems from given facts and situations, and active engagement through diagram representation or manipulative hands-on materials. The reason why deaf students have difficult in solving word problems is because teachers often lack adequate preparation in mathematics and mathematics education and have insufficient knowledge about the value of word problems. With less training themselves, they allocate less weekly time to teaching and learning mathematical problem solving and word problem

situations, provide minimal homework related to solving word problems, and develop the perception that English skills are the primary barrier to learning. However, Pagliaro (1998) claims that the more familiar teachers are with mathematics reform, the more problem-solving activities they will offer in their classrooms.

According to Kantowski (1994), being a successful word problem solver involves having good reading and comprehension skills, having selective attention, being able to do sustained analysis, analogies and thinking about one's own thinking. Instruction should be student-centred. For example, students should be given practice in problem representation and encouraged to use analogies to understand problem situations and relate the problem situation via analogy to knowledge that they already have. They should also be given a variety of problems from simple to complex, familiar to unfamiliar, since most real world problems are not well defined. It is critically important that students have the experience of recognising and solving problems related to specific domains, representing problems in written English, posing new problems from given information, and using analogies to relate problem situations to knowledge already known. Teachers need to ensure that the strategies they use focus on strengthening critical thinking and metacognitive skills (Hembre, 1992).

Arguably, the nature of instructional language in mathematics poses many challenges to students and teachers. According to Kelly *et al.* (2003), linguistic content of the problems and/or the English language abilities of the students are the primary contributing factors to students' difficulties with mathematics and the word problems therein. Rudner (1978) revealed that English language structures used in both written and verbal instructions for mathematics cause special difficulty for students. Moreover, Kelly and Mousley (2001) concluded that students might not be linguistically challenged when solving word problems but their attitudes towards word problems greatly influences their performance. Consequently, mathematical problem solving requires skill in reading as well as computing, and ability to state associations. It is through reading that the learner identifies the problem. Besides, to understand all the conditions of the problem situation, the learner must be able to read.

2.8.6 The Role of Problem-Solving in Teaching Mathematics as a Process

Problem-solving is an important component of mathematics education because it is the most appropriate approach which is able to achieve at school level all the three values of mathematics: functional, logical and aesthetic.

Firstly, mathematics is an essential discipline because of its practical role to the individual and society. Through a problem-solving approach, this aspect of mathematics is developed. Presenting a problem and developing the skills needed to solve that problem is more motivational than teaching the skills without a context. Such motivation gives problem-solving special value as a vehicle for learning new concepts and skills or the reinforcement of skills already acquired (Stanic & Kilpatrick, 1989).

Approaching mathematics through problem solving creates a context, which simulates real life and therefore justifies the mathematics rather than treating it as an end in itself. The NCTM (1989) recommended that, problem solving be the focus of mathematics teaching because, it encompasses skills and functions, which are an important part of everyday life. Furthermore, it can help people to adapt to changes and unexpected problems in their careers and other aspects of their life. The council endorsed this recommendation that problem solving should underlie all aspects of mathematics teaching in order to give students experience of the power of mathematics in the world around them. They see problem solving as a vehicle for students to construct, evaluate and refine their own theories about mathematics and the theories of others.

According to Resnick (1987), a problem-solving approach contributes to the practical use of mathematics by helping people to develop the facility to be adaptable when, for instance, technology breaks down. It can thus help people transfer into new work environments at this time when most are likely to be faced with several career changes during a working life time (NCTM, 1989). Resnick expressed the belief that, school should focus its effort on preparing students to be good adaptive learners, so that they can perform effectively when situations are unpredictable and task demands change.

Cockroft (1982) also advocated problem solving as a means of developing mathematical thinking, as a tool for daily living, echoing that problem-solving ability lies at the heart of mathematics, because it is the means by which mathematics can be applied to a variety of unfamiliar situations.

Secondly, problem solving is, however, more than a vehicle for teaching and reinforcing mathematical knowledge and helping to meet everyday challenges. It is also a skill, which can enhance logical reasoning. Students can no longer function optimally in school by just knowing the rules to follow to obtain a correct answer. They also need to be able to decide through a process of logical deduction what algorithm, if any, a situation requires. Besides, the students should be able to develop their own rules in a situation where an algorithm cannot be applied directly. For these reasons, problem solving can be developed as a valuable skill in itself, a way of thinking (NCTM, 1989).

Finally, a problem-solving approach is valuable as an aesthetic form. Problem solving allows the students to experience a range of emotions associated with various stages in the solution process. Mathematicians who successfully solve problems argue that the experience of having done so contributes to an acknowledgement of the power and beauty of mathematics (NCTM, 1989). They also speak of the willingness or even desire to engage with a task for a length of time, which causes the task to cease being a 'puzzle' and allows it to become a problem. It is this engagement, which motivates the solver to pursue a problem. Apparently, it is necessary for certain techniques to be available for the involvement to continue successfully. Thus, problem-solving techniques can be made available most effectively through making problem solving the focus of the mathematics curriculum. Although mathematical problems have traditionally been a part of the mathematics curriculum, it has been only comparatively recently that problem solving has come to be regarded as an important medium for teaching and learning mathematics (Stanic & Kilpatric, 1989). In the past, problem solving had a place in the mathematics classroom, but it was usually used in a token way as a starting point to obtain a single correct answer, usually by following 'correct' procedure.

The National Council of Teachers Mathematics (1989) recommended that the mathematics curriculum be organised around problem solving, focusing on:

a) Developing skills and the ability to apply these skills to unfamiliar situations.
b) Gathering, organising, interpreting and communicating information.
c) Formulating key questions, analysing and conceptualising problems, defining problems and goals, discovering patterns and similarities, seeking out appropriate data, experimenting, transferring skills and strategies to new situations.
d) Developing curiosity, confidence and open-mindedness.

One of the aims of teaching through problem-solving is to encourage students to refine and build onto their own processes over a period of time as their experiences allow them to discard some ideas and become aware of further possibilities (Carpenter, 1989). As well as developing knowledge, the students are also developing an understanding of when it is appropriate to use particular strategies. Through using this approach, the emphasis is on making the students more responsible for their own learning rather than letting them feel that the algorithms they use are the inventions of some external and unknown 'expert'. There is considerable importance placed on exploratory activities, observation and discovery, and trial and error. Students need to develop their own theories, test them, test the theories of others, discard them if they are not consistent, and try something else (NCTM, 1989). Students can become even more involved in problem solving by formulating and solving their own problems, or by rewriting problems in their own words in order to facilitate understanding. It is of particular importance to note that, they are encouraged to discuss the processes, which they are undertaking, in order to improve understanding, gain new insights into the problem and communicate their ideas (Thompson, 1985; Stacey & Groves, 1985).

In conclusion, there is little doubt that the mathematics programs in Kenyan secondary schools can be enhanced by the establishment of an environment in which students are exposed to teaching via problem solving, as opposed to mere traditional methods of teaching. The challenge for teachers, at all levels, is to develop the process of mathematical thinking alongside the knowledge and to seek opportunities to present even routine mathematics tasks in problem-solving contexts.

2.8.7 Significance of Mathematical Problem-Solving

According to Johnson and Rising (1972) and Polya (1973), learning to solve problems is significant for several reasons, namely:

a) It is a process whereby new concepts are learned and new knowledge discovered.
b) It is a meaningful way of practicing computational skills.
c) Through problem-solving the students actively learn to transfer concepts and skills to knew situations; and
d) Problem-solving provides a means of stimulating intellectual curiosity.

2.9 Theoretical Framework

Proponents of cognitive theories include: Piaget, Gagne, Bruner, Skemp, Ausubel and Relan, among others. They postulate that new knowledge is acquired through the process of its discrimination, assimilation and accommodation into learner's old schema of knowlegde. According to Relan (1992), the learner can regulate his/her own mathematical problem solving activities if the classroom environment has been structured conducively to enhance efficiency in the learning process. The conducive classroom environment enables the learner to acquire information and transform it for easier comprehension and meaningful learning, besides participating fully in mathematical problem solving activities. This serves to sustain effort and persistence in mathematical problem solving activities and may improve achievement.

Constructivist theorists assert that individuals actively construct the knowledge they possess. This construction of knowledge is a life-long and an effortful process requiring significant mental engagement by the learners. Further, the constructivists agree that the knowledge already possessed by the learners affect their ability to learn new knowledge. Thus, constructivist theorists view prior knowledge and sense-making as very conspicuous in learning new knowledge. Constructivist theorists have their roots in the ideas of Bartlett and Piaget, as cited in Okere (1996).

This study was guided by two theories namely; cognitive structural theory of learning and constructivist theory of learning. According to the cognitive structural theory, learning involves active cognitive processing of information rather than mere stimulus-response

association (Bruner, 1990). The items of information acquired through learning mathematics are stored, filed and cross-indexed rather than stored in isolation from one another. This theory asserts that mathematical knowledge is organised into categories that simplify the task of processing and retaining information by allowing the individual interpret the new in reference to the familiar. Furthermore, this theory focuses on the mental processes that go on in the individual. It is primarily concerned with internal processes individuals use to acquire, organise and store information. Learning according to cognitive theorists, is change within the individual's mental structure that provides them with the ability to change their outward behaviour (Rivard, 1996). Piaget, a cognitive theorist, believed that acquisition of knowledge is a continuous self-construction process. This concurs with Driscoll (1994) view that knowledge is invented and reinvented as the child develops and interacts with the world surrounding him/her. Thus, learning mathematics is an ongoing process of developing an increasingly sophisticated cognitive structure for representing and interacting with the world.

However, Okere (1996) argues that recent research has led to the development of constructivist theories in which learners construct meaning from input by processing it through existing cognitive structures. Constructivists assert that we learn through a continual process of constructing, interpreting and modifying our own representations of reality based on our experiences with reality (Driver & Bell, 1986; Relan, 1992). This is done in ways that leave the input open to further processing and possible reconstruction. Furthermore, constructivists hold that learning is an active process where students are actively involved in meaning construction. Rather than having a teacher as a sole dispenser of facts and lower level cognitive information, constructivists believe that the teacher should serve as a facilitator who attempts to structure an environment in which the learner organises meaning on a personal level (Cooper & Robinson, 2002).

In reality, a constructivist teacher should take into account what students bring to the classroom as a starting point; to create a set of experiences that provide as many opportunities for the students to encounter new ideas in situations where they can be used to solve problems perceived and valued by the students. Thompson (1985) asserts that the task of the constructivist curriculum developer is to select problematic situations that provide occasions for students to think in ways that have a generating power in regard to the objectives of

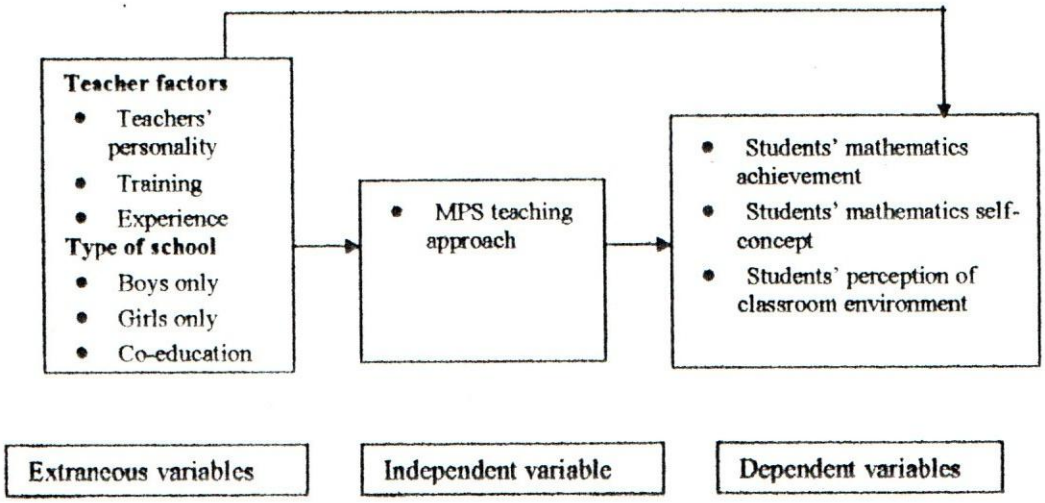
instruction. Thompson advocates the use of situations in which the students are encouraged to generate their own feedback with regard to a problem situation. Confrey (1987) supports this notion and gives it structure by recommending a set of questions that will help the students to become autonomous problem solvers. These questions are helpful for the constructivist teacher because it helps the teacher develop a model of the students' understanding. It also puts the responsibility of the solution process back into the hands of the learner. Thus, constructivists view learning as being dependant on the degree to which learners can activate existing cognitive structures to subsume the new input or construct new ones (Okere, 1996). Applied to the present study, learning mathematics is viewed as an activity, which involves constructing meaning through social processes whereby learners interact with each other and the environment.

The current mathematics curriculum is organised hierarchically and spirally (KIE, 2002). Organisation of topics is such that the earlier topics in the syllabus act as pre-requisites to those that come later. This makes learners to process and reconstruct new learning experiences as they ascend the academic ladder. In addition, mathematics instruction does not mean that the learner only attends to information presented but must interpret and integrate it into the existing knowledge base (Okere, 1996). To acquire knowledge, the learner must perceive, classify, evaluate, manipulate presented information and apply it in mathematical problem solving. This underlies two principles namely, the concept of acquisition and the rule of application (Kiboss, 1997). Depending on the type of activities incorporated in the Mathematical Problem-Solving (MPS) teaching approach, these principles revolve around the use of prior knowledge, defining and exemplifying concepts and application of these concepts in mathematical problem solving (see Appendix A).

The extraneous variables of the study were: the teacher factors that constituted teachers' personality, training and experience; and the type of school that comprised of boys' only, girls' only and co-educational schools. The independent variable was MPS teaching approach while students' mathematics achievement, self-concept and perception of the classroom environment were the dependent variables. Students' mathematics achievement was measured by the scores obtained on the Mathematics Achievement Tests (See 3.5.1, Appendices B & C). Students' mathematics self-concept was represented by scores obtained on the Mathematics Self-Concept Questionnaire (see 3.5.2 & Appendix D). Students'

perception of the classroom environment was represented by scores obtained on the Mathematics Classroom Environment Questionnaire (see 3.5.3 & Appendix E).

The relationship between the variables can be presented diagrammatically as shown in Figure 2.



Source: Adapted from Githua (2002), p. 64

Fig 2: Relationship Between the Variables

From Figure 2, it is clear that learning is affected by factors such as teacher factors and type of school. Teachers' personality affects the instructional process. Teacher training affects his/her ability to create meaningful learning experiences. It equips the teacher with adequate content on the subject matter. Teacher experience enables the teacher to see the strengths and weaknesses of the instructional approaches used in teaching the subject, hence affects his/her ability to appropriately implement the curriculum objectives. Type of school affects students' achievement (say) in that it can create a conducive classroom environment for both boys and girls, which can lead to improved students' performance and vice versa. The teaching approach used in mathematics instruction has influence on the students' achievement in that it can enhance or debilitate students from being creative and developing mathematical problem solving skills that can lead them to become autonomous problem-solvers. Consequently, the teaching approach affects the students' mathematics achievement, self-concept and perception of the classroom environment.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter looks at the research design, target population, sampling procedure and sample size, instruments used in data collection, data collection procedures and the analysis of data.

3.2 Research Design

The study involved a quasi-experimental Solomon Four-Group design. This is because secondary schools classes once constituted exist as intact groups and school authorities do not allow such classes to be broken up and re-constituted for research purposes (Gall, Borg & Gall, 1996). The non-equivalent group, pretest-posttest approach was used to partially eliminate the initial difference between the experimental and control groups (Gibbon & Herman, 1997). The design is the Solomon Four Group Design, which is considered rigorous enough for experimental and quasi-experimental studies. This is because it provides effective and efficient tools for determining cause and effect relationship, besides it provides adequate control of other variables that may contaminate the validity of the study (Borg & Gall, 1989). The design helped to achieve four main purposes:

(i) To assess the effect of the experimental treatment relative to the control condition.

(ii) To assess the interaction between pre-test and treatment condition.

(iii) To assess the effect of the pre-test relative to no pre-test; and

(iv) To assess the homogeneity of the groups before administration of the treatment (Borg & Gall, 1989).

Sharma (2002) notes that the non-equivalent control group design is a particular strong quasi-experimental procedure. However, it is important that the groups be as similar as possible and that there be opportunity for both a pre-test and post-test in both the treatment and the control groups.

The quasi-experimental procedure control all major threats to internal validity except those associated with interactions of selection and history, maturation and instrumentation (Gibbon & Herman, 1997). In this study, no major event was observed in any of the sample schools that would have introduced interaction between selection and history. Random assignment of

the groups to experimental and control groups was employed to control the interaction between selection and maturation (Borg & Gall, 1989). To control for interaction between selection and instrumentation, the instruments were administered under similar conditions across the schools (Sharma, 2002). Hence, there was reasonable control of the threats to internal validity of the study. The design is shown in Table3.

Table 3

Solomon Four-Group Experimental Design

Groups	Pre-test	Treatment	Post-test
1	O_1	X (MPS teaching approach)	O_2
2	O_3	C (Conventional teaching approach)	O_4
3		X (MPS teaching approach)	O_5
4		C (Conventional teaching approach)	O_6

Source: Adapted from Gibbon and Herman (1997)

In this design, subjects were assigned randomly to four groups. Groups 1 and 3 received the experimental treatment (X) that was the use of MPS teaching approach in teaching. One experimental group (Group 1) received a pre-test (O_1) whereas Groups 2 and 4 received treatment (C) (teaching using Conventional teaching approach). Control Group 2 received a pre-test (O_3) and finally all the four groups received post-test (O_2, O_4, O_5 & O_6). The research design is a combination of two group designs, the post-test only and the pretest-posttest which control extraneous variables of testing, history and maturation (Gibbon & Herman, 1997).

3.3 Population

The target population consisted of Form Three students from public schools in Vihiga District. Form Three students were chosen because the topic Commercial Arithmetic chosen for the study is taught at this level (Kenya Institute of Education [KIE], 2002), they could express their mathematical ideas in written form and also because their mathematics self-concept was at the lowest ebb (Githua, 2002).

The district has 83 schools: 57 district schools, 22 provincial schools and 4 private schools (District Education Office Vihiga [DEOV], 2003). District co-educational day schools were selected. This is because there are more district co-educational day schools as compared to provincial and private co-educational day schools, hence availability of subjects for the study. In addition, students admitted to these schools have almost the same qualifications based on the Kenya Certificate of Primary Education (KCPE) examination performance (District Education Office Vihiga [DEOV], 2003), thus providing a basis for generalisation of the results. Besides, the students in this category of schools represent a population of students with average academic ability as opposed to those in National and Provincial secondary schools whose performance at KCSE examinations is well above average. There were 40 such schools hence, an estimated accessible population of about 5300 students.

3.4 Sampling Procedure and Sample Size

3.4.1 Sampling Procedure

The sampling frame consisted of district co-educational day schools in Vihiga District. Purposive sampling was used to identify the secondary school category and the class level that formed the study population. However, simple random sampling technique was used to draw four schools out of the accessible 40 schools for this study. This technique was appropriate because it ensured that all schools had an equal chance of being included in the study sample (Mugenda & Mugenda, 1999). Because of the smaller number of schools to sample from, balloting method was employed. This involved assigning a numeral to each of the 40 schools, placing the numbers in a container and then picking a number at random with replacement. Schools corresponding to the numbers picked and having only one stream at the Form Three level were included in the study sample. However, the schools were required to be far apart to avoid interaction between the experimental and control groups.

3.4.2 Sample Size

A sample size depends on a number of factors, including: number of variables in the study, type of research design, method of data analysis and the size of the accessible population (Borg, 1989). However, according to Mugenda and Mugenda (1999), at least 30 students per group are required for experimental research (though a difference of four students cannot make any statistically significance difference). Thus, from above (see 3.2 & 3.4.1), four

schools were sampled and one stream from each school included in the study sample. The four schools were appropriate since the study was conducted within a specified time frame and resources of the researcher, besides providing sufficient sample. Although it was assumed that the average enrolment was forty students per stream, giving the approximate sample size of the study as 160 students, the actual sample size that participated was 163 students. However during data coding, it was found that seventeen students had either incomplete data and/or missed some test, hence reduced the sample size for data analysis to 146 students. These subjects were used in their four intact classes in the four schools that were randomly assigned to experimental groups 1 and 3, with 34 and 39 students respectively; and control groups 2 and 4, with 30 and 43 students respectively. Table 4 gives a breakdown of the sample size from the four secondary schools.

Table 4

Sample Size of the Study

Group	Number of Students
1	34
2	30
3	39
4	43
Total	**146**

3.5 Instrumentation

The instruments used in assessing the students' mathematics achievement, self-concept and perception of the classroom environment were developed and validated prior to the actual conduct of the study. There were five types of instruments, namely: Mathematics Achievement Tests (MAT1 & MAT2), Mathematics Self-Concept Questionnaire (MSCQ), Mathematics Classroom Environment Questionnaire (MCEQ) and Classroom Observation Schedule (COS).

3.5.1 Mathematics Achievement Tests (MATs)

Mathematics Achievement Test1 (MAT1) and Mathematics Achievement Test2 (MAT2) were developed by the researcher. The tests were given to six University lecturers who gave their comments after studying the items. Language and other noticeable problems were corrected. The tests were then given to three secondary school mathematics teachers who were also mathematics examiners with KNEC. They reviewed the items and made their comments. Their feedback was used to improve the MATs items. MAT1 was used as a pre-test and had items on the topics (Quadratic Expressions, Approximation & Errors, Trigonometry, Surds & Logarithms, Formulation & Variation) that had been covered by the Form Three students (see Appendix B). Its purpose was to establish the entry behaviour of the learners before the treatment. MAT2 was used as a post-test. This instrument was used to assess students' achievement in Commercial Arithmetic in mathematics and contained items on: simple interest, compound interest, repayments of loans, appreciation, depreciation, hire purchase and income tax (see Appendix C). The twenty items in MAT2 were developed based on the table of specification designed for the topic Commercial Arithmetic on the aforementioned constitutes against the three cognitive levels as stated in the Blooms taxonomy as shown in Table 5.

Table 5

Table of Specification for MAT2 Items

Cognitive level\Content Area	Knowledge	Application	Comprehension	Total
Simple interest	1	1	1	3
Compound interest	2	1	1	4
Repayments of loans	1	1	0	2
Appreciation	1	1	1	3
Depreciation	1	0	1	2
Hire purchase	1	2	0	3
Income tax	1	1	1	3
Total	**8**	**7**	**5**	**20**

The tests (MAT1 & MAT2) were pilot tested using one co-educational day school that was not part of the study, but having similar characteristics as the sample schools. This school was drawn from Kakamega District. This ascertained the tests' suitability, content validity and reliability. The reliability coefficients were ascertained using Cronbach's Coefficient Alpha method, since the items on the instruments were not scored dichotomously (Gall, Borg & Gall, 1996). This was appropriate because the instruments contained items that had different weights. Reliability coefficients of 0.87 and 0.88 were obtained for MAT1 and MAT2 respectively. These values of reliability coefficients were acceptable for the study, since Fraenkel and Warren (1990) assert that an alpha value above 0.70 is considered appropriate to make possible group predictions that are sufficiently accurate.

3.5.2 Mathematics Self-Concept Questionnaire (MSCQ)

This students' questionnaire MSCQ, was adapted from Githua (2002) and modified to suit this study. This questionnaire contained 30 structured items that solicited students' feelings about Commercial Arithmetic in mathematics. This number of items was appropriate because the implementation of this study was limited to the time that was made available by the school authorities and that they could capture the required information from the respondents. This instrument was based on students' attitudes, feelings and knowledge about their mathematical skills, abilities, enjoyment and interest in Commercial Arithmetic as measured on a five point Likert scale (see Appendix D). This instrument was pilot tested for reliability in one co-educational day school, other than those included in the study to determine its reliability. The school was drawn from Kakamega District. The respondents in the pilot study had similar characteristics with those in the actual study. The Cronbach's Coefficient Alpha method was used to obtain the reliability of this instrument (Gall, Borg & Gall, 1996). The method was appropriate because it determines the reliability of an instrument by a single administration and can assess multiple response items. For the MSCQ instrument, the alpha value obtained was 0.88, which was acceptable for the study (Borg & Gall, 1989).

3.5.3 Mathematics Classroom Environment Questionnaire (MCEQ)

This students' questionnaire MCEQ, was adapted from Kiboss (1997). Kiboss developed an instrument to measure the students' perception of the classroom environment in physics. The instrument was modified to suit this study for data collection on learners' perception of their

mathematics classroom environment. It contained 20 structured items which addressed the mode of instruction, time adequacy, learning provisions, instructional materials and teachers' and students' learning activities which were measured on a five point Likert scale (see Appendix E). This instrument was pilot tested in one co-educational day school (in Kakamega District) that did not participate in the actual study. Its reliability was determined using Cronbach's Coefficient Alpha method. It was found to have a reliability coefficient of 0.74, which was acceptable for use in the actual study (Borg & Gall, 1989).

3.5.4 Classroom Observation Schedule (COS)

A Classroom Observation Schedule (COS) was adapted from Flanders, as cited in Kathuri and Pals (1993) and Kiboss (1997) and modified to suit this study. COS was used to observe some lessons in Commercial Arithmetic for purposes of providing data on teachers' and students' activities during the instructional process. It is worth noting that the COS instrument had two sections: A and B, which provided data on the teachers' and students' activities respectively. This contained eleven teacher related items and thirteen student related items on teaching style, questioning, responding, reinforcement, talk-initiation, silence, organisation and communication skills, among others (see Appendix F). Six lecturers (with at least ten years of teaching experience) from the Faculty of Education of Egerton University validated the COS instrument before pilot testing for reliability. The purpose of validating the COS instrument was to assess its suitability, quality of the design, item content, surface features, pedagogical issues and the adequacy of the language used. However, the reliability of the two sections of the COS was ascertained (from the pilot test observation scores) separately using Cronbach's Coefficient Alpha method. Specifically, reliability coefficients of 0.74 and 0.79 were obtained for sections A (Teacher Activity) and B (Student Activity) respectively.

Table 6 gives a summary of the Cronbach's reliability coefficients of the five instruments used in the study.

Table 6

Reliability Coefficients of the Instruments

Instruments	Reliability Coefficients
Mathematics Achievement Test1 (MAT1)	0.87
Mathematics Achievement Test2 (MAT2)	0.88
Mathematics Self-Concept Questionnaire (MSCQ)	0.88
Mathematics Classroom Environment Questionnaire (MCEQ)	0.74
Classroom Observation Schedule (COS)	
Teacher Activity	0.74
Student Activity	0.79

From the results presented in Table 6, the reliability coefficients got are above 0.70 threshold for acceptable reliability (Fraenkel & Warren, 1990). Consequently, the tools were appropriate for use during data collection in the actual study.

3.6 The Development and Use of Instructional Materials

The instructional materials used in the study were based on the KIE approved mathematics syllabus (KIE, 2002). The MPS teaching approach had two manuals, one for the teacher (Teachers' manual) and one for the students (Students' manual). The students' manual was derived from the teachers' manual (see Appendix A). These manuals contained the mathematics content that was covered during the instructional process.

3.7 Data Collection

To generate data required for this study, teachers involved in teaching the experimental group were in-serviced for a period of one week by the researcher as pertaining to the requirements and the use of the MPS teaching approach. This period was appropriate because the teachers involved in teaching the experimental groups were trained. MAT1, MSCQ and MCEQ were first administered to students in the experimental group 1 and the control group 2 for purposes of ascertaining their entry level and homogeneity. Experimental groups 1 and 3 were exposed to a series of 22 lessons in teaching the topic Commercial Arithmetic using

MPS teaching approach (see Appendix A), while control groups 2 and 4 were exposed to the same using the conventional teaching approach, where learning was mainly teacher centred. In the process, the researcher observed some lessons and tallied the observations in COS. After all the students in this study had completed the topic, MAT2, MSCQ and MCEQ were administered (at the same time) to all the groups. The researcher scored and coded collected data for analysis.

3.8 Data Analysis

Data was analysed using both descriptive and inferential statistics. Raw data was analysed using means, standard deviations and percentages. Statistical tests of significance were determined using t-test and Analysis of Variance (ANOVA) at an alpha (α) level of 0.05. The ANOVA was performed to determine the differences in the four means of the post-test scores. An F-test was used to determine whether the differences were significant. When dealing with two means, a t-test was used because of its superior power in detecting differences between two means. Data collected was analysed on computer using Statistical Package for Social Sciences (SPSS) for Windows version 11.5. Table 7 shows a summary of the analysis.

Table 7

Summary Table of the Analysis of Data

Hypotheses	Independent Variable	Dependent Variables	Statistical Test
Ho1: There is no statistically significant difference between the achievement scores of students who are exposed to MPS teaching approach and those who are not exposed to it.	MPS teaching approach	Students' mathematics achievement scores	One-way ANOVA t-test
Ho2: There is no statistically significant difference between the mathematics self-concept scores of students who are exposed to MPS teaching approach and those who are not exposed to it.	MPS teaching approach	Students' mathematics self-concept scores	One-way ANOVA t-test
Ho3: There is no statistically significant difference between the perception of the mathematics classroom environment scores of students who are exposed to MPS teaching approach and those who are not exposed to it.	MPS teaching approach	Students' perception of classroom environment scores	One-way ANOVA t-test
Ho4: There is no statistically significant gender difference in achievement of students taught through MPS teaching approach.	Gender	Students' mathematics achievement scores	t-test

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This study investigated the effects of MPS teaching approach on Form Three students' mathematics achievement, self-concept and perception of their classroom environment. This chapter presents the results and discussions of the study. It describes the data generated from the study using descriptive and inferential statistics while the results are discussed thereafter. The results are presented in form of tables and their implications are discussed. Analysis of Variance (ANOVA) and t-test are used to test the four hypotheses of the study. The sections that follow in this chapter contain information on the following areas:

a) Results of the pre-tests
b) Effect of MPS teaching approach on students' achievement
c) Effect of MPS teaching approach on students' mathematics self-concept
d) Effect of MPS teaching approach on students' perception of their mathematics classroom environment
e) Effect of MPS teaching approach on the achievement of boys and girls
f) Analysis of teachers' and students' activities during mathematics lessons

4.2 Results of Pre-tests

The Solomon Four-Group Design used in this study enabled the researcher to have two groups sit for pre-tests. The aim for pre-testing was to ascertain whether or not the students selected to participate in this study had comparable characteristics before presenting the topic Commercial Arithmetic. To achieve this aim, the students in groups 1 and 2 sat for the pre-tests MAT, MSC and MCE. This made it possible for the researcher to:

i) Assess whether there was any interaction between the pre-test and the treatment conditions
ii) Assess the effect of the pre-test relative to no pre-test
iii) Assess the similarity of the groups before the administration of the treatment (Borg & Gall, 1989).

The effect of pre-test on students and the interaction between treatment and pre-test are discussed in *section 4.8.1.*

Table 8 shows the t-test of the pre-test scores on the MAT, MSC and MCE.

Table 8

Independent Samples t-test of the Pre-test Scores on MAT, MSC and MCE

Group 1, N = 34				Group 2, N = 30	
Variable	**Group**	**Mean**	**SD**	**t-value**	**P-value**
MAT	1	24.38[a]	14.64	0.265	0.79(ns)
	2	23.47[a]	12.82		
MSC	1	100.44[b]	15.17	0.323	0.75(ns)
	2	99.47[b]	6.99		
MCE	1	58.32[c]	5.37	1.378	0.17(ns)
	2	56.67[c]	4.05		

[a, b, c] denotes similar mean scores ($t_{tabulated}$ 1,62 = 1.96; $t_{computed}$ = 0.265; 0.323; 1.378; df = 62)

Key

ns = not significant at $p<0.05$ level

SD = Standard Deviation

df = degrees of freedom

MAT maximum score = 70

MSC maximum score = 150

MCE maximum score = 100

As shown in Table 8, the pre-test mean scores of both groups (1 & 2) obtained were similar on MAT, MSC and MCE measures. However, a further analysis of these results was necessary in order to establish whether the mean scores were statistically different at 0.05 α-level. The t-test results analysis reveals that the pre-test mean scores for groups 1 and 2 on MAT, MSC and MCE measures are not statistically different at 0.05 α-level.

Table 9 shows a summary of the pre-test scores on MAT based on students' gender.

Table 9

Independent Samples t-test of the Pre-test Scores on MAT based on Students' Gender

Variable	N	Gender	Mean	SD	t-value	df	P-value
MAT	40	Male	24.68[a]	14.52	0.541	62	0.59(ns)
	24	Female	22.75[a]	12.45			

[a] denotes similar mean scores ($t_{tabulated}$ 1,62 = 1.96; $t_{computed}$ = 0.541)

ns = not significant at $p<0.05$ level

The results in Table 9 indicate that the male students had a mean score of 24.68, while that of the female students was 22.75. Thus, it is clear that the MAT pre-test mean scores of the male and female students are similar. A further analysis of these results was necessary in order to establish whether the mean scores were statistically different at 0.05 α-level. The t-test result reveals that the MAT pre-test mean scores of the male and female students are not statistically different ($t(1,62) = 0.541$, $p>0.05$).

An examination of Table 8 indicates that the pre-test mean scores for groups 1 and 2 on MAT, MSC and MCE are not statistically different at 0.05 α-level. From the results presented in Tables 8 and 9, it suffices that the pre-test MAT, MSC and MCE mean scores of students in the groups 1 and 2 are not statistically different at 0.05 α-level. Similarly, the pre-test MAT mean scores of male and female students in the groups 1 and 2 are not statistically different. This indicates that the groups used in the study were comparable and had similar entry behaviour, hence homogeneous. This made them suitable for the study.

4.3 Effect of MPS Teaching Approach on Students' Achievement

In order to determine the effect of MPS teaching approach on students' achievement in mathematics, an analysis of the students' post-test MAT scores was carried out. Hypothesis one (Ho1) of the study sought to find out whether there was any statistically significant

difference between the achievement of students who were exposed to MPS teaching approach and those who were not exposed to it.

Table 10 shows the MAT post-test mean scores obtained by the students in the four groups.

Table 10

MAT Post-test Mean Scores Obtained by the Students in the Four Groups

Group	N	Mean Score	SD
1	34	44.38[a]	17.07
2	30	24.23[b]	12.34
3	39	42.64[a]	19.09
4	43	23.14[b]	14.17
Total	**146**	**33.52**	**18.72**

[a, b] denotes similar mean scores

Results in Table 10 show that the MAT post-test mean scores for the experimental groups 1 and 3 (44.38 & 42.64) and that of the control groups 2 and 4 (24.23 & 23.14) respectively, are quite similar. However, the MAT post-test mean scores for the experimental groups 1 and 3 are much higher than that of the control groups 2 and 4. This suggests that the experimental groups performed much better than the control groups in the MAT. In order to determine whether the difference in the MAT post-test mean scores was statistically significant, a one-way ANOVA was performed. The results of the one-way ANOVA based on these mean scores are shown in Table 11.

Table 11

ANOVA of the Post-test Scores on the MAT

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	14476.91	3	4825.64	18.87*	0.00
Within Groups	36319.53	142	255.77		
Total	50796.44	145			

* Denotes significant mean differences at $p < 0.05$ ($F_{tabulated}\ 3,142 = 2.68$; $F_{computed} = 18.87$)

The results in Table 11 reveal that the differences between the MAT post-test mean scores (of the four groups) are statistically significant ($F(3,142) = 18.87$, $p<0.05$).

Having established that there was a significant difference between the means, it was necessary to carry out further tests on the various combinations of means to find out where the difference occurred (SPSS, 1998). Table 12 shows the results of the Least Significance Difference (LSD) post hoc comparisons. LSD post hoc comparisons were preferred over the others since they could best help establish whether there was a statistically significant difference in achievement of the students who were taught through the MPS teaching approach and those taught through the conventional teaching approach.

Table 12

Post Hoc Comparisons of the Post-test of MAT Means for the Four Groups

	(I) Group	(J) Group	Mean Difference (I–J)	P-value
LSD	1	2	20.15*	0.00
		3	1.74	0.64
		4	21.24*	0.00
	2	1	-20.15*	0.00
		3	-18.41*	0.00
		4	1.09	0.77
	3	1	-1.74	0.64
		2	18.41*	0.00
		4	19.50*	0.00
	4	1	-21.24*	0.00
		2	-1.09	0.77
		3	-19.50*	0.00

* = The mean difference is significant at $p<0.05$

The results in Table 12 show that the pairs of MAT mean scores of groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 were significantly different at the 0.05 α-level. However, the mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 were not statistically different. Since the MAT pre-test mean scores indicated that there was no significance

differences between the entry levels of the groups involved in the study, then it was not necessary to confirm the post-test results by performing Analysis of Covariance (ANCOVA). Differences in the MAT post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 were not significant. It is also evident from Table 10, that the MAT post-test mean scores of the control groups 2 and 4 were almost similar and much lower than those of the experimental groups 1 and 3.

The results indicate that:

i. The MAT pre-test did not interact significantly with the treatment conditions. If this were the case, the groups, which took the pre-test, would have obtained different results from those that did not take it (Borg & Gall, 1989).

ii. The pre-test MAT did not affect the students in the learning of the content. If this were the case, the students who sat for pre-test would have different results from the others. This made the pre-test suitable for the study (Kothari, 1990).

iii. The use of MPS teaching approach resulted in higher students' achievement than the conventional teaching approach since the experimental groups 1 and 3 obtained significantly higher mean scores.

Considering the results presented in Tables 10, 11 and 12, it was found that the post-test mean scores obtained by students in the experimental groups 1 and 3 (44.38 & 42.64 respectively) were not significantly different at $p = 0.05$ α-level. In addition, the mean scores of the control groups 2 and 4 (24.23 & 23.14 respectively) are not significantly different. However, the mean scores obtained by students in the groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 are significantly different at $p<0.05$. In view of these findings, the null hypothesis Ho1 suggesting that there is no statistically significant difference between the achievement of students who are exposed to MPS teaching approach and those who are not exposed to it is rejected.

A comparison of the students' scores in the pre-test and post-test MAT was carried out. Table 13 shows a summary of these scores together with the mean gain.

Table 13

Comparison of the Mean Scores and Mean Gain Obtained by Students in MAT

	Overall (N = 64)	Group 1 (N = 34)	Group 2 (N = 30)
Pre-test Mean	23.95	24.38	23.47
Post-test Mean	34.94	44.38	24.23
Mean Gain	10.98	20.00	0.77
df	63	33	29
t-value	6.81	17.67	0.40
p-value	0.00	0.00	0.69

In Table 13, the experimental group 1 had a higher mean gain (20.00) in the MAT than the control group 2 (0.77). The experimental group thus gained more than the control group. The paired sample t-test between the pre-test and post-test mean scores reveal that the experimental group 1 gained significantly ($t(33) = 17.67$, $p<0.05$) from the teaching as compared to the control group 2 ($t(29) = 0.40$, $p>0.05$). Hence, the experimental group that was taught through the MPS teaching approach had a higher mean gain than the control group that was taught through the conventional teaching approach. This strengthens the position that the MPS teaching approach resulted in higher achievement than the conventional teaching approach.

4.4 Effect of MPS Teaching Approach on Students' Mathematics Self -Concept

The post-test MSC scores were analysed to determine the effect of MPS teaching approach on students' mathematics self-concept to learn mathematics using one-way ANOVA. This was done in order to test hypothesis two (Ho2) that sought to find out whether there was any statistically significant difference between the MSC of the students who were exposed to MPS teaching approach and those who were not exposed to it.

Table 14 shows the MSC post-test mean scores obtained by the students in the four groups.

Table 14

MSC Post-test Mean Scores Obtained by Students in the Four Groups

Group	N	Mean Score	SD
1	34	125.59[a]	7.22
2	30	101.53[b]	7.11
3	39	123.10[a]	11.13
4	43	100.02[b]	8.09
Total	**146**	**112.45**	**14.66**

[a, b] denotes similar mean scores

An examination of the results in Table 14 show that the MSC post-test mean scores for experimental groups 1 and 3 (125.59 & 123.10) and that of the control groups 2 and 4 (101.53 & 100.02) respectively, are quite similar. However, the MSC post-test mean scores for the experimental groups 1 and 3 were much higher than that of the control groups 2 and 4. This suggests that the experimental groups (1 & 3) had higher MSC post-test mean scores than the control groups (2 & 4).

In order to determine whether the difference in the MSC post-test mean scores was significant, a one-way ANOVA was performed. The results of the one-way ANOVA are shown in Table 15.

Table 15

ANOVA of the Post-test Scores on the MSC

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	20509.90	3	6836.63	91.19*	0.00
Within Groups	10646.27	142	74.97		
Total	31156.27	145			

* Denotes significant mean difference at $p<0.05$ ($F_{tabulated}$ 3,142 = 2.68; $F_{computed}$ = 91.19)

An examination of Table 15 shows that the difference in the post-test MSC mean scores is significant ($F(3,142) = 91.19$, $p<0.05$). Having established that there was a significant difference between the MSC post-test mean scores, it was necessary to carry out further tests on the various combinations of the mean scores to find out where the difference occurred. Table 16 shows the results of the LSD post hoc comparisons.

Table 16

Post Hoc Comparisons of the Post-test of MSC Means for the Four Groups

	(I) Group	(J) Group	Mean Difference (I–J)	P- Value
LSD	1	2	24.05*	0.00
		3	2.49	0.22
		4	25.56*	0.00
	2	1	-24.05*	0.00
		3	-21.57*	0.00
		4	1.51	0.47
	3	1	-2.49	0.20
		2	21.57*	0.00
		4	23.08*	0.00
	4	1	-25.56*	0.00
		2	-1.51	0.47
		3	-23.08*	0.00

* = The mean difference is significant at the 0.05 level

The LSD post hoc comparisons indicate significant differences ($p<0.05$) between groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4. The differences between the mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 are not significant at 0.05 α-level (Table 16). Since the MSC pre-test mean scores indicated that there was no significant differences between the entry levels of the groups involved in the study, then it was not necessary to confirm the post-test results by performing Analysis of Covariance (ANCOVA).

Differences in the MSC post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 were not significant. It is also evident from Table 14, that the MSC

post-test mean scores of the control groups 2 and 4 were almost similar and much lower than those of the experimental groups 1 and 3.

The results indicate that:

(i) The MSC pre-test did not interact significantly with the treatment conditions. If this were the case, the groups, which took the pre-test, would have obtained different results from those that did not take it (Borg & Gall, 1989).

(ii) The pre-test MSC did not affect the students in the learning of the content. If this were the case, the students who sat for pre-test would have different results from the others. This made the pre-test suitable for the study (Kothari, 1990).

(iii) The use of MPS teaching approach resulted in higher students' MSC post-test mean scores than the conventional teaching approach since the experimental groups 1 and 3 obtained significantly higher post-test mean scores.

From the results presented in Tables 14, 15 and 16, it suffices that the MSC post-test mean scores of students in the experimental groups 1 and 3 (125.59 & 123.10 respectively) are not statistically different at $p = 0.05$. Similarly, the MSC post-test mean scores of the control group 2 and 4 (101.53 & 100.02 respectively) are not statistically different. However, the mean scores obtained by the students in groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 are significantly different at $p<0.05$. Thus, groups that were taught by MPS teaching approach had higher MSC post-test mean scores than those that were taught through conventional teaching approach. In view of these findings, the null hypothesis Ho2 indicating that there is no statistically significant difference between the MSC of the students who are exposed to MPS teaching approach and those who are not exposed to it is rejected.

Groups 1 and 2 responded to pre-test and post-test MSC. A comparison of their results is shown in Table 17, which also shows the corresponding paired samples t-test values for each group.

Table 17

Comparison of the Pre-test and Post-test Scores in MSC and Corresponding Samples t-values

	Overall (N = 64)	Group 1 (N = 34)	Group 2 (N = 30)
Pre-test Mean	99.98	100.44	99.47
Post-test Mean	114.31	125.59	101.53
Mean Gain	14.33	25.15	2.07
df	63	33	29
t-value	6.11	8.11	1.14
p-value	0.00	0.00	0.27

The results in Table 17 reveal that the experimental group 1 had a higher mean gain (25.15) in the MSC than that of the control group 2(2.07). The experimental group thus gained more than the control group. The paired sample t-test between the pre-test and post-test mean scores was not significant for the control group 2 ($t(29) = 1.14$, $p>0.05$). However, the experimental group 1 had a significantly higher post-test MSC mean ($t(33) = 8.11$, $p<0.05$). This indicated that the MPS teaching approach raised the students' MSC more than the control condition where results showed no significant rise in students' MSC. This supports the fact that the MPS teaching approach resulted in higher students' MSC than the conventional teaching approach.

4.5 Effect of MPS Teaching Approach on Students' Perception of their Mathematics Classroom Environment

The post-test MCE scores were analysed to determine the effect of MPS teaching approach on students' perception of their mathematics classroom environmental using one-way ANOVA. This was done in order to test hypothesis three (Ho3) that sought to find out whether there was any statistically significant difference between the perception of the mathematics classroom environment of the students who were exposed to MPS teaching approach and those who were not exposed to it.

Table 18 shows the MCE post-test mean scores obtained by the students in the four groups.

Table 18

MCE Post-test Mean Scores Obtained by Students in the Four Groups

Group	N	Mean Score	SD
1	34	89.03[a]	4.29
2	30	58.43[b]	13.93
3	39	87.46[a]	3.99
4	43	57.74[b]	12.71
Total	**146**	**73.11**	**17.98**

[a, b] denotes similar mean scores

An examination of the results in Table 18 show that the MCE post-test mean scores for experimental groups 1 and 3 (89.03 & 87.46) and that of the control groups 2 and 4 (58.43 & 57.74) respectively, are quite similar. However, the MCE post-test mean scores for the experimental groups 1 and 3 were much higher than that of the control groups 2 and 4. This indicates that the experimental groups (1 & 3) had higher MCE post-test mean scores than the control groups (2 & 4).

In order to determine whether the difference in the MCE post-test mean scores was significant, a one-way ANOVA was performed. The results of the one-way ANOVA are shown in Table 19.

Table 19

ANOVA of the Post-test Scores on the MCE

	Sum of Squares	df	Mean Square	F	P-Value
Between Groups	33264.03	3	11088.01	115.55*	0.00
Within Groups	13626.22	142	95.96		
Total	46890.25	145			

* Denotes significant mean difference at $p<0.05$ ($F_{tabulated}$ 3,142 = 2.68; $F_{computed}$ = 115.55)

An examination of Table 19 shows that the difference in the post-test MCE mean scores is significant ($F(3,142) = 115.55$, $p<0.05$). Having established that there was a significant difference between the MCE post-test mean scores, it was necessary to carry out further tests on the various combinations of the mean scores to find out where the difference occurred. Table 20 shows the results of the LSD post hoc comparisons.

Table 20

Post Hoc Comparisons of the Post-test MCE Means for the Four Groups

	(I) Group	(J) Group	Mean Difference (I-J)	P-Value
LSD	1	2	30.60*	0.00
		3	1.57	0.50
		4	31.29*	0.00
	2	1	-30.60*	0.00
		3	-29.03*	0.00
		4	0.69	0.77
	3	1	-1.57	0.50
		2	29.03*	0.00
		4	29.72*	0.00
	4	1	-31.29*	0.00
		2	-0.69	0.77
		3	-29.72*	0.00

* = The mean difference is significant at the 0.05 level

The LSD post hoc comparisons indicate significant differences ($p<0.05$) between groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4. The differences between the MCE post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 are not significant at 0.05 α-level (Table 20). Since the MCE pre-test mean scores indicated that there was no significant differences between the entry levels of the groups involved in the study, then it was not necessary to confirm the post-test results by performing Analysis of Covariance (ANCOVA).

Differences in the MCE post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 were not significant. It is also evident from Table 18, that the MCE post-test mean scores of the control groups 2 and 4 were almost similar and much lower than those of the experimental groups 1 and 3.

The results indicate that:

(i) The MCE pre-test did not interact significantly with the treatment conditions. If this were the case, the groups, which took the pre-test, would have obtained different results from those that did not take it (Borg & Gall, 1989).

(ii) The pre-test MCE did not affect the students in the learning of the content. If this were the case, the students who sat for pre-test would have different results from the others. This made the pre-test suitable for the study (Kothari, 1990).

(iii) The use of MPS teaching approach resulted in higher students' MCE post-test mean scores than the conventional teaching approach since the experimental groups 1 and 3 obtained significantly higher MCE post-test mean scores.

From the results presented in Tables 18, 19 and 20, it is evident that the MCE post-test mean scores obtained by students in the experimental groups 1 and 3 (89.03 & 87.46 respectively) were not significantly different at $p = 0.05$. Likewise, the MCE post-test mean scores of the control groups 2 and 4 (58.43 & 57.74 respectively) are not statistically different. However, the MCE post-test mean scores obtained by the students in the groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 are significantly different at $p = 0.05$. Thus, groups that were taught through the MPS teaching approach had higher MCE post-test mean scores than those that were taught through the conventional teaching approach. Therefore, the null hypothesis Ho3 indicating that there is no statistically significant difference between the perception of the mathematics classroom environment of the students who are exposed to MPS teaching approach and those who are not exposed to it is rejected.

Groups 1 and 2 responded to pre-test and post-test MCE. A comparison of their results is shown in Table 21, which also shows the corresponding paired samples t-test values for each group.

Table 21

Comparison of the Pre-test and Post-test Scores in MCE and Corresponding Samples t-values

	Overall (N = 64)	Group 1 (N = 34)	Group 2 (N = 30)
Pre-test Mean	57.55	58.32	56.67
Post-test Mean	74.69	89.03	58.43
Mean Gain	17.14	30.71	1.77
df	63	33	29
t-value	7.50	21.23	0.71
p-value	0.00	0.00	0.48

An analysis of the results in Table 21 portrays that the experimental group 1 had a higher mean gain (30.71) in MCE than that of the control group 2 (1.77). The experimental group thus gained more than the control group. The paired sample t-test between the pre-test and post-test mean scores was not significant for the control group 2 ($t(29) = 0.71$, $p>0.05$). However, the experimental group 1 had a significantly higher post-test MCE mean ($t(33) = 21.23$, $p<0.05$). This indicated that the MPS teaching approach significantly improved the students' perception of the classroom environment more than the control condition where results showed no significant improvement in the perception of the classroom environment.

4.6 Effect of MPS Teaching Approach on the Achievement of Boys and Girls

Among groups 1 and 3, which were taught through MPS teaching approach, there were 47 boys and 26 girls. An independent sample t-test was carried out in order to test hypothesis four (Ho4) that sought to establish whether there is any statistically significant gender difference in achievement of students who are taught through the MPS teaching approach.

The post-test MAT results obtained by the boys and girls, in groups 1 and 3, are presented in Table 22.

Table 22

Independent Sample t-test of the Post-test MAT Scores of Boys and Girls Exposed to MPS Teaching Approach

Gender	N	Mean	SD	t	df	P-value
Boys	47	43.83[a]	19.21	0.24	71	0.81(ns)
Girls	26	42.77[a]	16.17			

[a] denotes similar mean scores ($t_{tabulated}$ 1,71 = 1.96; $t_{computed}$ = 0.24)

ns = not significant at $p<0.05$ level

An examination of the results in Table 22 show that the MAT post-test mean scores for the boys (43.83) and that for the girls (42.77) respectively, are quite similar. However, boys had a slightly higher post-test mean score than the girls. A further analysis was necessary in order to establish whether the mean scores were statistically different at 0.05 alpha level. The t-test results indicate that the difference in MAT post-test mean scores of boys and girls are not statistically significant ($t(71) = 0.24$, $p>0.05$). In view of this, the null hypothesis Ho4 indicating that there is no statistically significant gender difference in achievement of students who are taught through the MPS teaching approach is accepted. This implies that boys and girls who are exposed to MPS teaching approach perform equally well.

4.7 Analysis of Teachers' and Students' Activities during Mathematics Lessons

Classroom Observation Schedule (COS) was used to observe some lessons in Commercial Arithmetic for purposes of providing data on teachers' and students' activities. Data was collected from at least four lessons taken from each of the experimental and control groups respectively. The frequency of the classroom activities observed in the study was calculated as a percentage and the results are reported in Table 23.

Table 23

Comparison of Teachers' and Students' Activities during Mathematics Lessons in Commercial Arithmetic by Percentage

Category	Group			
	1	3	2	4
Teacher Activity				
Reinforces behaviour	5.19	5.45	3.19	2.70
Asks question based on students' ideas	2.60	3.47	4.25	4.86
Demonstrates how to perform	5.19	5.95	8.52	10.80
Supervises activities	4.76	4.46	3.72	2.70
Gives directions	3.03	2.97	5.95	4.86
Explains or lectures	1.73	1.49	4.25	4.86
Encourages students to write facts of situation	2.60	1.98	1.06	2.70
Guides and shares in the process of solving problems	2.16	1.98	4.79	3.78
Promotes analysis, organisation and communication skills	4.76	3.96	2.66	3.24
Reviews solutions	3.90	5.45	3.72	3.24
Encourages students to make generalisations	4.33	4.46	3.19	2.70
Total	**40.26**	**41.58**	**44.68**	**46.49**
Student Activity				
Responds to questions	4.33	4.46	3.19	2.70
Follows instructions	15.16	9.91	16.67	16.76
Initiates classroom talks	7.79	8.92	5.86	7.02
Asks questions or seeks clarity over ideas presented	5.19	6.44	1.60	2.16
Expresses agreement or disagreement with action	3.03	2.97	4.79	4.32
Writes and/or copies notes	2.60	2.97	3.19	4.86
Periods of silence/inactivity	0.87	1.49	2.66	3.24
Consults other students	1.73	2.48	1.06	2.16
Identifies key information	4.33	4.95	2.66	2.16
Identifies what to solve	3.90	4.46	2.13	1.62
Makes a plan	3.46	2.48	3.19	2.16
Analyses method of solution	3.90	3.96	3.19	2.70
Constructs many solution processes	3.46	2.97	2.13	1.62
Total	**59.74**	**58.42**	**55.32**	**53.51**

A perusal of the results in Table 23 show the classroom activities observed during the class instructions. The table suggests possible similarities and differences between the teachers'

and students' activities in the experimental and control groups. It indicates that on overall, the teachers in the experimental groups 1 and 3 did less of the class activities (as depicted by 40.26% & 41.58% respectively) as compared to those in the control groups 2 and 4 (as depicted by 44.68% & 46.49% respectively). On the other hand, the students in the experimental groups 1 and 3 as compared to control groups 2 and 4 dominated the classroom activities. This is in evident of 59.74% and 58.42% and 55.32% and 53.51% for the experimental groups 1 and 3 and control groups 2 and 4 respectively. The differences in the teachers' and students' activities obtained by the experimental groups as compared to the control groups were due to the MPS treatment.

4.8 Discussion of the Results

4.8.1 Results of the Pre-tests

This study employed the Solomon Four-Group Design. The students were put in four groups such that groups 1 and 3 were the experimental groups while groups 2 and 4 were the control groups. Groups 1 and 2 took the pre-test while groups 3 and 4 did not take the pre-test. Such an arrangement enabled the researcher to determine the presence of any interaction between pre-test and the MPS treatment; determine the effect of the pre-test relative to no pre-test; determine the similarity of the groups before applying the treatment and generalise to the groups which have not received the pre-test (Sharma, 2002).

Sanders and Pinhey (1979) assert that when the two experimental groups (1 & 3) are similar to each other in the post-test as opposed to the two control groups, then the researcher is in a strong position to attribute the differences to the experimental condition. A greater difference in the post-test between groups 1 and 3 in comparison to that between groups 2 and 4 results if the pre-test interacts with the treatment. This is as a result of a sensitisation effect - that means the pre-test facilitates the learning of the experimental group in contrast to the control group. The post-test students' mathematics achievement, self-concept and perception results in this study did not indicate any interaction between the pre-test and the MPS treatment.

Higher post-test performance by groups 1 and 2 than that of groups 3 and 4 could have been the results if the pre-test provided a practice effect. This is not the case since a comparison of the post-test results of the four groups fails to indicate any practice effect provided by the pre-

tests. The results therefore portrayed that the pre-tests MAT, MSC and MCE were suitable for the study.

A comparison of groups 1 and 2 students' pre-tests MAT, MSC and MCE mean scores revealed non-significant differences (Table 8). The results were similar when the MAT pre-test mean scores were compared based on gender (Table 9). This results shows that the groups were quite similar before the administration of the treatment.

4.8.2 The Effect of MPS Teaching Approach on Students' Achievement in Mathematics

The researcher found that students who were taught through MPS teaching approach achieved significantly higher scores in the MAT than those who were not taught through it. This implies that the use of MPS teaching approach is more effective in enhancing students' achievement than the conventional teaching approach.

Successful MPS teaching approach focuses on teaching mathematics topics through problem-solving contexts and inquiry-oriented environments, which are characterised by the teacher helping the students to conceptualise mathematical ideas and processes by engaging them in doing mathematics (Begle, 1979). The teacher acts as a facilitator in the teaching-learning process who structures a conducive learning environment that fosters interaction between students/students and teacher/students, mathematical dialogue and consensus between students. Consequently, the teacher should provide enough information to establish background/intent of the problem; accept right/wrong answers in a non-evaluative way; guide, coach, ask insightful questions and share in the process of solving problems. In addition, the teacher should know when it is appropriate to intervene and when to step back and let the students make their own way (Lister & Raymond, 1994). Moreover, the teacher should be able to encourage students to make generalisations about rules and concepts. Further, successful MPS teaching approach should always constitute problem-solving strategies that engage learners in problem solving and mathematics reasoning (Kelly *et al.* 2003). These comprises of:

a) Identifying the target goal.

b) Making a plan.

c) Identifying the key information.

d) Evaluating one's plan of solution.

e) Hypothesis generation and testing.

f) Estimation.

g) Trial-and-error.

h) Dividing a problem into sub-problems.

This study was done with these issues in mind. Hence, the higher achievement reported.

In the teaching of agriculture using problem-solving approach, Flowers (1986) and Boone (1988) found a significant improvement in the students' achievement, and these results are consistent with the findings of the current study. In addition, the findings of this study concur with the arguments of Montgomery (1990) that conceptualisation in mathematics teaching depends upon practical activity. Besides, the results agrees with Hamachek (1995), Okere (1996) and Githua (2002) that subjects that have structured information such as mathematics and sciences, require direct teaching that demand the teacher to review pre-requisites, state lesson objectives, give guided practice accompanied with feedback, allow supervised individual work and finally give review through a question and answer session or problem solving. Further, the current findings support the findings of Mondoh and Yadav (1998) that learners' achievement in mathematics depends on the effective use of modern teaching techniques that emphasises a heuristic approach (in this case – the MPS teaching approach). Moreover, the findings comes in support of Beyer (2001), Cook (2001), Lochhead and Zietsman (2003) and Kelly *et al* (2003), that successful MPS teaching approach always constitute problem-solving strategies that engage learners in problem-solving and mathematics reasoning.

In essence, the MPS teaching approach should be incorporated in mathematics teaching in Kenyan secondary schools. This is likely to cause a significant improvement in students' achievement in KCSE mathematics examinations. In view of this, secondary school mathematics teachers are strongly encouraged to use this approach in their mathematics instruction.

4.8.3 The Effect of MPS Teaching Approach on Students' Mathematics Self-Concept

The results of this study indicate that the MPS teaching approach resulted in higher students' mathematics self-concept than the conventional teaching approach.

A common teaching approach in Kenya's secondary schools is the expository approach that is characterised by teachers who adopt a chalk-and-talk style that is heavily textbook oriented. As a result, learning becomes teacher-centred. This in turn fails to account for individual needs among the learners (Ayot & Patel, 1987; Gibbs, 1988; Montgomery, 1990; Changeiywo, 2001).

In contrast to the expository approach, the MPS teaching approach builds on the body of knowledge already possessed by the learners, enables them to make effective use of the relevant learning resources, stimulates their interest and helps to create a suitable learning environment in the classroom (Shiundu & Omulando, 1992). The MPS teaching approach also constitutes problem-solving strategies that take into account the learners needs. According to Good and Brophy (1995), Oloyende (1996) and Mondoh (1997), teachers can improve students' satisfaction in learning mathematics by being friendly and sensitive to their needs. This enhances their mathematics self-concept, which in turn leads to higher levels of achievement (Hemke, 1990). The current findings attest to this.

The teacher serves as a facilitator, creates a conducive problem-solving environment, use group-work and facilitates the formation of positive attitudes towards problem solving. Students work in collaborative groups as they receive encouragement from fellow group members. This further increases their mathematics self-concept. This support Marsh (1990), who asserts that, individuals change their self-concept with change in cognitive development, social situations, interactions with peers, teachers and institutions such as home and schools. Further, Marsh (1991) contends that maximising self-concept of ability in mathematics facilitates the attainment of academic achievement. Hence the higher achievement realised in the MPS classrooms.

Additionally, the teacher initiates and sustains students' interest in mathematics as well as encouraging them to engage in learning/problem-solving activities. This increases their

confidence and interest in mathematics, which in turn arouses their curiosity to learn and achieve in the subject. Moreover, the teacher encourages students to generate their own explanations why worked examples of problems are correct, represent problems and explain inductively principles underlying worked examples. Besides, the teacher should give clear and positive expectances to students, which further enhances their mathematics self-concept (Horn, 1995). All this strengthens the case of the teacher being a facilitator in the teaching-learning process in the MPS classrooms. It is worth noting that the MPS teaching approach met these requirements. In view of this, the MPS teaching approach enhanced students' mathematics self-concept, which aroused their interest in the subject and consequently improved their achievement. This agrees with Biehler and Snowman (1997) who found that high mathematics self-concept is essential in learning mathematics and is achieved when students feel that their competence in the subject is valued. In addition, the findings of the present study support the findings of Githua (2002) that students' mathematics self-concept correlates positively with their mathematics' achievement.

The higher mathematics self-concept acquired by the students who were taught through MPS teaching approach strengthens the case for the implementation of this approach in secondary school mathematics teaching. Once it is implemented, teachers will have an easier task, as they will deal with students with high mathematics self-concept.

4.8.4 The Effect of MPS Teaching Approach on Students' Perception of their Mathematics Classroom Environment

The results of this study reveal that students who were taught through MPS teaching approach achieved significantly higher scores in the MCE than those who were not taught through it. This implies that the use of MPS teaching approach is more effective in fostering students' perception of their classroom environment than the conventional teaching approach.

Costello (1991) notes that students' perception of mathematics and the environment in which it is learnt might be negatively affected by the teachers' approach in presenting the subject matter. Consequently, the teachers' role in the lesson is a major determining factor of the classroom environment. According to Horn (1995), Okere (1996) and Ramogoro and Kiboss (1997), meaningful learning often develops best in classroom environments that give students

more opportunities for more participatory interaction. It seems likely that, this is the reason why the teacher in the MPS treatment groups provided more student participation opportunities as seen in Table 23. This is in line with Kiboss (1997; 2000), Wasike (2003) and Wekesa (2003) who found a strong relationship between the nature of the conducive classroom environment and the acquisition of the necessary knowledge, concepts and skills in sciences and mathematics.

The MPS teaching approach resulted in a conducive classroom environment. The teacher was responsible for restructuring and controlling the mathematics' classroom environment in order to allow the students to work interactively in collaborative groups. This led to improved students' achievement. Thus, this study has shown that the MPS teaching approach results in a better perception of the classroom environment. In view of this, it suffices to point that the MPS teaching approach should be adopted for mathematics instruction in Kenyan secondary school classes. This is likely to cause a suitable classroom environment that will help students learn collaboratively, leading to improved performance at KCSE mathematics examinations. Hence, MPS teaching approach should be implemented in secondary school mathematics classes.

4.8.5 The Effect of MPS Teaching Approach on the Achievement of Boys and Girls

The results of this study have shown that there are no statistically significant difference between the achievement of boys and girls who are taught through MPS teaching approach. They also show that boys and girls who are taught through MPS teaching approach perform significantly better than those who are taught through conventional teaching approach. Therefore, the MPS teaching approach appears to be more effective in enhancing students' achievement in mathematics (regardless of their gender) than the conventional teaching approach.

The Forum for African Women Educationists (FAWE), cited in Wachanga (2002), in a study aimed at improving the participation and performance of girls in mathematics and sciences in primary and secondary schools, reported that girls' achievement in mathematics in Kenya was much lower than that of boys partly due to their negative attitude towards mathematics. Further, it reported that the teacher in the normal competitive classes consciously and

unconsciously discourage girls' participation in learning. For example, some teachers assume that girls would be unable to answer certain types of questions or perform certain mathematical activities. Other teachers make remarks that indicate that they feel that girls are unintelligent and lazy. According to Campbell (1995), boys receive more praise and teacher initiated contacts while girls are criticised more frequently for the academic quality of their work. This differential treatment can contribute to faulty perceptions that mathematics is a male domain. Sadker and Sadker (1986) revealed that male and female teachers give more attention to boys than to girls in secondary schools. This practice has the effect of reinforcing in girls the belief that they are less capable, which in turn negatively affects their self-esteem and confidence resulting in poor achievement.

This study has shown the interactiveness of the lesson components. Contrary to earlier studies in America and Kenya, which indicates that some students have greater interaction with their teachers than others do (Sanga, 1982; Maritim, 1984; Sadker & Sadker, 1986; Campbell, 1995), the findings of this study have placed all the students on the same level. This implies that all the students in the MPS classrooms, irrespective of their gender, have equal opportunities to interact and participate fully in the lessons. Indeed, studies have shown that collaborative socialisation during the teaching and learning process is critically important in students' performance (Eshiwani, 1983; Kirembu, 1991; Okere, 1996; Kiboss, 1997; Githua, 2002; Wachanga, 2002; Wasike, 2003; Wekesa, 2003).

The MPS teaching approach assist the mathematics teacher in balancing the classroom interaction patterns between boys and girls. By using this approach, the teacher is able to give similar attention to boys and girls and this leads to improved achievement by both boys and girls. In this regard, it is evident that the disparity between girls' and boys' achievement at KCSE mathematics examinations can be addressed by using MPS teaching approach.

4.8.6 Analysis of Teachers' and Students' Activities during Mathematics Lessons

A good context for teaching and learning is that in which the teacher and the learner freely interact with, and the concepts to be acquired are simplified (Driver & Bell, 1986; Okere, 1996; Kiboss, 2000). The MPS teaching approach used in this study provided such an environment. The quantitative results indicate that the teacher, besides facilitating the

teaching-learning process, structured a conductive classroom environment in which the learners organised meaning on personal levels. This concurs with Okere (1996) and Cooper and Robinson (2002) who contend that the teacher should serve as a facilitator, rather than a sole dispenser of facts as well as lower level cognitive information. In addition, the MPS teaching approach provided adequate opportunities for students' participation and that it fostered the spirit of co-operation. Perhaps this is the reason why the MPS treatment groups out-performed the control groups who were denied the treatment on all the dependent measures.

The MPS teaching approach enhanced the students' cognitive, affective and social domains. The extent of students' participation in the learning process, the teachers' facilitative role and appropriate classroom environment observed in the MPS classes emerges in support of the MPS's strength in improving students' achievement in the topic Commercial Arithmetic. Consequently, the students' gains in achievement observed in the mathematics topic Commercial Arithmetic could not be attributed to the MPS teaching approach alone. Rather it was the collaboration of the students in the MPS treatment groups, the teachers' facilitative role and the students' reciprocal relationship that were responsible for the knowledge gains in the topic Commercial Arithmetic, enhanced students' mathematics self-concept and better perception of the mathematics classroom environment observed in this study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

The purpose of this chapter is to present the summary of the findings, conclusions reached and recommendations emanating from the results of the study. The implications are discussed and suggestions made on possible areas for further research.

5.2 Summary of the Findings

There were four hypotheses set for this study. On all the hypotheses, the findings of this study are in affirmative of a significant effect of the MPS teaching approach. The findings are in favour of the students exposed to the MPS teaching approach. The inferential statistics have revealed that there were differences between the mean scores obtained by the students in the MPS treatment groups (1 & 3) and those of the control groups (2 & 4) that were statistically significant. Therefore, the results show the effects of the MPS teaching approach in engendering cognitive and affective gains. On the whole, the MPS teaching approach has to a large extent been successful in attaining the objectives of the study.

The MPS teaching approach for teaching and learning the topic Commercial Arithmetic enabled the students to acquire the needed knowledge, concepts and skills. Further, it was established that the students exposed to MPS teaching approach had an increase in their mathematics self-concept and a better perception of their mathematics classroom environment. This can be inferred from the higher mean gains obtained on all the dependent measures by students exposed to it as compared to those not so exposed.

First and foremost, the results show a positive influence on students' achievement in favour of the teaching approach. This is portrayed by the significant higher gains in the students' achievement scores in the treatment groups unlike those in the control groups. The higher the mean scores in the students' achievement, in favour of the treatment groups, indicate that the MPS teaching approach had an effect on students' achievement in the topic Commercial Arithmetic.

Secondly, the results portray a positive influence on students' mathematics self-concept in favour of the teaching approach. This can be inferred from the significant higher gains in the students' mathematics self-concept scores in the treatment groups unlike those in the control groups. The higher the mean scores in the students' mathematics self-concept, in favour of the treatment groups, ascribe the effect of MPS teaching approach on students' mathematics self-concept.

Thirdly, the results indicate that the MPS classroom environment was conducive for meaningful learning. The students' perceptions of the mathematics classroom environment show a significant difference between the MPS and conventional classroom environments. The conducive classroom environment seen in the MPS classrooms facilitated mutual interactions during the lessons in the topic Commercial Arithmetic. The MPS teaching approach provided appropriate opportunities for interpersonal communication, interactions and relationship among the boys and girls. This is the reason why students in the treatment groups had significant learning gains unlike those in the control groups. The higher the mean scores in the students' mathematics classroom environment, in favour of the treatment groups, confirm that the MPS teaching approach had an effect on students' perception of their classroom environment.

Finally, the results suggest that gender did not exert any significant influence on the students' achievement in the MPS classrooms. It is clearly evident that the boys and girls performed equally well. An analysis of the teachers' and students' activities in COS buttresses the fact that the MPS teaching approach provided equal opportunities for boys and girls to collaborate, support and interact together as they participated in the lesson and problem-solving group activities. The teacher served as a facilitator who structured a conducive classroom environment in which the learner organised meaning on a personal level. Hence, the MPS teaching approach helped mathematics teachers to balance classroom interaction between boys and girls enabling them to give similar attention to both sexes, which led to improved achievement by both.

On the whole, the foregoing suggests an effect of the MPS teaching approach on students' mathematics achievement, self-concept and perception of the classroom environment.

5.3 Conclusions

The following conclusions have been drawn from the analysis of the data presented in chapter four.

a) There were significant learning gains obtained by the students exposed to the MPS teaching approach as compared to the low learning gains obtained by those students not exposed to the MPS treatment. Therefore, the MPS teaching approach facilitates students' learning in mathematics better than the conventional teaching approach.

b) The MPS teaching approach positively affected the students' mathematics achievement and fostered the perception of their classroom environment by engaging them in interactive endeavours that resulted in their autonomous learning and subsequent ownership of the lessons.

c) Students who are taught through MPS teaching approach have higher mathematics self-concept to learn and achieve in mathematics than those who are taught through the conventional teaching approach.

d) The effect of gender did not seem to exert any significant influence on students' achievement in the topic Commercial Arithmetic. This proves conclusively that gender does not affect the students' achievement in mathematics when they are taught through the MPS teaching approach.

5.4 Implications of the Study

The MPS teaching approach used in this study has demonstrated a great potential of promoting certain cognitive and affective skills of Form Three students in mathematics. Based on the findings of this study, the issue of students having problems in conceptualising the topic Commercial Arithmetic may be resolved by the use of the MPS teaching approach. In this view, the poor performance of students in mathematics in general and Commercial Arithmetic in particular may be solved using the MPS teaching approach.

Indeed, the MPS teaching approach enables the students to state exactly what the problem is, search for a strategy by identifying the structure of the problem, use the search model identified to solve the problem, interpret the results in the form of a generalisation and analyse the best appropriate method of solution. Thus, with the recent call for teachers to

adopt teaching approaches that are more flexible and catering for both girls and boys fairly (Mondoh, 1997; Changeiywo, 2001; Githua, 2002; Wachanga, 2002), the findings of the present study might prove useful in providing a starting point in this direction. The findings have shown that the MPS teaching approach resulted in higher students' achievement and thus should be used in mathematics teaching at secondary school level.

When MPS teaching approach is used, the students' gender does not affect achievement in mathematics. This approach is therefore likely to assist in changing the trend where boys' achievement has been much better than that of girls at KCSE mathematics examinations. Better girls' achievement would lead to an improvement in their representation in scientific and technological fields.

The Education Inspectorate in its effort to make teachers more effective should encourage mathematics teachers to use the MPS teaching approach. Besides, the teacher education institutions such as universities should make MPS teaching approach part of the content covered during training.

The performance levels of the control groups have demonstrated the weaknesses of the conventional teaching approach. In contrast to this, the MPS teaching approach proved to be effective in promoting co-operative learning, which forms part of the solution to large classes in the context of inadequate human and material resources. The findings have shown that the MPS teaching approach has the potential of encouraging high student participation in mathematics lessons and problem-solving activities. The MPS teaching approach engendered social interactions that foster a sense of autonomous learning among students than the conventional teaching approach used in this study. In general, MPS teaching approach promotes a conducive classroom environment that enhances the development and acquisition of mathematical concepts and skills and active student participation. In addition, it enhances students' mathematics self-concept, which raises and maintains their motivation to learn and consequently excel in mathematics.

5.5 Recommendations

Based on the findings and conclusions made in this study, it is recommended that the MPS teaching approach be adopted for mathematics instruction in Kenyan secondary schools. This is due to the positive influence exerted on the students' achievement by the MPS teaching approach.

In addition, Teacher Education curriculum developers should include MPS teaching approach in the training syllabus, thus making it part of the mathematics teacher education curriculum content. Further, the content of MPS teaching approach should be included in the regular in-service courses (e.g. Strengthening of Mathematics and Sciences at Secondary Education [SMASSE]) organised by the Ministry of Education, Science and Technology, for practicing teachers.

The MPS teaching approach exerted a positive influence on the students' classroom environment in comparison to the conventional teaching approach. This implies that the problem of unconducive classroom environment may be addressed by incorporating the MPS teaching approach in the teaching at the secondary school level. Arguably, the MPS classroom environment can militate against the teaching-learning needs of both the teacher and the student.

Finally, mathematics educators should encourage secondary school mathematics teachers to use MPS teaching approach in their teaching since the use of this approach enhances students' mathematics self-concept that leads to higher levels of achievement.

5.6 Suggestions for Further Research

The present study suggests that the MPS teaching approach can be effective in improving mathematics instruction, enhancing students' mathematics self-concept and fostering their perception of the classroom environment. However, there are areas that warrant further investigation such as the following:

a) A study aimed at determining the students' interaction patterns during the MPS lessons in boys' only and girls' only classes.

b) An inquiry to determine the students' attitude towards mathematics when taught through the MPS teaching approach.

c) Systematic studies to determine the longevity or otherwise the effects of MPS teaching approach on students' achievement, motivation and interest, among other variables.

d) Studies involving larger sample sizes in terms of the number of participating students, teachers and schools to confirm whether or not the present findings hold.

e) An experimental study should be conducted to determine the effect of MPS teaching approach on students' mathematics achievement, self-concept and perception of the classroom environment in boys' only and girls' only classes.

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APPENDICES

APPENDIX A

Mathematical Problem-Solving (MPS) Teaching Approach

The following is a preview of the teachers' and learners' activities that constitutes the MPS teaching approach module:

Teacher's Activities

1. The teacher provides a wholesome emotional climate for learning problem solving. This is done through:
   - Providing ample time for thinking, analysing and experimenting.
   - Being receptive to questions.
   - Being patient with students who cannot solve problems.

2. The teacher establishes and maintains students' motivation as follows:
   - Makes reasonable assignments and provides ample time.
   - Concentrates on a few problems and treats them leisurely and thoroughly.
   - Finds interesting and unusual relevant problems.

3. The teacher provides ways of increasing students' understanding of a problem situation. This is accomplished as follows:
   - Shows students how to read and re-read problems.
   - Helps students how to re-state problems.
   - Ensures that students understand the problem by asking them questions.
   - Encourages students to write facts of the situation.
   - Makes learners write a related problem.
   - Simplifies conditions or uses smaller numbers.
   - Gives a general question and lets learners specify the variables or conditions involved.
   - Guides, coaches and shares in the process of solving problems.

4. The teacher gives instructions on establishing a search model. This is done as follows:
   - Uses flow charts to illustrate a solution.
   - Uses concept maps and advance organizers to explain mathematical concepts and skills.
   - Uses symbols and writes equations for the relationship involved.

5. The teacher shows the learner how to ask him/herself questions e.g.
   - What facts are given?
   - What are you trying to find out?
   - What ideas have you studied that are related to this situation?
   - What problems have you solved that are analogous to this one?

6. The teacher concentrates heavily on reading skills. This is done as follows:
   - Asks questions designed to identify failure to understand the problem itself.
   - Asks students to read problems aloud.
   - Asks students to re-read difficult problems.

7. Emphasises the method to the solution rather than the solution i.e. students finds several methods of solution for each problem. As such, the teacher emphasises flexibility and variety in problem solving.
8. Encourages experiments, trial-and-error, estimation, intuition, guessing and hunches to suggest a method of solution.
9. Provides problems (from textbooks and past papers) at frequent intervals to enable students get adequate practice in solving problems.
10. Promotes analysis, organisation and communication skills by having students state or write their solution in an orderly logical form.
11. The teacher divides students into groups so that they work as a team as well as individually.

Learner's Activities

1. States exactly what the problem is. This is accomplished by fulfilling the following:
   - What information is given?
   - What are you trying to find out?
   - Stating the problem in their own words.
   - Writing a similar problem.
2. Relates the problem to a familiar idea. This is done through:
   - Searching their memory to recall ideas, facts, assumptions, formulae or experiences related to the problem.
   - Reducing the situation to simpler conditions.
   - Solving a simpler related problem.
3. Searches for a strategy by identifying the structure of the problem. This is done as follows:
   - Identifying the known facts.
   - Identifying the conditions and the variables.
   - Identifying the pattern by organising the given facts.
4. Using the search model (determined by the strategy above) to solve the problem. The following is done:
   - Performing computations involved.
   - Checking the answer to see whether the results satisfy the conditions given.
   - Stating the complete answer to the problem.
5. Interprets the results in the form of a generalisation as follows:
   - Applying solution to situations in which the conditions are changed.
   - Determining when a solution is impossible, meaningless or trivial.
   - Writing a generalisation in terms of formula, theorem or principle.
6. Analyses method of solution by:
   - Writing sequence of steps in a logical order.
   - Indicating the process whereby information is generalised.
   - Identifying the type of reasoning involved.

INTRODUCTION TO TEACHERS

The following is a mathematics module on the topic Commercial Arithmetic developed for Form Three teachers. Although Commercial Arithmetic is a topic for mathematics, it is meant

to introduce students to concepts related to other subjects and fields of application that they will be learning in the course of their secondary education and thereafter.

The design and development of this module is to assist teachers in producing a person who will be numerate, orderly, logical, accurate and precise in thought (KIE, 2002). In addition, the person should be competent in appraising and utilising the knowledge learned from Commercial Arithmetic in playing a positive role in the development of a modern society. As such a person will make precise and logical use of Commercial Arithmetic knowledge to concretise problems from everyday situations, comprehend, analyse, synthesise and evaluate a set of numerical data to both familiar and unfamiliar situations.

The purpose and objective of MPS module revolves around the methodology, delivery and evaluation of mathematical knowledge gained from Commercial Arithmetic. MPS teaching approach that was adopted in the teaching and learning of Commercial Arithmetic is a process of using previously acquired facts, skills, concepts, principles and strategies to solve problems and in the process acquire new knowledge. This provides a frame of reference upon which clues regarding the content, methodology and reinforcement of group learning are embedded.

The content of this module is based on the KIE secondary school mathematics syllabus, teachers' guide and approved textbooks for Form Three students. The topical areas covered are:

1. Derivation and application of simple interest formula
2. Calculation of Compound Interest using step-by-step method
3. Derivation and application of Compound Interest formula.
4. Application of Compound Interest formula in appreciation, depreciation, repayments of loans and hire purchase.
5. Calculation of income tax

The course content entails group learning. This is the learning in which students work together in structured groups towards achieving a common goal. The users of MPS module are therefore expected to interact through class instruction and group discussions. Teachers should place their students into groups consisting of 5-8 students that will be used in performing group activities given after every lesson.

The module revolves around the following specific objectives:

a) Calculation of Simple Interest using formula
b) Calculation of Compound Interest (CI) using step-by-step method
c) Derivation and use of CI formula
d) Application of CI formula in appreciation, depreciation, repayments of loans and hire purchase
e) Calculation of Income tax

THE MPS LESSONS

The KIE mathematics syllabus, teachers' guide and textbooks indicate that the teaching of mathematics is influenced by such factors as the teachers' quality and competence, the topic to be covered, facilities available, class size etc. As such, the teaching methods applied include lecture, discussion, teaching by examples and project work stipulated in the KIE approved mathematics syllabus for secondary schools. However, such expository methods are

teacher dominated and may not be appropriate for teaching the topic Commercial Arithmetic. It is against this background that MPS lessons sought to provide opportunities for students to exercise some control over their classroom learning environment.

The MPS module shall be set as a centre stage for Form Three normal classroom interaction engaging the factors aforementioned in a normal classroom setting and those teachers' and students' activities that constitutes the MPS teaching approach. The topic Commercial Arithmetic shall be broken down into sub-topics to be followed in the lessons. This shall be restructured in this module and MPS teaching approach will be used during the instruction. Some examples and exercises similar to those that appear in mathematics texts shall be used. A description of each lesson topic and the respective objectives are specified. It is believed that at the end of the topic, students should be able to comprehend and apply correctly the mathematical knowledge gained in the topic Commercial Arithmetic.

LESSON PLANS

Commercial Arithmetic in mathematics is a wide topic that can be taught under several sub-topics and lesson objectives. The MPS module consists of 22 lessons taken from the topic Commercial Arithmetic under the Form Three mathematics curriculum. A single and double-lesson takes a duration of 40 and 80 minutes respectively.

WEEK ONE

Lesson 1

Lesson topic: Simple Interest

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

a) Define the terms Principal, Rate and Interest period.
b) Derive and apply the Simple Interest formula

Lesson Development

Step I: The teacher shall introduce learners to the topic Commercial Arithmetic and by using illustrations lead learners to define the terms Principal, Rate and Interest Period.

Step II: The teacher and the learners shall discuss the derivation of the simple interest formula and apply it to solve problems

Step III: The teacher shall give a class exercise to be done individually by students as s/he goes round to check on student's progress in the exercise

Step IV: The lesson is summarised by the teacher asking questions to recapitulates the key points in the lesson. Finally, the teacher organises students for group activities that will come after each lesson and gives the group activity of the lesson.

Teacher's Activities

i) Explains what is required of students to do
ii) Gives brief notes on the content required
iii) Organises students for group activities and gives the group activity of the lesson.
iv) Supervises students' work.
v) Helps students on how to re-state problems.

Students' Activities

i) Attends to the teacher and takes notes.
ii) Responds to questions asked by the teacher or asks questions
iii) Works individually to perform the class exercise.
iv) Participates in class discussions.
v) Analyses the method of solution.

Group Activity 1

Amina borrowed sh 75,0000 for the purpose of building a house. For the first 5 years she was charged 9% per annum simple interest and she paid sh 5000 of the loan. The rate of interest was then reduced to 8% for the next 5 years. She managed to pay off a further sh 10,000. The rate of interest remained at 8% and she paid off the rest of the loan in a further 3 years. Find the total amount charged for the loan.

Lesson 2 and 3

Lesson topic: Simple and compound interest.

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

(a) State and apply the simple interest formula.
(b) Explain the meaning of compound interest.
(c) Calculate compound interest.

Lesson Development

Step I: The teacher and the learner briefly review the previous lesson on simple interest.

Step II: The teacher first introduces the lesson by asking learners to suggest what they understand by the terms principal, interest, rate and simple interest.

Step III: By using examples, the teacher shall guide learners to apply the Simple Interest formula.

Step IV: The teacher shall guide students in explaining the meaning of CI and its calculation.

Step V: The teacher shall give a class exercise to be done individually by students as s/he goes round to check on students' progress in the exercise.

Step VI: The lesson is concluded by the teacher asking questions to recapitulate the main points in the lessons and finally gives take-away assignment and group activity.

Teacher's Activities

i) Guides learners to define compound interest
ii) Explains what is required of learners to do.
iii) Helps learners carry out the class exercise.
iv) Supervises and assesses the students' work.
v) Emphasises the method to the solution rather than the solution.

Students' Activities

i) Attends to the teacher's instructions and take notes.
ii) Differentiate the terms simple and compound interest.
iii) Participates in class discussion.
iv) Works individually during class exercise.
v) Searches for a strategy by identifying the structure of the problem.

Group Activity 2

How much more interest does sh 3000 earn after five years invested at 8% per annum compound interest than if it is invested for the same period and rate at simple interest?

Lesson 4

Lesson topic: Compound Interest using-by-step method.

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

a) Calculate compound interest using step-by-step method.
b) Apply the method in solution of problems.

Lesson Development

Step I: The teacher and the learner briefly review the previous lesson on compound interest.

Step II: The teacher leads the learners to discuss examples on calculation of compound interest using step-by-step method.

Step III: The teacher shall give a class exercise for students to do individually as s/he goes round to supervise the work.
Step IV: The lesson is concluded by the teacher giving students several problems on finding compound interest using step-by-step method.

Teacher's Activities

i) Explains the calculation of CI using step-by step method.
ii) Supervises the learners' classroom activities.
iii) Gives homework and group activity.
iv) Asks student to read problems aloud.
v) Helps student to re-state problems.

Students' Activities

i) Attends to the teacher and take notes
ii) Participates in class discussion.
iii) Calculate CI using step-by-step method.
iv) Interprets the results in the form of a generalisation.
v) Analyses method of solution.

Group Activity 3

In Rafiki Building Society, the rates of interest are as follows: first year 5%, second 8%, third 15% and fourth 22%. If a trader deposits sh 2500 for 4 years, find the total amount at the end of the fourth year. Hence or otherwise, find the compound interest made by the trader.

Lesson 5

Lesson topic: Compound Interest formula.
Lesson Objectives: By the end of the lesson, the learner should be able to :

a) Derive the compound interest formula.
b) Apply the compound interest formula in solving problems.

Lesson Development

Step I: The teacher and the learners shall review briefly the calculation of CI using step-by-step method discussed in lesson 4 of this module. Further, they will revisit the formula for finding the simple interest whereby the teacher shall link it to the derivation of compound interest formula.
Step II: The teacher shall lead learners in the derivation of the CI formula. The learners' attention is drawn to steps followed in derivation of the formula and its application to solve problems. The teacher shall provide an exercise to be done by students (as a group) on the use of CI formula.
Step III: The learners shall individually do an exercise given in class as the teacher moves round the class supervising the exercise.
Step IV: The teacher shall conclude the lesson by giving group activity for the lesson and a take-away exercise to be done individually at home.

Teacher's Activities

i) Supervises class exercises
ii) Provides class exercise, homework and gives group activity.
iii) Leads students in class discussion.
iv) Helps students to re-state problems.
v) Ask students to read problems aloud.

Students' Activities

i) Attends to the teacher and takes notes.
ii) Participate in class/group discussion.
iii) Ask questions and/or respond to questions asked in class.
iv) Search for a strategy by identifying the structure of the problem.
v) Writes a generalisation in terms of formula.

Group Activity 4

A man bought a house with a loan of sh 100,000 from National Housing Corporation. A rate of 5% compound interest is charged on the loan over the repayment period of 10 years. Calculate the total cost of the loan.

Lesson 6 and 7

Lesson topic: Application of CI formula

Lesson Objectives: By the end of the lessons, the leaner should be able to:

a) State the CI formula
b) Apply the CI formula to calculate the compound interest and the principal

Lesson Development

Step I: The teacher and the learners shall review the previous lessons on the application of the CI formula.

Step II: The teacher shall provide problems and guide the learners in solving them by using the CI formula.

Step III: Individually the learners shall solve problems as a class exercise.

Step IV: The lesson is concluded by the teacher asking questions on the application of the compound interest formula activity.

Teacher's Activities

(i) States and explains the application of CI formula for calculating accumulated amount, principal and compound interest
(ii) Guides learners to identify problems where CI formula is applied
(iii) Provides and supervises class exercises
(iv) Gives homework and group activity
(v) Encourages students to write facts of the situation.

Students' Activities

(i) Attends to the teacher and takes notes
(ii) Participates in group/class activities
(iii) Applies the CI formula to solve problems
(iv) States exactly what the problem is
(v) Analyses method of solution

Group Activity 5

A businessman wishes to have shs 30000 in 3 years time for the purchase of a Van. What sum of money must he invest now at 4% per annum compound interest to buy the van?

WEEK TWO

Lesson 8

Lesson topic: Application of CI formula

Lesson Objectives: By the end of the lesson, learners should be able to calculate accumulated amount when the time is:

a) Half-yearly, quarterly etc.
b) Given as a mixed fraction

Lesson Development

Step I: The teacher and the learners shall review the previous lesson on how to calculate accumulated amount and principal by use of CI formula.

Step II: The teacher shall guide learners on how to calculate accumulated amount when compounded semi-annually, quarterly and when time is given as a mixed fraction.

Step II: The learners shall attempt a class exercise supervised by the teacher.

Step IV: The teacher concludes the lesson by asking students to explain the main points in the lesson. Then, one exercise is given, to be done at home by students and another as group activity.

Teacher's Activities

i) Guides students in class discussion.
ii) Supervises class exercises.
iii) Gives homework and group activity.
iv) Encourages students to write data in the problem.
v) Emphasises the method to the solution rather than the solution.

Students' Activities

i) Attends to the teacher and takes notes.
ii) Participates in class/group discussion.
iii) Attempts class exercise.
iv) Responds to questions asked by the teacher
v) Searches for a strategy by identifying the structure of the problem.

Group Activity 6

Using the information in activity 5, calculate the sum of money that must be invested at 5 % per annum compounded semi-quarterly to realise the goal.

Lesson 9 and 10

Lesson topic: Application of compound interest formula

Lesson Objectives: By the end of the lesson, learners should be able to apply CI formula to calculate:

a) Rate when given amount, principal and time
b) Time when given amount, principal and rate.

Lesson Development

Step I: The teacher and the learners briefly review the previous lesson on the use of CI formula.

Step II: The learners shall be guided on how to apply the CI formula to calculate rate and time. Then, they will use this knowledge to solve more problems.

Step III: The teacher shall give a class exercise to be done individually by students as s/he goes round supervising the exercise.

Step IV: Using questioning as a technique, the teacher shall ask students to recapitulate the main points in the lesson. Then, s/he gives them some exercise on calculating rate and time using the compound interest formula and group activity.

Students' Activities

i) Attends to the teacher and takes notes.
ii) Participate in class/group discussion.
iii) Ask questions and/or respond to questions asked in class.
iv) Search for a strategy by identifying the structure of the problem.
v) Writes a generalisation in terms of formula.

Group Activity 4

A man bought a house with a loan of sh 100,000 from National Housing Corporation. A rate of 5% compound interest is charged on the loan over the repayment period of 10 years. Calculate the total cost of the loan.

Lesson 6 and 7

Lesson topic: Application of CI formula

Lesson Objectives: By the end of the lessons, the leaner should be able to:

a) State the CI formula
b) Apply the CI formula to calculate the compound interest and the principal

Lesson Development

Step I: The teacher and the learners shall review the previous lessons on the application of the CI formula.

Step II: The teacher shall provide problems and guide the learners in solving them by using the CI formula.

Step III: Individually the learners shall solve problems as a class exercise.

Step IV: The lesson is concluded by the teacher asking questions on the application of the compound interest formula activity.

Teacher's Activities

(i) States and explains the application of CI formula for calculating accumulated amount, principal and compound interest
(ii) Guides learners to identify problems where CI formula is applied
(iii) Provides and supervises class exercises
(iv) Gives homework and group activity
(v) Encourages students to write facts of the situation.

Students' Activities

(i) Attends to the teacher and takes notes
(ii) Participates in group/class activities
(iii) Applies the CI formula to solve problems
(iv) States exactly what the problem is
(v) Analyses method of solution

Group Activity 5

A businessman wishes to have shs 30000 in 3 years time for the purchase of a Van. What sum of money must he invest now at 4% per annum compound interest to buy the van?

WEEK TWO

Lesson 8

Lesson topic: Application of CI formula

Lesson Objectives: By the end of the lesson, learners should be able to calculate accumulated amount when the time is:

Teacher's Activities

i) Guides, coaches and shares in the process of solving problems.
ii) Supervises student's work.
iii) Gives exercises/group activity.
iv) Help learners write a related problem.
v) Guides learners to write their solution in an orderly logical form.

Students' Activities

i) Attends to the teacher and takes notes.
ii) Participates in class/group activities.
iii) Applies CI formula to calculate rate and time.
iv) Interprets the results in the form of a generalisation.
v) Analyses the method of solution.

Group Activity 7

Find the rate per annum at which sh 7000 invested at compound interest amounts to sh 20000 after 5 years.

Lesson 11

Lesson topic: Repayments of loans

Lesson Objective: By the end of the lesson, learners should be able to calculate debt remaining after a given period of time.

Lesson Development

Step I: The teacher and the learners reviews the previous lesson on the use of the CI formula to calculate time and rate when the other variables have been given

Step II: The teacher shall guide learners on how to calculate the debt remaining after payments of certain periodical amounts by using worked out examples. The learners shall then work on more problems on reductions and investments.

Step III: The teacher shall supervise a class exercise given to students to do individually.

Step IV: The teacher shall conclude the lesson by asking students to distinguish between a loan and an investment. Finally s/he shall give a take-away exercise and group activity.

Teacher's Activities

i) Helps students to re-state problems.
ii) Supervises classroom activities
iii) Gives exercises
iv) Simplifies problem by using smaller numbers
v) Encourages experiments, trial-and-error, estimation and intuition to suggest a method of solution.

Students' Activities

i) Attends to the teacher and takes notes
ii) Works individually during the class exercise
iii) Participates in class activities
iv) Applies the CI formula in investments and reductions
v) Analyses the method of solution

Group Activity 8

A lady borrows sh. 50000 from her co-operative at a rate of 2% per month on the reducing balance. She arranges to be paying back sh. 1500 at the end of each month.

a) How much money does the lady still owe the co-operative after 6 months?
b) What is the total interest paid during the 6 months?

c) How much money goes to service the loan only in the third month?

Lesson 12

Lesson topic: Appreciation

Lesson Objectives: By the end of the lesson, learners should be able to:

a) Define appreciation
b) Identify items that appreciates in value
c) Apply step-by-step method (or use of multiplying factor) and compound interest formula to work out problems on appreciation

Lesson Development

Step I: The teacher shall use the question and answer technique to solicit responses from learners on how to define appreciation

Step II: By discussion, learners shall come up with examples of items/assets that appreciates in value after a period of time

Step III: Through some illustration by some examples, the teacher shall guide learners on the use of step-by-step method (or the multiplying factor method) and compound Interest formula to work out problems on appreciation. The learners shall further work out problems individually as the teacher supervises.

Step IV: The lesson is concluded by the teacher asking questions to recapitulates the main points in the lesson and gives homework and group activity.

Teacher's Activities

i) Helps students to re-state problems
ii) Supervises class activities
iii) Gives exercise and group activity
iv) Promotes organisation by guiding students to write their solution in an orderly logical form
v) Emphasises flexibility and variety in problem solving

Students' Activities

i) Attends to the teacher and takes notes
ii) Works individually during class exercises
iii) Participates in group work
iv) Searches for a strategy by identifying the structure of the problem
v) Analyses the method of solution

Group Activity 9

A house was bought for sh 150000. It appreciates by 10% in its first year, 40% in the second year and by 20% in each subsequent year. How much was it worth after five years?

Lesson 13 and 14

Lesson topic: Appreciation and Depression

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

a) Define appreciation and depreciation
b) Identify items that depreciates in value
c) Apply compound interest formula to solve problems on appreciation and depreciation

Lesson Development

Step I: The teacher and the learners review the previous lesson on appreciation. Further, they will revisit the use of CI formula to solve problems on appreciation

Step II: Through question and answer technique, the teacher shall guide learners to define depreciation. Further, the learners shall give examples of items / assets that depreciate in value.

Step III: By using some examples, the teacher shall draw students' attention to the use of step-by-step method and compound interest formula to work out problems on depreciation. The learners shall work out problems on appreciation and depreciation using the formula and / or the multiplying factor method as the teacher supervises

Step IV: The lesson shall be concluded by the teacher asking students to differentiate between appreciation and depreciation. Finally, s/he gives take-away assignment and group activity.

Teacher's Activities

i) Explains the use of CI formula to solve problems on appreciation and depreciation
ii) Supervises class activities
iii) Gives exercises and group activity
iv) Encourages students to write data in the problem
v) Emphasises the method to the solution rather than the solution

Student's Activities

i) Attends to the teacher and takes notes
ii) Participates in class / group discussion
iii) Identifies problems involving appreciation and depreciation and solves them
iv) Analyses the method of solution
v) Attempts to construct one or more solution processes

Group Activity 10

A radio was bought for sh 8000. Its value appreciated at the rate of 11% per annum for 3 years. Thereafter, its value depreciated at the rate of 9% per annum for 2 years. What was its worth after five years?

WEEK THREE

Lesson 15

Lesson topic: Hire Purchase

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

a) Explain the meaning of the terms Hire Purchase, Instalments and Deposit
b) State the relationship between Instalments, Deposit and Hire Purchase
c) Solve problems involving Hire Purchase

Lesson Development

Step I: By using illustrations, the teacher shall lead learners in explaining the meaning of Hire Purchase, Instalments and Deposit

Step II: The teacher and the learners shall discuss the relationship between instalments, deposits and hire purchase. Then, they will solve problems involving these variables.

Step III: The teacher shall provide more problems on Hire Purchase and let learners apply the knowledge got to solve them. Then a supervised class exercise will be given to students to do individually.

Step IV: The lesson is concluded by the teacher asking questions on the key points in the lesson and finally gives homework and group activity

Teacher's Activities

i) States and explains the meaning and relationship between Hire Purchase, Instalments and Deposit (or down payment).
ii) Guides learners in working out problems
iii) Provides and supervises class exercises
iv) Gives homework and group activity
v) Emphasises the method to the solution rather than the solution

Students' Activities

i) Attends to the teacher and takes notes
ii) Participates in group/class activities
iii) Works individually to perform the class exercises
iv) States exactly what the problem is.
v) Searches for a strategy by identifying the structure of the problem

Group Activity 11

The price of a house is sh 240,000. Tabby paid a deposit of 10% of the cost price. National Building Society financed the balance. The society charged 8% per annum compound interest on the balance for the first 5 years and 10% for the remaining 5 years.

a) What was the amount of each monthly instalment for the first 5 years?
b) What was the amount of each monthly instalment for the other period?
c) How much more did Tabby pay for the house?

Lesson 16 and 17

Lesson topic: Hire Purchase

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

a) Define carrying charge
b) Apply the compound Interest formula to solve problems on Hire Purchase

Lesson Development

Step I: The teacher and the learners shall review briefly the calculation of Hire Purchase, Instalments and deposit discussed in lesson 15. Further, they will revisit the definition of Principal, rate and Interest period (Time) and the application of the simple and compound interest formulae discussed in lessons 1, 5, 6 and 7 of this module.

Step II: By using an illustration, the teacher shall define the term 'carrying charge' and explain how it is calculated. The learners shall be guided on how to use the compound interest formula to solve problem on Hire Purchase (by using worked out examples).

Step III: The teacher shall give a class exercise to be done individually by students as s/he goes round to check on students' progress in the exercise

Step IV: The lesson is concluded by the teacher asking questions to recapitulates the main points in the lesson.

Teacher's Activities

i) Explains the meaning of 'carrying charge'
ii) Shares in the process of solving problems
iii) Provides and supervises class exercises
iv) Gives homework and group activity
v) Promotes analysis and organisation by helping students write their solution in an orderly logical form.

Students' Activities

i) Attends to the teacher's instructions and take notes
ii) Responds to questions asked by the teacher or asks questions
iii) Works individually during class exercises
iv) Analyses the method of solution

Group Activity 12

A radio is sold under Hire Purchase terms. A deposit of sh. 560 is required and a monthly instalment of sh. 400 for one year. If the cash price of the same radio is sh. 3820, find the carrying charge.

Lesson 18

Lesson Topic: Taxes

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

a) Define the term Tax
b) Differentiate between Direct and Indirect taxes
c) Give examples of Direct and Indirect taxes
d) Work out problems involving taxes

Lesson Development

Step I: The teacher shall define the term Tax and state its two main types. Further, s/he will explain the difference between direct and indirect taxes and give examples of each.

Step II: The teacher and the learners shall discuss the ways in which the government earns revenue (through taxation). Through illustration by some examples, the teacher shall guide learners in solving problems involving taxes

Step III: The teacher shall give a class exercise for students to do individually as s/he goes round to supervise the work.

Step IV: the teacher giving students several problems involving taxes and group activity concludes the lesson.

Teacher's Activities

i) Explains the meaning of tax, direct and indirect taxes
ii) Supervises the learners' classroom activities
iii) Gives homework and group activity
iv) Encourages students to write facts of the situation
v) Emphasises the method to the solution rather than the solution

Students' Activities

i) Attends to the teacher and takes notes
ii) Participates in class/group activities
iii) Work individually during the class exercises
iv) Searches for a strategy by identifying the structure of the problem
v) Analyses the method of solution

Group Activity 13

A car costing sh. 80, 000 is charged sh 108,000 import tax. An importer makes 40% profit on his total cost price and sells to Mr. Mrima who pays 15% sales tax before taking the car.

a) What is the rate of the import tax?
b) What is the selling price of the car before sales tax is added?
c) How much does Mr. Mrima pay for the car (excluding Sales tax)?
d) What is the total amount paid by Mr. Mrima?

Lesson 19

Lesson topic: Income Tax

Lesson Objectives: By the end for the lesson, the learner should be able to:

a) Define Income, Gross income, Taxable income and Income tax
b) State and explain the different types of Personal relief
c) Read and apply correctly the Rates of Taxation tables to solve problems

Lesson Development

Step I: The teacher and the learners shall review briefly the previous lesson on Taxes.

Step II: The teacher shall introduce the lesson by defining the term Income. S/he will guide the learners in explaining the meaning of Gross Income, Taxable income and Income Tax.

Step III: The teacher and the learners shall then discuss the different types of personal relief and where they are applied. By use of a chart, the teacher shall explain how the Rates of Taxation tables are read and applied in solving problems. The teacher shall give a class exercise for students to do individually as s/he goes round to supervise it.

Step IV: Using questioning as a technique, the teacher shall ask students to recapitulates the main points in the lesson. Then, the teacher gives some exercise on calculation of income tax using Rates of Taxation tables.

Teacher's Activities

i) Explains the meaning of Income, Gross Income, Taxable income and Income tax
ii) Supervises students' work
iii) Prepares Rates of Taxation table
iv) Promotes analysis by guiding students to write their solution in a sequential order

Students' Activities

i) Attends to the teacher's instructions and takes note
ii) Participates in class discussions
iii) Applies the Rates of Taxation table to solve problems
iv) Identifies the known facts
v) Identifies what to solve and makes a plan

Group Activity 14

Mr. Mwebi's income in one year came from the following sources:

Basic Salary	sh. 36,000
Rent from his houses	sh. 72,000
Commissions	sh. 25, 000
Dividend on shares	sh. 75, 000

He is allowed a tax relief of sh. 1600 per annum and claims no other relief. Calculates his gross income and the income tax he should pay.

Lesson 20 and 21

Lesson topic: Income Tax

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

a) Income tax payable by a married or single person.
b) The amount of Pay As You Earn (PAYE) payable per month

Lesson Development

Step I: The teacher and the learners shall review the previous lesson on the use of the Rates of Taxation table in calculating Income tax.

Step II: The learners' attention shall be drawn to the calculation of income tax for a person who claims family relief, single relief or special single relief. The teacher will lead learners in defining the term PAYE and further explain the procedure for calculating it.

Step III: The teacher shall give a class exercise for students to do individually as s/he goes round to supervise the work

Step IV: The lesson is then concluded by the teacher giving students several problems on calculation of Income tax. Finally, group activity is given.

Teacher's Activities

i) Guides, coaches and shares in the process of solving problems
ii) Gives reasonable assignments and provides ample time for solving them
iii) Guides students on how to re-read or re-state problems
iv) Supervises class exercises
v) Promotes organisation by having students write their solution in an orderly logical form

Students' Activities

i) Attends to the teacher and takes notes
ii) Participates in class / group activities
iii) Constructs one or more solution processes
iv) Analyses method of solution by writing sequence of steps in a logical order

Group Activity 15

Mr. Kenya is a bachelor and earns sh 3750 per month. How much PAYE does he pay every month? If he had a life insurance policy for which he paid premiums of sh 200 per month, how much income tax would he pay?

Lesson 22

Lesson topic: Income Tax

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

a) Define Nominal rent and House rent
b) Calculate the taxable income of an employee who has a house provided on nominal rent or free
c) Calculate the income tax payable by an employee who has a house provide on nominal rent or free.

Lesson Development

Step I: The teacher and the learners shall review briefly the previous lesson on calculation of Income tax.

Step II: The teacher shall guide learners in defining the terms nominal rent and house rent. Further, s/he shall lead learners in distinguishing between the two terms. Using an example, the teacher shall guide learners to calculate taxable income and income tax payable by an employee who has been provided with a house on nominal rent or free.

Step III: Individually, the learners shall solve problems as a class exercise. The teacher shall go round the class to supervise the exercise.

Step IV: The teacher summarises the lesson and finally gives an assignment and group activity.

Teacher's Activities

i) Guides students in class discussions
ii) Supervises class exercises
iii) Promotes analysis, organisation and communication skills by having students write their solutions in an orderly logical form
iv) Reviews solution through question and answer sessions
v) Gives homework and group activity

Students' Activities

i) Attends to the teacher and takes notes
ii) Ask questions and / or responds to questions asked in class
iii) Participates in class / group discussions
iv) Identifies the known facts and makes a plan of solution

Group Activity 16

Amos earns sh. 6500 per month. He is a widower supporting two children and is provided with a house by his employer at a nominal rent of sh. 300 per month. Calculate the:

a) Taxable income
b) Income tax paid by the employee per year.

APPENDIX B

Mathematics Achievement Test1 (MAT1)

Adm. No..... Form ..... Gender ....

Instructions

Answer all questions.

Read the questions carefully to ensure that you understand before answering.

1. Form quadratic equations whose roots are: 2 and -3. (3mks)
2. Round off the following to four significant figures:
   (i) 21.763 (1mk)
   (ii) 0.0070956 (1mk)
   (iii) 430,947 (1mk)
3. The difference between two numbers is 5. If their product is -6, find the numbers. (4mks)
4. If x lies between 0° and 180° and sinx = 0.5, find the two possible values of x. (2mks)
5. Factorise the quadratic expression: $8x^2 + 6x - 9$ (3mks)
6. Given that tanx = 5/12, find the value of:
   (i) cosx
   (ii) sinx (4mks)
7. The value of a car is sh. 54,000 to the nearest sh. 1,000. Find the lower and upper limits of the value of the car. (3mks)
8. If P varies directly as Q and P = 5 when Q =3, find Q when P = 15. (3mks)
9. Solve the triangle XYZ in which y = 9cm, z = 6.5cm and angle YXZ = 72° (4mks)
10. Simplify without using tables: (log27 – log9) / log3 (3mks)
11. Rationalise and simplify the denominator in: $5/(3-\sqrt{2})$ (3mks)
12. Solve the equations:
    (i) Log (4x – 9) = 3log3. (3mks)
    (ii) 2lox + ½ log81 = log6x (4mks)
13. A parallelogram has a base of 12cm and a height of 8cm.
    (i) Find the limits within which its area lies (4mks)
    (ii) Find the relative error in the area (2mks)
14. P is partly constant and partly varies as Q. Q = 3 when P = 1 and Q = 4 when P = 10. Find:
    (i) P in terms of Q (3mks)
    (ii) P when Q = 6 (1mk)
15. Make u the subject of the formula: x = ub/(u +2c) (3mks)
16. Find the area of triangle ABC in which AB = 6cm, BC = 15cm and angle ABC = 30° (3mks)
17. A quantity y varies directly as x and inversely as the square of z. If y = 4 when x = 2 and z = 5, find an equation connecting y, x and z. (3mks)
18. Solve the quadratic equation $2x^2 - 9x - 5 = 0$ (3mks)
19. Divide 360° into 3 angles in the ratio 3:5:7. (3mks)
20. Find the value of x:
    $9^{(x-2)} = 27^x$ (3mks)

APPENDIX C

Mathematics Achievement Test2 (MAT2)

Adm. No..... Form ..... Gender..... ...

Instructions
Answer all questions.
Read the questions carefully to ensure that you understand before answering.

1. Calculate the simple interest on sh. 6,000 deposited for 3 years at 20 % per annum. (3 mks)
2. Tabitha deposited sh. 10,000 for 4 years and earned a simple interest of Sh. 4000. Find the rate of interest. (4 mks)
3. Find the accumulated amount if sh. 800 is deposited for 5 years at 10% per annum compound interest. (4 mks)
4. A businesswoman borrowed sh. 1,500 at a rate of 9% per annum compound interest. She paid sh. 450 at the end of each year for two years. How much did she have to pay at the end of the third year in order to settle her debt? (4 mks)
5. A commercial plot was valued at sh. 80,000. The plot appreciates in value at 20% in the first year, 15% in the second year and depreciates by 10% in the third year. Find the value of the plot at the end of the third year. (4 mks)
6. The cash price of a television set is sh. 6,500. A man buys it by making a down payment of sh. 2,300 followed by 12 monthly instalments of sh. 490. Calculate the carrying charge. (3 mks)
7. The hire purchase of an iron box is sh. 840. If a down payment of sh. 160 is made and the balance is paid in 10 equal monthly instalments, calculate the size of each instalment. (3 mks)
8. A man earned £2700 in one year. He paid income tax at the rate of sh. 2 in the pound for the first £1800 and sh. 3 in the pound for the rest of his income. Calculate how much P.A.Y.E he paid every month if he claimed sh. 200 per month married relief. (3 mks)
9. A man wishes to save sh. 200,000 in 4 years' time. Find the sum of money he has to deposit now at 12% per annum interest, compounded semi-annually to realize his goal. (4 mks)
10. A sewing machine valued at sh. 25,000 can be bought by cash at a discount of 10% or by instalments whereby a deposit of sh. 3,000 is paid followed by 15 monthly instalments of sh. 1,500 each.
    Find
    a) The cash price of the machine (2mks)
    b) The hire purchase price of the machine (2mks)

11. The area covered by a desert is 40,000 km^2 at present. If the desertification rate is estimated to be 2% every 10 years, calculate the area of the desert in 30 years. (4mks)

12. A seedling is 4 cm high. If its average growth rate is 20% per week, find its height after 5 weeks. (4mks)
13. What was the population of Nakuru 4 years ago if the present population is 800,000 and the growth rate is 5% per annum? (4 mks)
14. A school bus was bought for £ 75,000. Each year its value decreases by 10%. Find its value after 3 years. (4mks)

15. The first sh. 3,300 of Oyolo's earning is taxed at the rate of sh. 2 in every sh. 20. The rest is taxed at the rate of sh. 3 in every 20. If he pays a total tax of sh 375 a month, how much money does he earn per month? (4 mks)
16. In one month a man paid sh. 100 as income tax. He was allowed a tax relief of sh. 150. If the rate of tax was sh. 2 for every sh. 20. What was his salary for that month? (4 mks)
17. A businesswoman deposited sh. 10,000 in a bank, which paid compound interest at the rate of 10% per annum. At the end of one year, she withdrew sh. 4,000. What was the amount she had in the bank at the end of the second year? (4 mks)
18. Wendy deposited sh. 1,200 in a bank that paid compound interest at the rate of 10% per annum. If she withdraws all the interest that had been earned during the first two years, how much did she withdraw? (4 mks)
19. Mwebi invested a certain amount of money is a business that paid simple interest at the rate of 15% per annum. At the end of 9 months, she withdrew sh. 1125, which was the interest the money had earned. How much money had she invested? (4mks)
20. Mercy deposited sh 2,000 in a bank which paid compound interest at the rate of 20% per annum. Mercy withdrew all the money at the end of 2½ years, how much did she withdraw? (4 mks)

APPENDIX D

Mathematics Self-Concept Questionnaire (MSCQ)

Adm. No..... **Form .....** **Gender .....**

We would like to know your feelings about the mathematics topic Commercial Arithmetic.

Instructions

1. This is not a test and there are no ***correct*** or ***wrong*** answers.
2. It is important that you give your ***honest*** view.
3. Read the items with ***care*** in order to understand before making your choice.
4. **Circle** around the letter(s) that correspond to your choice.
5. The letter choices are: SD = Strongly Disagree, D = Disagree, U = Uncertain, A = Agree and SA = Strongly Agree.

Example: Mathematics is an important subject SD D U A (SA)

In the example, the respondent strongly agreed with the statement and circled the letters SA. Now, use the key provided to indicate your level of feelings with the items listed below.

Items	**Choice**
1. The topic Commercial Arithmetic was easy to me	SD D U A SA
2. The topic Commercial Arithmetic made sense to me	SD D U A SA
3. Teacher using MPS teaching approach to teach the topic Commercial Arithmetic explained the concepts clearly	SD D U A SA
4. The topic Commercial Arithmetic has no value	SD D U A SA
5. MPS teaching approach used to teach Commercial Arithmetic made me:	
a) Feel confident about the topic	SD D U A SA
b) Want to apply my knowledge to solve problems in the topic	SD D U A SA
c) Feel eager to learn the topic	SD D U A SA
d) Frustrated	SD D U A SA
6. Learning Commercial Arithmetic through MPS teaching approach was:	
a) Stimulating	SD D U A SA
b) Boring	SD D U A SA
c) Useful	SD D U A SA
7. Learning Commercial Arithmetic was:	
a) A pleasure	SD D U A SA
b) Too stressful	SD D U A SA
c) A source of anxiety	SD D U A SA
d) Fearful	SD D U A SA
e) Exciting	SD D U A SA
f) Motivating	SD D U A SA
g) Too demanding	SD D U A SA

8. Solving problems in Commercial Arithmetic was:

a) Stimulating	SD	D	U	A	SA
b) Rewarding	SD	D	U	A	SA
c) Interesting	SD	D	U	A	SA
d) Confusing	SD	D	U	A	SA
e) Time-consuming	SD	D	U	A	SA
f) Boring	SD	D	U	A	SA

9. MPS teaching approach made me:

a) Appreciate mathematics	SD	D	U	A	SA
b) Dislike Mathematics	SD	D	U	A	SA
c) Interested in mathematics	SD	D	U	A	SA
d) Scared of mathematics	SD	D	U	A	SA
e) Like mathematics	SD	D	U	A	SA

10. MPS teaching approach provided a variety of methods that were used to solve problems in Commercial Arithmetic SD D U A SA

APPENDIX E

Mathematics Classroom Environment Questionnaire (MCEQ)

Adm. No..... **Form** ..... **Gender** .....

We are interested to know what you perceive about the mathematics classroom environment during the teaching and learning of the topic Commercial Arithmetic.

Instructions

1. This is not a test and there are no ***correct*** or ***wrong*** answers.
2. It is important that you give your ***honest*** view.
3. Read the items ***carefully*** and ***understand*** before choosing what truly reflects your perception of the classroom environment during Commercial Arithmetic lessons in mathematics.
4. **Circle** around the letter(s) that correspond with your view of learning in this topic.
5. The letter choices are: A = Always, S = Sometimes, U = Uncertain, H = Hardly and N = Never.

Example : A student who agrees with the following statement would answer as follows:

The lesson was enjoyable (A) S U H N

Items	**Choice**				
1. We were encouraged to ask questions in class	A	S	U	H	N
2. The teacher praised us for good work	A	S	U	H	N
3. The teacher used examples to explain mathematical formulae and concepts	A	S	U	H	N
4. Questions were given and discussed in groups	A	S	U	H	N
5. We could solve problems from different textbooks and past papers	A	S	U	H	N
6. Mathematical problems discussed were clear	A	S	U	H	N
7. We expressed ourselves mathematically during discussions	A	S	U	H	N
8. We worked in groups	A	S	U	H	N
9. Boys had more opportunity in class discussion than girls	A	S	U	H	N
10. Our teacher paid more attention to girls than boys	A	S	U	H	N
11. We copied notes during mathematics lessons	A	S	U	H	N
12. We solved mathematical problems individually	A	S	U	H	N
13. Everyone was expected to participate in the group work	A	S	U	H	N
14. We understood mathematical formulae and concepts	A	S	U	H	N
15. Boys received more individual help than girls	A	S	U	H	N
16. We depended on each other more than the teacher	A	S	U	H	N
17. Mathematical problems were tested and solved individually in class	A	S	U	H	N
18. Students were friendly and worked together as a team in class	A	S	U	H	N
19. We competed against each other in class	A	S	U	H	N
20. We had enough time to finish our work	A	S	U	H	N

APPENDIX F

Classroom Observation Schedule (COS)

School ____ Lesson ____ Date _____ Time ____

(A) Teacher Activity	Tally
(i) Reinforces appropriate responses: praise, nodding head or saying go on etc (ii) Asks questions about the content or procedure based on students' ideas (iii) Guides or demonstrates how to perform: (a) A procedure (b) Re-read problems (c) Re-state problems. (iv) Goes round to ensure students are proceeding well with a given activity (v) Giving orders, directions or commands, to which students are expected to agree with (vi) Explains or lectures, giving opinions (vii) Encourages students to write facts of the situation (viii) Guides, coaches and shares in the process of solving problems (ix) Promotes analysis, organisation and communication skills by having students state or write their solutions in an orderly logical form (x) Reviews solution through question and answer session (xi) Encourages students to make generalisations about rules, formulae, concepts etc	
(B) Student Activity	
(i) Responds to teacher questions (ii) Follows instructions to: (a) Perform (b) Interpret (c) Compute (d) Check the answer (iii) Initiates classroom talk to: (a) Make suggestions (b) Express an idea (c) Develop opinions (iv) Asks questions or seek clarity over ideas presented (v) Expresses agreement or disagreement with action etc (vi) Writes or copies from the book, chalkboard etc (vii) Pauses or short periods of silence/ inactivity/ performance activity (viii) Consults other students (ix) Identifies the known facts or key information (x) Identifies what is to be solved (xi) Identifies the pattern by organizing the given facts or makes a plan (xii) Analyses method of solution by writing sequence of steps in a logical order (xiii) Attempts to construct one or more solution processes	

APPENDIX G

Letter of Authority to Conduct Research

REPUBLIC OF KENYA

MINISTRY OF EDUCATION SCIENCE AND TECHNOLOGY

Telegrams: EDUCATION", Nairobi

FAX No.
Telephone: 334411
NAIROBI
When replying please quote

JOGOO HOUSE
HARAMBEE AVENUE
P. O. Box 30040
NAIROBI

MOEST 13/001/34C 321/3

14th September, 2004

RONALD ELLUMBE MUTANGE
Egerton University
P.O. BOX 536
NJORO

Dear Sir

RE: RESEARCH AUTHORISATION

Please refer to your application for authority to conduct research on "Effects of problem solving Teaching Approach on students Mathematics, Achievement, Self concept and perception of Classroom Environment". I am pleased to inform you that you have been authorised to conduct research in Vihiga for a period ending 30th September, 2005.

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

Upon completion of your study, you are expected to submit two copies of your research findings to this Office.

Yours faithfully

B. O. ADEWA
FOR: PERMANENT SECRETARY

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