EFFECTS OF JIGSAW COOPERATIVE LEARNING STRATEGY ON STUDENTS' ACHIEVEMENT IN SECONDARY SCHOOL MATHEMATICS IN LAIKIPIA EAST DISTRICT, KENYA.

NAOMI WATETU MBACHO.

A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Education in Science Education of Egerton University.

EGERTON UNIVERSITY

APRIL 2013

Declaration

I declare that this is my original work and has not been presented for the award of a degree or diploma in this or any other university.

Sign…………………………… Date……………………….

Naomi W. Mbacho

EM14/2384/09

Recommendation

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

Sign…………………………… Date……………………….

Prof. Bernard N. Githua

Department of Curriculum and Instruction

Egerton University

Sign………………………… Date………………………

Prof. Johnson M. Changeiywo

Department of Curriculum and Instruction

Egerton University

COPYRIGHT

DEDICATION

This work is dedicated to my parents, my husband Francis, my daughter Sasha and my sons Lee and Collins.

ACKNOWLEDGEMENT

ABSTRACT

Secondary school students in Kenya have continued to perform poorly in mathematics in the Kenya Certificate of Secondary Education (K.C.S.E) national examinations. This raises concern for all stakeholders in education due to the importance they attach to mathematics. The factors that are attributed to the students' dismal performance in the subject include; inadequate facilities in the schools like the text books and qualified teachers, poor attitude towards the subject by the students and teachers, gender stereotypes, lack of role models, and the instructional methods used by teachers. This study sought to address the problem of ineffective instruction by teachers by finding out if the use of Jigsaw Cooperative learning Strategy during instruction of Surds and further logarithm in mathematics to form three students had effects on their performance. Surds and further logarithm are topics that are performed poorly in the KCSE. There is however inadequate documented information in research conducted in Kenya on effects of the use of Jigsaw Cooperative learning Strategy on students' achievement in mathematics. Solomon four non-equivalent control group design was used in the study. The two experimental groups received the Jigsaw cooperative learning Strategy as treatment and two control groups were taught using the conventional learning/teaching methods. A simple random sample of four district secondary schools was selected from Laikipia East District. The sample size was 160 students out of population of about 20,000 students in the district. A mathematics achievement test (MAT) was used for data collection. The instrument was piloted in a school which was not used in the study in the Laikipia East District. The instrument used had reliability coefficient of above the required threshold of 0.70. The instrument was validated by education experts from the Department of Curriculum and Instruction. Data was analyzed using t-test to test hypotheses at Coefficient alpha (ά) level of 0.05. Findings of this study show that learners taught using Jigsaw cooperative learning strategy performed better than those taught using Conventional learning methods. The results also show that there is no significant difference in achievement of girls and boys when taught using Jigsaw cooperative learning strategy. The findings are expected to be useful to students and teachers in secondary schools because they will be able to identify learning strategies which will enhance achievement in mathematics. Policy makers, curriculum developers and education officers are likely to benefit from this study in deciding on the appropriate learning strategy for learners to improve the quality of education in the country.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ANCOVA   Analysis of Covariance.

ANOVA   Analysis of Variance

C2   Control 2

CI   Control 1

CIRC   Cooprative Integrated Reading and Composition.

E1   Experimental group 1

E2   Experimental group 2

K.C.S.E   Kenya Certificate of Secondary Education.

K.I.E   Kenya Institute of Education.

K.N.E.C   Kenya National Examinations Council.

MAT   Mathematics Achievement Test.

PISA   Programme for International Student Achievement.

SACMEQ   School Effectiveness and Education Quality in Southern and Central Africa.

SMASSE   Strengthening of Mathematics and Science in Secondary Education.

STAD   Student Team Achievement Divisions

TIMSS   Trends in International Mathematics and Science Study.

UNESCO   United Nations Educational Scientific and Cultural Organization.

U.S.A   United States of America.

INTRODUCTION

1.1 Background information

Mathematics is offered as one of the core subjects in primary and secondary school education in Kenya. At tertiary levels, general mathematics is offered in nearly all science based programmes where it is not a core subject. This emphasizes the importance attached to the subject in development of science and technology. According to Cockroft (1982) quoted in Githua (2002), the knowledge of mathematics as a tool for use in everyday life is important for the existence of any individual and society. Mathematics is used as a filter in employment and placement because it is associated with clear thinking and ability to solve problems in everyday life (Orton & Frobisher, 1996). Mathematics as a discipline is applied to all other disciplines such as military, research, applied science and commerce. According to Cockroft (1982) quoted in Githua (2002), mathematics is a dispensable tool in the development of science and technology. It is also a fact that without advances in sciences and technology no country can make meaningful progress in improving the quality of life of its people. Mathematics equips students with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think.

Despite the important role mathematics play in society, there has been persistent poor performance in the subject globally. For instance, the United States of America (U.S.A) is viewed as a global leader in many aspects, including finance. medical research, higher education, sports and scientific fields; yet, according to the Programme for International Student Achievement (PISA,2007) and Trends in International Mathematics and Science Study (TIMSS,2007), the U.S.A is still very far from being world class in mathematics and science education. In Africa the poor performance is still registered in mathematics for instance, South Africa participated in TIMSS in 1995 and South Africa learners came last with a mean score of 351 which was lower than the international benchmark of 513. In Kenya, the performance in mathematics has continued to be very poor as is reflected in candidates' work at the Kenya Certificate of Secondary Education (K.C.S.E) mathematics examinations results (K.N.E.C,

2010). The students' mean score in mathematics at K.C.S.E national examinations by gender in the year 2009 and 2010 are shown in Table 1.

Table 1:

Students' Percentage Mean Score in Mathematics at KCSE for the years 2009 and 2010

Year	Male	Female	Grand mean
2009	23.63	18.11	20.87
2010	25.75	19.71	22.73

Source: K.N.E.C, 2010 pp 14

Despite the importance that mathematics play in progress towards attaining the stated educational goals, many studies have shown poor performances in the subject (Ogunniyi, 1996). This is also attested by KCSE mathematics examination results (KNEC, 2010). Report of the Kenya National Examinations Council indicated a grand mean score of 20.87 and 22.73 during the years 2009 and 2010 respectively which was below 25%. The Kenya National Examination Council (K.N.E.C) has continued to raise concern over the poor performance at the K.C.S.E mathematics examinations. There have been serious implications, which may lead to lack of admissions into careers and institutions of higher learning in future. Employers have taken particular interests in this problem and criticized the school for their inability to teach mathematics effectively. For this reason parents have began to send students for private tuition in mathematics during holidays while learners' interest in mathematics during scheduled lessons deteriorated. There is therefore need to develop different methods of teaching that are effective in mathematics since the methods used for teaching currently are teacher centered and does not enhance learners participation in mathematics classrooms.

The poor mathematics performance of students is further worsened by gender imbalance leading `to the problem which now constitutes a major research focus across the globe (UNESCO, 2003). The issue of gender inequality in Science, Technology and Mathematics Education has produced inconclusive results, one meta analysis covering the period 1974 – 1987 on mathematics and gender led to two conclusions: the average gender gap is very small

(statistically insignificant), and the fact that the differences tend to decline with time (Friedman, 1989). In Kenya, the gender difference in mathematics achievement is evident at the KCSE examination results (KNEC, 2010).During the years 2009 and 2010 the females performed more than 3 percentage points lower than boys in the country despite the fact that they constitute more than half of the country's population K.N.E.C, 2010. The persistent poor performance in mathematics as compared to other subjects is also registered in Laikipia East District. The students' performance index in mathematics out of twelve points as compared to other subjects at K.C.S.E in the years 2006, 2007, 2008 in the District are shown in Table 2.

Table 2

Students' Mathematics Performance Index compared with that of other Subjects at KCSE

Year \ Subject	2006	2007	2008	2009	2010	2011
English	5.2170	5.0871	4.917	5.0222	5.0933	5.0453
Kiswahili	5.7550	5.2163	4.6328	4.8675	4.6722	5.0023
Mathematics	**2.9340**	**2.6115**	**3.1340**	**2.7862**	**2.800**	**3.0022**
Biology	4.0170	4.5948	4.6581	4.8098	3.9511	4.0221
Chemistry	3.6390	3.5119	3.4536	3.6785	3.3800	3.0120
Physics	5.4740	5.1130	5.3151	4.9542	3.6000	4.1892
Geography	4.6370	5.2657	4.4728	4.89670	4.1788	4.8750
History	5.9860	5.7851	5.3339	5.2220	5.3221	5.0211
C.R.E	6.9410	6.6537	5.4162	5.3000	5.8411	6.0290
Business	5.8010	6.4953	6.1285	6.0320	6.3444	5.0022
Home science	6.5730	5.7419	5.0000	5.3450	4.8989	3.9626
Agriculture	5.8300	6.1886	5.3030	5.8886	5.7655	6.0219

Source: DEO's office, Laikipia East District. Pp 10

The mean performance index in mathematics out of a maximum score of twelve points in Laikipia East District has been the lowest of all subjects for the past six years as indicated in

Table 2. This underachievement and gender differences in mathematics performance is attributed to ineffective teaching methods employed in mathematics classrooms (O'Connor, 2000).

In Africa the factors attributed to learners' poor performance in mathematics includes: inadequate teaching and learning resources; poor educational administration; teacher/learner attitude towards the subject; and poor teaching methodology (Opolot-Okurot,2005). Factors that contribute to poor performance in Africa in general and Kenya in particular are similar. There is therefore need for a search of teaching methods which will arouse students' interest to learn mathematics. The conventional teaching methods used by mathematics teachers generate in the learners a lasting aversion against numbers (Glassersfeld, 1991). The use of an appropriate teaching strategy is critical to the successful learning and teaching of mathematics. Knowledge of how a specific teaching method or strategy impacts on mathematics learning may assist the teachers to choose the teaching strategy which is effective and hence improve the quality of outcomes in mathematics classrooms.

This study therefore sought to find out the effects of use of Jigsaw Cooperative Learning Strategy during instruction on learners' achievement in the mathematics topics of Surds and Further logarithms that are taught to Secondary schools form three students in Laikipia East District of Kenya. Cooperative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject (David & Roger, 2001).Each member of a team is responsible not only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. Students work through the assignment until all group members successfully understand and complete it.

Over the past decade, cooperative learning has emerged as a leading approach classroom instruction. Students completing cooperative learning group tasks tend to have higher academic test scores, higher self esteem, greater numbers of positive social skills, fewer stereotypes of individuals of other races or ethnic groups, and greater comprehension of the content and skills they are studying (Johnson, Johnson, & Holubec, 1993; Slavin 1991; Stahl and Vansickle, 1992). Students work in small groups thereby cooperating to ensure their own learning and the learning

of all others in their group (Johnson, Johnson, & Holubee, 1993). This emphasis on academic learning success for each individual and all members of the group is one feature that separates cooperative learning groups from other group tasks (slavin, 1991).

To be successful in setting up and having students complete group tasks within a cooperative learning framework, a number of essential elements or requirements must be met which includes: a clear set of specific student learning outcome objectives, clear and complete set of task-completion directions or instructions, heterogeneous groups, equal opportunity for success, positive interdependence, face-to-face interaction, positive social interaction behaviors and attitudes, access to must-learn information, opportunities to complete required information-processing tasks, sufficient time is spent learning, individual accountability, public recognition and rewards for group academic success, post-group reflection (or debriefing) on within-group behaviors (Cohen, 1992).

According to Aronson (2000), Jigsaw is a cooperative learning strategy that enables each student of a 'home' group to specialize in one aspect of a learning unit. Students meet with members from other groups who are assigned the same aspect and after mastering the material, return to the 'home ' group and teach this material to the group members. Jigsaw can be used whenever material can be segmented into separate components. Each group member becomes an expert on a different concept or procedure and teaches it to the group (Panitz, 1996).Just like a Jigsaw puzzle, each piece (student part) is essential for the completion and full understanding of the final product. Therefore, each student is essential for the understanding of the whole concept being taught. According to Aronson, the advantage of Jigsaw learning strategy is that students perform the challenging and engaging tasks in their experts groups with enthusiasm since they know they are the only ones with that piece of information when they move to their respective groups. Students who tutor each other must develop a clear idea of the concept they are presenting and orally communicate it to their partner (Neer, 1987).

The Jigsaw learning strategy can be used to learn most of the topics in secondary schools mathematics syllabus. The effect of the strategy to the learning of the topics Surds and Further

logarithms was studied. These are major topics in the secondary school mathematics curriculum. The topics are taught at form three level (KIE, 2000).They have been among the difficult areas for students to learn in the secondary school mathematics syllabus in Kenya. This is evident in the baseline survey by SMASSE Laikipia East trainers where the topics Surds and Logarithms were second and third respectively in order of difficulty to the learners as shown in Table 3. According to K.I.E (2007) Surds and Logarithm was among the areas that students performed poorly in 2006 and 2007 national examinations.

Table 3:

Topics Found Challenging in Secondary School Mathematics during Baseline Survey by SMASSE Laikipia East Trainers, Kenya.

Class / Topics	Form One	Form Two	Form Three	Form Four
Topics in order of difficulty	i) survey ii) Integers	i) Linear motion ii) Similarity ii) Indices and Logarithms (Negatives)	i) Vectors ii) Surds iii) logarithms iv) Errors and approximation v) Compound proportion	i) Linear Inequality ii) Locus iii) Transformations

Source: Laikipia East SMASSE Baseline Survey, 2007 Kenya.

1.2 Statement of the Problem

For a country to excel in technical and scientific fields, mathematics should be performing well in primary and secondary school levels of education. Despite the importance of mathematics as a basic preparation of learners for full participation and functioning members of the society the students' performance in the subject has been poor. Therefore with dismal students' mathematics

performance in Kenya's national examinations, as seen in the past KNEC reports the country's pace of industrialization will be slow and Kenya's vision 2030 will be hard to achieve. Laikipia East District is among the poor performing districts in mathematics in Rift valley province. One of the major reasons for poor performance is the teachers' use of ineffective teaching strategies. However, there is inadequate documented information in research conducted in Kenya in general and in Laikipia East District in particular on the effects of Jigsaw cooperative learning strategy on students' achievement in mathematics. There was need therefore to establish whether Jigsaw learning strategy could improve the achievement in mathematics.

1.3 Purpose of the Study
The purpose of this study was to investigate the effects of Jigsaw cooperative learning strategy on students' achievement in secondary school mathematics.

1.4 Objectives of the Study
The following specific objectives guided the study;
  i. To find out whether there is any difference in mathematics achievement between students who will be taught mathematics using the Jigsaw Cooperative Learning Strategy and those who will be taught using the Conventional learning/teaching methods in secondary schools.
  ii. To find out whether gender affects achievement when Jigsaw Cooperative Learning Strategy is used in secondary schools mathematics classes.

1.5 Hypotheses of the Study
The following Null hypotheses were addressed and tested in the study.

Ho1; There is no statistically significant difference in students' achievement in mathematics between those taught using Jigsaw Cooperative Learning Strategy and those taught using Conventional Learning/Teaching Methods.

Ho2; There is no statistically significant gender difference in achievement among secondary school students when taught Surds and Further logarithms using Jigsaw Learning Strategy.

1.6 Significance of the Study

The findings of this study are beneficial to secondary school mathematics teachers by helping them to use learning strategies which arouse the interest of the learners and with high participation of the learners. The outcomes of the study will help the mathematics teachers appreciate that girls can also perform well in mathematics by use of appropriate learning strategies and thus have positive attitude towards girls in mathematics classrooms. This study will help the secondary school students to identify the learning strategy that enhances achievement in mathematics. The head teachers and the head of departments will benefit from the suggestions on how to support the teachers on use of appropriate learning methods. This study will inform the teacher educator about effective teaching strategies in preparation of the teachers and thus enhancing students' achievement in mathematics. The study is also beneficial to education officers and also policy makers in deciding on the appropriate learning strategies for learners to improve the students' mathematics achievement.

1.7 Scope of the Study

All schools within Laikipia East district were included in the study population. All the Form Three students were eligible respondents. The topics studied are Surds and Further logarithms that are taught to form three students in secondary schools.

1.8 Limitations of the study

The study was limited to learners in district schools. District Schools in Kenya have entry behaviour of students with lower academic achievement as opposed to higher academic achievement of students in provincial and national schools. Furthermore most district schools have inadequate resources as compared to better funded provincial and national schools. Thus the results of this study should not be generalized to provincial and national schools but to only district schools.

1.9 Assumptions of the Study

The following assumptions were made in the study:

    i.   Entry behaviours of the students in District Schools are assumed to be similar.

ii. All the qualified mathematics teachers with minimum of two years experience of teaching form three mathematics are assumed to have equal experience to teach mathematics.

1.10 Definition of Operational terms.

The following constitutive and operational definition of terms was used for the purpose of this study.

Conventional teaching methods: Refers to learning/teaching methods that teachers frequently use and have used for a long time (The Free Dictionary, Jan 20, 2012). In this study it refers to the ordinary teaching   methods used to teach mathematics which are mainly teacher centred.

Culture: These are the beliefs and attitudes about something that people in a particular group or organization share (The Free Dictionary, Jan 20, 2012). In this study it refers to a traditional way of doing things.

Critical thinking: This is a process which involves making fair, careful judgment about the good and bad qualities of something (The Free Dictionary, Jan 20, 2012). In this study it refers to high order thinking.

Expert group: An expert is a person with special knowledge, skill or training in something (The Free Dictionary, Jan 20, 2012). In this study it refers to a group of students with identical assignments who come together for discussion.

Jigsaw: Jigsaw puzzle is a picture printed on cardboard or wood, which has been cut up into a lot of small pieces of different shapes that you have to fit together again (The Free Dictionary, Jan 20, 2012). In this study it refers to a grouping strategy in which members of the class are organized into learning groups called "Home groups" and then rearranged in new groups to share their learning.

Jigsaw cooperative learning strategy: This is where each student of a "home" group specializes in one aspect of a learning unit. Students meet with members from other "home" groups who are assigned the same aspect, and after mastering the material, return to the "home" group and teach the material to their group members (Aronson, 2000).

Logarithm of a number: This is the exponent by which a fixed number, the base, has to be raised to produce that number (Buckwell, 2005). In this study Logarithm is a topic involving logarithmic notation.

Mathematics achievement: This is a measure of the degree of success in performing tasks in mathematics after teaching or instructions (The Free Dictionary, Jan 20, 2012). In this study it refers to performance in mathematics especially in KCSE examinations measured in percentage scores in a mathematics test or a national examination.

Surds: These are irrational numbers that are left in square root form (or cube root form etc) (Buckwell, 2005). In this study Surds is a topic involving numbers in square root form.

Threesomes: A group of three people. In this study it refers to three students.

Learning communities: Learning is the knowledge you get from reading and studying. A community is a group of people who share the same religion, race, job, etc (The Free Dictionary, Jan 20, 2012). In this study it refers to a group of students who are assigned a subtopic together.

2.1 Introduction

In this chapter the relevant literature on the use of cooperative learning approach during instruction is reviewed. The significance of mathematics as a discipline is first discussed. Then the conventional teaching methods used by teachers are explained and the reasons for poor performance in mathematics looked at. The cooperative learning is then discussed in terms of its principles, benefits and the various methods and jigsaw strategy is one of them. The gender differences in mathematics are then discussed. The theoretical and conceptual frameworks are then outlined.

2.2 Significance of mathematics as a discipline

Mathematics is used as a filter in employment and placement because it is associated with clear thinking and ability to solve problems in everyday life (Orton & Frobisher, 1996). Mathematics as a discipline is applied to all other disciplines such as military, research, applied science and commerce. According to Cockroft (1982) quoted in Saitoti (2000), mathematics is a dispensable tool in the development of science and technology. It is also a fact that without advances in sciences and technology no country can make meaningful progress in improving the quality of life of its people. Mathematics equips students with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think.

Despite the important role mathematics play in society, there has been persistent poor performance in the subject globally. For instance, the United States of America (U.S.A) is viewed as a global leader in many aspects, including finance. medical research, higher education, sports and scientific fields; yet, according to Programme for International Student Achievement (PISA) and Trends in International Mathematics and Science Study (TIMSS), the U.S.A is still very far from being world class in k-12 mathematics and science education. In Africa the poor performance is still registered in mathematics for instance, South Africa participated in TIMSS in 1995 and South Africa learners came last with a mean score of 351 which was lower than the

international benchmark of 513. In Kenya, the performance in mathematics has continued to be very poor as is reflected in candidates' work in the Kenya Certificate of Secondary Education (K.C.S.E) mathematics examinations results (K.N.E.C, 2007).

2.3 Conventional Teaching Methods

Conventional teaching or the traditional teaching methods are the ordinary teaching methods used by teachers to deliver the contents of the syllabus to the learners (Macharia, Githua & Mboroki, 2009). Most conventional methods of teaching mathematics are teacher-centred .The teacher demonstrates and summarizes the main points and there is surface learning of concepts, principles and skills (Dean, 1982). These methods are highly dependent on the skills of the teacher and not useful in enhancing learners interpersonal and communication skills. (Macharia, Githua &Mboroki, 2009).Teachers need to help students develop the skills they will use every day to solve mathematical and non-mathematical problems which include the ability to reason, explain and justify ideas. The teacher should also help students to use resources to find needed information to work with other people on a problem and to generalise to different situations as well as the traditional ability to carry out computations. Zemelman, Daniels and Hycles (1988) describe the mathematic teachers' goal as helping all students to feel that mathematics is personally helpful and meaningful and to feel confident that he or she can understand and apply mathematics in life.

Traditional teacher-centred teaching like drilling, individual worksheet practice, lecturing and flashcards are considered effective depending on traditional definition of mathematics as merely collection of formulae, rules and procedures that must be memorized and mastered. However the current definition emphasizes that mathematics integrated as a whole, is the study of structures and the relationships between things and a way to study and understand the world around us (Dean,1982). Conventional teaching methods used in teaching mathematics increases students' anxiety and negative attitude towards the subject. Debbie Dicker a 15 years veteran mathematics teacher at Highland Park High School in U.S says she finds groups to be especially productive because they give students more source of support and help motivates learners by overcoming

their insecurity about problem solving because they can see more able peers struggling over difficult problems.

2.4 Reasons for Poor Performance in Mathematics

The poor performance in mathematics has been attributed to negative attitudes towards the subject by students and inadequate teaching methodology in many parts of the world. Daris and Hersh (1990) identified impatience in solving mathematics problems by students as one of the reasons for resistance, resentment and rejection hence negative attitude towards mathematics. In South Africa, the teaching and learning of mathematics, science and technology were the hardest hit (Department of Education (DoE), 2001a). Several studies for instance (Howie, 2003) have reported a number of shortcomings in the teaching and learning of mathematics and science in South Africa. For example, the Third International Mathematics and Science Study (TIMSS) conducted in 1995, in which South Africa participated with 41others, reports that South African mathematics learners came last with a mean score of 351. This mean was significantly lower than the international benchmark of 513. Less than2% of these learners reached or exceeded the international mean score (Beaton *et al*., 1996).Also, the South African mean was lower than that of Morocco, Tunisia, and other developing countries such as Chile, Indonesia, Malaysia, and the Philippines (Howie, 2001; Naidoo, 2004).

Burstein (1992) in a comparative study of factors influencing mathematics achievement found out that there is a direct link between students' attitudes towards mathematics and student outcomes. He also found that 25% in England and 26% in Norway accounted for the variation in students' attitude towards mathematics that were due to student gender, maternal expectation, expectations of the students friends, and success attribution (belief about success in mathematics). Student beliefs and attitudes have the potential to either facilitate or inhibit learning. Gibbons, Kimmel and O'Shea (1997)opined that students' attitudes about the value of learning science may be considered as both an input and outcome variable because their attitudes towards the subject can be related to educational achievement in ways that reinforce higher or lower performance. This means that those students who do well in a subject generally have more

positive attitudes towards that subject and those who have more positive attitudes towards a subject tend to perform better in that subject.

Mondoh (1994) argues that negative attitudes towards mathematics play a role in determining our thoughts, memory, learning process and behavior in the course of learning the subject. According to the UNESCO(2008) research project, The School Effectiveness and Education Quality in Southern and Eastern Africa (SACMEQ), the attributed factors for poor performance in mathematics in Africa includes: inadequate teaching and learning resources; learning conditions which includes class size, relationship between mathematics teachers and students; poor administration; teacher/learner attitude towards the subject and poor teaching methodology. Bolaji (2005) in a study of the influence of students' attitude towards mathematics found that the teachers' method of mathematics teaching and his personality greatly accounted for the students' positive attitude towards mathematics. In Kenya, the same factors that contribute to poor performance in Africa also contribute to poor performance in mathematics in addition to the poor organization of the syllabus and gender stereotypes. According to SMASSE (2000), the causes of poor performance in mathematics in Kenya include; outdated teaching practices and lack of basic mathematics content knowledge by mathematics teachers which have resulted in poor teaching standards.

2.5 Cooperative learning

According to David & Roger, (2001) cooperative learning is an approach of organizing classroom activities into academic and social learning experiences. Students must work in groups to complete the two sets of tasks collectively. Everyone succeeds when the group succeeds. According to Kagan, (1994) there are three types of Cooperative Learning;

*Formal***:** This approach is structured, facilitated, and monitored by the educator over time and is used to achieve group goals in task work (for example, completing a unit). Any course material or assignment can be adapted to this type of learning, and groups can vary from 2 to 6 people with discussions lasting to a lesson. Types of formal cooperative learning strategies include Jigsaw, assignments that involve group problem solving and decision making, laboratory or experiment assignments, and peer review work (such as editing writing assignments). Having

experience and developing skill with this type of learning often facilitates informal and base learning.

Informal: This approach incorporates group learning with passive teaching by drawing attention to material through small groups throughout the lesson or by discussion at the end of a lesson, and typically involves groups of two (such as turn-to-your-partner discussions). These groups are often temporary and can change from lesson to lesson (very much unlike formal learning where two students may be lab partners throughout the entire semester contributing to one another's knowledge of science). Discussions typically have four components that include formulating a response to questions asked by the educator, sharing responses to the questions asked with a partner, listening to a partner's responses to the same question, and creating a new well-developed answer. This type of learning enables the student to process, consolidate, and retain more information learned.

*Group Base***:** These are peer groups that gather together over as long term (such as over the course of a year, or several years such as in high school or post-secondary studies) to develop and contribute to one another's knowledge mastery on a topic by regularly discussing material, encouraging one another, and supporting the academic and personal success of group members. Base group learning is effective for learning complex subject matter over the course or semester and establishes caring, supportive peer relationships, which in turn motivates and strengthens the student's commitment to the group's education while increasing self-esteem and self worth. Base group approaches also make the students accountable to educating their peer group in the event that a member was absent for a lesson.

2.5.1 Principles of Cooperative Learning

The elements of a cooperative learning according to Johnson, Johnson & Holubees (1994) are as follows:

There should be positive interdependence in the group. The group members should perceive that they are linked to each other in a way that one cannot succeed unless everyone succeeds. It should promote interaction in that students need to do real work together in which they promote each other's success by sharing resources and helping, encouraging, and applauding each others' effort to achieve. This includes orally explaining how to solve problems, teaching one's

knowledge to others, checking for understanding, discussing concept being learned, and connecting present with past learning.

There should be individual and group accountability. The group must be accountable for achieving its goal and members must be accountable for contributing his or her share of the work. Individual accountability exists when the performance of each individual is assessed and the results are given back to the group and the individual in order to ascertain who needs more assistance, support and encouragement in learning.

The students should be taught the required interpersonal and small group skills. Since cooperation and conflict are inherently related, the procedures and skills of managing conflicts constructively are especially important for the long-term success of the learning groups (Johnson, 1973).There should be group processing where group members discuss how well they are achieving their goals and maintaining effective working relationships.

2.5.2 Benefits of Cooperative Learning Strategy

Cooperative learning strategies has the following benefits:

It Promotes Thinking Skills.

According to Panitz (1996) cooperative learning promotes critical thinking skills. Clarification and explanation of one's answer is a very important part of collaborative process and represents a high order thinking skills. Johnson (1973) indicates that cooperative learning stimulates critical thinking and help students clarify ideas through discussion and debate. Students receive immediate feedback or questions about their ideas and formulate responses without having to wait for intervals to participate in the discussion (Peterson & Swing, 1985).This stimulates thinking as opposed to the passive reception of knowledge in most of the conventional teaching methods.

The students also develop communication skills in the group work. Students who tutor each other must develop a clear idea of the concept they are presenting and orally communicate it to their partner (Neer, 1987).These communication skills are essential in the overall achievement of the student. Cooperative discussion improves students' recall of text content. The student's

critical thinking skills increases and their retention of information and interest in the subject matter improves (Kulik & Kulik 1979).

It Involves the Students Actively in the Learning Process

According to Slavin (1987) cooperative learning creates an environment of active, involved, exploratory learning. Also Panitz (1996) indicates that cooperate learning involves students actively in the learning process. Pairs of students working together represent the most effective form of interaction, followed by threesomes and larger groups (Schwartz, Black & Strange, 1991). Involving students actively in learning encourages students' responsibility in learning (Baird & White, 1984). Promotive interaction, a foundation principle of cooperative learning, builds students' responsibility for themselves and their group members through a reliance upon each others' talents, and assessment process which rewards both individuals and groups.

Also the students are involved in developing curriculum and class procedures in cooperative learning (Kort, 1992).Students who participate in structuring the class assume ownership of the process because they are treated like adults, and their opinions and observations are respected by the authority figure in the class (Meir & Panitz 1996). The cooperative learning helps the students to wean themselves away from considering teachers as the sole source of knowledge and understanding (Felder, 1997).Informal discussion and debate often yields more productive research break through than attending lectures. Cooperative learning has the effect to elevate students to the teacher's level and create a high expectation that they have the ability to obtain and understand knowledge themselves.

Cooperative learning promotes a learning goal rather than a performance goal. This approach focus on the process of learning and how individuals function within the groups but not necessarily competitively as opposed to other conventional methods which emphasize competitive testing to access students' competence and create an evaluation hierarchy based upon grades. This method fits in well with the constructivist approach when students become actively involved in defining questions in their own language and working out answers together instead of reproducing material presented by the teacher or the textbook (Wooley, et al

1990).Cooperative learning allows students to exercise a sense of control on task (Sharan & Sharan, 1976). The locus of control is with the student because the teacher serves as facilitator and not a director. Students are given a leeway to decide how they will function and what their group's product will be.

It Improves Classroom Results

The use of cooperative learning strategy promotes high achievement and class attendance (Hagman & Hayes, 1986). Students who develop personal professional relations with teachers by getting to know them, and who work on projects outside the class, achieve better results and tend to stay in school (Cooper, 1992). Teachers get to know and understand their students well when cooperative learning occurs and the teachers are able to know and deal with the student's problems hence catering for individual differences in the class. Students are inspired by the teacher who takes time to get to know them and encourage them to aspire for better performance. There is a strong positive correlation between class attendance and success in courses (Johnson & Johnson 1994) which may help account for the improved performance. According to Felder (1997) additional benefits occur when cooperative learning is used for instruction in that students' grades are improved, they show longer retention of information, transfer information better to other courses and disciplines, and have a better class attendance.

Cooperate learning promotes a positive attitude towards the subject matter. Cooperative learning strategies for the classroom have improved students' academic achievement and attitudes towards self, peers and school (Johnson, 1973). When the students are successful they view the subject matter with a very positive attitude because their self esteem is enhanced. Cooperative learning enhances student satisfaction with the learning experience. This aspect is especially helpful to individuals who have a history of failure (Turnure & Zeigler, 1958). Cooperative learning enhances self management skills. In order to function within their groups the student need to come prepared with assignments completed and must understand the material which they are going to contribute in the group. Students are trained about their responsibilities toward the group and how to be an effective group member. These promotive interactions help students learn self management techniques. Cooperative learning increases students' persistence in the

completion of assignments (Felder, 1997). When individuals get stuck they are more likely to give up; groups are much more likely to find ways to keep going.

It Models Appropriate Student Problem Solving Techniques

Cooperative learning fosters modeling of problem solving techniques by students' peers (Schunk & Hanson, 1985).Students often learn more by listening to their peers than they do by listening to an authority figure like a teacher (Levin, Glass & Meister 1984). In addition to shifting responsibility for learning onto students, cooperation learning provides an opportunity for students to demonstrate their knowledge by helping their peers (Bargh & Schul, 1980); an especially important advantage over the lecture method or class discussion form of teaching. Weaker students improve their performance when grouped with achieving students (Cohen, 1994). Swing & Peterson (1982) found out that student of low achievement benefited from participation in groups heterogeneously composed on achievement in comparison to participation in homogenously low-achieving groups. Many students are hesitant to speak out and offer opinions publicly in a traditional classroom setting for fear of appearing foolish. But in cooperative learning students explore alternative solutions to problems in a safe environment.

Benefits the Students Socially

The cooperative learning enables the teacher to move around the class in order to observe students interacting (Cooper, 1992). An opportunity is created whereby the teacher can talk to the students directly or in small groups. A natural tendency to socialize with the students on a professional level is created by approaches to problem solving and about activities which influence performance in class. Cooperative learning develops a social support system for the students. It establishes a positive atmosphere for modeling and practicing cooperation (Pantiz, 1996). Cooperative learning develops learning communities (Pantiz, 1996). Students help each other and in doing so build a supportive community which raise the performance level of each member (Kagan, 1986). This in turns leads to a higher self esteem in all students (Webb, 1982). Collaborative efforts among students results in a higher degree of accomplishment by all participant as opposed individual, competitive system in which many students are left behind (Slavin, 1987).

Davidson points out the following benefits of cooperation learning as they apply to mathematics teaching;

i) Mathematical problems can be solved by several different approaches.

ii) Students in groups can help one another master basic facts and necessary computorial procedures.

iii) Students can persuade one another by the logic of their arguments to find solutions to mathematical problems.   (Davidson, 1990: pp221)

In this study Jigsaw learning strategy was used. This is because this method has many advantages over the other cooperative strategies which includes;

i)   Jigsaw method can be used to cover a large amount of material quickly.

ii)   Students do the Jigsaw method challenging and engaging tasks in their expert groups with enthusiasm since they know they are the only one with that piece of information when they move to their respective groups.

iii)   Students create their own meaning and prove that they have really learnt the material. (Burns, 1984: pp115)

2.5.3 Methods of Cooperative Learning

There are different methods of cooperative learning which uses collaborative approach in learning.According to Aronson, (2000)modern methods of Cooperative Learning includes:

Group investigation

According to Sharan, (2006) in group investigation, students form interest groups within which to plan and implement an investigation, and synthesize the findings into a group presentation for the class. The teacher's general role is to make the students aware of resources that may be helpful while carrying out the investigation. It includes four important components: investigation, interaction, interpretation and intrinsic motivation. Investigation refers to the fact that groups focus on the process of inquiring about a chosen topic. Interaction is a hallmark of all cooperative learning methods, required for students to explore ideas and help one another learn. Interpretation occurs when the group synthesizes and elaborates on the findings of each member

in order to enhance understanding and clarity of ideas. Finally, intrinsic motivation is kindled in students by granting them autonomy in the investigative process.

Implementation of group investigation proceeds in six steps. First, the teacher presents a multi-faceted problem to the class, and students choose an interest group. The problem posed here is particularly important, as a variety of re-actions from students is necessary for appropriate group formation. Teachers should avoid giving their own ideas or rejecting ideas from students. Second, groups plan their investigation the procedures, tasks and goals consistent with the chosen subtopic. Third, groups carry out the investigation as planned in the above step. The teacher's role at this step is to follow the investigative process, offering help when required: suggesting resources, ensuring a variety of skills is being used. Fourth, groups plan their presentation. They evaluate what they have learned, and synthesize it into aform that can be understood by the class. Fifth, groups conduct the presentation. Finally, the teacher and students evaluate the investigation and resulting presentations (Sharan, 2006). Throughout the process, group representatives often make reports to the class, helping group members appreciate that they are part of a larger social unit.

Constructive Controversy

This cooperative approach was introduced by David Johnson and Roger Johnson in 1994. It has been researched and validated, and it's recognized as a leading model for developing robust and creative solutions to problems. Constructive Controversy is not about simply arguing and creating conflict for its own sake – it follows a formal procedure to manage controversy in a positive way using the following steps: First, each team presents its case to the wider group. The objective is to help the group understand the particular choice, and convince people of its validity. Second, the other teams then have the opportunity to argue against the position. This is an open discussion – the presenting team listens to the counter-arguments, tries to disprove them, and defends its original position as best as it can. Third, the emphasis is on logic and critical thinking. Remind the teams that the overall objective is to gain a better understanding of all options in order to make the best decision possible. Encourage them to ask for solid data, and push the team to defend its conclusions. The next team presents its case, and discussion follows.

22

This continues until all teams have presented their positions. Lastly, it's the time to drop the advocacy roles, and bring the group together to make a final decision. Take the time to explore what people have learned from the Constructive Controversy process, and then bring together ideas to create a final proposal.

Student Teams-Achievement Divisions (STAD)

In Student Teams-Achievement Divisions (STAD) (Slavin, 1994), students are assigned to four-member learning teams that are mixed in performance level, gender, and ethnicity. The teacher presents a lesson, and then students work within their teams to make sure that all team members have mastered the lesson. Finally, all students take individual quizzes on the material, at which time they may not help one another. Students' quiz scores are compared to their own past averages, and points are awarded on the basis of the degree to which students meet or exceed their own earlier performance. These points are then summed to form team scores, and teams that meet certain criteria may earn certificates or other rewards. The STAD method is most appropriate for teaching well-defined objectives with single right answers, such as mathematical computations and applications, language usage and mechanics, geography and map skills, and science facts and concepts. However, it can easily be adapted for use with less well-defined objectives by incorporating more open-ended assessments, such as essays or performances.

Cooperative Integrated Reading and Composition (CIRC)

According to Slavin, (1994) this is a comprehensive program for teaching reading and writing in the upper elementary grades. Students work in four-member cooperative learning teams. They engage in a series of activities with one another, including reading to one another, making predictions about how narrative stories will come out, summarizing stories to one another, writing responses to stories, and practicing spelling, decoding, and vocabulary. They also work together to master main ideas and other comprehension skills. During language arts periods, students engage in writing drafts, revising and editing one another's work, and preparing for publication of team books. Three studies of the CIRC program have found positive effects on students' reading skills, including improved scores on standardized reading and language tests (Slavin, 1994).

Learning Together and Alone,

This is a model of cooperative learning developed by David Johnson and Roger Johnson (1994), it involves students working in four- or five-member heterogeneous groups on assignments. The groups hand in a single completed assignment and receive praise and rewards based on the group product. This method emphasizes team-building activities before students begin working together and regular discussions within groups about how well they are working together.

Cooperative Scripting

Many students find it helpful to get together with classmates to discuss material they have read or heard in class. A formalization of this age-old practice has been researched by Slavin, (1991) and his colleagues. In it, students work in pairs and take turns summarizing sections of the material for one another. While one student summarizes, the other listens and corrects any errors or omissions. Then the two students switch roles, continuing in this manner until they have covered all the material to be learned. A series of studies of this cooperative scripting method has consistently found that students who study this way learn and retain far more than students who summarize on their own or who simply read the material (Cohen, 1992). It is interesting that while both participants in the cooperative pairs gain from the activity, the larger gains are seen in the sections that students teach to their partners rather than in those for which they serve as listeners (Slavin, 1991).

Complex instruction

Complex instruction invokes the use of status treatments to equalize academic status within working groups in order to obtain the participation of all children in the work of the group. It has two major status treatments. The first is using multiple ability curriculum, curriculum that is designed is such a way as to require the use of a variety of cognitive abilities (eg. making a list, drawing an novel machine, seeing closely, acting out a part, thinking ahead, etc.) that enable a group to complete a given group task. Multiple ability curricula have by definition a number of learning pathways available for children who are not particularly strong at the more traditional cognitive abilities of reading and writing.

Complex instruction group work looks similar to other forms of cooperative learning. As such, it utilizes classroom norms and groups roles like other forms of cooperative learning. Where Complex instruction differs from other forms of cooperative learning due to the assumptions it makes about why children participate (or don't participate) in collaborative learning groups. This is important because participation (talking and working together) is key to learning in groups (Cohen, 1994). Children who don't participate, don't learn. Children, who participate, do. Complex instruction posits that children don't fail to participate because they are too shy or don't want to participate. They don't participate because other children in the group see them as having nothing to offer to the group.

The second status intervention is called assigning competence. When a non participating child starts to make an effort to participate (because the multiple ability tasks taps strength of theirs) the teacher moves in and assigns competence to that child. This means the teacher notes what the child did and points out to the group how useful that action can be for completing its task. These two interventions are powerful enough to create the necessary talking and working together among all children in a group that leads to the impressive achievement gains characteristic of Complex Instruction (Cohen, 1994). Work with teachers is basically focused on understanding the theory behind and application of these two status interventions.

Jigsaw

In Jigsaw (Aronson, 2000), students are assigned to six member teams to work on academic material that has been broken down into sections. For example, fractions might be divided into improper fractions, mixed fractions, addition and subtraction of fractions, multiplications and division of fractions and BODMAS. Each team member reads his or her section. Next members of different teams who have studied the same sections meet in expert groups to discuss their sections. Then the students return to their teams and take turns teaching their teammates about their sections. Since the only way students can learn sections other than their own is to listen carefully to their teammates, they are motivated to support and show interest in one another's work. In a modification of this approach called Jigsaw II (Slavin, 1994), students work in four- or five-member teams, as in STAD. Instead of each student being assigned a unique section, all students tackle a common topic. However, each student receives a subtopic on which to become an expert. Students with the same subtopics meet in expert groups to discuss them, after which they return to their teams to teach what they have learned to their teammates. The students take individual quizzes, which result in team scores, as in STAD.

Mathematics teachers are expected to teach in a way that enables students to learn mathematical concept while acquiring process skills, positive attitudes, values and problem solving skills. A variety of teaching strategies have been advocated for use in a mathematic classroom ranging from teacher-centered approach to more student-centered approach. Cooperative learning is the instructional use of small group so that the students work together to maximize their own and each other's learning. It is grounded in the belief that learning is most effective when students are actively involved in sharing ideas and work cooperatively to complete an academic task.

Jigsaw is a cooperative learning technique which was first developed in the early 1970's by Elliot Aronson and his associates. Since then, many schools have used the technique with success. According to Aronson (2000) Jigsaw groups are developed in the class whereby each student in the group is assigned his/her part to work on. Then the groups are reconstituted with students having identical assignment put together. Then the students go back to their initial

Jigsaw groups to present their well organized report to the group. Just like jigsaw puzzle, each piece (Student part) is essential for the completion and full understanding of the final product thus each student is essential hence the Jigsaw instructional strategy is effective.

A study by Panitz (1996) indicates that knowledge is discovered by students and transformed into concepts students can relate to. It is then reconstructed and expanded through new learning experiences. Learning consists of active participation by the students versus passive acceptance of information in the conventional teaching. Panitz also found out that Jigsaw can be used wherever material can be segmented into separate components. Each group member becomes an expert on a different concept or procedure and teaches it to the group

Jigsaw steps according to Aronson,(2000) are:

i. *The teacher divides the students into 4 or 5 people's jigsaw groups which should be diverse of gender, ethnicity, race and ability.*
ii. *The teacher appoints one student from each group as a leader who should be the most mature in the group.*
iii. *The teacher divides the lesson into 4 or 5 segments.*
iv. *The teacher gives each student in each group a segment of what is to be learned.*
v. *The students are given time to write down their segment and become familiar with it.*
vi. *Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their specific task and also refer from the text books.*
vii. *The teacher brings the students back to their jigsaw groups.*
viii. *The teacher asks each student to present his or her task to the group*
ix. *The teacher floats from group to group observing the process. If any group is having any trouble, the teacher makes an intervention.*
x. *The teacher gives a quiz on what has been learnt to be marked by the teacher.*

(Aronson,2000: pp33)

Hanze and Berger (2007) in a study compared using the Jigsaw classroom technique with traditional direct instruction in a 12th grade physics class. Students were given a test of academic performance (pretest) and a questionnaire looking at personality variables (goal orientation, self-concept, and uncertainty orientation). The topics (Motion of Electrons and Electromagnetic Oscillations and Waves) were introduced through direct instruction in both conditions. When comparing traditional instruction and the Jigsaw classroom, there was clear difference in the learning experience. Students in the Jigsaw classroom did show higher achievement scores in areas that they had been assigned. The Jigsaw classroom students had a more favorable view of

the learning experience than those in the traditional instruction condition. Students in the Jigsaw classroom reported stronger intrinsic motivation, greater interest in the topic, and more cognitive activation and involvement. Students were more involved and more interested in the material when in the Cooperative learning setting of the Jigsaw classroom. Students in the Jigsaw classroom were seen as being more competent, more socially related to other students, and more autonomous. There was an indirect effect on performance because students viewed themselves as more competent.

2.6 Implementation of the Jigsaw Cooperative Learning Strategy in mathematics classrooms.

According to Foyle & Lyman (1988), the steps involved in successful implementation of cooperative learning activities are as follows:

i) The content to be taught is identified, and criteria for mastery are determined by a teacher.

ii) The most useful cooperative learning technique is identified, and the group size is determined by a teacher.

iii) Students are assigned to groups.

iv) The classroom is arranged to facilitate group interaction.

v) Group processes are taught or reviewed as needed to assure that the groups run smoothly.

vi) A teacher develops expectations for group learning and makes sure students understand the purpose of the learning that will take place. A time line for activities is made clear to students.

vii) A teacher presents initial material as appropriate, using whatever techniques she or he chooses.

viii) A teacher monitors student interaction in the groups, and provides assistance and clarification as needed. A teacher reviews group skills and facilitates problem-solving when necessary.

ix) Student outcomes are evaluated. Students must individually demonstrate mastery of important skills or concepts of the learning. Evaluation is based on observations of student performance or oral responses to questions; paper and pencil need not be used.

x) Groups are rewarded for success. Verbal praise by the teacher or recognition in the class newsletter or on the bulletin board can be used to reward high-achieving groups.

In this study the weakness of the use of Jigsaw teaching cooperative strategy was considered and improved upon. The teachers of the experimental groups had developed a culture of group work among their learners which includes low levels of noise allowed in the group, a no put down approach to working together and willingness to help each other. If there is no such culture, the teacher did modeling in a classroom setting which happened effectively by use of fishbowl method. In this method the teacher sets up one group in the room and all other students in the class are seated around the group watching how it works, while the teacher instructs it and gives commentary along the way.

The teachers in experimental schools organized groups so that students were mixed as heterogeneously as possible according to gender, academic abilities, and race. To avoid dominance in the Jigsaw groups by the more talkative students, the teachers in the experimental schools selected a leader in each group in a fair manner who kept the discussion moving on well (Aronson, 2000). The teachers also moved around the classroom to monitor the students' discussions.

2.7 Gender Differences in Mathematics Achievement

Mathematics is a science subject and some gender-based science researchers have reported that what both the 'feminist empiricists' and the 'liberal feminist critics' seem to agree is that females in principle will produce exactly the same scientific knowledge as males provided that sufficient rigour is undertaken in scientific inquiry (Howes, 2002;Barton, 1998; Sinnes, 2006). They also believe that inequality in science and science education is caused by political, educational and social factors external to science. There is need therefore to give boys and girls exactly the same opportunities and challenges. In Nigeria, gender-achievement studies include Abiam and Odok (2006) who found no significant relationship between gender and achievement in number and numeration, algebraic processes and statistics. They however found the existence of a weak significant relationship in Geometry and Trigonometry.

This poor Mathematics performance of students is further worsened by gender imbalance leading to the problem which now constitutes a major research focus across the globe (UNESCO, 2003). In a study by Opolot-Okurut (2005) it was found that for all the attitudinal variables (anxiety, confidence and motivation), males had higher mean scores than females globally the issue of gender inequality in Science, Technology and Mathematics Education has produced inconclusive results, one meta analysis covering the period 1974 – 1987 on Mathematics and gender led to two conclusions: the average gender gap is very small (statistically insignificant), and the fact that the differences tend to decline with time (Friedman, 1989).Another meta-analysis of 100 studies in gender and Mathematics performance corroborated the above findings(Hyde, Fennema & Lamon, 1990). Some scholars blame the colonizers of Africa for applying direct transfer of Western Science curricula, examinations and teaching methods, which fail to address the continental challenges of Africa. Yoloye (1998) submitted that the result of this direct transfer of western curricula in science and mathematics education in most African countries that is exemplified by decontextualized knowledge being transmitted by poorly trained teachers in under-resourced and sometimes overcrowded classrooms.

According to Makau (1997), mathematics achievement is the attainment, accomplishment or successful performance in a mathematics examination, measured in scores that a candidate obtains in an examination. In Kenya, gender differences in mathematics achievement begin to appear at the upper primary school level and increase in secondary schools (Makau, 1994; Obura, 1991). In the 2007 KCSE examinations results, for instance, girls obtained a lower mathematics percent mean score of 18.5% as compared to 21.9% for boys (KNEC, 2007).

Research done by Michelle Maraffi (2006) on girls attitudes, self expectations and performance in mathematics reveals that parents and teachers' attitudes, expectations and actions with regards to girls performance in mathematics affect and has potential to improve girls' performance and that teaching style such as use of cooperation rather than competitive learning also plays a pivotal role in girls relationship with mathematics. Girls attitudes towards mathematics reinforced by their socio-cultural beliefs; modes of teacher-students interactions; boys negative attitudes towards them as mathematics learners; contribute to their low performance in the KCSE

examinations and under-representation in mathematics related courses thereafter (Eshiwani, 1984; Makau, 1994 & Mwangi, 1983). Girls are not well represented in science and technology courses in secondary and tertiary studies around the world with African girls having the lowest enrolment rates in the world. In Kenya, adolescent girls fair poorly relative to boys in an educational system characterized by enormous growth, deteriorating quality, and rising costs. Girls have been performing more poorly in the KCSE examinations than boys for the past years although women consist most of the population. Low participation of women in mathematics has serious consequences not only for women but also for a society increasingly influenced by technology.

2.8 Theoretical Framework

This study was guided by the Constructivist theory of learning espoused by Piaget (Demetriou, Shayer & Efklides, 1992). The theory of constructivism suggests that learners construct knowledge out of their experiences. Constructivism is often associated with pedagogic approaches that promote active learning, or learning by doing like the Jigsaw learning strategy. Social constructivism thus emphasizes the importance of the learner being actively involved in the learning process, unlike previous educational viewpoints where the responsibility rested with the instructor to teach and where the learner played a passive, receptive role (Tobias & Duffy, 2009).

Formalization of the theory of constructivism is generally attributed to Jean Piaget, who articulated mechanisms by which knowledge is internalized by learners (Piaget, 1973. According to the social constructivist approach, instructors have to adapt to the role of facilitators and not teachers (Bransford, 2000). Whereas a teacher gives a lecture that covers the subject matter, a facilitator helps the learner to get to his or her own understanding of the content. In the former scenario the learner plays a passive role and in the latter scenario the learner plays an active role in the learning process. The emphasis thus turns away from the instructor and the content, and towards the learner. A teacher tells, a facilitator asks; a teacher lectures from the front, a facilitator supports from the back; a teacher gives answers according to a set curriculum, a facilitator provides guidelines and creates the environment for the learner to arrive at his or her

own conclusions; a teacher mostly gives a monologue, a facilitator is in continuous dialogue with the learners (Rhodes & Bellamy, 1999).

Social constructivist scholars view learning as an active process where learners should learn to discover principles, concepts and facts for themselves, hence the importance of encouraging group work in learners. McMahon (1997) agrees that learning is a social process. He further states that learning is not a process that only takes place inside our minds, nor is it a passive development of our behaviours that is shaped by external forces and that meaningful learning occurs when individuals are engaged in social activities. This is evident in the Jigsaw cooperative strategy where there is social interaction by learners and teachers in the learning process in the group work. Jigsaw cooperative learning strategy is one of the strategies that learners with different skills and backgrounds collaborate in tasks and discussions to arrive at a shared understanding of the truth in a specific field (Duffy & Jonassen, 1992).

2.9 Conceptual Framework

The conceptual framework of the study was based on the Ausubel's model of meaningful reception learning and systems theory developed by Ayot and Patel (1987). The framework shows Jigsaw teaching strategy as an intervention in the teaching and learning process of mathematics. The representation of the relationship among variables within the conceptual framework is shown in Figure 1.

-Jigsaw learning strategy. -Conventional learning/teaching methods. -Gender of the learners.	Teacher characteristics. -Training -Experience.	Student's achievement in mathematics. -scores
Independent variables	**Extraneous variables**	**Dependent variable**
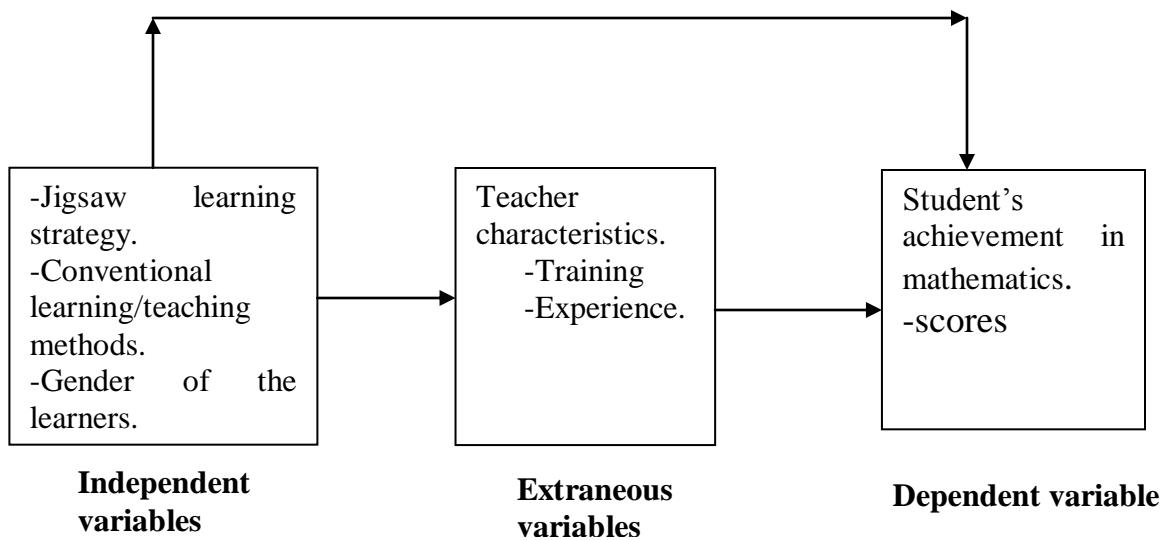
Figure 1: The Diagrammatic Representation of the Relationship Between the independent, extraneous and dependent variables of the Study.

The framework shows the dependent variable in this study as the students' achievement in Surds and Further Logarithm. The independent variables were the Jigsaw learning strategy presented to students, the 'conventional' or traditional learning/teaching methods and the learners' gender. Jigsaw cooperative learning strategy was hypothesized to influence positively students' achievement in mathematics as compared to the use of 'conventional' or traditional teaching method .The extraneous variables which could have influenced the outcome of the study were the teachers' characteristics which was controlled by using teachers who have a minimum qualification of a diploma in education and have taught form three class for at least 2 years.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

This chapter gives a description and rationale of research methodology used. It describes the research process that was used in the study which includes the research design, location of the study, population, sampling procedures and sample sizes, instruments used, data collection procedures and data analysis. A summary of statistical tests that were used in the testing of the hypotheses is given.

3.2 Research Design

The study used a quasi-experimental research method to explore the relationship between variables, as the subjects are already constituted and school authorities don't allow reconstitution for research process (Borg & Gall, 1989).This study used the Solomon 4-group; non equivalent control group design which is appropriate for experimental and quasi-experimental studies (Ogunniyi, 1992).The design overcomes external validity weaknesses found in other designs and also provides more vigorous control by having two control groups as compared to other experimental designs. This design involves a random assignment of intact classes to four groups.

GROUP	NOTATION
E_1	0_1 X 0_2 (Experimental group)
C_1	0_3 - 0_4 (Control group)
E_2	- X 0_5 (Experimental group)
C_2	- - 0_6 (Control group)

Figure 2: The Solomon 4-group, non-equivalent control group design.

In Figure 2, the variables are defined such that: O_1 and O_3 are pretest; O_2, O_4, O_5, O_6 are post-test; and X is treatment. Group E_1 received pre-test, treatment and post test; Group C_1 received pre-test and post test without treatment; Group E_2 received the treatment and post-test; Group C_2 received post-test only. Two schools were experimental schools and in the experimental schools one received post test only while the other received post test and pre-test. The other two schools were control schools and in the control schools, one received post test only while the other school received post test and pre-test. The effects of maturation and history were controlled by having two groups taking pre- test and post tests. To avoid contamination, the treatment and control groups were from different schools. The regression effects were taken care of by two groups not taking pre-tests.

The pre-test was treated as a normal classroom test that students regularly take in the course of instruction while the post test was taken as a normal test that is administered after a topic has been covered. The mathematics teachers in the two experimental schools were given a guide on how to teach the topic by the researcher when students were on recess. However, only the results from one stream in each school were analyzed and used for the testing of the hypotheses of the study.

3.3 Location of the study

The study was conducted in Laikipia East District, Rift Valley Province of Kenya. It targeted all secondary schools students. Laikipia East District was chosen because it was among the low performing district in mathematics in K.C.S.E examinations in Rift valley province for the past three years. According to the Area Education Officer (AEO), mathematics has been performed poorly in the district over the years.

3.4 Population of the Study

The schools that participated in the study were from Laikipia East District. The target population was secondary school students in Laikipia East District. The target population was 10,800 students. The accessible population was form three mathematics secondary school students in the District mixed-sex school in Laikipia East district because the topic surds and logarithms is taught at this level (KIE, 2000). Also Form three class is a mature group of students and not an

examination class. The District has about 2000 form three students. There is1 provincial school and 32 district schools in Laikipia East District. 27 of the 32 District schools are mixed-sex schools. The mixed-sex schools were used for this study so as to capture the boys and girls in the same class subjected to the same learning environments. Laikipia East District was chosen for this study because of its dismal performance in mathematics compared with other Districts in Rift valley Province.

3.5 Sampling Procedure and Sample Size.
Simple random sampling was employed to select four schools out of the possible 27 mixed-sex District schools in the District. Balloting was used to select the sample schools. Four schools were chosen because the Solomon 4 group design requires four groups. Each school formed a group in the Solomon 4 group design so that interaction by the subjects was minimized during the exercise. The assignment of groups to either experimental or control groups was done by simple random sampling. The classes used for the exercise were composed of 40 students. According to Mugenda and Mugenda (1999) the required size is at least 30 per group.

3.6 Instrumentation
The Mathematics Achievement Test (MAT) was used to collect the required data. The same instrument was used to collect data for the pre test and the post test. The MAT was developed by the researcher. It was a 36 item instrument that tested the student's knowledge, comprehension, application and mathematical skills on working out short answer questions that was set on all the subtopics of surds and further logarithms. The total score for the instrument were 80 marks. These scores were distributed to 36 items. The items were allocated between is 1 to 3 marks each. It was pilot tested in a school that was not be used for study in Laikipia East District.

3.6.1 Validity of the Instrument.
Validity is the degree to which results obtained in the analysis of the data actually represent the phenomenon under study (Mugenda & Mugenda, 1999). The developed instrument was modified to answer the set objectives of the study. The instrument was validated by four experts in education research from the Faculty of Education and Community Studies, Egerton University, to assess the content, construct and face validity. Their comments were incorporated into the

instrument before being taken to the field. This showed that the items in the instrument were precise and comprehensive enough to provide to the anticipated type of data and also determined that the research objective was achieved.

3.6.2 Reliability of the Instrument

According to Gay and Airasian (2003), the more reliable a test is, the more confidence we can have that scores obtained from the administration of the test are essentially the same scores that would be obtained if the test were re-administered. The MAT was pilot tested in a school which was not used in the study in Laikipia East district. According to Coolican (1994), there is a significant need for a researcher to carry out a pilot study before the actual field work so as to discover the flaws in research instrument and hence permit their necessary refinement. Reliability of the instrument was estimated using Cronbach's coefficient alpha, which is suitable when items are not dichotomously scored (Gall, Gall & Borg, 2003, Frankel & Wallen, 2000). Cronbach's alpha assesses the homogeneity of the items and uses one administration of the instrument. The result of the reliability estimate of the MAT was obtained as 0.87. The instrument met the threshold reliability coefficient of 0.70 and higher which is recommended (Gall, Gall & Borg, 2003; Frankel & Wallen, 2000; Mugenda & Mugenda, 1999).

3.7 Data Collection Procedures

The study commenced after obtaining the research permit from the national council of science and technology. Then the DEO Laikipia East was approached to allow for data collection in the district. The researcher then moved to the schools used for the research and approached the principles seeking permission to be allowed to collect data in their schools. The researcher then distributed the pre-test to one of the control and one of the experimental schools. The topics surds and further logarithms were taught in the experimental schools using Jigsaw learning strategy. The same topics were also taught in the control schools at the same time using conventional teaching strategy. The researcher then distributed the post test to the four schools. The researcher then obtained results of the pre tests and post tests from the schools.

3.7.1 How Jigsaw Learning Strategy was used to Teach

The topics that were taught by use of Jigsaw cooperative learning strategy are Surds and Logarithms to form three students. The subtopics of Surds are; rational and irrational numbers, operation on Surds, rationalizing the denominator and applications of Surds. The subtopics of Further Logarithms are logarithmic notations, laws of logarithms, logarithmic expressions and, logarithmic equations. Appropriate group work for each of the sub topics were constructed and used during instruction at the beginning of each mathematic lesson. For each of the subtopic to be taught the ten steps of creating and use of Jigsaw learning strategy as recommended by Aronson (2000-2010) were followed. The group work was assigned to the groups and each student in the group assigned questions. The students with the same questions formed the expert group where they discussed their questions. The students then went back to their initial group to present their findings to the other members of the group. All this was done with close supervision of the teacher. The teachers then evaluated the learners by asking questions and marking the students' work. The teachers then at the end of the topic gave a post test which was distributed to them by the researcher.

3.8 Data Analysis

The software that was used for data analysis was the SPSS. The scores obtained from pre-test and post-test for experimental group was compared in terms of mean scores and standard deviation. Paired samples t-test at coefficient alpha level of 0.05was used in order to find out whether there was any significant difference before and after the implementation of Jigsaw cooperative learning in the mathematics class. Besides this, the scores obtained from the post-test for the four groups were analyzed using one-way ANOVA. The ANOVA was used because the groups were more than two. The scores of the post test were also analysed using ANCOVA with the KCPE results of the students used as the covariate. KCPE results were used because it is national examination which was uniform for all the students.

Paired samples t-test at coefficient alpha level of 0.05was used in order to find out whether there was any significant difference in mathematics achievement in gender after the implementation of Jigsaw cooperative learning in the mathematics class.

Table 4

A Summary of Data Analysis

Hypotheses	Independent variable	Dependent variable	Statistical Methods
Ho1:There is no statistically significant difference in mathematics achievement between students who were taught mathematics using the Jigsaw cooperative learning strategy and those who were taught using the conventional teaching/learning methods in secondary schools.	-Jigsaw cooperative learning strategy. -Conventional teaching/learning methods.	Student's mathematics achievement scores.	t- test ANOVA ANCOVA
Ho2: There is no statistically significant gender difference in achievement among secondary school students when taught surds and further logarithms using Jigsaw learning strategy.	Learner's Gender	Student's mathematics achievement scores	Paired t-test

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

In this study Jigsaw learning strategy was used to learn the topics surds and further logarithm in form three classes of secondary schools in Kenya. This chapter presents the results of the study using both descriptive and inferential Statistics. The quantitative results are presented in form of tables. A total of 160 Form three secondary school students took part in the study. Out of the total, 75 were girls and 85 were boys. All the 160 subjects were exposed to the same content on surds and further logarithms over a period of three weeks. The experimental group learnt through Jigsaw learning strategy while the control group learnt through the conventional teacher directed learning/teaching method. Two null hypotheses were addressed and tested at the coefficient alpha (ά) level of 0.05 namely:

Ho1; There is no statistically significant difference in students' mathematics achievement
between students who are taught mathematics using Jigsaw Cooperative Learning Strategy
and those taught using Conventional Learning/Teaching Methods.

Ho2; There is no statistically significant gender difference in achievement among secondary
school students when taught Surds and Further logarithms using Jigsaw Learning Strategy.

Each of the two hypotheses is restated, results presented in tabular form and finally a conclusion made indicating whether the hypothesis is rejected or accepted at stated level of significance. The results and discussion are presented in the order in which the hypotheses are stated.

4.2 Pre- test analysis

Prior to treatment, data was collected from the subjects in experimental 1 (E1) and control 1 (C1) groups using a MAT on the topics Surds and Further logarithms to make it possible for the researcher to assess the homogeneity of the groups before treatment application. Table 5 shows

the pretest results obtained by groups E1 and C1 on the MAT. The scores of the learners were fed to the computer and SPSS program was used to generate the results.

Table 5

Pre-test mean scores on MAT and t-value results

Leaning Method	N	Mean	SD	df	t-test	p-value
Experimental 1	38	16.47	11.72	74	0.879	0.382
Control 1	38	14.18	10.98			

*Critical values (df= 120, t=1.98, p<0.05)
Calculated values (df=74, t=0879, p=0.382)

The results shown in Table 5 above indicate that the differences between mean scores of groups E1 and C1 on the MAT was not statistically significant at the ά=0.05 level using the t-value. t test was used because after thirty subjects t-value is the same as z-value. The P-value is greater than 0.05, an indication that the groups are homogeneous thus suitable for the study. Further, comparison by gender of students' pretest MAT based on the topics Surds and Further logarithms mean scores was done as shown in the Table 6.

Table 6

Comparison by Gender of Students' Pre-Test MAT Scores

Gender	N	Mean	SD	df	t-value	p-Value
Male	43	15.93	9.98	74	0.525	0.601
Female	33	14.54	13.02			

*Critical values (df= 120, t=1.98, p<0.05)
 Calculated values (df=74, t=0.525, p=0.601)

The results in the Table 6 above indicate that there are no statistically significant differences between boys and girls in the pretest scores using t-value at alpha level of 0.05. This is an indication that the groups are homogeneous and comparable.

4.3 Effects of the Jigsaw Learning Strategy on the Students' Achievement.

The performance of both experimental and control groups on the MAT were used to compare the effectiveness of the two learning methods; Jigsaw learning strategy and the conventional teaching method on the subjects' achievements. The results presented in Table 7 shows the comparisons by learning method of the students' MAT mean gain on E1 and C1 groups. Mean gain is the difference between the pretest and the post test score of the same group.

Table 7

Comparison of the Mean Score Gain Obtained in the MAT for E1 and C1

Learning method	N	Post-test	Pre-test	Mean Gain	df	t-value	p-value
Experimental 1	37	29.58	16.47	13.68	73	6.86	0.000*
Control 1	38	14.95	14.18	0.76			

*Critical values (df= 120, t=1.98, p<0.05)
Calculated values (df=73, t=6.86, p=0.000)

The data presented in Table 7 indicate that the mean gain of the E1 group is 13.68 and the mean gain of C1 group is 0.76. Thus the mean gain of E1 group is higher than the mean gain of C1 group. Further statistical test using t-test at alpha (ά) level of 0.05 also shows that there is a significant difference between the mean scores of the E1 and C1 groups (P < 0.05). This difference can be attributed to the Jigsaw learning strategy influence on the students' achievement on the mathematics topics surds and further logarithms. Analysis of the students' post-test was also carried out. Table 8 show the distribution of the post test mean scores obtained by the subjects on the MAT.

Table 8

Students' means score in the MAT Obtained by the Students in the Four Groups

Learning Method	N	Mean	SD
Experimental 1	40	29.58	16.56
Experimental 2	42	33.79	13.58
Control 1	38	14.95	11.95
Control 2	40	16.96	9.91

The result presented in the Table 8 indicates that the posttest mean scores of the experimental groups (E1 and E2) are higher than the posttest mean scores of the control groups (C1 and C2). This is a strong indication that before the start of the mathematics topics, the subject achievement levels were similar in that their differences were not significant in the MAT pretest. However, after their exposure to the topics surds and further logarithms, there was a marked difference on their post test scores in the E1 and E2 groups. However, a further analysis using the ANOVA test was deemed necessary to establish whether or not the difference in the mean scores is statistically significant at the $\acute{\alpha}= 0.05$ level. The comparison of the post-test mean scores using One-way ANOVA is shown in Table 9.

Table 9

Comparison of Students' Post-Test MAT Scores using ANOVA

Source	Sum of squares	df	Mean square	F-ratio	p-Value
Between groups	10352.778	3	3450.926	19.671	.000*
Within groups	27367.716	156	175.434		
Total	37720.494	159			

*Critical values {(df=3,100),F=2.70, p<0.05)}

 Calculated values {df=(3,156),F= 19.671, p=0.000}   Fcal>Fcritical

The one-way ANOVA test results shown in Table 9 indicate that there is a statistically significant difference between the mean scores of the experimental groups and that of the control groups ($P < 0.05$).While these results indicate that they are statistically significant, they however do not show us in which direction the difference is. As such, a further analysis using Scheffe's Post HOC tests of multiple comparisons was done yielding the results presented in Table 10. Scheffe's method was preferred since the sizes of the subsamples selected from the different populations were not equal; moreover, comparisons other than simple pair-wise between two means were not of interest (Kleinbaum &Kupper, 1978).

Table 10

Post Hoc Comparisons of the MAT Post-Test Scores for the Four Groups

(I) Learning method(J)	Learning method	Mean difference (I – J)	p - Value
Experimental 1	Experimental 2	-4.21	.559
	Control 1	14.63*	.000
	Control 2	12.60*	.001
Experimental 2	Experimental 1	4.21	.559
	Control 1	18.84*	.000
	Control 2	16.81*	.000
Control 1	Experimental 1	-14.63*	.000
	Experimental 2	-18.84*	.000
	Control 2	-2.03	.928
Control 2	Experimental 1	-12.60*	.001
	Experimental 2	-16.81*	.000
	Control 1	2.03	.928

* Statistically significant at Alpha (ἀ) = 0.05 p<0.05

The results in Table 10 reveal that there is a statistically significant mean score difference between the experimental groups and control groups. The results also indicates that there is no statistically significant mean score difference between two experimental groups or two control groups. For instance, the mean difference between E1 and C1 and E2 and C2, was statistically significant ($P < 0.05$). But the mean difference between E1 and E2 ($P = -4.21$) and C1 and C2 ($P = -2.03$) was not statistically significant.

The main threat to the internal validity of non-equivalent control group experiments is the possibility that the group differences on the post-test may be due to initial or pre-existing group differences rather than to treatment effect (Gall *et al*., 1996). Since this study involved non-equivalent control groups it was necessary to confirm the above results by performing analysis of covariance (ANCOVA) using the students' Kenya Certificate of Primary Education (KCPE) mathematics scores as the covariate. KCPE scores were used because it is a national examination and uniform for all the students. ANCOVA reduces the effects of initial group differences statistically by making compensating adjustments to post-test means of the groups involved (Gall *et al*., 1996; Borg and Gall, 1989). The adjusted students post tests MAT mean scores are shown in Table 11.

Table 11

The Adjusted Students' Post-Test MAT Means Scores using KCPE Mathematics Scores as the Covariate

Learning method	Mean
Experimental 1	27.56
Experimental 2	34.94
Control 1	15.17
Control 2	16.76

The post test means for experimental schools were higher than the post test means of control schools with a difference of more than 10 scores. The adjusted students' post-test MAT mean

scores were then compared using ANCOVA to find out if there were any statistical significant difference at alpha (ȧ)level of 0.05.

Table 12

 ANCOVA of the Post-test Means Scores on the MAT

Source	Sum of Squares	df	Mean Square	F-ratio	p-Value
Contrast	10352.778	3	3469.067	24.212	0.000*
Error	27367.716	153	143.277		

*Critical values (df= 120,F=2.70, p<0.05)

Calculated values (df=3, F=24.212, p=0.000)

The ANCOVA test results shown in Table 12 indicate that there is a statistically significant difference between the mean score of the experimental groups and that of the control groups. However these results do not give us the differences between the specific groups. Hence, there was need for further analysis using Scheffe post HOC test which yielded the results presented in Table 13 on page 47.

Table 13

 Multiple comparison of the Students' Post-test MAT Scores

(I) Learning method	(J) Learning method	Mean difference (I – J)	p - value
Experimental 1	Experimental 2	-7.38*	.008
	Control 1	12.39*	.000
	Control 2	10.80*	.000
Experimental 2	Experimental 1	7.38*	.008
	Control 1	19.77*	.000
	Control 2	18.18*	.000
Control 1	Experimental 1	-12.39*	.000

46

	Experimental 2	-19.77*	.000
	Control 2	-1.59	.559
Control 2	Experimental 1	-10.80*	.000
	Experimental 2	-18.18*	.000
	Control 1	1.59	.559

* Statistically significant at Alpha (ά) = 0.05 level. P<0.05

The same results indicated by the ANOVA are registered in ANCOVA as shown in Table 13 with an exception of the mean differences between the experimental groups. By using ANCOVA tests, there was a significant difference between the groups E1 and E2 and between E2 and E1 (P<0.05) but no significant difference between the control groups. The differences in the experimental schools was not expected which could be as a result of the state of the schools whereby one school (E1) was purely day school and the other (E2) was a boarding school. Hence E2 did better than E1 because they had more practice time creating the differences. Moreover, the absolute difference between two experimental schools was 7.38 and between control groups and experimental groups were in all instances greater than 10. This showed that the absolute difference was lower between two experimental schools. The hypothesis suggesting that there was no statistically significant difference in students' Mathematics achievement between students who are taught mathematics using Jigsaw cooperative learning strategy and those taught using conventional teaching method was rejected.

4.4 Effect of the Jigsaw Learning Strategy on Gender Differences in Students' Achievement in Mathematics

Hypothesis two of the study sought to find out whether there were statistically significant gender differences in achievement among secondary school students when taught surds and further logarithms using Jigsaw Learning Strategy. To test the hypothesis, the mean gain obtained by male and female subjects exposed to Jigsaw learning strategy were compared by use of t-value at alpha (ά) level of 0.05 as shown in Table 14.

Table 14

47

Comparison of the Students' MAT Mean gain Score by Gender

Gender Gain	N	Post-test	Pre-test	Mean	df	t-value	p-value
Male	42	22.95	15.93	7.02	73	0.098	0.922
Female	33	21.83	14.55	7.28			

Critical values (df= 120, t=1.98, p<0.05)
Calculated values (df=73, t=0.098, p=0.922)

The results presented in Table 14 reveal that boys' mean gain was 7.02 and girls' mean gain was 7.28 in the MAT. Further statistical tests show that there was no statistical significant difference between girls and boys achievement after using the Jigsaw learning strategy (P>0.05).The girls' mean gain was slightly higher than boys' mean gain. This may be attributed to the Jigsaw learning strategy which uplifted girls' performance in mathematics.

Table 15

Comparison by Gender of Students' Post-test MAT Scores

Gender	N	Mean	SD	df	t-value	p-Value
Male	85	24.98	14.68	158	0.80	0.423
Female	75	21.01	16.22			

*Critical values (df= 120, t=1.98, p<0.05)

Calculated values (df=158, t=0.80, p=0.423)

Table 15 indicates no statistically significant gender differences in the students' mathematics achievements. Both male and female students performed relatively the same. Further comparisons by gender of students' MAT mean scores in each group was done. Comparison by gender of students MAT mean scores in each group confirms no differences between performance of boys and girls as shown in Table 16.

Table 16

Comparison of students' MAT mean scores by gender and learning method

Gender	N	Mean	SD	DF	t-value	p-value
Experimental 1						
Male	22	28.50	16.22	39	.449	.656
Female	18	30.89	17.34			
Experimental 2						
Male	24	32.96	13.08	40	.451	.654
Female	18	34.89	14.53			
Control 1						
Male	21	17.15	11.40	36	1.270	.212
Female	17	12.24	12.39			
Control 2						
Male	18	19.17	11.71	38	1.276	.210
Female	22	15.18	7.99			

* Statistically significant at Alpha (ἀ) = 0.05 level. P<0.05

4.5 Discussions

4.5.1 Effects of the Jigsaw Learning Cooperative Strategy on Students' Achievement

HypothesisHo1 sought to find out whether there were statistically significant differences in students' mathematics achievement between students who are taught mathematics using Jigsaw Cooperative Learning Strategy and those taught using Conventional Learning/Teaching Methods. In the findings of this study, the Ho1 was rejected. These findings support earlier studies that concluded that the use of the Jigsaw learning strategy improved achievement scores compared to the conventional teaching methods (Hanze & Berger, 2007).

The results further confirm Burns (1984) assertion that Jigsaw learning strategy results to high achievement because the learners do the challenging and engaging tasks in their experts groups with enthusiasm since they know they are the only one with that piece of information when they move to their respective groups. The Jigsaw learning method makes learning interesting and there is high interaction of the students. Involving students actively in learning, which is an important aspect in Jigsaw learning, encourages students' responsibility in learning (Baird & White, 1984). This is necessary in order for them to develop a variety of problem solving techniques and to transform what they have learnt for better use. Cooperative learning enhances social interaction which is essential to meet the needs of at risk students (Slavin, Leavy & Madden, 1989). Positive interactions however, do not always occur naturally and social skills instruction therefore preceded team learning in this study. The social skills taught included, effective communications, building and maintaining trust, leadership and managing conflicts as recommended by (Goodwin, 1999).

Team names also gave a sense of belonging and this ensured competition between teams rather than between individual students. Students assisted one another in the learning process and it was the duty of each member to make sure that other group members had mastered the concepts learnt in expert groups. The high achievers and low achievers learnt together because the activities required teamwork to accomplish. The method resulted in better student-student and student-teacher interactions thereby improving the students' attitudes towards mathematics hence demystifying the subject. Each type of classroom reward structure promotes a different pattern of interaction among students (D'amico & Schumid, 1997). Jigsaw learning strategy falls under a cooperative structure, which promotes collaborative interaction among learners. The control conditions were either under competitive structure which promotes cautious and defensive students-students' interaction or an individualistic structure which allows little or no student-student interaction. The cooperative structure in this study resulted in better achievement in mathematics than the competitive and individualistic structures in the control conditions. It would be desirable therefore to implement this strategy in secondary school mathematics teaching.

4.5.2 Effect of the Jigsaw Learning Cooperative Strategy on Gender in Students' Achievement in Mathematics.

The findings of this study showed that there was no significant difference in mathematics achievement between boys and girls when taught by the use of Jigsaw learning strategy. It was further found that both girls and boys performed significantly better when exposed to Jigsaw learning strategy than those who were taught through conventional teaching methods. Though there are recorded gender differences in mathematics achievement at KCSE (KIE, 2001; KNEC, 2002), studies conducted by Mondoh (2001) indicated that girls can perform as well as boys if they are given the chance to interact and discuss mathematics concept freely in mathematics classrooms. In this study Jigsaw learning strategy proved a conducive learning environment in which their sex was disadvantaged in learning mathematics. The use of Jigsaw learning strategy in teaching secondary schools mathematics could be used to reduce gender disparity in KCSE mathematics examinations.

Much research has been done regarding gender differences in achievement in mathematics. According to Costello (1991) and Mondoh (2001), there is little gender differences in overall response to statements among 11-year-old children. However, during secondary school years, girls' attitudes towards mathematics deteriorate more than those of male students (Costello, 1991). At the age of 15 male students tend to underrate, while girls tend to overrate the difficulty level and devalue their own expertise in the subject (Costello, 1991, Mondoh, 2001).The conventional whole class teaching methods may not be able to address these differences. However, the Jigsaw learning strategy in this study proved it could close this gap. Boys' and girls' participation in mathematics studies at all levels of education refers to their enrolment and extent of being retained and active in mathematics classrooms and in mathematics related courses (Abagi,1995).Girls' enrolment in Kenya's Secondary schools and Public Universities is much lower than boys. However national figures indicate that girls account for 50% of primary schools enrollment with slight variations in individual districts (Abagi, 1995). Girls are under-represented in mathematics classrooms in mathematics related courses at Kenya's tertiary Institutions (Eshiwani, 1984: Mureithi, 2000; Mwathi, 2000). Furthermore, out of 157 mathematics lectures in Kenya's public Universities, only 9 (5.7%) were females compared to

148 (94.3%) males (Mwathi, 2000). These statistics shows that girls do not like mathematics and that the underperformance in mathematics could be as a result of ineffective teaching methods of mathematics.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusions, implications and recommendations emanating from the findings of this study. The suggestions on possible areas for further research are made.

5.2 Summary of the Findings

Based on the findings of the study, the following conclusions related to the hypotheses of the study were generalized to the learners of mathematics in District mixed-sex secondary schools in Laikipia East District of Kenya.

i)   Student who are taught mathematics using Jigsaw learning strategy perform better than those taught with conventional teaching methods.

ii) Gender does not affect students' achievement in mathematics when students are taught using Jigsaw learning strategy.

5.3 Conclusion

Jigsaw learning strategy is an effective teaching method in mathematics since the findings of this study confirms that it leads to high achievement of the subject and also reduces gender disparities in mathematics achievement.

5.4 Implications of the Study

The use of Jigsaw learning strategy in teaching results in better students' performance in mathematics. The use of Jigsaw learning strategy is therefore a suitable method for teaching. Curriculum developers should encourage teachers to use this method in teaching mathematics to improve the current trend of dismal performance in mathematics especially in District schools. The teacher training colleges and universities should emphasis Jigsaw learning strategy as an effective method of teaching mathematics.

The study also demonstrates that students' gender does not affect their mathematics achievement. This implies that when Jigsaw learning strategy is used, it is likely to improve the current under-achievement of female students at KCSE mathematics examination. Consequently, improved female students' achievement would lead to better female representation to scientific and technological fields currently dominated by men.

5.5 Recommendations

The findings of this study suggest that the use of the Jigsaw learning strategy can be an effective approach to mathematic instruction. From these findings, this study proposes the following recommendations:

i) Mathematics curriculum developers should include the teaching of mathematics using Jigsaw strategy as part of the teacher education syllabus during the training of mathematics teachers. This makes it part of the curriculum which may address the problem of dismal performance in the subject.

ii) Teachers should be encouraged by education stakeholders such as the inspectorate and the K.I.E to use Jigsaw learning strategy in teaching mathematics. However, it should be used to the topics where it is applicable.

iii) During in-service training of teachers organized by the Ministry of Education Science and Technology (MOEST), such as SMASSE, the use of Jigsaw learning strategy in teaching mathematics should be incorporated. This is because the quality of teachers and the kind of training they have is a major determinant of the quality of education in any nation.

5.5.1 Recommendations for Further Research

This study suggests that the Jigsaw learning strategy can effectively improve mathematics instruction in secondary schools. However there are areas that warrant further investigations.

i) A study on other types of cooperative strategies and their effects on achievement and motivation to learn mathematics should be carried out.

54

ii) A comparative study should be conducted on the students' attitudes towards teaching using Jigsaw strategy versus when taught by conventional teaching methods.

iii) Research on the topics that can be taught effectively using Jigsaw strategy should be identified from mathematics curricula.

REFERENCES

Abagi. O.,(1995). Household-based factors and school participation of girls: Lessons from the existing Surveys. Academy Science Publishers, Nairobi, Kenya Abridged Research Report No.6.

Abiam, P. O. & Odok, J. K. (2006). Factors in Students' achievement in different branches of secondary school Mathematics. *Journal of Education and Technology.*1(1), 161 – 168. Asim, A.

Aronson, E. (May/ June 2000). *Nobody left to hate Developing the emphatic Schoolroom. TheHumanis*t, 60, 17-21.

Aronson, E., (1978) *The Jigsaw Classroom* (Beverly Hills, CA: Sage Publications,)

Ayot, H.O. & Patel, M.M. (1987) *Instructional Methods*. Nairobi, Kenya: Kenyatta University.

Baird, J., White, R. (1984) "*Improving learning through enhanced metacognition: A classroom study*", Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA 1984

Bargh, J., Schul, Y. (1980) "*On the cognitive benefits of teaching*" Journal of Educational Psychology 72 pp593-604

Barton, A. C. (1998). *Feminist Science Education*. NewYork: Teachers College Press.

Beaton, A.S; Mullis, I.V.; Martin, M.O; Gonzalez, ;. Jelly, D.L & Smith, T.A, (1996). *Mathematics achievement in the middle school years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College.

Bolaji, C. (2005). A study of factors influencing students' attitude towards mathematics in the

Borg, W.R. & Gall, M.O (1989). *Educational research: An introduction,* 5th Edn. Longman, White plains, N.Y.

Bransford, J., (2000). *How People Learn: Brain, Mind, Experience, and School (expanded edition),* Washington: National Academies Press.

Buckwell, G & Karaimu, E,. Secondary Mathematics Student's Book 3, Macmillan Kenya ltd, Kijabe street,Nairobi.

Burns, M. (1984), "*The Math Solution*". Marilyn Burns Education Associates publishers, reprinted in "Cooperative Learning in Mathematics" Neil Davidson editor, 1990

Burstein, L. (1992). The analysis of multilevel data in educational research and evaluation.

Cockcroft, W.J.. (1982). *Mathematical counts Report of the committee of inquiry into the teaching of mathematics in schools in England and Wales*. London: HMSD.

Cohen, E,(1992). Restructuring the Classroom: Conditions for productive small groups.Madison, Wisconsin center for Education Research, 1992. ed 347 639.

Cohen, E.G. (1994), "*Finding Out/Descrubrimiento: Complex Instruction In Science" Cooperative Learning* 1:30-31.

Coolican, H. (1994). *Research Methods in Psychology,* (2nd ed.). London: Hodder and Sloughlon Education.

Cooper, C., (1992), "*Coming of age*", *Cooperative Learning* vol 2 pp3-5.

Costello, J., (1991). Teaching and Learning mathematics 11-16. London: Routledge.

D'amico, M & Schumid, R.F. (1997). Psychology Applied to teaching (8th ed). New York, NY: Houghton Miffin Company.

Daris, P& R. Hersh., (1990): "*The mathematical experience*". Harmondsworth:Penguin.

David & Roger Johnson.,(2001) "An Overview of Cooperative Learning." [Online] Available: <http://www.clcrc.com/pages/overviewpaper.html>2 December 2010.

Davidson, N. (Ed.) (1990), "*Cooperative Learning in Mathematics*: A Handbook for Teachers", Menlo Park, CA: Addison-Wesley.

Dean, P.G. (1982). *Teaching and learning of mathematics*. London, Wobun Press.

Demetriou, A., Shayer, M., & Efklides, A. (1992). *Neo-Piagetian theories of cognitive development*: *Implications and applications to education*. London: Routledge.

Department of Education.,(2001). *National Strategy for Mathematics, Science and Technology.* development: Implementing the teaching and content standards in science. *School Science andMathematics*; 97(6), 302-310.

Devries, D. L. et.al., "*Teams-Games-Tournaments: Review of Ten Classroom Experiences*," Journal of Research and Development in Education 12:28-38, 1978.

Dictionary, Encyclopedia and Thesaurus (Jan 20, 2012?): The Free Dictionary. www.the freedictionary. com

Duffy G. & Jonassen R.M., (1992) *Collaborative Teaching in Schools*. London: Hodder and Sloughlon Education.

Education in General and Further Education and Training. Pretoria: Government Printer.

Eshiwani, G.S., (1984). *A Study of Women's Access to Higher Learning in Kenya with Special References to Mathematics and Science Education.* Bureau of Educational Research,, Kenyatta University college, Nairobi, Kenya pp 2-4, 55-56, 65-62.

Eshiwani, G.S., 1984. A Study of Womens' Access to Higher Learning in Kenya with Special Reference to Mathematics and Science Education. Bureau of Educational Research, Kenyatta University College, Nairobi, Kenya pp. 2-4, 55-56.

Felder, R.M., (1997). e-mail *communication from felder*@eos.ncsu.edu WWW page *http://www.ncsu.edu/unity/lockers/users/f/felder/public/rmf.html.*

Foyle, & Lyman. L.,(1988). *Interactive learning.* Videotape currently in production. (For further information, contact Harvey Foyle or Lawrence Lyman, The Teacher's College, Emporia State University, 1200 Commercial St., Emporia, KS 66801.)

Frankel, J.R and Wallen, N.E. (2000) *How to Design and Evaluate Research in Education*, Newyork, NY: Mc Graw-hill Company Inc.

Friedman, L. (1989). Mathematics and the gender gap: A meta analysis of recent studies on sex differences in Mathematical tasks. *Review of educational Research,* (59),185 – 213.

Gall, M.D., Gall. J,P. & Borg, W. R. (2003). Education Research: An Introduction (7th ed) Newyork: Person Education Inc.

Gay, L.R. and Airasian,P. (2003).*Education research: Competences for analysis and application*. Upper saddle River, merit prentice Hall.

Gerlach, V.S. & Ely,D.P. (1980) *Teaching and Media. A systematic approach*. Englewood Cliffs, N.J.:Prentic-Hall.

Gibbons, S; Kimmel, H and O'Shea, M. (1997). Changing teacher behaviour through Training.NewYork: Teachers College Press.

Githua, B. N. (2002) *Factors related to the motivation of learn mathematics among secondary school students in Kenya's Nairobi Province and three districts of Rift valley thesis*; Egerton University Njoro; Kenya.

Glassersfeld, E. (1989). Cognition, construction of knowledge, and teaching. Synthese, 80(1), 121-140.

Glassersfeld, E. V. (1991). *Radical Constructivism in Mathematics Education.* Boston. Kluwer Academic Publishers.

Goodwin,M.W.(1999). Cooperative Learning and Social Skills to Teach and how to Teach them. Interventions in School & Clinic, 35, 29-34.

Hagman, J., Hayes, J. (1986) *"Cooperative learning: Effects of task, reward, and group size on individual achievement"*Technical report 704, Scientific Coordination Office, US Army Research Institute for the Behavioral Sciences, ERIC document #278720.

Hanze, E.& Berger W., (2007), "*Restructuring the classroom: Conditions for productive small groups",* Review of Educational Research   Spring 1994 vol 64 pp1-35

Howes, E. V. (2002). *Connecting girls and science. Constructivism, feminism, and education reform*. NewYork: Teachers College Press.

Howie ,S.J., (2001). *Third International Mathematics and Science Study Repeat (TIMSS-R)*. Pretoria: Human Sciences Research Council.

Howie, S.J., (2003). Language and other background factors affecting secondary pupils' performance in Mathematics in South Africa. *African Journal of Research in Mathematics Science andTechnology Education,7;1-20.*

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance. A meta-analysis. *Psychological Bulletin*, 107, 139 – 155.

Janke, R. (1980) "*Computational errors of mentally-retarded students"* Psychology in the Schools 17 pp30-32

Johnson, D. W. (1973) "*Communication in conflict situations: A critical review of the research",*International Journal of Group Tensions 3 pp46-67.

Johnson, D.W, Johnson,R.T and Holubec.E.J.,(1993). Circles of learning: Cooperation in the Classroom, 4th edition. Interaction book.

Johnson, D.W. & Johnson, R.T. (1994). *Cooperative learning*: What special educators need to know. The Pointer, 33, 5-10.

Johnson,D.W,Johnson,R.T.,& Holubec ,E.J.(1994). *Cooperative learning in the classroom*. VA: Association for supervision and Curriculum development.Junior Secondary Schools; Mathematics teaching in Nigeria. Retrieved on Nov. 2005 from*http://www2.ncsu.edu/ncsu/aern/bolajim.html*.

Kagan, S. (1986) "*Cooperative learning and sociological factor in schooling" in "Beyond language: Social and cultural factors in schooling language minority students."* Los Angeles,CA: California State University Evaluation, Dissemination and Assessment Center.

Kagan, S. (1994*). Cooperative leaning*. Son clemente Califonia: Kagan Publishing.

Kagan, S.,(1985) Cooperative Learning: Resources for Teachers (Riverside, CA: University of California).

Kenya National Examinations Council (2010) *KCSE Mathematics reports in Kenya*, Government Printers, Nairobi, Kenya.

KIE (2000-2007), *Examination report*, Vol 1. Kenya Institute of Education, Nairobi, Kenya.

Kleinbaum, D.J & Kupper, L.L, (1998). Applied regression analysis and other multivariate methods. Massachsetts: Duxbury.

Kort, M.S., (1992) "*Down from the podium" in "New Directions for Community Colleges*", San Francisco, CA: Josey-Bass.

Kulik, J.A., Kulik, C.L., (1979), "College Teaching" in Peterson and Walberg (Eds.) *"Research in Teaching: Concepts, findings and implications"*, Berkeley, CA: McCutcheon Publishing.

Levin,H., Glass,G., Meister, G., (1984), "*Cost-effectiveness of Educational Interventions",* Stanford, CA: Institute for Research on Educational Finance and Governance.

Macharia, K.,Githua, B., Mboroki, G., (2009). *Methods of instructions*. Kijabe: Kenya.

Makau, B.M, (1994), *In:Paper Presented at the National Symposium of Education for Girls at Garden Hotel*, Machakos, Kenya.March 21-24.

Makau, B.M., (1997). *Measuring and analyzing gender differences in primary and secondary Schools. In: Research Framework* No. 2. Academy Science Publishers, Nairobi, Kenya. Pp 8-15.

Maraffi, M. (2006) Girls Attitude, Self-Expectations, and performance in mathematics. An Annonated Bibliography. [online]. Available:http://www.mathforum.org/ Last visited 15/07/10.

Mcmahon, W.S.,(1997) *Social Learning* Stanford, CA: Institute for Research on Educational Finance and Governance.

Meier, M., & Panitz, T., (1996), "*Ending on a high note: Better enfings for classes and courses".*College Teaching, Fall 1996.

Mondoh, H.O. (2001). Comparative actitivities carried out by boys and girls during their free time in relation to their achievement in mathematics: A Case study of Eldoret municipality , Kenya, *Journal of Education and Human Resources*.pg.59-61.

Mondoh, H.O., (1991). *An investigation of teaching effectiveness and students' achievement in mathematics*. Unpublished doctoral thesis Bananas Hindu University India.

Mugenda, M.O. & Mugenda, A.G. (1999). Research methods. *Qualitative and quantitative approaches.* Nairobi, Kenya: CTS Press.

Mureithi, E. (2000). Women in Mathematics. Strengthening Mathematics and Computer Science Training and Research in Kenyan Universities. In Proceedings and recommendation of a workshop and Computer science: Chiromo Campus University of Nairobi: 27th February- 4th march.

Mwangi, D. T., (1983). *Factors influencing the performance and learning of mathematics in secondary school students in Kenya.*In: KERA Research Report No. 24. Bureau of Education Research, Kenyatta University College, Nairobi, Kenya, pp. 5-10.

Mwathi, C., (2000). Women lecturers in Mathematics: Strengthening Mathematics and computer science training research in Kenyan Universities. In: Proceedings and research.

Naidoo, D.,(2004). Linking the utilization of research findings to research in MST education. Paper presented at the *12th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*. University of Cape Town.*chnology Education*, 7:1-20.

Neer, M.R. (1987), "*The development of an instrument to measure classroom apprehension",* Communication Education 36, pp154-166.

Nelson, J. R. & Johnson, A. (1996). Effects of Direct Instruction, Cooperative Learning and Independent Learning Practices on the Classroom Behavior of Students with Behavioral Disorders: A Comparative Analysis. *Journal of Emotional & Behavioral Disorders*, 4, 53-63.

O' connor, M. (2000). *The open-ended approach in mathematics Education.* Nairobi; Kenya SMASSE Project.

Obura, A.P., (1991).Changing Images: *Portrayal of Girls and Women in Kenyan Textbooks*. African Center for Technology Press, Nairobi, Kenya.

OECD. (2003). *The PISA 2003 assessment framework.* Paris, France.

Ogunniyi, B.M (1992). *Understanding research in social science*. Nigeria: Journal of Equipment Education.

Ogunniyi, B.M., (1996). Science, Technology and Mathematics. The Problem of Developing Critical Human Capital in Africa. *International Journal of Science Education*, 18(3), 284.

Opolot-Okurot, C. (2005). Student attitudes toward mathematics in Uganda Secondary Schools. *African Journalof Research in Mathematics, Science and Technology Education*, 9 (2), 167-174.

Orton A. & Frobisher L. (1996*). Insights in Teaching Mathematics*. London Cassel.

Panitz, T (1996), *"Getting students ready for cooperative learning", Cooperative learning and College Teaching*, v6 N2, winter 1996.

Parker, R &M. Hetherington (1999): "*Child Psychology: A Contemporary view point.*" Boston: Mc Graw Hill.

Peterson, P., Swing, S., (1985), *"Students cognitions as mediators of the effectiveness of small-group learning",* Journal of Educational Psychology 77(3) pp299-312.

Piaget, Jean. (1973). *To Understand is to Invent.* New York: Grossman. (http://curriculum.calstatela.edu/faculty/psparks/theorists/501const.htm).

Piaget. J.,(1967)*Constructivism in Science and Mathematics Education*, Michael R. Matthews..

Prater, M.A., Bruhl, S. & Serna, L.A. (1998). Acquiring Social Skills through Cooperative Learning and Teacher-Directed Instruction. *Remedial and Special Education*, 19, 160-172. *Review of Research in Education*; 8, 158-223. Federal Republic of Nigeria 2004: NationalPolicy on Education (Revised), NERC.

Rhodes, S ., & Bellamy,G., (1999) Teaching of Mathematics and Sciences Washington, DC: National Education Association.

Saitoti G (2000) Key note address. *Strengthening mathematics and computer science and Research inKenyan Universities*. Proceedings and recommendations of career improvement workshop in mathematics and computer science at Nairobi University, Chiromo campus on 27/2-4/3/2000.

Schlemmer, P., Schemmer, D. (2008). *Teaching beyond the test:* Differented project-based learning in a standard-based age.Minneapolis, MN:Free spirit.

Schunk, D., Hanson,A., (1985), *"Peer models: Influence on children's self-efficacy and achievement",* Journal of Educational Psychology 77(3) p313

Schwartz, D.L., Black, J.B., Strange, J., (1991), "*Dyads have fourfold advantage over individuals inducing abstract rules",*Paper presented at the annual meeting of the American Educational Research Assn . Chicago.

Sharan, S,(2006). Group Investigation and Student Learning: An Experiment in Singapore Schools. Marshall Cavendish Academic.

Sharan, Y, (2006), Cooperative learning. Englewood Cliffs,NJ: Prentice Hall.

Sharan, Y., Sharan, C., (1976), _"Small Group Teaching",_ Englewood Cliffs,NJ: Prentice Hall.

Sinnes, A. T. (2006). Approaches to gender equity in science education. Two initiatives in sub-Saharan African seen through a lens derived from feminist critique of science. Oslo: Unipub.http://www.ils.u10.no/forskninig/palidrgrad/doktorarhandlinger/docs/AstridSinnes Avhandlingfeminist critque of science.oslo: Unipub.pdf.

Slavin, R. E.,Steven & Associates, (1978) "Learning Together: Cooperative Groups and Peer Tutoring Produce Significant Academic Gains," American Educator, Summer 1987, pp. 6-13

Slavin, R.E. (1997). _Educatioal Psychology: Theory and practice_ (5th ed).Boston: Allyn and Bacon.

Slavin, R.E., & Associates (1987). Cooperative learning and the cooperative school. Educational Leadership, 45, 7-13.

Slavin, R.E., (1994), "_Student Teams Achievement Divisions_" Journal of Research and Development in Education, 12 (June) 1978, pp39-49

Slavin, R.E., Karweit, N., (1981) "_Cognitive and affective outcomes of an intensive student team learning experience"_, Journal of Experimental Education 50 pp29-35

Slavin, R.E.,(1987), _"Cooperative Learning: Student Teams_" 2nd Ed. Washington, DC: National Education Association.

Slavin, R.E.,(1991).Student Team Learning: A practical guide to Cooperative learning. Washington, DC: National Education Association, 339 518.

Slavin, R.E.,Leavy. N.L., & Madden, N.A. (1989). _Effective Programs for Students at Risk_. Boston: Allyn and Bacon.

SMASSE, (2000)., _Mathematics Teaching Methods_. Nairobi. SMASSE.

Stahl, R. & Vansickle, R.L., (1992). Cooperative Learning in the Social Studies Classroom: an invitation to social study. Washington, DC: National Council.

Swing, S., Peterson, P., (1982), "_The relationship of student ability and small group interaction to student achievement",_ American Educational Research Journal, 19 pp259-274.

Tobias, S.; Duffy, T. M. (2009). _Constructivist instruction: Success or failure?_. New York: Taylor & Francis. ISBN 9780415994231.

Turnure, J., Ziegler (1958), "*Outer-directedness in the problem solving or normal and retarded students",* Journal of Abnormal and Social Psychology , 57 pp379-388.

UNESCO (1992), *Reports on Education*, Paris, UNESCO.

UNESCO (2003). Gender and education for all: the leap for equality. Global monitoring report 2003/2004. *http://www.unesco/oc.unesco.org/education/eta-report/2003pdf/chapter3.pdf*.

UNESCO (2008), *The School Effectiveness and Education Quality in Eastern and Southern Africa,* Paris, UNESCO.

Webb,N.M., (1982), "*Group composition, group interaction and achievement in small groups*", J 74(4) pp475-484 Journal of Educational Psychology.

Wikipedia. (2010) *Jigsaw Teaching Strategy*-Wikipedia, the free encyclopefdia. [online]. Available:*http://en.wikipedia.org/wiki/jigsaw*. Last visited 28/08/10.

Wooley,S., Switzer,T., Foster, G., Landes,N., Robertson,W., (1990), *"BSCS Cooperative learning and science program",* Cooperative Learning 11(3).

Yoloye, E. A. (1998). Students' gender and science achievement: Historical perspectives and their present and future practice. In Naido, P., & Savage, M. (Eds.), *AfricanScience and Technology in the new millennium.* Cape Town: Junta & Co.

Zemelman, S., Daniels, H. & Hyde, A. (1988), *Best practice: New standards for teaching and learning in America's schools* (2nd edition).Portsmouth, NH: Heineman.

APPENDIX A

TRAINING MANUAL ON JIGSAW

Purpose of this manual

The purpose of this manual is to assist mathematics teachers used in this study to plan and implement the jigsaw learning strategy in the topics surds and further logarithm taught to form three students. The jigsaw learning strategy improves learners' participation in the lesson as it makes learning more interesting to students and can be used to cover a large amount of material quickly.

Aim of the manual

The aim of this manual is to minimize variability among teachers when they teach the topics surds and further logarithms using jigsaw learning strategy.

Jigsaw learning strategy is a cooperative learning strategy whereby learners form groups and are given tasks in their groups. Each learner is given a task in the initial groups and those with the same task then form the expert groups where they discuss their tasks. They then go back to the initial groups as experts to represent their findings to the others.

Instructional objectives

Instructional objectives are the end results in a lesson stated in the terms of changes of learner's behavior. Behavior includes mental (cognitive), emotional (effective) and physical (psychomotor) reactions. Instructional objectives should be stated in terms of learning outcomes because we are concerned with the products of learning rather than with the process of learning.

Reasons for having instructional objectives

1. They provide directions to the teaching process.
2. Set the stage for evaluation of the student's learning.

The instructional objectives are classified into the following domains;

Cognitive domain

Objectives in cognitive domain relate to the intellectual abilities and skills. The objectives in this domain can be grouped into six major classes:

i) Knowledge –the objectives measures recall with the use of the words List, State, etc

ii) Comprehension - the objectives measures understanding with the use of the words Classify, Convert, Describe, Explain, etc

iii) Application - the objectives measures application to other situations with the use of the words Apply, Using, Compute, etc

iv) Analysis - the objectives uses the words Analyses, differentiate, compare, and contrast.

v) Synthesis- the objectives uses the words such as Compose, arrange.

vi) Evaluation- the objectives uses the words Assess, evaluate, criticize, appraise.

Affective domain

An objective in affective domain relates to attitudes, interests, believes and values. Objectives in this area are beginning to appear more frequently in the curriculum because they relate to issues and topics that are meaningful to young people such as drugs, HIV/AIDS, Pollution etc. Five major classes of effective domain are:

i) Receiving – the objectives uses the words such as choose, listen.

ii) Responding - the objectives uses the words such as Discuss, Report.

iii) Valuing - the objectives uses the words such as Accept, Argue about it, Complete.

iv) Organization - the objectives uses the words such as Organize, Relate, and Modify.

v) Characterization by value - the objectives uses the words such as Propose, Oppose, and Verify.

Psychomotor domain

Objectives in psychomotor reflects motor skills and hard eye conditions. They have a place in teaching of science especially in the laboratory. The terms used in writing objective in this area include: Build, Construct, Calibrate, Display, Measure etc.

Objectives in this domain are grouped into 6 classes;

i) Reflex Action.

ii) Perception abilities-interprets various stimulus.

iii) Physical abilities- physical strength and stamina required for sustained effort.

iv) Skilled movements- refers to efficiency and skills in performing complex tasks e.g. swimming, driving.

v) Non- discursive communication- communication without producing sound (gesture, facial expression).

vi) Basic fundamental movement- these are walking, gripping, finger manipulation.

Instructional objectives for the topics Surds and Further Logarithms

SURDS (9 lessons)

By the end of the topic, the learner should be able to;

a) Define rational and irrational numbers.

b) Simplify expressions with surds.

c) Rationalize denominators with surds.

Content

i) Rational and irrational numbers

ii) Simplification of surds.

iii) Rationalization of denominators.

Resources

i) Charts illustrating processof rationalization.

ii) KLB Secondary mathematics pupils book 3 pg 72-79.

iii) Advancing in mathematics form 3 pg 51-54.

FURTHER LOGARITHMS(11 lessons)

By the end of the topic, the learner should be able to;

a) Derive logarithm relation form and vice-versa.

b) State the laws of logarithms.

c) Use logarithm laws to simplify logarithmic expression and solve logarithmic equations.

d) Apply laws of logarithms for further computations.

Content

i) Logarithmic notations.

ii) The laws of logarithms.

iii) Simplification of logarithms expressions

iv) Solutions of logarithms equations.

v) Further computations using logarithmic laws.

Resources

i) Charts illustrating logarithmic laws.

ii) Logarithm tables.

iii) Calculators.

iv) KLB secondary mathematics pupils book 34 pg 77-79.

v) Advancing in mathematics pg 59-62.

The Jigsaw learning model

Jigsaw learning is a cooperative strategy whereby students learn in groups. There is formation of the initial groups known as the ``home'' groups where each learner is given a task. Then these groups are dispersed and others are constituted known as the 'experts' groups with the help of the teacher. The 'expert' groups are formed by learners with the same task who discuss their tasks in details and also refer to textbooks. They then go back to their 'home' groups to present their findings to the others.

The role of the teacher in this model is that he/she;

    i. Divides the students into groups which should be diverse of gender and ability. These are the initial groups called the 'home' groups.

    ii. Appoints one person from each group as a leader who should be the most mature in the group. Also he/she divides the lesson into tasks and writes them into the blackboard.

    iii. Gives each student in each group a number. Those with number 1 takes the first task, those in number two takes the second task and so on.

iv. Ensures that students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

v. Brings the students back to their jigsaw groups and asks each student to present his or her task to the group as he floats from group to group observing the process.

vi. Make an evaluation of the lesson by either asking questions or giving an assignment on what has been learnt to be marked.

TEACHING MODULE USING JIGSAW LEARNING STRATEGY IN THE TOPICS SURDS AND FURTHER LOGARITHMS TO FORM 3 STUDENTS

WEEK 1

LESSON 1

Objectives of the lesson;

By the end of the lesson, the learner should be able to define a rational number.

Learning activities

i. The teacher divides the students into 5 person's jigsaw groups which should be diverse of gender and ability. These are the initial groups called the 'home' groups.

ii. The teacher appoints one person from each group as a leader who should be the most mature in the group. The teacher also ensures that every group has a form 3 mathematics textbook.

iii. The teacher divides the lesson into the following five tasks and writes them into the blackboard.

Convert the following rational numbers to decimals.

1 .a) $\dfrac{22}{7}$ b) $\dfrac{4}{3}$

2. Convert the following decimals to fractions

a) 0.0105   b) 4.27

Convert the following recurring decimals to rational numbers

3.$0.\dot{1}\dot{2}$ **4**. $1.\dot{7}$ **5**. $0.\dot{1}3\dot{2}$

iv. The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on.

v. The students are given time to write down their segment and become familiar with it.

vi. Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

vii. The teacher brings the students back to their jigsaw groups.

vii. The teacher asks each student to present his or her task to the group

ix. The teacher floats from group to group observing the process.

x. The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 2

Objectives of the lesson;

-By the end of the lesson, the learner should be able to: 1) define an irrational number.

2) Identify a rational and an irrational number.

Learning activities

➢ The teacher describes briefly a rational and an irrational number giving examples. He/she then writes the following tasks to the students in the blackboard;

State with reasons whether the following are rational or irrational numbers;

1.$3\sqrt{8}$ **2**. $3\sqrt{2} \div \sqrt{2}$ **3**. 4Π

4. Find the irrational numbers between 3 and 4.

5. Find the irrational numbers between 1/2 and 1/3.

➢ The teacher tells the students to go to the 'home' groups formed in the first lesson.

➢ The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on.The students are given time to write down their segment and become familiar with it.

➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

➢ The teacher brings the students back to their Jigsaw groups.

➢ The teacher asks each student to present his or her task to the group.

➢ The teacher floats from group to group observing the process.

➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 3-4

Objectives of the lesson;

By the end of the lesson, the learner should be able: 1) to define a Surd.

2) to add Surds.

3) to subtract Surds.

Learning activities

- The teacher defines Surds giving examples. The teacher further works out some examples on addition and subtraction of surds. He/she writes the following tasks on the board;

1. a) $\sqrt{3} + 7\sqrt{3}$ **b)** $5\sqrt{3} - 2\sqrt{3}$

2. a) $\sqrt{5} + \sqrt{20} + 5\sqrt{5}$ **b)** $7\sqrt{3} - 2\sqrt{27}$

3. a) $7\sqrt{3} + 2\sqrt{27}$ **b)** $\sqrt{7} - 7\sqrt{3} - \sqrt{81}$

4.a) $\sqrt{6} + \sqrt{24}$ **b)** $3\sqrt{25} - 5$

5. a) $\sqrt{15} + \sqrt{60} + \sqrt{135}$ **b)** $\sqrt{144} - \sqrt{12} - 6$

- The teacher tells the students to go to the 'home' groups formed in the previous lesson.

- The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

- Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

- The teacher brings the students back to their Jigsaw groups.

- The teacher asks each student to present his or her task to the group.

- The teacher floats from group to group observing the process.

- The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 5

Objectives of the lesson;

By the end of the lesson, the learner should be able to multiply Surds.

Learning activities

- The teacher works out some examples on multiplication of surds. He/she writes the following tasks on the board;

1) a). $\sqrt{2} \times 4\sqrt{2}$ b) $(\sqrt{7} - \sqrt{3})^2$ **2)** a) $\sqrt{5} \times \sqrt{20}$ b) $(\sqrt{2} + 3\sqrt{3})^2$

3) a) $(\sqrt{7} + \sqrt{5})(\sqrt{7} - \sqrt{5})$ **4)** $(2\sqrt{7} - \sqrt{5})(4\sqrt{7} - 3\sqrt{5})$ **5)** $(3\sqrt{2} + 2\sqrt{3})(5\sqrt{2} - 5\sqrt{3})$

- The teacher tells the students to go to the 'home' groups formed in the previous lesson.

- The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.
- Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.
- The teacher brings the students back to their Jigsaw groups.
- The teacher asks each student to present his or her task to the group.
- The teacher floats from group to group observing the process.
- The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 6-7

Objectives of the lesson;

By the end of the lesson, the learner should be able; 1) to divide Surds.

 2) to solve problems using Surds.

Learning activities

- The teacher works out some examples on division of surds. He/she writes the following tasks on the board;

 1) a)$\sqrt{12} \div \sqrt{3}$ b) $4\sqrt{5} \div \sqrt{5}$c) $\sqrt{125} \div 5$

2) a) $2\sqrt{27} \div 2\sqrt{3}$b) $48 \div \sqrt{8}$ c) $\sqrt{12}\sqrt{45} \div \sqrt{3}\sqrt{5}$

 3.Find the length of *b* in the following triangles. Leave your answer as Surds.

 a)b)
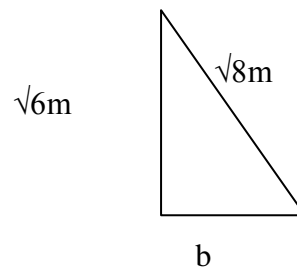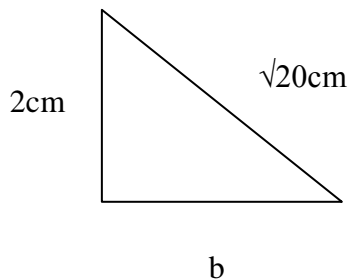
 4. a) An equilateral triangle has a length of 10 cm. find its area leaving your answer as a Surd.

 b) In the diagram below, find the length of side CD.
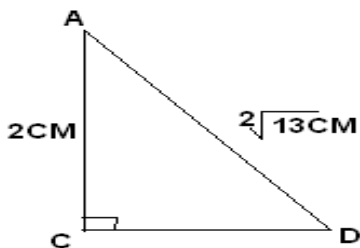
5. The area of an equilateral triangle is $\sqrt{768}$ cm² .Find the length of its **sides.**

➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

➢ The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

➢ The teacher brings the students back to their Jigsaw groups.

➢ The teacher asks each student to present his or her task to the group.

➢ The teacher floats from group to group observing the process.

➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

WEEK 2

LESSON 1

Objectives of the lesson;

By the end of the lesson, the learner should be able to rationalize the denominator of Surds.

Learning activities

➢ The teacher illustrates the process of rationalizing the denominator using a chart. He/she then works out some examples on rationalizing the denominator of surds. He/she writes the following tasks on the board;

Rationalize the following leaving your answer in the simplest form**;**

1. a) $\dfrac{1}{\sqrt{5}}$ 　　　 b) $\dfrac{\sqrt{5}}{\sqrt{8}}$ 　　　 c) $\dfrac{\sqrt{2}+1}{\sqrt{2}}$

2. a) $\dfrac{\sqrt{6} + \sqrt{2}}{\sqrt{2}}$ b) $\dfrac{\sqrt{15} + \sqrt{5}}{\sqrt{3}}$ **3**. a) $\dfrac{\sqrt{3} - 2}{\sqrt{5}}$ b) $\dfrac{1}{2 - \sqrt{3}}$

4. a) $\dfrac{1}{2\sqrt{3} + \sqrt{2}}$ b) $\dfrac{\sqrt{2}}{\sqrt{2} + 1}$ **5**. a) $\dfrac{\sqrt{5} + 1}{\sqrt{5} + \sqrt{1}}$ b) $\dfrac{\sqrt{5} + \sqrt{2}}{\sqrt{3} - \sqrt{2}}$

- ➤ The teacher tells the students to go to the 'home' groups formed in the previous lesson.
- ➤ The teacher gives each student in each group a number between1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.
- ➤ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.
- ➤ The teacher brings the students back to their Jigsaw groups.
- ➤ The teacher asks each student to present his or her task to the group.
- ➤ The teacher floats from group to group observing the process.
- ➤ The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 2

Objectives of the lesson;

By the end of the lesson, the learner should be able to apply Surds to real life situations.

Learning activities

- ➤ The teacher works out some examples on application of surds. He/she writes the following tasks on the board;

1. Use $\sqrt{5}=2.236$ to evaluate;

a) $\dfrac{10}{\sqrt{5}}$ b) $\dfrac{8}{\sqrt{5} - 1}$

Solve the following equations leaving your answers as Surds;

2. $x^2 - 2x - 5 = 0$

3. $10x^2 - 40x + 3 = 0$

4. $5x^2 - x - 1 = 0$

5. $3x^2 + 19x - 1 = 0$

➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

➢ The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

➢ The teacher brings the students back to their Jigsaw groups.

➢ The teacher asks each student to present his or her task to the group.

➢ The teacher floats from group to group observing the process.

➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 3-4

Objectives of the lesson;

By the end of the lesson, the learner should be able to change an index number to logarithmic notation.

Learning activities

➢ The teacher describes briefly index and logarithmic notation giving examples. He/she then writes the following tasks to the students in the blackboard.

Tasks

1. Write down the logarithm of each of the following numbers to the stated base.

   a) 32, base 2   b) 512, base 8   c) 27, base 9   d) 0.25, base 5

2. Rewrite the following expressions in logarithmic notation

   a) $3^4 = 81$ b) $0.001 = 10^{-4}$ c) $b^0 = 1$

3. Express the following in index notation.

   a) $\log_2 32 = 5$ b) $\log_3 x = 8$ c) $p = \log_q r$

76

Evaluate the following logarithms.

4. a) $\log_2 8$ b) $\log_5 625$ c) $\log_8 4$

5. a) $\log_4 1/8$ b) $\log_{0.2} 25$ c) $\log_8 0.125$

> ➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

> ➢ The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

> ➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

> ➢ The teacher brings the students back to their Jigsaw groups.

> ➢ The teacher asks each student to present his or her task to the group.

> ➢ The teacher floats from group to group observing the process.

> ➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 5

Objectives of the lesson;

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

- to apply the laws of logarithms.

Learning activities

> ➢ The teacher explains the laws of logarithms and then works out some examples on application of the laws. He/she writes the following tasks on the board;

Tasks

1. Given that *log 2=0.3010* and *log 3=0.4771*. Evaluate;

   a) *Log 6*   b) log 18   c) *log 45*

2. Evaluate to 2 decimal places $\log_2 5.45$

Express each of the following as a single logarithm

3. a) Log 2 + log 5   b) Log 2 + log 3 –log 7   c) 3 log 2 + 2log 5

4. a) 3 log x -2- log 4y   b) ½ log x + log $x^{1/3}$

5. a) $3 \log x^2 - 8 \log x^{1/4}$ b) $\log_2 64 - \log_2 16$

➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

➢ The teacher gives each student in each group a number between1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

➢ The teacher brings the students back to their Jigsaw groups.

➢ The teacher asks each student to present his or her task to the group.

➢ The teacher floats from group to group observing the process.

➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 6-7

Objectives of the lesson;

By the end of the lesson, the learner should be able to simplify and evaluate logarithmic notations.

Learning activities

The teacher works out some examples on simplifying and evaluating logarithmic notations. He/she writes the following tasks on the board;

Tasks

1. Use logarithm tables to evaluate the following, giving your answers to 2 decimal places.

 a) $\log_4 8$ b) $\log_5 11.5$ c) $\log_{12} 2.532$

2. Express the following equations in index form.

 a) $\log_a y = n$ b) $\log_m x + 2 \log_m y = 3$ c) $3 \log_b x + 2 = 1$

3. Without using tables or calculators, find the value of;

$$\frac{\text{Log } 0.8 - \log 32 + \log 8}{\text{Log } 0.7 + \log 7 - \log 49}$$

Given that log 2 = 0.3010

4. If x=log (a-by) –log a, find the value of y when a=4, b=2 and x=-2

5. Write the following formula without using logarithms;

M log A = 4-1/2 log B.

➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

➢ The teacher gives each student in each group a number between1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

➢ The teacher brings the students back to their Jigsaw groups.

➢ The teacher asks each student to present his or her task to the group.

➢ The teacher floats from group to group observing the process.

➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

WEEK 3

LESSON 1,2

Objectives of the lesson;

By the end of the lesson, the learner should be able to solve equations involving logarithms.

Learning activities

The teacher solves some equations involving logarithms. He/she writes the following tasks on the board;

Tasks

1. Solve for x in the equations

   a) Log x = 4   b) log x = -3

   c) $\log_x 81 = 4$ d) $4 \log_x (2\ 10/27) = 12$

2. Solve the following equations;

   a) $2^x = 128$ b) $3^{2x} = 27$

   c) $6^x = 15.36$ d) $6.23^x = 0.618$

3. Find the value of y in;

   a) $2 \log_4 y = \log_4 3 + \log_4 9 - \log_4 y$.

   b) $\log (y + 3) = \log (y - 6) + \log 3$.

   c) $\log (3y - 2) - \log (y + 10) + 1 = 0$.

4. Find the values of x in the equations;

   a) $\log_3 x = \dfrac{9}{\log_3 x}$

   b) $\text{Log}_3 x + \dfrac{3}{\text{Log}_3 x} = 4$.

   c) $\text{Log}_2(x + 4) = 2 - \log_2 x$.

5. a) Given that $\log_2 (x - 5y + 4) = 0$ and $\log_2(x + 1) - 1 = 2 \log_2 y$, find the values of x and y.

   b) By taking log 5 = 0.7, obtain an estimate of y in the equation $10^{y-5} = 5^{y+2}$, giving your answer to the nearest integer.

   ➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

- The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.
- Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.
- The teacher brings the students back to their Jigsaw groups.
- The teacher asks each student to present his or her task to the group.
- The teacher floats from group to group observing the process.
- The teacher gives an assignment on what has been learnt to be marked by the teacher.

LESSON 3-4

Objectives of the lesson;

By the end of the lesson, the learner should be able to solve equations involving logarithms.

Learning activities

The teacher solves some equations involving application of logarithms. He/she writes the following tasks on the board.

Tasks

Without using tables or calculators, evaluate the following;

1.

a) $\dfrac{\text{Log } 64}{\text{Log } 8}$

c) $\dfrac{\log 2}{\log 32}$

b) $\dfrac{\text{Log } 32 - \log 128}{\text{Log } 2 - \log 8}$

d) $\dfrac{\log 3}{\log 81}$

2. a) log 6 ¼ + log 1 3/5..

   b) $\dfrac{4\log 3 + 3 \log 2}{3\log 6 + \log 3}$

3. $\sqrt{\dfrac{\text{Log } 4096}{1+ \frac{1}{2}\log 0.16 + \frac{1}{3}\log 8}}$

4. If $xy^n = 475$, find n given that $x = 2.5$ and $y = \sqrt{10}$ giving your answer correct to 2 decimal places.

5. Find the least integral value of n for which 0.95^n is less than 1

➢ The teacher tells the students to go to the 'home' groups formed in the previous lesson.

➢ The teacher gives each student in each group a number between1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on. The students are given time to write down their segment and become familiar with it.

➢ Students from each Jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task and also refer from the text books.

➢ The teacher brings the students back to their Jigsaw groups.

➢ The teacher asks each student to present his or her task to the group.

➢ The teacher floats from group to group observing the process.

➢ The teacher gives an assignment on what has been learnt to be marked by the teacher.

MATHEMATICS ACHIEVEMENT TEST

NAME…………………………………………………..CLASS:………………

1 HOUR

END OF MONTH CONTINOUS ASSESSMENT TEST

MATHEMATICS FORM 3

INSTRUCTIONS

Write your name and your class in the spaces provided.

Answer all the questions in the spaces provided.

Electronic calculators should NOT be used.

All working must be clearly shown when necessary

For Examiner's Use Only

Questions	Maximum score	Students score
1-15	80	

1. State with a reason whether the following is rational or irrational number

a) $\underline{22}$ (1 mark)

   7

b) $\sqrt{2} + 1$ (1 mark)

c) $(\sqrt{5})^2$ (1 mark)

2. Write the following rational numbers as terminating or recurring decimals;

a) $\underline{5}$ (2 marks)

   11

b) 19   (2 marks)

    $\overline{32}$

c) $\underline{31}$ (2 marks)

    16

d) $\underline{-11}$ (2 marks)

    9

3 Express the following recurring decimals as fractions in their lowest terms;

a) $0.\dot{3}$ (2 marks)

b) $0.3\dot{4}$ (2 marks)

c) $82.3\dot{7}$ (2 marks)

d) $1.\dot{1}1\dot{2}$ (2 marks)

4. Write down irrational numbers that lie between 1 and 2   (3 marks)

5.Simplify;

a) $\sqrt{3} + \sqrt{12}$ (2 marks)

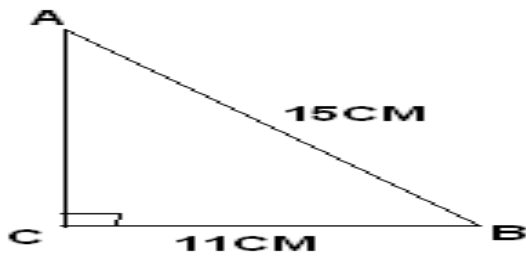b) $(\sqrt{2})^3 \times (\sqrt{8})^2$ (2 marks)
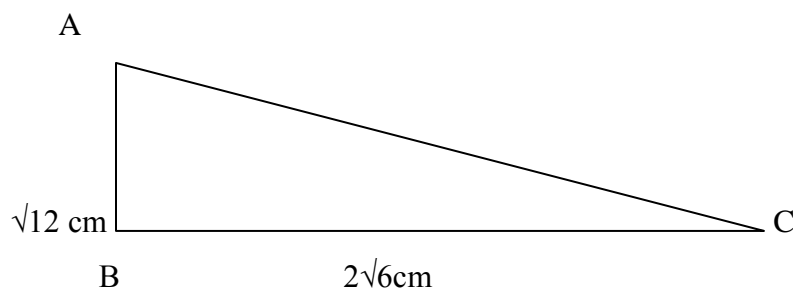
c) $(\sqrt{3})^2 \div (\sqrt{6})^3$ (2 marks)

6. Find the area of the triangle ABC in the diagrams below and leave your answers as a Surd.

a)

15CM

11CM

(3 marks)

b)

A

√12 cm

B   2√6cm   C

(3 marks)

7. Write the following with rational denominators:

a) $\dfrac{1}{\sqrt{5}}$ (3 marks)

b) $\dfrac{\sqrt{7}}{\sqrt{7} - \sqrt{3}}$ (3 marks)

c) $\dfrac{\sqrt{6} + \sqrt{3}}{\sqrt{3} - 2\sqrt{6}}$ (3 marks)

8. Solve the equation $5x^2 + 3x - 1 = 0$, leaving your answer as a Surd.   (4 marks)

9. The area of an equilateral triangle is $\sqrt{48}$ cm². Find the length of the side. (3 marks)

10. Use logarithms tables to evaluate the following expression and give your answer to four significant figures. (3 marks)

$$\frac{\sqrt[3]{5.31} \times \sqrt{0.073} \times \sqrt[3]{144}}{\sqrt{0.00542}}$$

11. Express the following in logarithmic form.

a) $5^0 = 1$ (2 marks)

b) $A^{-3} = 27$ (2 marks)

c) $4^{-1/2} = 0.5$ (2 marks)

12. Evaluate the following;

   a) $\log_5 125$ (2 marks)

   b) $\log_{10} 0.0001$ (2 marks)

   c) $\log_{27} 1/81$ (2 marks)

\

   d) $\log_{0.1} 1000$ (2 marks)

13. Express the following as a single term and simplify where possible;

   a) $\log_{10} 7 + 3 \log_{10} 2 - \log_{10} 28$ (2 marks)

b) $\log_x 5 - 2\log_x 15 + 3\log_x 3 - \log_x 16$ (2 marks)

14. Solve for x in the following;

   a) $1024 \times 2^x = 1.$ (2 marks)

   b) $4 \log x + \log 81 = 2 \log 6x.$ (2 marks)

   c) $\log (3x-2) - \log (x +10) + 1 = 0.$ (2 marks)

15. Express n in terms of x and y given that $\log y = \log (10x^n)$ (3 marks)