EFFECTS OF MASTERY LEARNING STRATEGY ON MATHEMATICAL COMPETENCE AMONG SECONDARY SCHOOL STUDENTS IN MACHAKOS COUNTY, KENYA

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A Research Thesis Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Doctor of Philosophy in Educational Communication and Technology (Mathematics Education) School of Education
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DECLARATION

I declare that this proposal is my original work and has not been presented in this or any other university.

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DEDICATION

This work is dedicated to my late father Mzee Francis Ivivi who has been my Icon in the field of academia.

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The successful completion of this work would not have been successful without the support I received during the course of my studies. I therefore wish to thank Machakos University and the school of Education for the opportunity to pursue degree of Doctor of Philosophy in Mathematics Education.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

B-MLS: Bloom's Mastery Learning Strategy

CGL : Conventional Group Learning

CRT : Criterion Referenced Test

KCSE : Kenya Certificate of Secondary Education

KICD : Kenya Institute of Curriculum Development

KNEC : Kenya National Examinations Council

LFM : Learning for Mastery

MLS : Mastery Learning Strategy

MOE : Ministry of Education

NRC : National Research Council

NACOSTI: National Council for Science, Technology and Innovation

SPSS : Statistical Package for Social Sciences

ABSTRACT

Despite the fact that Mathematics is considered as a vital subject that supports the development of critical and logical thinking., majority of students across the world dislike mathematics and stay away from many careers related to Mathematics. The students' lack of interest for mathematics could be attributed to poor quality of instruction and the instructional method deployed but not lack of ability to learn. The purpose of the study was to establish the effect of Mastery Learning Strategy on Mathematical Competence among Secondary School Students in Machakos Sub-County Kenya. The study was guided by four objectives: to investigate the impact of mastery learning strategy on students' competence on a Mathematical test; to investigate the impact of mastery learning strategy on students' attitude towards Mathematics; to investigate the impact of mastery learning strategy on students' level of errors and misconceptions committed in Mathematics and to investigate the impact of mastery learning strategy on students' level of self-efficacy when solving a Mathematics problem. Two co-educational Schools were randomly sampled, then using the Solomon's FOUR randomized Group Design, two Form two streams were randomly selected from each school and randomly assigned to Experimental Group and the Control Group respectively. A pretest was given before the intervention. The Experimental group was taught using Mastery Learning Strategy (MLS), while the Control group was taught using Conventional Group Learning (CGL). The research used a competence test, an attitudinal test towards Mathematics, errors and misconception in Algebra assessment test and the level of self-efficacy test. The Analysis of Variance (ANOVA), indicated that the mean score difference for all the groups was significant at $\alpha = 0.05$ as evident by the Fishers ratio and p-value. A Chi-Square analysis revealed that there was a strong association between the use of MLS and the quality of competence in Mathematics. The computed z score value of $|-2.72|$ was greater than the critical value of z = 1.96 at 5% level of significance, therefore the proportion difference between the two groups was statistically significant. It was noted that the use of MLS had a statistically insignificant effect on Mathematical concept errors, the conceptual understanding errors and the word Mathematical problem errors. It was established that the Gender of the learners did not have an effect on the learning outcomes resulting from use of MLS. MLS was recommended for improved competence performance, changed attitude towards Mathematics, and a sure strategy to boost the morale and self-efficacy among the students. Therefore, the study recommends that teachers and learners should be exposed to MLS to help break the cycle of failure in Mathematics. The study also recommends a replication of the research for other topics in Mathematics; another region and different respondents to ascertain the validity and reliability of the findings. It was concluded that MLS is an effective teaching strategy that can bring a positive change in the learning of Mathematics, attitude towards Mathematics and on self-efficacy.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter discusses the background to the study, statement of the problem, purpose of the study, objectives, significance of the study, assumptions, limitations and delimitations of the study, theoretical framework based on mastery learning and conceptual framework as well as definition of the terms used in the study.

1.1 Background to the Study

Mathematics is considered as a vital subject which is a unique and fundamental part of the school curriculum globally and as an instrument for the development of all other sciences. However, majority of students across the world dislike Mathematics and stay away from many careers related to Mathematics (Scarpello, 2007). Mathematics has often been termed the "gatekeeper" of success or failure for high school graduation and career success (National Research Council [NRC], 1989). Mathematics competence opens doors to a productive future, a lack of Mathematical competence keeps those doors closed. As a result, great pressure has been put on Mathematics teachers and on the students' part to succeed in Mathematics more than in any other subject (Miheso, 2002).

Despite great advances in knowledge about student learning and tremendous amount of investments in terms of time, effort and money our schools still have not progressed towards the goal of efficient learning for all students (Sharma, 1998; Ogogo,2001). Thus, the schools continue to provide successful and rewarding experiences for only about one third of our learners. Students fail so often and so universally that most people are convinced that failure is an essential and inevitable aspect of an educational process (Torshen, 1977). However, failure often produces harmful consequences that work against goals of education (Ogogo,2001). Many dedicated teachers have doubted their own professional abilities when they could find no alternative other than giving a failing grade to a student (Torshen, 1977). It is noted further that many students who received repeated and consistent evidence that their work was unsatisfactory, have been convinced that school was a place where they could not succeed. When sincere attempts to teach and to learn meet with repeated negative responses, the instructional process can actually eliminate those activities that are essential to productive education (Sharma, 1998).

During his/her stay in school, a student needs to attain mastery of essential learning tasks, to see himself as a competent student and to receive evaluations that indicate to him that his performance has been successful (White, 1960: Skinner, 1968: Kelly, 1971). If he/she fails to attain mastery or to achieve the status of one who is competent and successful, the chances for healthy development can be substantially reduced.

Explanations for poor competence in Mathematics have indicated that the following factors are significant: students' attitude and characteristics (Eshiwani, 1983; Fuller, 1985;); student entry behaviour (Bloom, 1976; Hanusheck,1989); use of recommended textbooks (Adedjei & Owoeye 2002); class size (Eshiwani, 1983; Lockheed 1993); teaching methods and classroom climate (Resnich 1985; Hatano & Inagake, 1991). This study addressed the teaching methods, students' attitude, self-efficacy and entry behavior as factors that leads to students' competence in Mathematics. As Wambugu (2008) observes the teaching approach that a teacher adopts is one factor that may strongly affect students' achievement.

The teacher faced with the job of creating an environment in which each student can develop his potential and attain competence is confronted with a monumental task. This task may be impossible unless the teacher can employ instructional methods and materials sufficiently appropriate for each student to enable him to master the basics of the curriculum (Sharma, 1998).

The concept and process of teaching in the classroom has changed over the years. The concentration of the teacher now is not only limited to a small section of students rather takes into its fold all the students in the class.

Since changing times require schools to develop critical, creative and independent thinkers, teachers can initially identify impediments to the attainment of these goals (Leongson,2002; and Limjap, 2002). Mateo (2011) in his study concluded that teaching strategies are not correlated with mathematics achievement but further stated that good teaching strategies resulted in more positive attitude and lesser anxiety towards mathematics. Carabbacan (2003 in Ayap,2007) asserted that the teacher in the classroom is the central figure who provides the structure within which the children can learn. In fact, the way the teacher presents an activity or concept, strongly influences the way the learners react to it. An effective teacher utilizes a variety of techniques and strategies to develop productive discipline and to motivate learners.

The study of House (2001) on the relationship between instructional activities and mathematics achievement of adolescents in Japan found out that students tended to show higher mathematics achievement when their teachers more frequently explained rules and definitions. As other researchers have pointed out, the teachers are the primary cause of students' failure in mathematics. Poor performance in mathematics can be traced back to teachers' failure to impart the necessary knowledge, skills, attitudes, and values to students. According to Sin Son (2003 in Mateo,2011), the teacher is the most critical factor in attaining quality education and the single most potent element in the complete structure of an effective mathematical program. The teacher should, therefore, motivate the students, create a desirable classroom climate conducive to learning, transmit knowledge and implement effective instructional strategies

Despite, the daily needs and the roles played by Mathematics in the society, there has been persistent poor performance in the subject worldwide. In United States of America, for example, the Program for International Students' Assessment (PISA), reported that students were graded beneath average in Mathematics (Ginsburg, Lei wand, & Pollock, 2009). Also, in India, students who sat for the same examination emerged second to last in global rating. In Africa, poor performance has also been registered in Mathematics at all levels of education with South Africa, Ghana, Morocco, and Botswana, students ranked below average in 2010 and 2015 Trends in International Mathematics and Science study. Countries like Nigeria have reported a high failure rate in Mathematics. Students in Kenya perform poorly in mathematics and sciences (Changeiywo, 2000). Needless to mention that in Kenya mathematics performance in the national examination is still wanting. The failure rate in mathematics at Kenya Certificate of Secondary Education (KCSE) examination in 2015 and 2016 was reported as 71% and 72.5% respectively. In Machakos County, Machakos sub-county the situation is not different. The failure rate in mathematics is on average 72.64% meaning a pass rate of 27.36% between the year 2010 and 2017 as indicated in Table 1.1 below.

Table 1.1 KCSE Mathematics Examination Results in Machakos Sub-County, 2010-2017

Year	% Pass	Year	% Pass	Year	% Pass
2010	25.4	2013	28.1	2016	28.2
2011	24.4	2014	29.8	2017	25.7
2012	27.7	2015	29.6		

Source: Sub-County Director of Education Office, Machakos (2021).

The table above shows the percentage pass in KCSE Mathematics from the year 2010 to 2017 in Machakos Sub-County. It is indicative from the table that something needs to be done about the teaching of Mathematics in Machakos sub-county to improve the level of competence which is on average at 27.36%. A new method needs to be tried to see its effect on competence in Mathematics in Machakos Sub-County.

A teaching strategy, often referred to as an instructional strategy, is a method or pedagogy used by teachers to encourage positive student engagement in a particular subject matter by having students demonstrate various talents they have accumulated over time. The impact of instructional tactics on learners' acquisition of mathematics is crucial. In order to get results, methodologies should be teacher-centered. A student's level of mathematical understanding may occasionally be influenced by the methods, approaches, and strategies teachers use. It is the responsibility of every mathematics teacher to help their students master mathematical concepts and internalize contextual knowledge that will position them for future application. If a mathematics teacher does not use an effective teaching strategy that may help students learn the necessary mathematical knowledge and facts during class activities—even if they themselves are proficient in the key mathematical concepts—their job will be hanging in the balance. Teachers of mathematics should implement teaching methods that can inspire students to take an interest in the topic and perform better. Dweck (2020) argued that if students consider mathematics ability that they either possess as a fixed ability (i.e. Innate inclination) or otherwise, there is the probability that the students lose interest when they experience difficulty with the subject. Students may eventually sustain their interest in mathematics despite problems or difficulties if they view mathematical skills as ideas that can be cultivated through self-study or easily getting assistance when necessary. Hence, more effective teaching strategies could encourage students to take an interest in mathematics instruction and help them achieve proficiency in the subject by playing a significant part in both the teaching and learning of mathematics. One of the required disciplines for entry into higher institutions in the Kenyan educational system is mathematics, which influences students' career choices in the field of science and technology. It is expedient for a mathematics teacher to use a technique that can enhance students' conceptual grasp of mathematics. Maria (2016) asserts that conceptual knowledge reveals mathematics teachers' proficiency in the use of language, signs, and mnemonic devices. He emphasized that any teacher who has this knowledge can help students' mathematics understanding and aid in their ability to reflect on the material. In order to teach mathematics effectively, it is necessary to create learning opportunities for students while also creating a supportive learning atmosphere that can endure any difficulties they may encounter.

According to Hollebrands (2004), it is essential for a teacher to adopt various approaches to teaching and learning so as to influence the students' understanding which is paramount in the teaching of Mathematics and it is called Mastery Learning Strategy. Mastery learning offers a powerful new approach to school learning which can provide almost all students with successful and rewarding learning experiences, now available to only a few (Carroll, 1963; Bloom, 1968).

Mastery learning is defined in terms of educational objectives which each student is expected to achieve. The term mastery was used by Morrison for the method of securing mastery of a subject matter, in which testing forms the beginning, middle and the end of the teaching-learning process so that teaching may be appropriately adapted to the needs of the learners (Good, 1967). Mastery Learning Strategy involves breaking down the subject matter to be learned into units of learning, each with its own objectives. Adepoju (2002) refers to mastery learning as an innovation which in its various forms is designed towards making learners to perform beautifully well in an academic task. Also, Adeyemi (2007) described mastery learning as a teaching strategy that involves a pre-specified criterion level of performance which students must master in order to complete the instruction and move on.

According to him, mastery learning involves frequent assessment of students' progress as mentioned above and it also provides corrective instruction and emphasizes on all participation, feedback and reinforcement. Students who do not achieve mastery receive remediation through tutoring, peer monitoring, small group discussions, or additional assignments (Aggarwal, 2004). Here, additional time for learning is prescribed for those requiring remediation. In the same vein, Wibler et al (1981) in Wambugu and Changeiywo (2007) opined that MLS helps the students to acquire prerequisite skills to move to the next unit. Mastery of each unit is shown when the students acquire the set pass mark of a diagnostic test. The teacher is also required to do task analysis and state the objectives before designating the activities.

Mastery learning strategy (MLS) can help the teacher to know student's area of weakness and correct it thus, breaking the cycle of failure. Results from research studies carried out on Mastery Learning strategy (MLS) suggest that mastery learning strategy (MLS) yields better retention and transfer of material, yield greater interest and more positive attitude in various subjects than Non-Mastery Learning Approaches (Ngesa, 2002; Wachanga and Gamba, 2004 and Wambugu and Changeigwo, 2007).

The principal defining characteristic of mastery methods is the establishment of a criterion level of performance held to represent mastery of a given concept or skill, frequent assessment of students' progress toward the mastery criterion, and provision of corrective instruction to enable students who do not initially meet the mastery criterion to do so on a later parallel assessment (Block & Anderson, 1975).

Mastery Learning Strategy (MLS), therefore, involves breaking down the subject matter to be learned into units of learning, each with its own objectives. Guskey (2007) reported that Bloom hypothesized that a classroom with a mastery learning focus as opposed to the conventional form of instruction would reduce the achievement gaps between varying groups of students. In Mastery learning, "the students are helped to master each learning unit before proceeding to a more advanced learning task" (Bloom 1984) in contrast to "conventional instruction". Mastery learning uses differentiated and individualized instruction, progress monitoring, formative assessment, feedback, corrective procedures, and instructional alignment to minimize achievement gaps (Bloom, 1971; Zimmerman & Dibenedetto, 2008). The strategy is based on Benjamin Bloom's *Learning for Mastery* model, which emphasizes differentiated instructional practices as strategies to increase student achievement. Bloom (1984) in Wambugu and Changeiywo (2007) in their research on group instruction showed scores of students taught through MLS were around the ninety-eighth percentile, or approximately two standard deviations above the mean. The theory of mastery learning is, therefore, based on the simple belief that all students can learn when provided with conditions (instruction and time) that are appropriate for their learning. The instructional strategies associated with mastery learning are designed to put that belief into practice in modern classrooms.

Goals of the Mastery Learning Structure

There are several goals for the classes which directly pertained to the mastery learning structure. Some of them are:

1. By being able to turn in assessments multiple times, students will be able to learn from their mistakes, and will not be allowed to be complacent with their learning.

2. The lack of formal deadlines will make the course more flexible for the students, allowing them to work around their schedules.

3. The first gap grading (Fall 2007) and the categorical divisions (spring 2007) will force students to learn the basics enabling them to better understand the more complicated material.

4. The grading scheme will give the students the (correct) impression that they are not competing against each other, which will encourage collaboration among students.

5. Students will be able work at their own pace, allowing extra time to absorb material for "late bloomers".

6. Dissecting the course into small, manageable chunks and giving explicit descriptions of what is expected will give the students a sense of accomplishment and allow them to set reasonable goals for focused study.

Work done by Wambugu (2006) in the teaching of Physics by using Mastery Learning Strategy (MLS) revealed that students taught using this approach outshined their counterparts taught using CGL. Mastery Learning Strategy has the unique quality of enabling mastery of content by the student through supplementary instruction and corrective activities of small units of the subject matter. Mastery learning also requires the teacher to do task analysis, thereby becoming better prepared to teach the unit. It operates on the position that almost every student can learn the basic skills and knowledge that are the realm of the school curriculum when the instruction is of good quality and appropriate for him, and when he spends adequate time in learning (Bloom, 1971: Carroll, 1971: Ogogo,2001).

According to Block and Anderson (2010), Mastery learning is an approach to learning intended to bring all students to a pre-established level of mastery on a set of instructional objectives. Students are taught well-defined objectives, formatively assessed, given corrective instruction if needed, and then summative assessed. This model provides teachers with timely feedback about the progress and deficiencies of students in meeting specific instructional goals and presents a curriculum that provides extra time and opportunities for all students to attain mastery. This learning approach takes care of individual differences in learning due to individual student's characteristics as well as their aspirations. Mastery learning as an instructional strategy is based on the principle that all the students can learn a set of reasonable objectives with appropriate instruction and sufficient time to learn. In mastery learning, students are not advanced to a subsequent learning objective until they demonstrate proficiency with the current one. Students must demonstrate mastery on unit examinations, typically 80% before moving into new material (Davis & Sorrel, 2011). Students who do not achieve mastery receive remediation through tutoring, peer monitoring, small group discussion, or additional homework. Remediation requires additional time.

Mastery Learning is anchored on behavioral learning theory which believes that learning is determined by experiences that learners are exposed to within the environment. Furthermore, mastery learning can be used in almost every subject, but it is more suitable in Mathematics instruction since it helps students to develop a solid foundation of Mathematical understanding in order to solve Mathematical problems which involve a higher-level thinking and reasoning. Hence, its application will promote a strategy that not only enhances academic achievement and attitude towards learning Mathematics but it also aids in teaching and learning.

The current interest in the mastery structure was rekindled by the theoretical model for school learning presented by John Carroll (1963a;1963b). Carroll model (1963a) for successful academic learning proposed the following:

$$\text{Degree of learning} = f\,\frac{(time\ spent\ to\ learn)}{(time\ needed\ to\ learn)}$$

That is, what students learn is a function of whether they spend the time they need to learn it. Contributing to *time spent* are two factors: *opportunity,* defined as the time allowed or scheduled for learning by the teacher, and *perseverance,* which is the time a student is willing or motivated to spend. Contributing to *time needed* are three factors: *quality of instruction,* which includes how well the material is sequenced, presented, and adapted to the learners; *ability to understand instruction,* defined as the extent to which students can comprehend the language of instruction and requirements of the task; and *aptitude*, expressed simply as the time required by an individual to learn some material or skill to some pre-established level. In mastery learning strategy every student is given the opportunity to learn by the teacher, that is, sufficient time is scheduled to master a given unit. The student then should be willing to spend time until they master the unit. On the other hand, the teacher should give quality instruction where the material being taught is well sequenced, presented, and adapted to the learners. The teacher should also plan to give every student enough time to learn some material or skill to some pre-established level.

In 1971, Bloom presented an additional model for school learning (Bloom, 1971, 1976) which proposed that the time a student spends in learning is directly proportional to the amount he/she learns. His is a group-based, teacher-paced model. In this model, whole group instruction is supported by enrichment and corrective instruction to meet the needs of the students. Some of the basic features of B-MLS include specific instructional objective relating to the learning task and that a course or subjects should be broken into small units of learning where each unit has an objective, a course mastery performance standard which the students will be expected to achieve on this examination is determined and that a test should be administered at the end of each unit.

After each test the teacher provides feedback for areas where the learners have challenges. For those students who have difficulties the teacher is expected to create time and provide alternative learning opportunities. Gagne and Paradise (1961) also came up with the suggestion that mastery of each unit or task is a necessary prerequisite for mastery of the latter, more difficulty or more complex tasks. The form two secondary school Mathematics syllabus has various topics. Mathematics is allocated six forty-minutes lessons each week. The main resource is the blackboard and the textbook. Real-life examples and/ or experiences are used in the teaching of algebra. On the other hand, Mastery learning approaches aim to ensure that all students have mastered key concepts before moving on to the next topic – in contrast with traditional teaching methods in which students may be left behind, with gaps of misunderstanding widening. The mastery learning provides students with a solid foundation to build and develop their knowledge. Mastery learning also provides the ability for students to work at their own pace and it also provides more peer interaction for shared learning moments and a more one-on-one educator interaction.

The current study contends that if the above discussed model is articulated in the teaching of Mathematics in Schools in Kenya, the level of competence in the subject may greatly be improved.

1.2 Statement of the Problem

Poor performance in Mathematics in Kenyan secondary schools has persisted for a long time despite concerted efforts both by the government, teachers and researchers. Community pressure for improved performance at this level results from the fact that, Mathematics education is known to contribute to the intellectual development of individual students, as well as prepare them to be informed and functioning citizens in contemporary society. As a result of this important function, Mathematics education is expected to provide students with competencies needed to take their rightful place in the fields of commerce, industry, technology and science. Not to mention that Mathematics is also a basic requirement in many courses offered at tertiary level.

The study of Mathematics has consistently been emphasized making it a compulsory subject in the formative years of education. In view of this role of mathematics, student outcomes in Mathematics as reflected by their performance are an issue of concern for any informed society. In this technological era, Mathematics literacy is a necessary component in that we are constantly called upon to carry out various calculation, make estimates, carry out measurements of various types, make predictions and make sense of the tremendous amount of data. The poor performer will also miss out in the Mathematics' purely aesthetic nature, that is, the beauty of order and harmony, proofs, logic and feelings of accomplishment associated with problem solving. Poor performance in Mathematics, therefore, inhibits participation in many occupations and career development. Several factors have been proposed to contribute to poor performance by various studies, however the instructional practices have not been exhaustively established. An effort by both the students and the teachers towards improving this situation by use of conventional methods has not been impressive.

Performance in Mathematics examination, which is a reflection of the level of competence, has been consistently low as agued in the preceding section of this chapter. It is contended here that this observation may be an indicator that the learning of Mathematics may not have been sufficiently adequate. The low grades may be improved if the learning of the subject is enhanced by improving the instructional practices. KNEC (2008) cites that ineffective teaching leads to inability to master simple and basic concepts as a reason for poor performance in Mathematics. This study, therefore, investigated the effectiveness of mastery learning strategy as opposed to the conventional methods in developing Mathematics competence and sought to provide empirical evidence on the effects of mastery learning strategy (MLS) on students' achievement in secondary school Mathematics.

It was the purpose of the study therefore, to examine the degree to which mastery learning strategy influenced the learning of Mathematics as compared to the conventional group learning. This method of teaching had not been tried out in Mathematics teaching and learning in Machakos sub-county where performance in the subject has continued to decline. The study was also meant to contribute to the understanding of effects of MLS on Mathematics competence in this Sub-county of Machakos county in Kenya.

1.3 Purpose of the Study

The Purpose of this study was to investigate the effect of Mastery Learning Strategy on Mathematical Competence among Secondary School Students in Machakos County, Machakos Sub-County, Kenya.

1.4 Objectives of the Study

The study was guided by the following objectives:

1) To compare the level of achievement on a Mathematics competence test of students taught using Mastery Learning Strategy and those taught using Conventional Group Learning in form two classes.
2) To determine whether there is a difference in attitude towards Mathematics of students taught using Mastery Learning Strategy and those taught using Conventional Group Learning.
3) To determine whether there is a difference in the type of misconceptions in Mathematical algebra between students taught using Mastery Learning Strategy and those taught using Conventional Group Learning.
4) To determine whether there is a difference in self-efficacy between students taught using Mastery Learning Strategy and those taught using Conventional Group Learning.

1.5 Hypotheses of the Study

The study was guided by the following hypotheses

H_{01}: There is no significant difference in the achievement of Mathematics competence test of form two students who were taught using the mastery learning strategy (MLS) and those who are taught using the conventional group learning (CGL).

H_{02}: There is no significant difference in attitude towards Mathematics of form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning.

H_{03}: There is no significant difference in the type of misconceptions in Mathematical algebra between form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning.

H_{o4}: There is no significant difference in self-efficacy between form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning.

1.6 Significance of the Study

Mathematics is a subject that causes many negative emotions. One of the main challenges to Mathematics teacher is to make a positive attitude in students toward learning Mathematics, have them enjoy the subject and believe in their ability in as far as learning Mathematics is concerned. Therefore, teachers should be aware of students' affective beliefs and inter relations of those in learning Mathematics so as to employ more effective strategies in teaching and to improve students' Mathematics learning by reducing their negative beliefs. The study, therefore, aimed at identifying the difficulties experienced by students in learning Mathematics by comparing the achievement of students' taught Mathematics through MLS with that of students taught through conventional group learning. The findings of the study may assist the teachers with information that will help them incorporate and adopt the approach in teaching various topics in Mathematics. The Kenya Institute of curriculum development may use the information to design appropriate interventions that will help improve the students' performance in mathematics. The study of MLS is therefore a crucial prerequisite for any further attempt to improve the quality of Mathematics education and the levels of student achievement.

1.7 Limitations to the Study

The study used the Quasi-experimental research design which would not give same results as a true experimental study since there was no adequate time for a full experiment; the school programme would have been distracted and the respondents were also protected from the effects of an unknown outcome. Mastery Learning Strategy also requires more time for content coverage, so the researcher arranged for extended time for contact with learners within the two weeks.

1.8 Delimitations of the Study

The study was delimited to one mastery learning strategy (Bloom's Mastery learning strategy) which is a group-based, teacher-paced model. In this model, whole group instruction is supported by enrichment and corrective instruction to meet the needs of the students and not the *Personalized System of Instruction* (PSI), or the Keller Plan, which is an individually based, self-paced approach in which students learn independently of their classmates. The study was also delimited to one sections of the syllabus namely algebra and not the entire syllabus. This was because of the fact that Algebra is a foundational component of Mathematics which is applied to other sub-branches of Mathematics and other subjects as well. It is also part of the basic Mathematics taught in tertiary institutions. It is a fascinating branch of Mathematics that involves complicated solutions and formulas to derive answers to the problems posed. Algebra is the part of Mathematics that helps represent problems or situations in the form of Mathematical expressions. It is a unifying thread of almost all of Mathematics. Therefore, a topic that students need to have a good grip of.

Form two students were purposively selected due to the fact that at this level the student is considered to have settled down and acclimatized to Mathematics teaching and learning in secondary schools. Form one students were in the school for about three months and were in the process of adapting to the teaching and learning of Mathematics in secondary schools. Form three students were more inclined towards the selected subjects of study as compared to form two's. The form fours were more pressurized by impending national examinations unlike the form twos'. Further most topics taught in form two were at introductory stage and performance was less likely to be affected by prerequisite knowledge that is necessary for forms three and four.

It focused on Secondary schools in Machakos sub-county where dismal performance in Mathematics has been persistent and therefore the findings reflected the situation in this county and not any other region. The mastery learning strategy (MLS) was applied to find effects on: type of misconceptions, self-efficacy, mathematics achievement and the students' attitude towards Mathematics. The students in co-educational Public secondary schools in Machakos sub-county were chosen due to the mixed gender for possible comparative analysis of results.

1.9 Assumptions

The study assumed that the Mastery learning approach and conventional method have different impacts on learning outcomes. It was also assumed that, the sample drawn from the population would be adequate to deal with the research problem.

1.10 Theoretical Framework

This study was guided by behaviorist theory of learning as initially proposed by B.F. Skinner (1984). The study emphasized the concept of mastery learning which is attributed to the principles of operant conditioning. According to operant conditioning theory, learning occurs when an association is formed between a stimulus and response (Skinner, 1984). Operant conditioning requires the use of reinforcement and punishment. In operant conditioning, reinforcement increases the likelihood that behavior will be repeated (Ntim,2010). In line with the behavior theory, mastery learning focuses on overt behaviors that can be observed and measured (Baum, 2005). The material that was taught to mastery was broken down into small discrete lessons that follow a logical progression. In order to demonstrate mastery over each lesson, students must be able to overtly show evidence of understanding of the material before moving to the next lesson (Anderson, 2000). This is line with Bloom's Mastery Learning Theory.

The instructional model proposed by Bloom (1968) was an extension of Carroll's paradigm, which had been conceived from the educational psychologist's perspective. Bloom applied the theory to classroom practice. He took the factors in Carroll's model, reclassified them under student characteristics and instructional characteristics, and accounted for variances in learning outcomes in terms of these. Factors particular to the student were twofold:

(1) "cognitive entry behaviors;" and (2) "affective entry characteristics." These two were explained as referring to the student's prerequisite prior learning's and his level of motivation for the task to be learned. The quality of

instruction was considered separately from other factors because of its implications in educational research and practice.

1.11 Conceptual Framework

The Conceptual framework to guide the study was based on the Systems Approach (Joyce & Weil, 1980), which holds that the teaching and learning process has inputs and outputs.

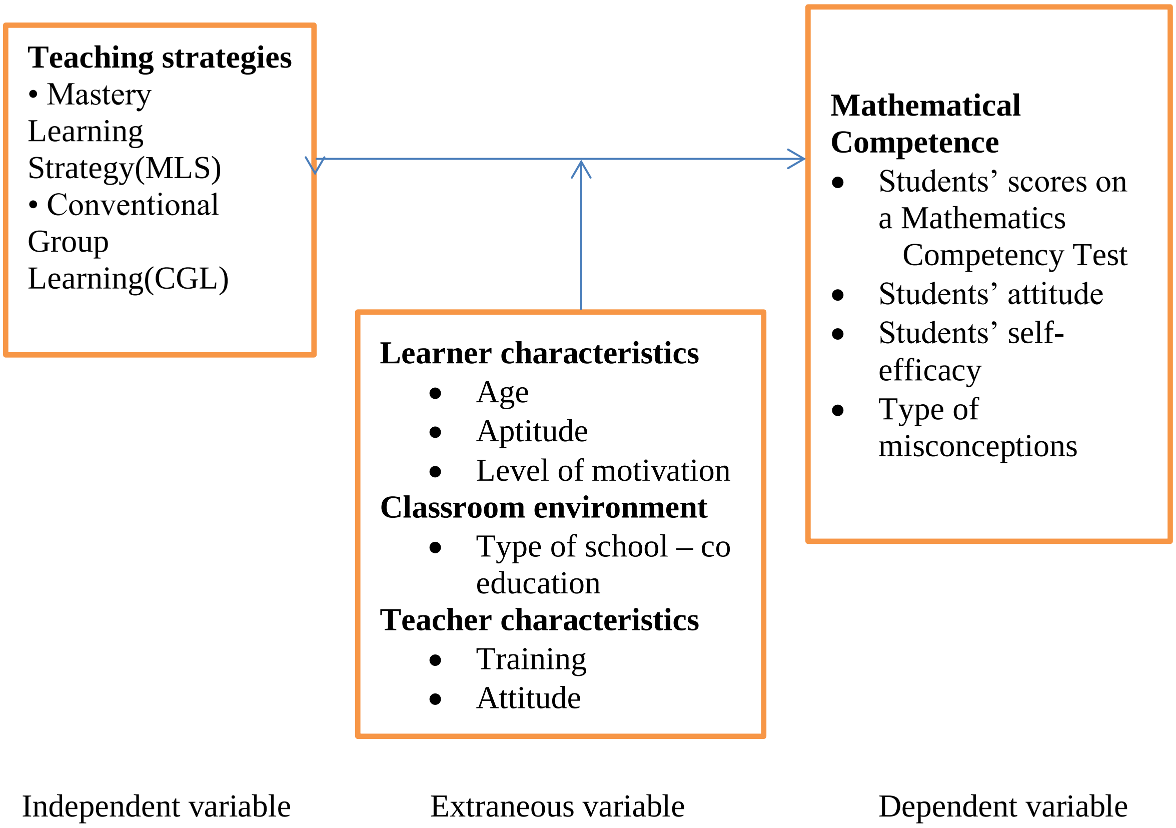

Figure 1.1: The Conceptual Framework

Source: Researcher

To achieve good results then the inputs must have suitable teaching materials. The study was based on the assumption that the blame for a students' failure rests with the quality of instruction and not lack of student's ability to learn (Bloom, 1981; Levine, 1985).

The framework is represented diagrammatically in figure 1.1. Figure1.1 shows the relationship of variables for determining the effects of using MLS and CGL on secondary school students' Mathematical Competence. Mathematics Competence was mainly influenced by the kind of instructional strategy employed which is the independent variable and other various factors which include: learner characteristics, classroom environment and teacher characteristics as shown in Figure1.1. These were extraneous variables which needed to be controlled. Teacher training determined the teaching approach a teacher used and how effective the teacher was able to use the approach. The teachers' attitude affects the classroom learning as well. The study involved trained Mathematics teachers to control the teacher variable. The type of school as a teaching environment affects the learning outcomes. The type of school used was coeducational to control the effect of the classroom environment. The learners' age and hence their class determined what they were taught. Therefore, form two students who are approximately of the same age were involved in the study. In this study the teaching method used influenced the learning outcomes which are students' competencies in Mathematics, the dependent variable.

1.12 Operational Definition of Terms

Academic Achievement: it is the score on a test

Aptitude: is the amount of time required by the learner to attain mastery of a learning task

Attitude: is emotional responses, beliefs, and behaviors towards mathematics.

Co-educational Schools: is a school where boys and girls are taught together.

Competencies: this refers to both cognitive and affective domain, in this case it will be the achievement in mathematics, the attitude towards mathematics, misconceptions in algebra and self-efficacy.

Corrective Teaching: will be the activity which will follow formative testing when mastery of the skill had not been achieved.

Conventional Group Learning: will be the instructional activities that the teacher uses in their day to day teaching.

Criterion Referenced Test: will be the concluding activity in mathematics in which all the skills in that domain will be tested.

Formative Evaluation: is the diagnostic procedure used after initial instruction to determine if mastery of a particular skill had been achieved. It will form the basis for corrective teaching where necessary.

Level of Achievement: refers to the degree of proficiency attained in Mathematics.

Mastery learning: refers to the group-based, teacher-paced model that is primarily associated with Bloom and his work.

Mastery Learning Strategy: Is a model where students are expected to master a learning objective or goal, before they can move on to the next goal.

Mathematics Achievement: is when a student demonstrates mastery (or achievement) when they score over 80 percent accuracy on an assessment.

Good performance: implies successfully attaining set cut-off marks in examination of a subject.

Poor performance: means attaining marks deemed too far below a designed cut-off mark.

Perseverance: Amount of time a student is willing to spend on a given task or unit of instruction.

Remediation: Is the provision of corrective instruction to enable students who do not initially meet the mastery criterion to do so on a later parallel assessment.

Self-efficacy: refers to an individual's belief in their capacity to achieve in Mathematics.

Type of misconceptions: refers to a wrong or inaccurate idea that students have in algebra

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter discusses review of previous research on the use of mastery learning as an instructional approach. A brief history and explanation of the model to be used are discussed together with research studies relating to achievement, attitude towards Mathematics, errors and misconceptions in Mathematics and student's self-efficacy in as far as the MLS is concerned, benefits and summary of the chapter.

2.2 Mastery Learning

A teaching strategy called mastery learning operates under the tenet of "take your time." It provides numerous chances to show that you understand the material being taught (Wambugu & Changeiywo, 2007; Adeyemo & Babajide, 2014; Filgona, Filgona & Sababa,2017). It entails segmenting the learning content into manageable parts with predetermined goals, followed by sequential organizing. The student moves through each unit in a planned manner. Before going on to the following unit, each student is given the necessary time to complete a certain activity. Each unit ends with a formative evaluation, followed by feedback and remedial work for the students. Before going on to the next unit, students must prove their proficiency on unit examinations (Bloom, 1968). Feedback highlights learners' learning challenges (Bloom, Hastings, and Madaus, 1971), and "corrective assignment" addresses these challenges (Guskey, 2005).

The Mastery Learning Approach follows a psychologically-based learning sequence. Learners go from simple to complex. The learner advances from lower to higher level of cognitive domain, i.e. from knowledge to understanding and so on, in accordance with Bloom's taxonomy of behavioral objectives (Filgona, Filgona & Sababa, 2017). A learner may be discouraged from moving on to the following higher order of cognitive domain if a lower order of cognitive domain is not mastered (Bruno, Ongaro & Fraser, 2007). Hence, before moving on to the next level, all learners should have a deeper knowledge of the concepts taught, according to Bloom's (1968) mastery learning theory. The concept of mastery learning is rooted in ancient Greek philosophy but the important work on mastery learning was done by John B. Carroll and Benjamin Samuel Bloom. Carrol (1963) gave theoretical model of mastery learning and Bloom (1968) translated it into the practical model of school learning.

The percentage of students who meet the mastery criterion has increased significantly thanks to the widespread usage of mastery learning methodologies. Under the right circumstances, students who achieve mastery do experience a change in how they feel about the subject and about themselves. Research on time and achievement in relation *to* mastery learning procedures show reduction in student variability and increases in learning efficiency and learning achievement.

Nonetheless, mastery learning does need careful thought and preparation before usage. As teachers and educators, you'll need to think about things like how you can manage students working at different paces, what kind of additional instruction you'll give kids who don't pass the first knowledge test with "mastery," and how you'll manage the time of students who advance more quickly. How will you measure the effectiveness of a mastery learning strategy in your classroom, in addition? These are all vital considerations

The Mastery learning approach is a style of classroom that allows for the most learning for the most students to occur. In Mastery the students learn with understanding unlike in the Conventional Group Learning where the students are pushed to complete the work or the questions are simplified and worked on almost to the end. So the teacher guides their thinking to a point where they basically are required to do no higher thinking of their own. They may receive decent grades but learning may not have occurred. This section establishes the source of the tenets of the mastery learning approach and explains the goals and outcomes expected from Mastery learning strategy. Before delving into the mastery learning strategy, it is prudent to consider its source. In a traditional classroom, students receive instruction aimed at getting the most students to learn the material in an allotted time period. This method leaves many students behind. One of the foundational beliefs to the idea of mastery learning is that all students can learn (Carroll, 1963). When one looks at assessments of learning, the measurements seem to contradict this statement. All students are not showing learning. Why? What is the factor holding them back?

In 1963, John Carroll proposed an answer to this question. A variable that had not been accounted for was time; every student can learn, but at different pace (Carroll, 1963). Time for learning is an important factor to consider in pacing in a classroom, but not the only factor. Another consideration that went into the development of the mastery learning strategy is what styles of learning are most effective for increasing student mastery. Bloom (1984) explored this topic and found that the most effective method of learning was in a one-to-one tutoring setting. However in the current form, most of our schools are not particularly conducive to forty students material at different speeds neither is it a feasible option in a class of forty students to have a one-to-one tutoring setting. The mastery learning style resulted in the average student performing above 84% of the traditional classroom (Bloom, 1984).

Given that the foundation of mastery learning strategy is that all students can learn (Carroll, 1963). Then this foundation requires the teacher to work flexibly with students to determine what learning is needed by which students. To facilitate this process, there are some common practices exhibited across mastery learning classrooms. First, complex full units are broken into smaller subunits that are short enough to measure understanding rapidly (Block 1971; Diegelmann---Parente, 2011). The subunits have discrete and measurable outcomes. The material for the students to learn is presented in a logical sequence that increases in conceptual complexity. Students remain with one skill or concept until they master it and then move on to the next subunit. Each subunit has a formative assessment attached to it to measure student mastery. If students show mastery, they move on to enrichment activities (Diegelmann---Parente, 2011). If mastery is not yet achieved, the teacher can target students who need reinforcement of concepts (Block,1971). This lends itself to smaller group settings, reaching toward the outcomes measured in one---to---one tutoring.

A visual representation of the classroom process, created by the researcher, is shown in Figure2.1.

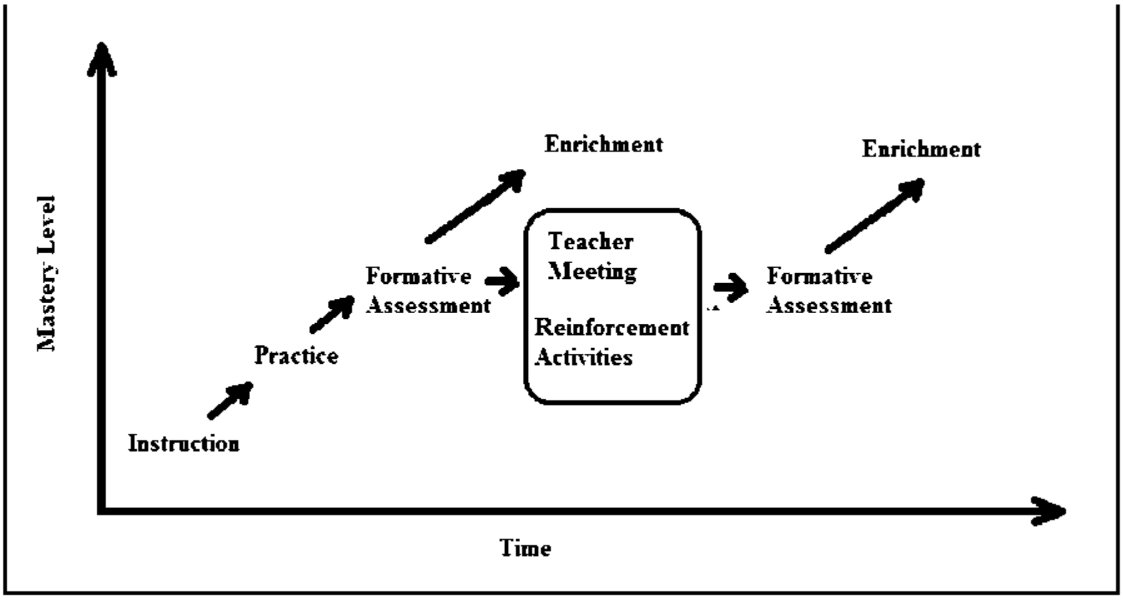

Figure 2.1. **This is a visual representation of the progression of students over time in the mastery learning approach. The arrows follow the path of the learners' mastery as a function of time. Important learning events are highlighted through the process.**

Another important aspect to the mastery learning strategy is that learning is the most important outcome in the classroom (Block, 1971), all students can learn. This idea manifests itself in a reduction in the importance of grades. Additionally, a grade is also not always the best indicator of the student's understanding of the material. If a student reaches a mastery level, then there is no concern for a grade. The outcomes are measured by mastery of material, not a grade (Diegelmann---Parente, 2011). Once students show mastery, then they can move on to enrichment activities.

Enrichment activities give these students exciting opportunities to broaden and expand their learning. Enrichment is a final key to the mastery learning strategy. Mastery of material does not mean the use of it is done. Initial mastery enables a person to begin really exploring a subject (Gentile, 2003). As seen in Figure 2.1 above the goal of education is for every student to reach a level of mastery that enables him or her to participate in enrichment level activities. The basic skills are mastered so that they can be applied to novel problems or ideas. Enrichment provides an opportunity to expand knowledge and internalize understanding (Gentile, 2003). The mastery learning strategy encourages students to move to understanding and then extend beyond understanding to apply and use what the mastery students have developed.

This clear picture of what the mastery learning strategy looks like in practice allows for new connections to be drawn. The study will, therefore, explore the relationship between the mastery learning strategy and the students' attitude, students' self-efficacy, students' learning outcomes in mathematics and students' misconceptions in algebra.

Basic Concepts of Mastery Learning

According to Phillip (2020), B.S. Bloom created MLS, which consists of several steps, including breaking up the content into sections, creating objectives specific to each subdivision, organizing instruction to achieve each division's goals, using formative assessments to identify trouble spots, and providing remedial instruction to help students clear up their ambiguities and reach mastery level. This method is crucial for understanding fundamental concepts, such as how to operate on numbers in the Natural, Integer, Rational, and Real number systems.

Learning via mastery is referred to as systematic learning through sequential steps, wh ere pupils are required to master the first step before moving on to the next. Accordin g to Stephen (2020), mathematics mastery is a teaching and learning strategy that ena bles students to gain a profound grasp of mathematics rather than only being able to m emorize formulas or rely on note-taking. In the mathematics teaching strategy, teaching from simple to complicated, concrete to abstract, and real to imaginary has been recommended as the best course of action (Richardson,2020). Most of the time, teachers use students' mental abilities as one of the reliable indicators for classifying them throughout time into high, middle, and poor mental resourcefulness. The instructor would make sure that each set of students worked under the identical conditions. A mastery learning approach offers the sustainability framework where students may apply their learning across a variety of subjects. As they develop their mathematical knowledge and abilities, MLS students can advance at their own rate, positioning them for successful implementation that will fundamentally alter how kids learn, how teachers instruct, and how schools are run. (Alex, 2016) claims that mastery learning techniques aid students in remembering mathematical concepts and procedures as well as practicing their calculation abilities. In order to understand useful information and prescribed methods, students are especially motivated to master mathematics subject. By encouraging in-depth knowledge through questioning, adopting conceptual variations, wise practices, and the translation of concrete concepts into representational and abstract ideas when solving mathematical problems, the MLS pedagogue aims to keep pupil’s collaborative (Rachna, 2011). It is not unrelated to mastery learning of mathematics to advance students' comprehension of mathematics and their capacity for critical thinking and reasoning through comprehensive transfer of new learning to pupils. Richardson provided a list of some efficient methods for studying mathematics that can improve students' comprehension and math test results. Clearly stating the instructions: establish a vocabulary for math and provide various learning opportunities to promote student discourse.

Mastery Learning Strategy and Mathematics Teacher

Teachers play a significant role in the academic success of their students. Teachers who are experts in the field are able to teach with finesse and aid in the growth of students' mathematical knowledge. One of the methods teachers have popularized to help students master mathematics content is MLS. A good math teacher helps his students see math learning challenges as real obstacles that peers and adults can assist in overcoming. According to Guskey (2019), the mastery learning approach evaluation is not a one-time, quick do-or-write experience but rather an ongoing endeavour to aid students in learning mathematics. MLS highlights the significance of assessment in teaching and learning mathematics. The teacher distributes the unit to students over the course of a few days or weeks, assigns a formative evaluation to gauge students' comprehension, and moves on after a sufficient apex is reached, as further detailed in Guskey, (2019). A learning technique for mathematics formulas that enables students to comprehend and master how the formula was created and how to use it to solve a mathematical problem is sought.

Regardless of the amount of time and resources required for success and subject mastery, MLS aims to make sure students understand any given concept (Kelik, 2019). The kids' academic mathematics deficiency is resolved thanks to the assimilation and use of MLS. Learning with a focus on mastery can raise accomplishment levels, change students' attitudes about learning, and strengthen their confidence when reviewing previously learned material. The use of MLS helped secondary school students' conceptual comprehension of mathematics, particularly that of abstract concepts. Deeper mastery resulted from repetition-based learning techniques. According to Oginni (2016) and Wilson (2020), concept repetition is one of the finest teaching methods because it enhances students' mathematics skills.

2.2.1 Advantages of Mastery

The advantages of Mastery far outweigh the potential problems of conventional teaching. Mastery is a very logical process. The process begins by defining the outcome it intends to produce. Then instructional and assessment procedures designed to maximize the likelihood that each student will arrive at the desired outcome are selected. The processes involved in the mastery program are not new. Each has been subjected to extensive use in educational settings. None of these processes has been proved to be bad in itself.

The mastery processes structure educational programs to help most students in a group to attain specific level of performance. The mastery process provides a format for structuring instructional programs. This format enables those who are concerned with educational process to participate actively in determining its direction. The mastery format provides a structure for continuous planning and progress. Educational resources can be more appropriately allocated when diagnostic evaluations have identified students' strength and weaknesses as well as their needs, goals and interests. It is flexible enough to be applied in open, informal classrooms and in the self-contained, formal classrooms, as well as classrooms that fall between these two extremes. The mastery components provide tools for identifying "what it means to do a good job", for monitoring the instructional progress to determine whether it is doing a good job and also to reform weaknesses in the educational program.

The mastery procedures help the educators and students to identify specifically what they are learning in an educational program. Its components provide tools for recognizing each student's progress. When a student faces challenging academic tasks and can succeed in mastering them, when the expectations concerning his performance are reasonable and realistic, and when the student knows that help is available when needed, the outlook is optimistic. Continuing academic progress results. If one goal is impossible to attain or otherwise non-productive, a more appropriate goal can be selected. If one road leads to a dead end, he can blaze a new trail. So, there is always a hope in mastery learning. Further this learning process inspires students to listen and engage in a group setting such that each member of the group plays a vital role in the group. When students relate and discuss freely, there is a high propensity for them to unveil the areas of their learning difficulty which the teacher can utilize in order to improve his classroom teaching, thus, Bloom indicates that it is an effective way to improve student attitudes and interest toward learning, besides helping them to master in specific knowledge [Ozden,2008; Kazu & Ozdemir,2005]. Research shows that the type of learning environment and teaching method can improve self-efficacy in the classroom (Bandura (more info)). A similar result was reported by Fencl and Scheel

This study sought to have mastery learning implementation in order to help students master mathematical knowledge, improve on their attitude, self-concept and interest toward learning.

2.2.2 A Brief History of Mastery Learning

Mastery Learning is no stranger to the world of academia. It was developed as a way for educators to provide more appropriate and higher quality instruction for students (Guskey, 1987). Early introductions can be traced as far back as the 1920s when Washburne and his associates (1922) developed the Winnetka Plan. The Winnetka plan promoted the notion of allowing students more time to achieve mastery and attempted to individualize instruction. Students were allowed to work at their own pace to achieve mastery and if they needed more time, they were given more time. The premise was that within the curriculum, time should be the variable and achievement should be the constant.

In 1963, the mastery approach resurfaced when Carroll introduced a Model of School Learning. In this model, Carroll challenged long standing beliefs concerning aptitude (Guskey, 1997). Traditionally, student aptitude was viewed as the level at which a student could learn. It was also believed that students with high aptitude could learn more complex concepts and students with low aptitude could only learn the basic fundamentals. Instead, Carroll argued that all students have the potential to learn even more complex concepts, but that the difference is the time each individual student requires to learn the information or skill (Guskey, 1997). Carroll proposed that these differences among students were a function of the following five characteristics: time allowed, perseverance, aptitude, quality of instruction, and ability to understand instruction (Block, 1971).

Carroll’s conceptual model proposed that if a student’s aptitude, the quality of instruction, and innate ability to understand instruction were high, then little additional learning time would be necessary. However, if a student’s aptitude, the quality of instruction, and innate ability to understand instruction were low, then additional learning time would be necessary (Block, 1971). Carroll’s model was limited in that it did not address the problem of how to provide adequate time or how to improve the quality of instruction (Guskey, 1997).

Despite Carroll’s efforts, it seems that mastery learning did not gain in popularity until a few years later when Bloom (1968) published his famous work, *Learning for Mastery*. Building upon the work of Washburne (1922) and Carroll (1963), Bloom focused on what he determined to be the most effective elements of one-to-one tutoring and individualized instruction. Specifically, Bloom examined how he could transfer the merits of these effective instructional methods to whole group instructional settings (Guskey, 1997). Bloom was able to develop what many consider to be an effective working model for mastery learning (Block, 1971). Bloom's *Learning For Mastery* (LFM) model is most widely recognized and is credited as the core foundation for other models developed later.

Primarily, mastery learning can be categorized as two types: group-based and individualized. The most common form of mastery learning, Bloom's *Learning For Mastery* (LFM) model, is a group-based, teacher-paced model. In this model, whole group instruction is supported by enrichment and corrective instruction to meet the needs of the students. The second form, the *Personalized System of Instruction* (PSI), or the Keller Plan, is an individually based, self-paced approach in which students learn independently of their classmates. Typically, students work at their own rate and move on to new material after they have demonstrated mastery of each unit. In this form, students can take as many tests as they desire to document that they have achieved mastery (Guskey, 1997). In this study, the term *mastery learning will* refer to the group-based, teacher-paced model that is primarily associated with Bloom and his work.

The current study worked on the principal that all students can learn if and only if each student was allowed sufficient time and quality instruction. Teachers should engage the students motivate them and create an environment that sparks their interest in mathematics. The study adopted Bloom's Mastery Learning model, which is a group-based, teacher-paced model. In this model, whole group instruction was supported by enrichment and corrective instruction to meet the needs of the students. The study reviewed both Carroll's and Bloom's models;

2.2.3 Carroll's Model of School Learning

Carroll attempted to provide a "schematic design" (1963, p. 723) that would comprehensively, yet simply, identify the factors that contributed to school learning and the interrelationships between and among those factors. He proposed a Mathematical formula that defined school achievement as a function of the relationship between the time spent on learning a task and the time needed to learn it to some criterion level. Figure below shows the Carroll model. "Time actually spent," or "engaged" time, was composed of time allotted and student perseverance at the task (Carroll, 1963, p. 729-731). "Time needed" varied with student aptitude for a particular task, the quality of instruction, and the student's ability to understand instruction. He further proposed that student perseverance, largely a question of motivation, was directly affected by the variables classified under "time needed," i.e., a student who was given instruction suited to his needs would be motivated to persevere until the task was mastered. Therefore,

Degree of learning = $f\left(\frac{time\ actually\ spent}{time\ needed}\right)$

Carroll's Model of School Learning

Source: Carroll, 1963, p 730.

2.2.4 Bloom's Mastery Learning Theory

Bloom's Mastery Learning was derived from Carroll's group-based mastery learning model which was only conceptual and theoretical. Bloom expanded and changed Carroll's model into an instructional and practical system for classroom learning in 1968 (Mitee and Obaitan, 2015). In Bloom's mastery learning approach, students learn with their class fellows cooperatively and the teacher controls the delivery and flow of instruction (Sood, 2013). According to Bloom (1968) mastery learning is an instructional method that presumes that all individuals can learn if they are provided with appropriate learning conditions.

Bloom further defined three kinds of such outcomes as being observable and measurable: (1) "level and type of achievement"; (2) "rate of learning"; and (3) "affective outcomes" (1976, p. 11).

Description of the Factors in Bloom's Model

The first classification of factors in Bloom's model were descriptors of what the student brought

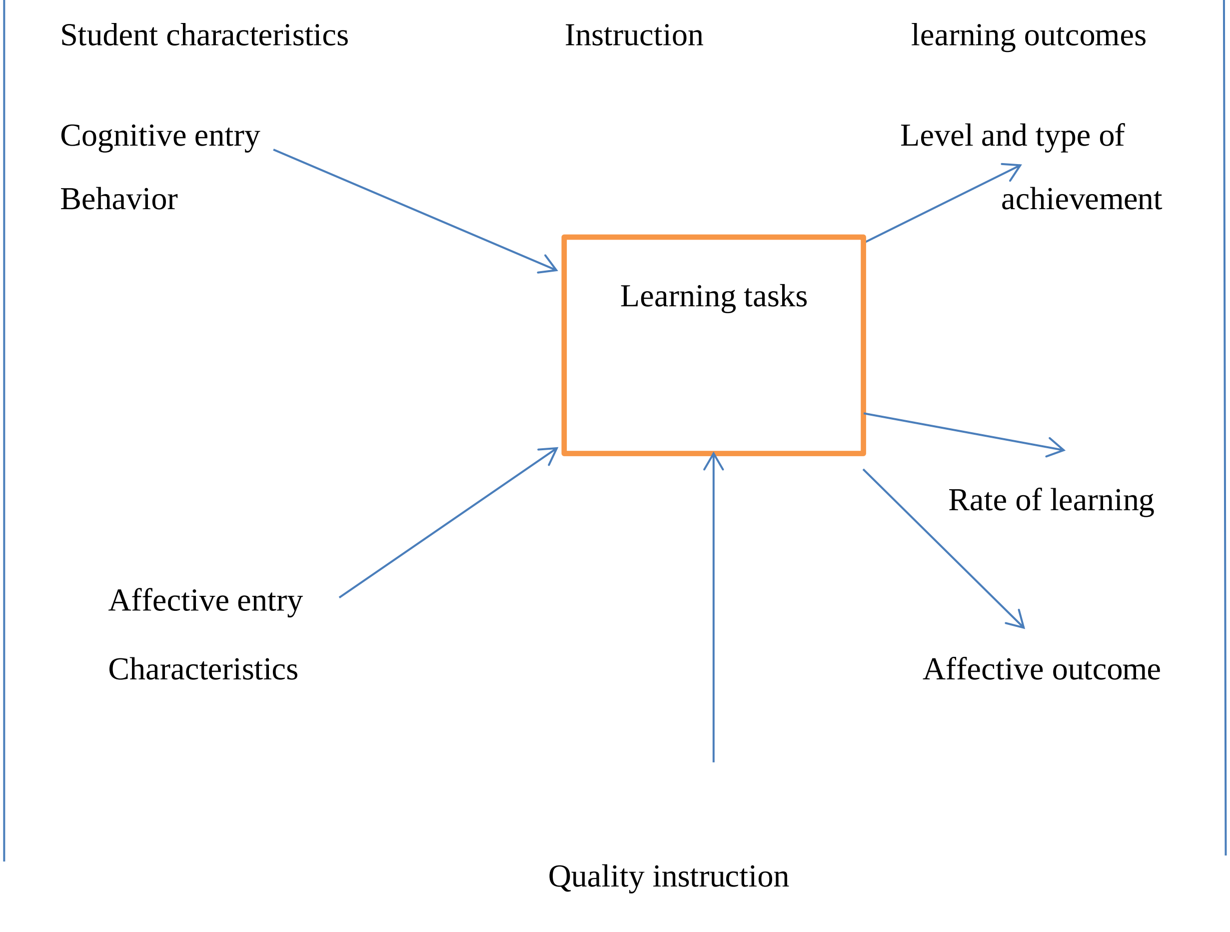

Figure 2.2: Relationship of Variables in Bloom's Theory of School Learning

Source: Bloom, 1976, p. 11.

To the learning task: cognitive entry behavior and affective entry characteristics. While recognizing the influence of factors other than these on an individual's development (environmental factors, social and cultural differences, and the like), Bloom intentionally focused his research on those factors in a student's history which he considered "more central to learning," more amenable to change, and more directly under the school's control (1976, p. 19). Their effects could be empirically validated. "Cognitive entry behaviors" was the phrase used to describe the prior learning that was prerequisite to the specific learning task which the learner faced. These behaviors could be identified and measured prior to instruction (Gagne' and Paradise, 1961; Atkinson, 1968;). They were seen as predictors of further learning, accounting for 50 percent of the variance in achievement (Bloom, 1976). "Affective entry characteristics" included the attitudes and tastes of the student in regard to the learning task. In addition, academic self-concept, or one's perception of self as learner, was considered part of the affect a learner brought to a task. "Quality of instruction" within mastery learning theory referred to directly observable components of the instructional cycle. Group-based instruction was made responsive to individual needs through the use of formative testing and corrective teaching based on the test results. Block (1970) found significant increases in Mathematics achievement using a cycle of group instruction, formative testing, corrective teaching and summative testing (Bloom, Madaus, and Hastings, 1971). Further, Arlin (1983) and Levin (1985) found, when other factors were held constant, that formative testing/ corrective teaching accounted for 25 percent of the variance in achievement.

Learning outcomes were classified in three categories for the purpose of measuring the effects of mastery learning techniques. The three classifications were achievement (cognitive and psychomotor), rate of learning, and affective outcomes. Benjamin

Bloom then outlined a specific instructional strategy to make use of this feedback and corrective procedure, labeling it *mastery learning* (Bloom, 1971a). The basic assumption of mastery learning is that almost all students can learn the essential knowledge and skills within a curriculum when the learning is broken into its component parts and presented sequentially. Mathematics as a subject has often been said to be too abstract for some children. "Any idea, problem, concept or a body of knowledge can be presented in a form that is simple enough for any particular learner to understand it" (Brunner 1966). Hence, the mode of representation of content is to be planned in such a way that the learner is able to master the corresponding competency. Presentation of learning experiences from concrete to semi-abstract to abstract levels may ensure attainment of a competency by every child. The current study sought to investigate the effect of mastery learning strategy on both cognitive and the affective behavior.

Bloom (1968) argued that if students were normally distributed with respect to aptitude and are given uniform opportunity to learn and quality of instruction, only few students would achieve mastery in their learning since the aptitude of each student will determine the degree of learning, which means students with high aptitude will perform well and those with low aptitude will perform poorly. On the other hand, if the students are given different opportunity to learn/time allowed for learning and quality of instruction that will match their need and situation, at least 80% or higher, even as much as 95% could achieve mastery in learning. Based on this, Bloom developed a mastery learning model called Learning for mastery (LFM). The use of MLS in teaching mathematics in secondary schools is likely to help improve their academic achievement because the basic idea of mastery learning can be summarized by the fact that, when given enough time and proper motivation, everyone can learn.

A critical review of the literature in the field of mastery learning revealed that little work has been done to examine the conditions under which mastery learning is more or less effective and the limits of students learning through the mastery learning approach. The present study was designed to investigate the effectiveness of Bloom's mastery learning strategies in relation to, achievement, misconception, attitude and self-efficacy in Mathematics in secondary school students in Machakos Sub-County, Machakos County, Kenya.

2.2.5 The Variables for Mastery Learning Strategies

The following are variables which all mastery learning strategies generally take into account.

1. **Ability to understand Instruction**

This means that the learner should be able to understand the nature of the task and the procedure he is to follow when learning

2. **Quality of Instruction**

Carrol (1963) emphasized good quality instruction where there is a variety of instructional approaches. Time variation can also be reduced by improving quality of instruction Use of feedback and use of frequent and varied reinforcements improve quality of instruction (Airasian. 1969; Block, 1970; Colllins, 1970). Guskey (1987,2007) noted that an instructional program that does not include implicit feedback and corrective procedures cannot be considered under mastery learning.

Positive effects of feedback are reported as important components of mastery learning (Obando & Hymel, 1991).

3. Perseverance

Carroll (1963a) defined perseverance as the time the learner is willing to spend in learning. This is 'persistence' on the student's part, that is, it is 'keeping on at a task'. Subjects high in achievement motivation persisted longer i.e. took more trials in the failure condition than in the success condition. Husen (1967) concluded that perseverance's also related to student attitudes and interest in learning. However, the research literature provided sufficient evidence to conclude that mastery learning increases the perseverance of the students (Sharma, 1998).

4. Time allowed for Learning

Carroll (1963b) emphasized that if time is held constant, then individual differences in aptitudes play an important role in achievement. In mastery learning it is achievement and not time which is held constant. Every student is given ample time to learn. When each student is allowed as much time as he needs to learn, 80 or 90 per cent of the students attain a level of achievement previously attained by only 25 per cent of those enrolled (Bloom, 1968).

In the application of the mastery learning strategy the current study considered the ability of the student, the quality of instruction where varied reinforcement, feedback and corrective procedures were considered, student's perseverance and time allowed for each student to learn.

2.2.6 The Mastery Components

The mastery model contains six major components: Objectives, Pre-assessment, Instruction, Diagnostic assessment, Prescription and Post-assessment. Each component of the Mastery structure has an important function in helping students to learn and progress at their own pace as well as provide each student with the greatest possible exposure to the instructions which would help him/her reach their goals.

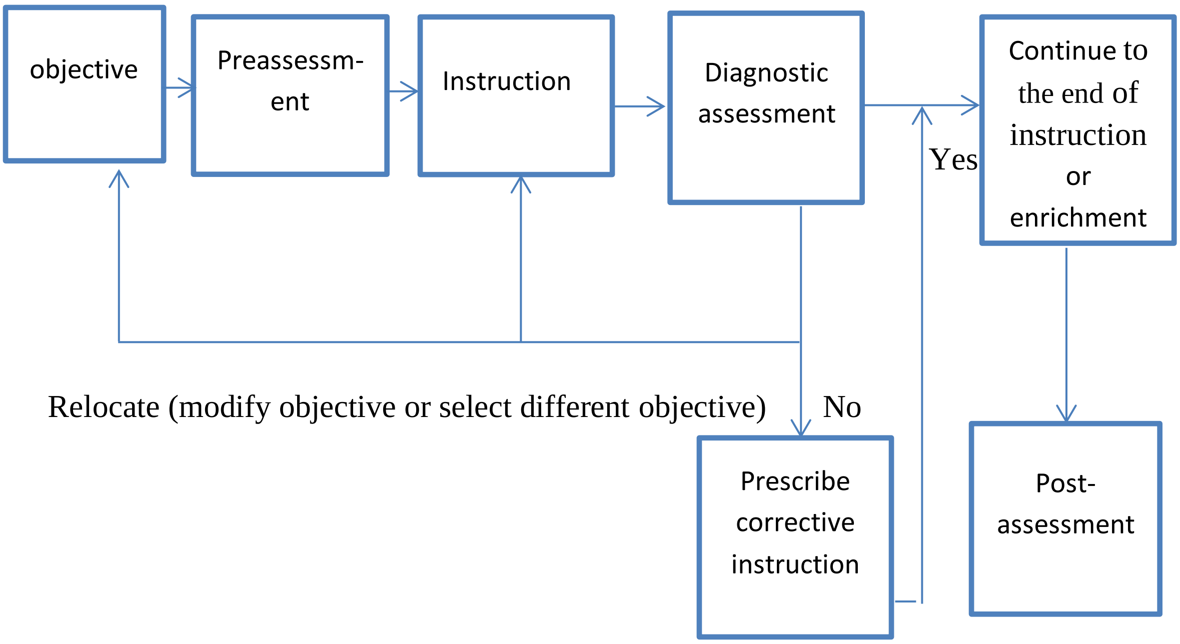

Figure 2.3: Components of the Mastery Structure

1) Objectives

Objectives are the first component of the mastery model. Objectives are the specific statements of the outcomes or goals that students in the instructional program are expected to reach at. They define the specific skills, the key concept and the ideas, or the specific facts that the student must learn in order to complete the program successfully.

In each skill, concept and fact area (defined in the objectives) the minimum level of performance essential for each student to attain is identified. These performance levels are called mastery levels or minimum pass levels.

2) Pre-assessment

The pre-assessment component of the mastery model determines each student's starting point and methods of instruction which the teacher uses in the program. This assessment identifies each student capacity relative to the outcomes he/she is expected to reach by the end of the program. It is normally given at the beginning of a unit and it incorporates ability tests in previous units and the other information supplied by the student.

3) Instruction

In selecting the instruction for a program, it is essential to use the instruction that will help the student to proceed from their initial status to mastery of the objective. There is no restriction on the type of instruction that can be used in a mastery program though it is essential to employ more than one instructional method.

4) Diagnostic Assessment

The diagnostic assessment component provides information concerning how well the instructional program is working and it measures what each student has learned and what he/she has failed to learn at regular intervals throughout the instructional program. Formative assessments can be used in diagnostic assessment and they vary in form depending on the subject area, the grade level, and the learning outcomes involved. They may be short quizzes, written assignments, oral presentations, skill demonstrations, or performances. In essence, formative assessments are any device teachers use to gather evidence of student learning. This can be-administered weekly, although they may be more frequent, depending on the subject area and nature of the class. The information is used to pace the student's learning and ameliorate those segments of the instruction that have not been effective. This component of the structure is crucial in adapting the instruction to the needs of the individual students.

5) Prescription

The prescription component of the mastery structure consists of the instructional activities recommended on the basis of the diagnostic assessment. According to the diagnosis of the problem, the student is provided with additional instruction or alternative instruction or they repeat the instruction they have just completed or any other prescription as the need be.

Bloom (1974) argued, however, that intense, individualized assistance offered early in an instructional sequence would drastically reduce the time needed for remediation in later units. Because corrective instruction guarantees that students have the learning prerequisites for subsequent units, initial instruction in later units can proceed more rapidly, allowing teachers to cover just as much material as they would using more traditional methods (Guskey, 2008).

The 'corrective' teaching designed to remedy identified learning problems should not be described as 're-teaching'. It should adopt a different approach to the original teaching e.g. using different example and involving peer tutoring or collaborative activities small group discussions, or homework. It also seems to be important that a high bar is set for achievement of 'mastery' (usually 80% to 90% on the relevant test).

When students complete their prescribed remedial instruction then an alternate form of the diagnostic assessment which includes different problems or questions is administered. The student continues recycling through the remediation and diagnostic evaluation until he/she performs at the minimum pass level. Recycling should be continued until the student has mastered the crucial skills, or the student should be placed in another objective sequence.

In mastery learning, assessments are not a one-shot, do-or-die experience; instead, they are part of an ongoing effort to help students learn. That is why after corrective activities, mastery learning teachers give students a second, parallel formative assessment that helps determine the effectiveness of the corrective instruction and offers students a second chance to demonstrate mastery and experience success. Although it includes somewhat different problems or questions, this second, parallel evaluation covers the same concepts and skills as the first. It accomplishes two significant goals as a result. In order to gauge the success of intervention tactics, it first confirms whether or not the correctives actually assisted the students in overcoming their unique learning challenges. It also gives pupils a second opportunity at success, which has strong motivational value.

Mastery learning teachers make a point of recognizing those students who do well on the initial formative assessments. But they also acknowledge that students who do well on the second formative assessment have learned just as much and deserve the same grades as those who scored well on their first try.

Relocation is prescribed for a student when the diagnostic assessment indicates that he/she does not have the prerequisites needed to perform successfully in this instruction. Such a student can receive special instruction to develop his/her prerequisite skills before he/she continuous in the program.

Enrichment materials and instructions are prescribed for the student when the diagnostic evaluation indicates that he/she has performed successfully. Enrichment is composed of additional learning activity at approximately the same skill level as the instructional activity, the student has recently completed. Students engaged in enrichment activities gain valuable learning experiences without necessarily moving ahead in the instructional sequence. This makes it easier for other students who have been doing corrective work to resume their place in the regular instructional sequence when they are done.

If more than one objective is included in an instructional sequence, then the instructional and diagnostic evaluations for the other objectives in the sequence are completed in the manner described above. Then, the final assessment procedure is administered.

6) Post assessment

This is the final component of the mastery model which determines whether each student has attained the outcomes identified in the objectives. Each student's mastery of the objectives is measured. If a student has not mastered a crucial objective, then the student is either recycled through the instructional program or additional instruction is prescribed for the student. The student will continue with the instruction until they reach at the minimum pass level.

The current study will investigate the end result in mathematics achievement, attitude towards Mathematics, self-efficacy and in errors and misconceptions when the students are taken through the six components of the mastery learning model.

2.2.7 Procedure of Mastery Learning

Guskey (2007) noted that Mastery learning curricular generally consist of discrete topics which all students begin together. After beginning a unit, students will be given a meaningful and formative assessment so that the teacher can conclude whether or not an objective has been mastered. At this step, instruction goes in one of two directions. If a student has mastered an objective, he or she will begin on a path of enrichment activities that correspond to and build upon the original objective. Students who do not satisfactorily complete a topic are given additional instruction until they succeed. If a student does not demonstrate that he or she has mastered the objective, then a series of correctives will be employed. To be optimally effective, correctives must be qualitatively different from the initial teaching. They must provide students who need it with an alternative approach and additional time to learn. These correctives can include varying activities, individualized instruction, and additional time to complete assignments. These students will receive constructive feedback on their work and will be encouraged to revise and revisit their assignment until the objective is mastered.

In a mastery learning classroom, teachers follow a scope and sequence of concepts and skills in instructional units. Following initial instruction, teachers administer a brief formative assessment based on the unit's learning goals. The assessment gives students information, or feedback, which helps identify what they have learned well to that point (diagnostic) and what they need to learn better (prescriptive). Students who have learned the concepts continue their learning experience with enrichment activities, such as special projects or reports, academic games, or problem-solving tasks. Students who need more experience with the concept receive feedback paired with corrective activities, which offer guidance and direction on how to remedy their learning challenge. In mastery learning classes, correctives techniques are adapted to the specific weaknesses of each individual student, while in traditional classes, no additional opportunities are provided for students to improve the course work (Mevarech, 2001). To be effective, these corrective activities must be qualitatively different from the initial instruction by offering effective instructional approaches and additional time to learn. Then another formative assessment is administered. Figure 2.4 below illustrates this instructional sequence.

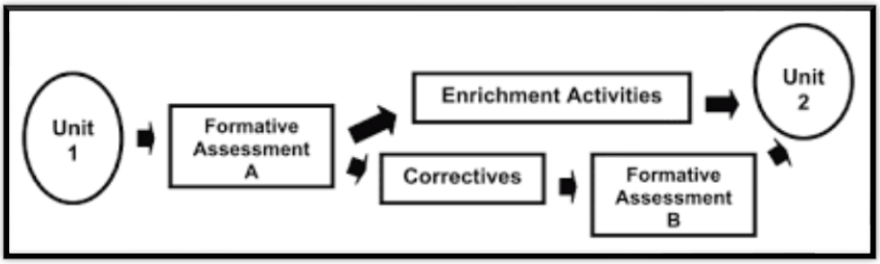

Figure 2.4: Mastery Learning Instruction Process (Guskey, 2005)

Another element of mastery learning that many other interventions share is the use of regular formative assessments to systematically monitor student progress and give students prescriptive feedback (Hattie & Timperley, 2007). These brief classroom assessments measure the most important learning goals from an instructional unit and typically are administered after a week or two of instruction. They reinforce precisely what students are expected to learn, identify what they learned well, and describe what they need to learn better.

Formative assessments vary in form depending on the subject area, the grade level, and the learning outcomes involved. They may be short quizzes, written assignments, oral presentations, skill demonstrations, or performances. In essence, formative assessments are any device teachers use to gather evidence of student learning. Feedback is always a part of mastery learning where students are given an opportunity to practice what they have learned and are given corrective feedback (Motamedi & Sumrall, 2000). A teacher's response to a student's work is known as feedback. Feedback in the classroom can be crucial to a student's learning process (Nichols, 2012). Feedback gives the teacher the chance to rectify or instruct the student on an individual basis. Feedback is a fundamental component of the process in a mastery learning classroom.

The student meets with the teacher after formative assessment to receive feedback (Diegelmann-Parente, 2011). Students who receive positive and encouraging feedback perform significantly better on subsequent assessments (Clair, 1979). Feedback is most effective when it is specific and provided as part of a dialogue rather than as a series of marks on a piece of paper (Clair, 1979). Benjamin Bloom recognized that students should not be compared through their academic achievements but rather the students should be helped to achieve the goals of the curriculum which they were enrolled (Eisner, 2000).

Those students who learn quickly and for whom the initial instruction was highly appropriate are provided with opportunities to extend their learning through enrichment and students who need extended time and opportunity to remedy learning problems are offered these through correctives. Jensen (2006) also supports mastery learning wherein a student who masters a skill or subject moves on to the next level of learning. In this process slow learners are not kept back and gifted students would perform to their own higher capacities.

The current study was designed to give every student optimum opportunity to learn where enrichment activities were given to those students who master an objective while corrective activities and additional time were administered to remedy learning challenges. These are additional opportunities now available but not available in traditional classes.

2.2.8 Bloom's Mastery Learning Strategy

Bloom's mastery learning structure (B-MLS) is a group- based and teacher-paced approach. Students learn cooperatively with their classmates and teacher controls the delivery and flow of instruction. This approach has had a major impact at the elementary and secondary levels of schooling (Eraut, 1989).

Some of the basic features of B-MLS include specific instructional objective relating to the learning task and that a course or subjects should be broken into small units of learning where each unit has an objective, a course mastery performance standard which the students will be expected to achieve on this examination is determined and that a test should be administered at the end of each unit. After each test the teacher provides feedback for areas where the learners have challenges. For those students who have difficulties the teacher is expected to create time and provide alternative learning opportunities. To increase student's effort, it is important to create groups of two or three students to meet regularly so as to help one another on areas that they experience challenges identified in the test.

The current study adopted the Bloom's mastery learning strategy where the topic was broken into units each of which had an objective which student were expected to attain. The students who will have difficulties the teacher is expected to provide alternative learning opportunities.

2.2.9 Comparison of Mastery Learning Strategy and Conventional Group Learning

The Mastery Learning Strategy stresses more of mastery of content, through corrective feedback and remediation unlike Conventional Group Learning. Research conducted on comparing effects of Mastery Learning alone, and Conventional teaching methods on student achievement Mevarech (1985) showed that Mastery Learning was the indicator that significantly increased achievement. Wentling (1973) when comparing Mastery Learning and Non-Mastery Learning as to how feedback relates to achievement found that students who received feedback in MLS had higher achievement scores for both immediate achievement and long-term retention.

However, time spent toward instruction showed no significant difference. Further, MLS allows students to have enough time to master the prerequisites before making progress. However, Arlin and Webster (1983) raised an important issue regarding the use of instructional time in Mastery Learning. He argued that low achievers in grouped Mastery Learning do better because of corrective instruction, but faster students may be slowed down waiting for the other students. However, this is taken care of in the enrichment process. This would, therefore, require the teacher to be willing to use the time outside the normal school timetable for corrective procedures and retesting. However, many teachers are hesitant to implement a mastery learning approach in their classroom for fear of falling behind in their lessons. Some critics argue that giving some students extra time to complete their assignments is unjust.

They contend that differentiated instruction is inherently unfair because students who receive additional feedback and time have an advantage over students who master the objectives the first time. The majority of this criticism stems from a misinterpretation of Bloom's approach. The implementation of a mastery learning approach in Bloom's ideal classroom would eventually result in a drastic decrease in the variation of student achievement. Students who initially require more corrective measures would "gain direct evidence of the personal benefits the process provides" (Guskey 2007). The results also show that Mastery Learning Strategy is beneficial to both boys and girls.

Mastery learning strategy assumes that virtually all students can learn what is taught in school if their instruction is approached systematically and students are helped when and where they have learning difficulties (Bloom, 1984). The most important feature of Mastery Learning Strategy is that it accommodates the natural diversity of ability with any group of students and that with careful preparation all students can be appropriately accommodated according to their respective levels of understanding and they can progress at their own rate.

The current study will compare the effects of mastery learning strategy and the conventional group learning in as far as the Mathematics achievement, attitude towards Mathematics, misconception and self-efficacy are concerned.

2.2.10 Benefits of Mastery Learning Strategy

Mastery Learning Strategy (MLS) is an instructional method, where students are allowed unlimited opportunities to demonstrate mastery of Content taught. MLS involves breaking down the subject matter to be learned into units of learning, each with its own objectives. Guskey (2007) reported that Bloom hypothesized that a classroom with a mastery learning as opposed to the conventional form of instruction would reduce the achievement gaps between varying groups of students. In Mastery learning, Bloom (1984) stated that "the students are helped to master each learning unit before proceeding to a more advanced learning task" in contrast to "conventional instruction". Mastery learning uses differentiated and individualized instruction, progress monitoring, formative assessment, feedback, corrective procedures, and instructional alignment to minimize achievement gaps (Zimmerman & Dibenedetto, 2008). The strategy is based on Benjamin Bloom's *Learning for Mastery* model, which emphasizes differentiated instructional practices as strategies to increase student achievement.

Research on mastery learning across grade bands has shown positive cognitive and effective learning outcomes in students in general, including learners considered at risk of academic failure (Guskey & Gates, 1986). In addition, the successful use of mastery learning has positive effects on teachers as well, as their expectations for student achievement improve. The poor performance of students in science subjects has assumed a dangerous dimension. In the light of this, science educators need to seek suitable ways of tackling the current mass failure if they are to halt the drifts of students to arts and social science subjects (WAEC- KNEC Reports, 2008).

In addition, we may not possibly realize our goals in science education unless and until we diagnose the factors contributing to these high failure rates in science subjects. We may even end up producing a large number of illiterate science students. Hence, an alternative method of instruction is needed.

The benefits of mastery programs appear to be relatively enduring, not just short-term, effects. Mastery learning programs also seem to have a positive effect on student attitudes. Mastery learning students are more satisfied with the instruction they receive and more positive toward the content they are taught than are students in conventional classes. In a mastery learning environment, the teacher directs a variety of group-based instructional techniques, with frequent and specific feedback by using diagnostic, formative tests, as well as regularly correcting mistakes students make along their learning path. Assessment in the mastery learning classroom is not used as a measure of accountability but rather as a source of evidence to guide future instruction. A teacher using the mastery approach will use the evidence generated from his or her assessment to modify activities to best serve each student. Teachers evaluate students with criterion-referenced tests rather than norm-referenced tests. In this sense, students are not competing against each other, but rather competing against themselves in order to achieve a personal best (Keller, 1968).

The mastery learning model has been found to be useful in a variety of settings. It gives struggling students the opportunity to master key concepts before being introduced to new material. At the same time, it presents a challenge to high achievers. This method of instruction allows gifted students to move quickly through the program, either to the next level (year) or to engage in extension studies that will broaden their understanding of the subject. The model also allows for personalized learning. Furthermore, feedback provided during this process is beneficial to the student. This model represents the idea that if given enough time and the right learning environment, any learner can learn. (Professional learning board blog).

The current study, where assessment is used as a source of evidence to guide future instruction will investigate the extent to which the mastery learning students will show a positive cognitive and effective learning outcome in Mathematics and a positive attitude towards Mathematics.

Teaching Strategies for Improving Algebra Knowledge in Secondary School Students

Algebra is often the first Mathematics subject that requires extensive abstract thinking, a challenging new skill for many students. Algebra moves students beyond an emphasis on arithmetic operations to focus on the use of symbols to represent numbers and express Mathematical relationships. Understanding algebra is a key for success in future Mathematics courses, including geometry and calculus. Many Mathematics experts also consider algebra knowledge and skills important for post-secondary success as well as for producing a skilled workforce for scientific and technical careers. Algebra requires proficiency with multiple representations, including symbols, equations, and graphs, as well as the ability to reason logically, both of which play crucial roles in advanced Mathematics courses (Star, J. R., et al., 2015). It is for that purpose that the study investigated the effects of mastery learning strategy and conventional group learning in learning of algebra

2.3 Empirical Literature

Numerous researchers [Davrajoo, et al (2010), Toheed and Jabeen (2017), Zan and Martino (2007), Tukur *(*2018), Wu (2001), Peters (2013), (Booth & Koedinger, 2008), (Phan, 2012), Wambugu and Changeiywo (2008).etc] have investigated on the use of CGL and MLS in as far as the learning outcome, attitude, misconception in Mathematics and self-efficacy is concerned as narrated in the following sections.

2.3.1 Effects of Mastery Learning Strategy in Teaching Mathematics on Student's Learning Outcomes

A number of research studies [Davrajoo, et al (2010), Hutcheson (2015), Tukur *(*2018) ……] have been conducted to compare mastery learning strategy with conventional group learning in various academic courses. A study by Davrajoo, et al (2010) investigated the effect of Algebraic Mastery Learning Module usage on mathematics achievement of low achievers with high anxiety in Mathematics. In this quasi-experimental study, 50 low achievers in Form Four from a secondary school were involved. Target participants were divided into two groups: an experimental group with MLS and conventional instruction strategy group. The content of activities for the two groups was the same but differed in its structure of teaching. In MLS the material to be learned was subdivided into small units, covering from one lesson to another. The activities were carried out for about three weeks of intervention period. The two groups completed Algebraic Comprehension Test before and after the intervention period. The results, further, showed that the experimental group improved in their achievement considerably better in than control group. The preliminary findings of this study provided evidence that the construction and mastery of the algebraic concepts assist students towards positive attitude in mathematics learning. Though similar in method and the structure in MLS with the current study, theirs is unique from this study based on the topic, target population, sample size and the study area.

Another similar study conducted by Toheed and Jabeen (2017) investigated the effect of Mastery Learning Strategy (MLS) on learning retention of secondary school students in the subject of Mathematics by comparing it with Conventional Teaching. The purpose of the study was to identify an instructional strategy that might have effect on learning retention of students. Significant difference was found in the learning retention of students in favor of experimental group. The study recommended that teachers may use MLS for teaching of Mathematics at secondary school level.

Hutcheson (2015), carried out an experimental study in order to find out the effect of mastery learning approach on student motivation in middle level science and arrived at the result that students showed an overall increase in their motivation and academic achievement when taught through mastery learning approach. Also, the findings of Furo (2014) and Lamidi, Oyelekan, and Olorundare (2015), who investigated the effects of mastery learning on students' academic performance in chemistry and discovered high academic achievement by students. An enhanced academic achievement was exhibited by students in geometry under the effect of mastery learning when Abakpa and Iji (2013) compared mastery learning with conventional teaching. They also discovered that mastery learning reduced gender differences and learning differences in both low and high ability students.

Udo and Udofia (2014) compared the effects of the Mastery Learning Strategy to the Conventional Lecture Method and discovered that mastery learning improved students' academic performance in in various areas of the subject. Mitee and Obaitan (2015) conducted an experimental study to investigate "the effect of mastery learning on senior secondary school students' cognitive learning outcomes in quantitative chemistry" and concluded that mastery learning is a very effective teaching method that outperforms traditional teaching methods. Agboghorom (2014) conducted an experimental study to investigate the effect of mastery learning approach on secondary students' integrated science achievement and concluded that Mastery learning approach resulted in higher achievement and found an effective teaching method.

Achufusi and Mgbemena (2012) conducted an experimental study to examine the "effect of using mastery learning approach on academic achievement of senior secondary school II physics students" and found that the experimental group achieved significantly ($p<0.05$) better than the control group. The female students achieved slightly better than their male counterparts but the difference was not significant at P=0.05. Sood (2013) conducted an experimental study to investigate the effect of mastery learning strategies on concept attainment in geometry among high school students and discovered that Bloom's LFM and Keller's PSI were significantly more effective in attainment of geometrical concepts when compared to conventional methods of teaching.

Mastery learning can also produce satisfactory affective learning outcomes. This is supported by Guskey and Pigott's (1988) meta-analysis, which examined 38 studies that used affective measures. Students' affect (attitudes) toward the subject they were studying, their affect toward schooling, their academic self-concept, and their grade expectations were the affective variables measured. Thirty-one reported effect sizes were positive (82%), while others were negative (18%) when compared to control conditions.

Guskey and Pigott's (1988) meta-analysis for affective outcomes of mastery learning method used in mathematics instruction reported twelve effect sizes. Nine effect sizes were found to be positive (75.00%), while three others were negative (25%). Five of the seven studies that assessed students' attitudes toward mathematics were positive (71%), while the other two were negative (19%). There were three effect sizes for academic self-concept in mathematics, two of which were positive (66.66%) and one of which was negative (33.33%). Attrition had one positive effect size reported. The relatively high rate of negative affective outcomes of mastery learning methods (18.42%) can be attributed to the fact that affective characteristics in students are extremely difficult to change in short periods of time.

In a study, Ihendinihu (2013) discovered that students who were taught using the MLS teaching method achieved statistically significant higher scores in the achievement test, not only for higher ability pupils but also for low achievers. McCane, Ott, Meek, and Robins (2017) discovered that the Mastery learning strategy model has a significant encouraging influence on student learning, particularly for lower group learners.

Tukur *(*2018) conducted a similar study on the effect of mastery learning strategy in enhancing the academic achievement of Mathematics in Nigeria. Eighty first-year senior secondary school students were used as subjects of the study. Mastery learning strategy was used in the treatment group (N=40) and Conventional Group Learning was employed for the Control Group (N=40). This investigation utilized the quasi-experimental design. The results of the study revealed that students who were exposed to mastery learning had enriched academic achievement in Mathematics. Apparently, results on the posttest mean scores of the students revealed that there was a significant effect on the academic achievement of the experimental group in which the MLS had been introduced. As such, students exposed to MLS performed better than those taught in the conventional teaching method (CGL). Moreover, results exemplify that there is a significant relationship between the students' attitudes toward Mathematics and their academic achievement in Mathematics. In terms of relationship the study found a significant relationship between *Tukur Madu Yemi* study and the current study in that both were investigating the effect of MLS on Mathematics competancy and students' attitude towards Mathematics. In terms of research design both used the quasi-experimental design. The only difference in the current study was the location of the study and the sampled group.

In another similar study, Uchechi, Ezinwanyi and Ihendinihu (2013), conducted a quasi-experimental study on effects of mastery learning strategy on students' achievement in Mathematics on Secondary School students in Nigeria. The study utilized pretest post-test non-equivalent groups. A sample of 150 students was drawn from three (3) Secondary Schools. Two experimental groups namely Mastery Learning and a Control Group were each constituted in the three Schools. Results of data analyses using mean, standard deviation and ANCOVA indicate that mastery learning strategy enhances students' achievement in Mathematics. The study recommends that Mathematics teachers should be encouraged to integrate mastery learning strategy in their instructions, and that curriculum planners should include a variety of teaching strategies that will accommodate both fast and slow learners in the curriculum. The topic of this research is unique from the current one in as far as the target population and location are concerned.

Patricia and Johnson (2008) used two groups of students from co-educational schools to investigate the effects of mastery learning and gender on physics achievement. The experimental group received mastery learning instruction, while the control group received traditional instruction. They discovered that the group taught using mastery learning outperformed the group taught using the traditional teaching method. They also discovered that gender had no effect on student achievement and concluded that mastery learning is an effective teaching method that physics teachers should be encouraged to use. Ogba (2000) investigated the effect of mastery learning on cognitive learning outcomes in junior secondary school mathematics and discovered that mastery learning outperformed conventional learning.

Another significant study was undertaken by Wambugu and Changeiywo (2008) which investigated effects of mastery learning approach on secondary school student's physics achievement. The study used a total of 161 secondary school students in Kenya using quasi-experimental and Solomon four Non-equivalent control group design for the period of three weeks treatment. The target population comprised of secondary school students in Kieni East Sub-County of Nyeri County. The accessible population was Form Two students in co-educational schools. Purposive sampling was used to obtain a sample of four co-educational secondary schools. Each school provided one Form Two class for the study hence a total of 161 students were involved. The experimental groups were exposed to MLS for a period of three weeks. The researchers trained the teachers in the experimental groups on the technique of MLS before the treatment. The results of this study revealed that mastery learning approach had higher achievement in physics compared to their counterpart in the control group. The researchers conclude that MLS is an effective teaching method, which physics teachers should be encouraged to use and should be implemented in all teacher education programmes in Kenya. The topic of this research is unique from the current one, including the target population. The researchers trained the teachers in the experimental groups on the technique of MLS before the treatment while in the current research the researcher taught the experimental group. This study was conducted in Nyeri while the current study was conducted in Machakos sub-county.

The review of related literature also shows that when students are provided with an enabling environment of mastery learning then they could attain a higher academic achievement and that mastery learning is a very effective means for students to master the curriculum. Ogogo, (2001) conducted a similar study on the impact of MLS on academic achievement of FI geography students. The study revealed that;

i) The group who were taught through MLS outperformed the CGL group.

ii) MLS showed a significant performance in terms of their mean scores as compared with the CGL groups.

In a similar study (Sharma, 1998) conducted a study on MLS ninth grade Biology learners at Panjab University Chandigarh – India. The study revealed that those students taught through MLS outperformed CGL group. This was in agreement with other similar study conducted by Ogogo, (2001).

This finding is similar to that of Wachanga and Gamba (2004), who investigated the effects of using the Mastery Learning Approach on secondary school students' achievement in Chemistry and discovered that the Mastery Learning Approach facilitates students' learning of Chemistry better than the traditional teaching method. It also agrees with Ngesa's (2002) findings that the Mastery Learning Approach resulted in higher student achievement in Agriculture than the traditional teaching method. Bloom (1984) in Wambugu and Changeiywo (2007) in his research on group instruction showed scores of students taught through Mastery Learning Approach were around the ninety-eighth percentile, or approximately two standard deviations above the mean. He contended that Mastery Learning students required more time to master more advanced materials.

According to LeDuc (2001), the goal of the mastery learning method is for all students to achieve high levels of learning. As a result, when learning and implementing this learning method, one should focus on high level mental skills and processes. His findings revealed a distinction between students exposed to the Mastery Learning Method and those exposed to the Conventional Teaching Method.

This result is consistent with the findings and recommendations of Aderemi (2006) and Kazu, Kazu, and Ozedemi (2008), who discovered that mastery learning is effective and, when used effectively in classroom teaching, improves students' achievement in a given task. This means that students exposed to the Mastery Learning approach perform better than students exposed to traditional teaching strategies.

This means that the Mastery Learning Approach teaching method is more effective at improving student performance. The current study will compare the performance of the students taught Mathematics through MLS against the CGL group.

2.3.2 Difference in Attitude towards Mathematics between Students taught using Mastery Learning Strategy and Conventional Group Learning

Attitude toward Mathematics play an important role in the teaching and learning process. Attitude can be defined as a feeling possessed by one person to another or something usually reflected by one’s behavior. It is having a direct or dynamic effect on one’s reactions towards a certain object or an event (Çanakçı & Özdemir, 2011). For Zan and Martino (2007), attitude towards Mathematics is just a positive or negative emotional disposition. Papanastasiou (2000) states that Mathematical attitude is the positive or negative attitude developed by the individual towards mathematics. A student can develop positive attitude towards Mathematics because he or she learns to associate positive experiences or events with it. Also, positive reinforcement creates room for the formation of positive attitude for Mathematics. And by no means is students’ observation of teachers and teachers’ behavior especially in relation to Mathematics among the least of the factors that influence their attitude towards Mathematics.

Attitude towards Mathematics has cognitive, affective and behavioral components. According to many researchers in the field, the positive or negative attitudes of students affects their success levels in Mathematics classes in a positive or negative way (Peker & Mirasyedioğlu, 2003). Perhaps the most important factor which influences Mathematics success levels of students is the students’ attitude towards Mathematics classes. As educators we always seek to improve the student learning experience. One way to tackle this issue is to consider students' attitudes towards Mathematics. When students display a positive attitude towards Mathematics, improvements can be seen in: Emotions, Motivation, Confidence, Engagement, Achievement just to mention a few. Instilling a positive attitude early could, therefore, be the key to improving achievement. Reinforcing positive attitudes boosts learning outcomes *and* motivates children to learn, grow and improve. When a positive attitude in Mathematics is encouraged, students will keep working harder, reaching higher and following their own paths to success.

In the studies conducted so far, it has been suggested that students with higher positive attitudes towards Mathematics also have higher levels of success (Peker & Mirasyedioğlu, 2003; Çanakçı & Özdemir, 2011). Instructively, research on the relationship between student attitude and performance has been done. Some studies have demonstrated a strong and significant relationship between Mathematics attitude and Mathematics achievement (Randhawa & Beamer,1992, Schenkel, 2009). In the Schenkel’s (2009) study of elementary school pupils, positive correlation between student attitude and student performance was found. Student beliefs and attitudes were found to have the potential to either facilitate or inhibit learning. Motanya (2018) in his study discovered a direct relationship between performance in Mathematics and the attitude of a student. Student with positive attitude perform well in Mathematics while those with negative attitude perform poorly and they even lack basic Mathematical concept.

A study by Davrajoo, et al (2010) investigated the effect of Algebraic Mastery Learning Module usage on Mathematics achievement. The preliminary findings of this study provided evidence that the construction and mastery of the algebraic concepts assist students towards positive attitude in Mathematics learning.

Mehar and Rana (2012) utilized the experimental and control groups to examine the effectiveness of Bloom's mastery learning model on achievement in economics with respect to attitude towards economics. The study was conducted on the students of 9th Grade from two different schools. At the end of the experiment, the results showed that the treatment group significantly outperformed the control group and showed a positive attitude towards learning economics. There is a relationship between this study and the current one in that Bloom's mastery learning model was used in the former study and it was also employed in the current study. The current study is also unique in terms of the topic, the study area and the target population.

Tukur *(*2018) conducted a study on the effect of mastery learning strategy in enhancing the academic achievement of Mathematics in Nigeria. Mastery learning strategy was used in the treatment group (N=40) while the conventional group learning was employed for the control group (N=40). This investigation utilized the quasi-experimental design. The results exemplified that there is a significant relationship between the students' attitudes toward Mathematics and their academic achievement in Mathematics. There some relationship between *Tukur Madu Yemi* study and the current study in that both are investigating the effect of MLS on Mathematics achievement and students' attitude towards Mathematics and both are using the quasi-experimental design. The only difference in the current study is the location and the study population.

Guzver and Emin (2005) investigated the effects of mastery learning and comparative and individualistic learning environment organizations on achievement and attitudes in Mathematics on 158 students in mathematics. The results indicated that mastery learning improved students' achievement and yields greater positive attitudes. However, the current study is unique in that it is group-based teacher-paced and not based on individualistic learning environment organization.

However, negative attitudes towards mathematics are far more common than they should be. Things like insecurity and Mathematics anxiety can greatly impact a student's learning environment and their overall achievement in mathematics. Nicolaidou and Philippou (2003) showed that negative attitudes are the result of frequent and repeated failures or problems when dealing with Mathematical tasks and these negative attitudes may become relatively permanent.

Adeyemo (2014) found a positive and significant relationship between students' attitudes toward Physics and their performance in his research. Students with a positive attitude toward physics outperformed students with a negative attitude toward physics. This finding is consistent with the findings of Akinbobola (2009), who discovered that improving students' attitudes toward physics improves students' performance in the subject. In a related study, Damavandi and Kashani (2010) found that the Mastery learning method improved weak students' performance and positive attitudes.

Some learning researchers have found a link between mastery learning and attitudes, academic performance, and other factors. Mehar and Rana (2012) used experimental and control groups to examine the effectiveness of Bloom's mastery learning model on economic achievement in terms of attitude toward economics. The research was carried out on 9th grade students from two different schools. The results of the experiment revealed that the treatment group significantly outperformed the control group and had a positive attitude toward learning economics. Barr and Wessel (2018) investigated rethinking course structure: increased participation and persistence in introductory postsecondary mathematics courses. The study combined mastery learning strategies with the advantages of small class sizes. The results showed that if the course structure is carefully planned, students can have a positive effect and attitude toward mathematics.

On the other hand, attitude to a large extent, is created by teachers' teaching methods among other factors. Hence the need to try out MLS as a strategy to create and maintain the students' high performance and positive attitude towards Mathematics and counteract the negative attitude students' have on Mathematics.

2.3.3 Type of Misconceptions in Mathematical Algebra between Students taught using Mastery Learning Strategy and Conventional Group Learning

Misconceptions, or flawed conceptual knowledge of Algebra can impact students' performance and learning. Mathematics educators should, therefore, embrace errors and misconceptions in their teaching and should not regard them as obstacles to learning but rather engage with them for better understanding of algebraic concepts by students.

Within the field of formative assessment, educators are increasingly recognizing the importance of diagnostic assessment. In addition to identifying concepts and skills that students struggle to master, diagnostic assessment, which is one of the components in MLS, aims to identify what each student has learned and what he/she has failed to learn at regular intervals and the underlying reasons why an individual student struggles with a specific concept or skill.

A misconception occurs when an incorrect rule(s) is used or when correct rules are used beyond their proper domain of application. Therefore "to teach in a way that will avoid students' misconception is not possible. Students will always make some incorrect generalization and they will continue having these misconceptions unless specific effort is made to uncover them" (skew & William, 1995). Booth (1988) noted that, "one way of finding out why students find algebra difficult is to identify the kind of errors that are commonly made by students in algebra and then to investigate the reasons for these errors".

Many misconceptions in algebra have their roots in students' misconceptions in arithmetic because algebra is seen as generalized arithmetic. For example, the arithmetic expression such as -5 x 4 = -20 could be generalized to give properties such as –p x r = -pr which in general terms is understood as $+ve \times -ve = -ve$. In here the variable is considered as pattern generalizer and this is a connection between arithmetic and algebraic concepts (Norton and Irvin 2007; Stancy and Chick,2004). Wu (2001) reinforced this idea and said that students who are not comfortable computing with numbers will be less disposed to manipulate symbols because computational procedure with numbers provide a natural entrée into symbolic use. Meaning that arithmetic concepts, especially in negative numbers, should be well understood, otherwise the student is likely to encounter difficulties in algebraic problems.

Under variables, the main reason for misconceptions was the lack of understanding of the basic concept of the variable in different contexts. The abstract structure of algebraic expressions posed many problems to students such as understanding or manipulating them according to accepted rules, procedures, or algorithms. Students misinterpreted a variable as a label or as a thing or a verb. They failed to perceive the variable as the number of a thing. Schoenfeld (1988) assert that understanding the concept of a variable is central for transition from arithmetic to algebra. Students' conceptions of the notion of a variable were also explored posing the question: Apples cost 'a' cents and bananas cost 'b' cents. If 3 apples and 2 bananas are sold, what does 3a+2b represent? Students displayed lack of understanding of the unitary concept when dealing with variables. This is a basic arithmetic concept and students wrote $5ab$ which was a serious misconception of adding unlike terms. In addition to the incorrect addition of unlike terms, the students regarded a as the label for apples and b as the label for bananas, rather than the unit price of an apple and the unit price of a banana and regarded a and b as prices of item. This is consistent with Wagner's (1989) observation where the students experienced some difficulty in shifting from a superficial use of a to represent apples to a mnemonic use of a to stand for the number of apples.

It is necessary to have correct conceptual knowledge in order to develop correct procedural skills. Work in Algebra has established that students with stronger conceptual knowledge are better at solving equations, and are able to learn new procedures more easily than peers with flawed conceptual knowledge (Booth, Koedinger, & Siegler, 2007). In particular, students who hold misconceptions about the equals sign or negative signs solve fewer equations correctly and have greater difficulty learning how to solve equations (Booth & Koedinger, 2008). Correction of these misconceptions can lead to improvements in equation solving skills (Booth & Koedinger, 2008). On a similar note, students also often misunderstand the meaning of operational symbols when paired with variables. For instance, since students are used to joining two terms when they see the addition symbol (i.e. $2 + ½ = 2 ½$), they will mistakenly believe that $2 + x$ is the same as $2x$ (Booth, 1988).

Inadequate understanding of the uses of the equal sign and its properties when it is used in an equation was a major problem that hindered solving equations correctly. Students tend to make errors in the interpretation of an equal sign. An equal sign can be attributed to two interpretations namely, the symmetric relation and the transitive relation. The symmetric relation indicates that the quantities on both sides of the equal sign are equal. The transitive relation indicates that a quantity on one side can be transferred to the other side using rules. In high school it is common to see erroneous statements like; "3x – 5 = 7 = 3x = 12 =x =4". Here the symmetric property of the equal sign is violated. Kieran (1981) further claimed that the equal sign is perceived by students as "it gives," that is, as a left-to-right directional signal rather than a structural property. In other words, students perceive the equal sign as a symbol inviting them to do something (or as a command to compute an answer) rather than a relationship (Weinberg, 2007; Foster, 2007). Sometimes the equal sign seems to play the role of such words as "therefore", "leads to ", etc. When students use the equal sign as a 'step marker' to indicate the next step of the procedure, they do not properly consider the equivalence property of it. The procedure for equation solving rest on the principle that adding the same number to or subtracting the same number from both sides of the equation conserves the equality (Filloy, Rojano, & Solares, 2003; Filloy, Rojano, &Puig, 2007). This principle is equally applicable to multiplying or dividing each side of the equation by the same number. Therefore, the solution should be as shown below;

$3x – 5 = 7$

$3x = 12$

$x = 4$.

One other explanation for the use of the equal sign as to do something is attributed to the fact that the equal sign mostly “comes at the end of an equation and only one number comes after it” (Falkner et. al., 1999, p.3). The equal sign in an equation, simply indicates that the expressions on the left and right sides have the same value. This confuses the students who believe that the equal sign means ‘the answer follows’ (Foster, 2007). Often students have an operational understanding of the equal sign – the belief that the equal sign indicates where the answer should go – rather than a relational understanding – the belief that the equal sign indicates equivalence (Kieran, 1980, 1981; Cheng-Yao, Yi-Yi, & Yu-Chun, 2014).

While this type of arithmetic thinking may be sufficient during the early years, it causes major problems once students are asked to think algebraically (Booth & Koedinger, 2008). Having a correct understanding of the meaning of the equal sign is imperative in order to manipulate and solve algebraic equations correctly (Carpenter, Franke, & Levi, 2003).

The formal distributive property of multiplication over addition is deeply deposited in their mind so that they intuitively misapply the rule in similar situations. In here the student is said to have used a known rule inappropriately, and incorrectly adapts a known rule so that it can be used to solve a new problem. This would mean that, errors are not random but are logically consistent and rule based. Students construct their misconceptions from their experiences and they find it very difficult to give them up. For example, students’ misinterpretations of $(a + b)^2$ as $a^2 + b^2$ or $3(a + b)^2$ as $3a^2 + 3b^2$ or $\log(x + y)$ as $\log x + \log y$ is viewed as emanating from the application of the distributive law intuitively. Also, this can be viewed as an inappropriate and/or incorrect use of a known rule in solving a new problem. The examples for these categories again emanated from the overgeneralization of the distributive law (Luka, 2013). Also, Booth, Barbieri, Eyer, and Blagoev (2014) observed that students start $(y+4)^2$correctly when they expanded. They worked the problem as (y+4) (y+4). The misconception appeared in the second step where they wrote y^2+ 16 as a final answer. A'yun and Lukito (2018) found a misconception related to second degree radical addition. Students worked $\sqrt{a+b}\ as\ \sqrt{a}+\sqrt{b}$ which was found by Mulungye (2016).

Matz (1980) noted that these errors are probably grounded in an overgeneralization of the "distributive property", which children encounter often in arithmetic and in introductory algebra, and where it is natural to work with each part independently, e.g.

$$x(y + z) = xy + xz$$

$$x(y - z) = xy - xz$$

$$\frac{b+c}{a} = \frac{b}{a} + \frac{c}{a}$$

$$(xy)^n = x^n y^n$$

On the other hand, errors can also be attributed to lack of meaning of algebraic expressions to students and/or absence of operational model in arithmetic itself, so that generalizations to the algebraic expressions are perhaps unlikely.

Students may find many algebraic problems difficult to solve because most of them require understanding of conceptual aspects of fractions, negative numbers and equivalence (Norton & Irvin, 2007; Stacey & Chick, 2004). Conceptual understanding consists of knowing the structure or rules of algebra or arithmetic such as the associativity, commutativity, transitivity, and the closure property. For example, students should understand that:

$\frac{1+3}{5}$can be separated as $\frac{1}{5}+\frac{3}{5}$in the same way as they understand the reverse process. Due to lack of such knowledge errors of the type $\frac{ac+b}{c}=a+b$, will be observed because the student failed to divide both ac and b with c.

Another error in algebra can be understood in the light of the duality of Mathematical concepts as processes or objects, depending on the problem situation and on the learner's conceptualization. One of the most essential steps in learning Mathematics is objectification: making an object out of a process. Due to this dual nature of Mathematical notations as processes and objects (Irawati & Ali, 2018), students encounter many difficulties. For instance,5x + 4 stands both for the process 'add five times *x* and four' and for an object as 5x + 4. This dual conception causes students to confuse between 5x + 4as a process or as an object. They simplify 5x + 4 as 9*x when* 5x + 4 is actually an object (for example, in a final answer). The student perceives that the answer should not contain an operator symbol. The student also perceives that the "+" sign "as an invitation to do something" and the student goes ahead to do it (Chow, 2011). The students perceive open algebraic expressions as 'incomplete' and try to 'finish' them by oversimplifying as in the case above where the student simplified 5x+4 as 9x because they consider an answer such as 5x+4 as incomplete. A typical explanation for this misconception is the tendency in many arithmetic problems to have a final single-digit answer or to interpret a symbol such as '+' as an operation to be performed, thus leading to conjoining of terms (Irawati & Ali 2018). Conjoining letters in algebra is to connect together the letters meaninglessly.

Many common errors in simplifying algebraic expressions seem to be instances of the retrieval of correct but inappropriate rules (Luka, 2013; Matz, 1980). For example, students incorrectly misapply $\frac{ax}{bx} = \frac{a}{b}$ into expressions like $\frac{a+x}{b+x}$ to get $\frac{a+x}{b+x} = \frac{a}{b}$. This is an application of a known rule to an inappropriate situation by incorrectly perceiving the similarities of the two situations. Needless to say, that word problems in algebra have been a challenge to students whose major problem have been translating the story from natural language to algebraic language that is into appropriate algebraic expressions (Bishop, Filloy, &Puig, 2008). This process involves assigning variables, noting constants, and representing relationships among variables. Among these processes, relational aspects of the word problem are particularly difficult to translate into symbols. Students used guessing or trial and error methods extensively in solving word problems. To emphasize student difficulties in translating relational statements into algebraic language, the "student-professor" problem which reads as, "there are six times as many students as professors at this university" was extensively discussed and students were asked to write an algebraic expression for the relationship. Many researchers found that there was a translation error such as **"**6S = P" where S and P represent the number of students and the number of professors respectively (Weinberg, 2007). Here the student assumes that the order of the key words in the problem statement will map directly into the order of symbols appearing in the equation. The error in the student-professor problem is consistent with what Chalklin(1989) refers to as the direct-translation problem solving. Chalklin explains the direct translation as a process that is often characterized by a phrase-by-phrase translation of the problem into variables and equations. In that they have used 6S to represent the group of students and P to represent the group of professors. For those who committed this error, the “=” symbol did not mean to represent a mathematical relationship. Instead, for them, it simply separated the two groups (Clement, 1982).

Since misconceptions and errors (M/Es) are emotionally attached with students, they are not easy to dislodge and remove (Egodawatte, 2011). This shows the crucial role of M/Es in the whole learning process. If errors are committed, it is said that they arise because the children are thinking and not because they are careless. Thus, teachers have to accept students’ errors for the purpose of analysis. The teacher should therefore generate an environment of engaging students for the correction of errors with reasons instead of correcting them mechanically. The analysis of error pattern provides us an effective and efficient method for pinpointing the specific misconceptions and problems that students are having while solving problems. By investigating students’ misconceptions and errors, the teacher can provide instruction targeted to their area of need. M/Es may be the best tools for crafting their learning experiences (Mukunda, 2020). Further Mukunda observed that exploring and analyzing students’ misconceptions and errors should be the fundamental system of teaching and learning (T/L) algebra.

In this regard, Upadhyay (2017) claimed that if one could find out weaknesses and misconceptions of students, more than half of the problems of teaching and learning tasks are done. The most important single factor influencing learning is to ascertain what the learner already knows, and teach him/her accordingly. This can be attained in mastery learning strategy during the diagnostic assessment process where a prescription is given as part of an ongoing effort to help students learn.

This study will determine whether, when students are exposed to MLS, the errors and the misconceptions are diagnosed and the underlying reasons as to why an individual student struggles with a specific concept or skill are identified and corrected before the students proceed on to another item. The mastery learning strategy will assist the teacher to interact closely with the students in class- discussions which will help uncover and deconstruct some of these misconceptions with the view to reconstruct correct conceptions.

Teacher education will, therefore, need to encourage various ways of teacher-student interaction during which teachers' use of student's experiences should be enhanced and students' Mathematical ideas be considered exhaustively. In general, understanding what these errors indicate about the misconception's students hold and remediating algebraic misconceptions through MLS may be necessary for increasing student success in Algebra and, subsequently, more advanced Mathematics classes.

2.3.4 Difference in Self-Efficacy between Students taught using Mastery Learning Strategy and Conventional Group Learning

Self-efficacy is about having the strong, positive belief that you have the capacity and the skills to achieve your goals. Self-efficacy refers to a person's belief in their own ability to complete a task or activity. It refers to a person's belief in their ability to control their behavior, exert influence over their surroundings, and remain motivated in the pursuit of their goal. People can have self-efficacy in a variety of situations and domains, including school, work, relationships, and other critical areas. For example, when faced with a challenge, do you believe you can overcome it, or do you give up in defeat, or do you doubt your own abilities to overcome the difficulties that life throws your way? If you tend to persevere in the face of adversity, you most likely have a high level of self-efficacy. Not only does a positive self-efficacy allow an individual to persist in the face of obstacles, but it can also increase the individual's desire to attempt challenging and novel tasks (Feng &Tuan, 2005).

As Bandura (1977) noted people with a strong sense of self-efficacy develop deeper interest in the activities in which they participate and they also form a stronger sense of commitment to their interests and activities. They also recover quickly from setbacks and disappointments. They view challenging problems as tasks to be mastered. On the other hand, people with a weak sense of self-efficacy avoid challenging tasks and they also believe that difficult tasks and situations are beyond their capabilities. They focus on personal failings and negative outcomes and they quickly lose confidence in personal abilities. He too identified mastery learning as a source of self-efficacy among others.

A person's self-efficacy may not accurately reflect their ability in that particular domain. Self-efficacy is more focused than self-esteem or confidence, which are broader terms that refer to self-worth beliefs and belief strength, respectively (Bandura, 2005). Other key experiences, such as optimism and realism, have shaped beliefs based on agency and self-efficacy. Prior to Bandura's work, psychologists did not recognize the value of optimism, particularly when a person's chances of achieving a desired outcome were low. Because of Bandura's work, the ability to maintain optimism in the face of adversity is now recognized as being key to success in a variety of roles.

What's encouraging is that anyone can develop self-efficacy. That is, self-efficacy is not a trait that some people possess while others do not. Rather, regardless of their past or current environment, everyone can exercise agency and strengthen their self-efficacy (Schunk & Ertmer, 2000).

According to Bandura (2008), mastery experiences are the most effective way to build self-efficacy. There is no better way to begin believing in one's own ability to succeed than to set a goal, persevere through obstacles on the way to goal-achievement, and enjoy the satisfying results. After enough repetitions, a person will come to believe that sustained effort and perseverance in the face of adversity will serve a purpose in the end; belief in one's ability to succeed will grow. In contrast, achieving easy success with little effort can lead to people expecting quick results, which can lead to them being easily discouraged by failure (Bandura, 2008).

The importance of mastery experiences becomes poignant when we consider it in the context of parenting and early developmental experiences. As a parent, there is a strong temptation to prevent a child from ever experiencing failure (sometimes referred to as ‘snowplow parenting’).A child who does not learn to overcome disappointment and draw on internal resources to overcome obstacles, on the other hand, will miss out on opportunities to develop self-efficacy. As a result, the child may be ill-equipped to deal with the challenges that await them in adulthood.

Failure is necessary for the development of resilience. This is accomplished by viewing each failure as a learning opportunity and a chance to achieve competence through a different approach. Another way that a person can build self-efficacy is by witnessing demonstrations of competence by people who are similar to them (Bandura, 2008). In this scenario, the person witnessing the display of competence perceives aspects of their own identity in the actor. That is, the actor may be of a similar age, ethnic background, sexuality, or gender as the observer (Bandura, 1997). The observer, who witnesses the actor’s success through dedicated efforts, will be inspired to believe that they, too, can achieve their goals. When we consider the power of role modeling for inspiring self-belief, we can begin to understand the importance of diverse representation in the media. In the past, one would have needed to find a role-model in one's immediate social surroundings. Now, through the internet and other digital mediums, people (especially young people) are being exposed to many potential role-models. If these viewers never see anyone like themselves displaying acts of competence across the various domains of life (e.g., speaking in the media, competing in elite sports), they are denied the opportunity to develop self-efficacy through this vicarious modeling (even in a mathematics class) and may be less likely than other populations to pursue their ambitions.

Self-efficacy can also be developed through social persuasion, in which a person is more likely to succeed if they are told they have what it takes. Self-efficacy thus becomes a self-fulfilling prophecy (Eden & Zuk, 1995). While not as effective as mastery in increasing self-efficacy, being told by someone we trust that we have the ability to achieve our goals will help us more than dwelling on our shortcomings (Bandura, 2008). As a result, a good mentor can boost self-efficacy not only by role-modeling but also by acting as a trusted voice of encouragement. They may also assist their mentee in recognizing opportunities to demonstrate competence (without being overwhelmed) and persuade them to enter the ring.

Other studies (aside from Bandura's) have even investigated the role of self-talk for strengthening self-efficacy and improving performance. For example, one study discovered that tennis players who gave themselves a motivational pep talk before practicing a specific swing performed significantly better than those who did not (Hatzigeorgiadis, Zourbanos, Goltsios, & Theodorakis, 2008). This finding suggests that we can persuade ourselves to believe in our abilities and strengthen our self-efficacy through verbal persuasion. Finally, our emotions, moods, and physical states all have an impact on how we evaluate our own efficacy (Kavanagh & Bower, 1985). According to Bandura (2008), it is more difficult to feel confident in our ability to succeed when we are tired and in low mood. This is especially true if we believe these emotional and physiological states indicate our incompetence, vulnerability, or inability to accomplish a goal. Introspection and education can help to keep these physical states from being misinterpreted. People can practice self-compassion, for example, after experiencing a personal or professional failure. Low mood can have a debilitating effect on self-efficacy and subsequent goal achievement at chronic levels, as people with chronically low mood are more likely to abandon goals sooner and are less likely to begin goals in the first place (Bandura, 2008). Indeed, while people suffering from depression have goals, they have more pessimistic beliefs about their ability to achieve them successfully and believe they have less control over the outcomes of their goals (Dickson, Moberly, & Kinderman, 2011). To summarize, changing negative misinterpretations of physical and affective states is critical for developing self-efficacy (Bandura, 2008). The strength self-efficacy scale is one tool which can help build insight and introspection, and alleviate the need for judging ourselves too harshly when we make mistake.

Bandura (2008) explains how self-efficacy exerts its effects through four different internal processes in his discussion of agency's links to positive psychology. One way is through cognitive processes. That is, one's functioning can be influenced by thinking in self-enhancing (optimistic) or self-debilitating (pessimistic) ways (Bandura, 1994; 2008). If someone believes that their actions impact their experience and the environment, they are more prone to a self-sustaining optimistic view. In other words, no matter what the circumstance is, ‘something’ can be done to affect the ultimate outcome. Without this belief, a more pessimistic thought process can dominate, and events might be interpreted as ‘out-of-my-hands.’ When the individual is a passenger in the ride that is their life, there is no room for agency.

Second way is believing in the power of motivation to influence any outcome is referred to as self-efficacy. If someone does not feel compelled to change an event, they are less likely to exert effort toward achieving a specific outcome - especially in the face of obstacles. This would be considered a waste of energy (Bandura, 1994). Thus, feeling confident in one's own abilities leads to self-determined motivation. It is no longer a question of "can I reach my goal?" rather than "what is required for me to achieve my goal?" Collective self-efficacy is frequently taken into account. That is, what does a group believe it is capable of accomplishing in terms of a common goal? "People's shared belief in their collective efficacy to achieve desired results is a key ingredient of collective agency," Bandura (2008, p. 3) writes.

Also, it is important to note that while states of physiology (such as our moods) influence self-efficacy, the reverse is true as well - self-efficacy can affect our emotions (Heuven, Bakker, Schaufeli, & Huisman, 2006). A healthy sense of self-efficacy helps us to not be at the mercy of our negative emotional states that stem from failures and disappointment. Instead, we rise from the ashes of our failures gracefully, with a healthy dose of optimism and resilience; we believe that we can ‘bounce back.’ A determination not to let negative emotions stymie our future efforts is a critical outcome of self-efficacy, and it is closely related to the concept of emotional intelligence (Emotional intelligence can provide a significant advantage for mastering our emotions).

And the final way is to understand the fact that it is critical to recognize that self-efficacy influences our decision-making processes when it comes to exposing ourselves to new environments and situations (Mun & Hwang, 2003). As previously stated, Bandura's perspective on the agentic human experience contends that humans have control over their own development. The alternative is that people's lives are at the mercy of fate. As a result, using self-efficacy, one can choose to expose themselves to environments that will best facilitate personal growth and development through deliberate choices and actions (Bandura, 2008).

On the other hand, academic self-efficacy refers to students' beliefs and attitudes toward their abilities to achieve academic success, as well as belief in their ability to complete academic tasks and learn the materials successfully (Bandura, 1997). Self-efficacy beliefs lead to the individuals' excellent performance through increasing commitment, endeavor, and perseverance (Pintrich, 2003). The learners with high levels of self-efficacy attribute their failures to lower attempts rather than lower ability, while those with low self-efficacy attribute their failure to their low abilities (Kurbanoglu, 2010). As a result, self-efficacy can influence task selection as well as task persistence. In other words, students with low self-efficacy are more likely to be afraid of doing their tasks, avoid, postpone, and abandon their assignments (Schunk & Eritmer, 2000).

Those with high levels of self-efficacy, on the other hand, are more likely to rely on themselves to solve complex problems, as well as to be patient during the process, make more efforts, and persevere longer to overcome the challenges (Schunk & Eritmer, 2000; Sadi & Uyar, 2013; Bandura, 1977). As a result, self-efficacy appears to be one of the most important factors in students' academic success and more so in learning mathematics.

Chemers and Garcia discovered that students' self-efficacy in their first year of university is a strong predictor of their future performance (Chemers & Garcia, 2001). Alyami et al. (2017) conducted a study on 214 university students and discovered that academic self-efficacy has a positive and significant effect on academic performance. Other studies have found that academic self-efficacy has a significant impact on students' learning, motivation, and academic performance (Sadi & Uyar ; Ferla et.al 2009; Putwain et al. 2013). Therefore, it can be concluded that, self-efficacy is a key driver of success across all domains of life. By enabling a person to master their thoughts, motivations, emotions, and decisions, self-efficacy becomes key to recognizing our ability to shape the world around us.

The quality of interactions may contribute or weaken the self-concept of the learner. In a survey in United State of America by Gliebe (2012), the findings state that Student's positive conception is helpful in achieving success throughout life. The success in learners' lives depends not only on cognitive ability, but also on emotional skills. Green, Nelson, Martin and Marsh (2006), in their report indicated that positive self-concept is an extremely important goal for educational programs to promote and help to link positive outcomes including higher academic achievement and effort. An important aspect of metamemory is perceived self-efficacy for memory functioning. Self-efficacy beliefs can improve or degrade performance by influencing cognitive, affective, or motivational intervening processes (Bandura, 2005). He went on to say that psychological procedures, in whatever form they take, alter the level and strength of self-efficacy.It is hypothesized that expectations of personal efficacy determine whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences. Persistence in activities that are subjectively threatening but in fact relatively safe produces, through experiences of mastery, further enhancement of self-efficacy and corresponding reductions in defensive behavior. Academic self-esteem can, therefore, be regarded as one's total evaluation of his academic competency, abilities, skills and general school work/activities.

Mathematics seems to be a challenging subject and intimidates many students. In a study of seventh-grade students, Chen found that "self-efficacy played a direct role in predicting students' Mathematics performance. The effects of prior mathematics achievement on mathematics performance were mediated largely through the students' self-efficacy beliefs" (2003, p. 79). Therefore, teachers should remind students of their previous successes in Mathematics and use specific encouraging words.

Honicke and Broadbent (2016) research on self-efficacy shows that self-construct is critical in determining people's life choices. Students who are confident in their abilities anticipate positive outcomes in both academic and social situations; thus, self-efficacy beliefs frequently function as self-fulfilling prophecies. Incorrect interpretations of one's capabilities have the opposite effect. Learners who lack confidence in their knowledge or skills anticipate negative outcomes before performing a task, undermining their ability to perform at the required level of excellence. According to a systematic literature review conducted by Richardson, Abraham, and Bond, the construct of self-efficacy has been discovered to be "the strongest correlate with university grade point average (GPA) from amongst 50 measures" in 241 studies (as cited in Bartimote-Aufflick, et.al, 2016, p. 1920). A recent meta-analysis of 59 studies reveals a positive relationship between academic self-efficacy and academic achievement (Honicke & Broadbent, 2016). The results of the study also point to the fact that students who have high levels of perceived self-efficacy are more likely to pursue challenging tasks and be more persistent than their counterparts with lower self-efficacy levels.

Stevens, Olivarez, and Hamman conclude that “self-efficacy and the sources of self-efficacy were stronger predictors of Mathematics achievement than general mental ability” (as cited in Siegle & McCoach, 2007, p. 280). The finding indicated that teachers’ positive feedback affects achievement of a student and has a big influence on the self-concept of a student. In MLS the teachers’ feedback is frequently used during remediation. This means that the teacher should give feedbacks that enhance students’ self-efficacy.

High self-efficacy correlates positively with greater aspirations, greater commitments, and a greater ability to recover from setbacks; high Mathematics self-efficacy correlates with greater persistence on long and difficult problems, and greater accuracy of computation (Hoffman & Schraw, 2009). In MLS perseverance is one of the variables and is the time the learner is willing to spend in learning. This is ‘persistence’ on the student’s part, that is, it is ‘keeping on at a task’. Such students will not be cowed by failure but will persist on. Hence showing high Mathematics self-efficacy.

Numerous studies showed a powerful link between high self-efficacy and high performance (Fast et al., 2010; Peters, 2013). In the social cognitive theory, self-efficacy plays the central role in how well an individual can learn; researchers have focused on the role that self-efficacy plays in the learning of Mathematics (Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014; Zientek et al., 2013). Compared to their peers, students with higher levels of self-efficacy also have higher levels of general achievement in Mathematics, more easily overcome negative outcomes, display more positive attitudes towards Mathematics, and possess a more comprehensive understanding of Mathematics (Phan, 2012; Tariq & Durrani, 2012).

As self-efficacy increases or decreases, it has a corresponding effect on learning and academic achievement (Phan, 2012). The educator has the capacity to increase students' self-efficacy through different teaching strategies, such as using problem posing (Akay & Boz, 2010). It is particularly exciting to note that teaching strategies used in the classroom can and do make a difference to students' self-efficacy. (Fencl & Scheel, 2005). The study investigated the impact of the MLS in teaching Mathematics on students' self-efficacy.

Bandura also noted that "The most effective way of developing a strong sense of efficacy is through mastery experiences,". That Students' successful experiences boost self-efficacy, while failures erode it. This is the most robust source of self-efficacy. This is in line with MLS which advocates the mastery experiences where by a student progresses to the next unit after mastery of the previous unit.

Many educators see self-esteem as that psychological variable that can help individuals to view themselves as active, competent skillful and capable persons to promote changes through effort investment, and higher goals setting which can cause the learning of new things possible. Thus, they have faith that a student who possesses high academic self-esteem can equally experience high academic achievement, because such a student with high self-esteem will always be encouraged to work harder, put in more effort, endure longer at task, and therefore perform highly than those with low self-esteem. Several researches have shown some relationship between academic self-esteem and students' academic achievement (Feroz, 2018; Aryana, 2010; Pullmann and Allik, 2008; Marsh and O'Mara, 2008; Faithi-Ashtiani *et al*, (2007). It has also been noted that students with higher Mathematics self-efficacy are more likely to attend class, do homework assignments, read the textbook, and ask for help in Mathematics courses than students with lower levels of mathematics self-efficacy (HendySchorschinsky, & Wade, 2014). This study will investigate whether MLS as a teaching strategy will boost self-efficacy of the students who will in turn will experience high Mathematics achievement.

In one of the studies relating self-esteem with academic achievement, Feroz (2018) found a significant positive correlation ($r=0.551$, $p<0.02$) amid cumulative Grade Point Averages (CGPAs) and self-esteem scores of undergraduate students. In the study, Feroz used random sampling technique to select a total sample of 600 undergraduate students (360 male and 240 female) from different departments at the University of Swat on the basis that the sample have spent at least four semesters at the university. The students responded to Rosenberg Self-esteem Scale (RSES) used to assess the intensity of their self-esteem. Scores generated from the students' response to RSES scale was correlated with the students' CGPAs from their previous semesters using the Pearson Correlation Coefficient test. From the results Feroz also discovered that high self-esteemed students had high academic outcome. In a related study, Aryana (2010) observed a strong relationship between self-esteem and academic success in pre-university students (both girls and boys) in Iran, while Pullmann and Allik (2008) [26] reported that academic self-esteem is a strong and an accurate determinant or predictor of learning and academic performance.

Faithi-Ashtiani *et al*, (2007) documented that academic achievement of students with low self-esteem is perceptibly less than the average of those with high self-esteem; showing that low self-esteem affects educational function/works and decline academic achievement. Similarly, a significant relationship was found between self-esteem, academic achievement and academic performance (Hall, 2007).

Owo and Ogologo (2019) investigated the effects of students' self-esteem and academic achievement in secondary school chemistry by comparing it with the conventional method. The study was carried out in Nigeria. The purpose of the study was to identify an instructional strategy that would have effect on learner's self-efficacy and academic achievement. The design of the study was quasi-experimental. Significant difference was found in the learner's self-efficacy and academic achievement in favor of experimental group. In these findings, Mastery Learning Strategy was revealed to be a potent and effective instructional strategy that can offer students the opportunities to enhance their self-confidence and readiness to participate in the learning of chemistry and achieve academic success in it.

This is because, in MLS all students are provided with suitable opportunities, enough time etc. to engage in learning, self-assessment of previous knowledge and mastering of all the educational goals. Students (especially the academically weak ones and the low self-esteemed ones) who received the chemistry instruction through MLS had increased positive perception of themselves, improved self-esteem and academic competency in relation to the learning of chemistry Owo and Ogologo, (2019). It was recommended that teacher may use Mastery Learnig Strategy for teaching of Chemistry at secondary school level. These students show more gain in self-efficacy after the intervention compared to the students taught using traditional method of instruction. It is therefore important to apply MLS so as to enhance learner's self-concept and achieve academic success. The design of the study in both studies is quasi-experimental although current study is unique in terms of the topic, location, the study area and population.

2.4 Research Gaps Identified

This study based on the literature review has identified the following Research Gaps.

i) MLS has been investigated in most countries except a few countries like Kenya where very little research on MLS has been done. Mastery learning strategy as observed from the various studies that have been conducted, can improve not only learners' Mathematics achievement but also their attitudes, motivation, retention and interest towards the subject. Secondary school learners and teachers face a lot of problems in the teaching and learning of the Mathematics. It was the intent of the current study to investigate the effect of mastery learning strategy on the teaching and learning Mathematics in Kenyan secondary schools.

ii) The effects of mastery learning strategy on high school Mathematics achievement, on students' attitude towards mathematics and the relationship between instructional strategy and learners' attitude towards Mathematics using quasi-experimental design was done in Nigeria (*Tukur Madu Yemi,*2018) but not in Machakos Sub-County.

iii) The study designs used by Wambugu and Changeiywo (2008) on MLS and CGL on learners' performance in physics include the quasi-experimental and Solomon four Non-equivalent control group design in Nyeri county. The researcher in this study has seen a gap in the use of the quasi experimental (Solomon four non-equivalent control group designs) in that this study compared students' achievement in physics in Nyeri county but not students' achievement in Mathematics based on MLS and CGL in public secondary schools in Machakos sub-county, Kenya.

iv) These researchers who have studied MLS and CGL on learners' achievement in Mathematics employed different types of sampling techniques like purposive sampling, randomly assigning subjects to pre-test and post-test groups (Toheed & Jabeen (2017) and (Uchechi, Ezinwanyi & Ihendinihu, 2013). The researcher in this study has found a gap from the fact that none of these studies have been done on comparison of students' Mathematics competence based on mastery learning and conventional teaching in public secondary schools in Machakos sub-county using these techniques.

v) A study was done in Kenya, at Kieni in Nyeri County on the effects of mastery learning approach on secondary school student's physics achievement. The gaps herein are on the research topic and the location of the study in that, as the researcher was interested on learners' achievement in physics, this is a mastery learning study on students' achievement in Mathematics, their self-efficacy and attitude towards Mathematics in public secondary schools in Machakos sub-county, Kenya.

vi) The researcher in this study employed a quasi-experimental (Solomon four non-equivalent control group design) to find out if it would deliver similar results. In this study, the researcher involved form two learners from public secondary schools in Machakos sub-county, Machakos County. Other studies conducted on MLS and CGL in Kenyan schools were not comparing the learning outcomes between students' Mathematics competence based on mastery learning and conventional teaching methods in public secondary schools but other components such as achievement in physics, economics etc. The researcher carried out a mastery learning study on the students' achievement in Mathematics, their attitude and self-efficacy towards Mathematics based on mastery learning and conventional teaching in public secondary schools in Machakos sub-county, Kenya.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter contains research methodology, description of research design, the target population of the study, sampling procedure and sample size, research instruments, validity and reliability, ethical considerations, data collection procedures and data analysis.

3.2 Research Methodology

The study employed quantitative research method since numeric data was required from the participants.

3.2.1 Research Design

A research design referred to a conceptual structure within which research is conducted. The function of a research design is to provide for the collection of relevant evidence with minimal expenditure of effort, time and money (Kothari, 2013). Therefore, for purposes of collecting data, the quasi-experimental (Solomon four non-equivalent group) design was employed because of the non-random assignment of students to the groups. Secondary school classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and reconstituted for research purposes (Best & Kahn, 2011; Fraenkel & Wallen, 2000). The design was also used to assess the effect of the treatment. The interaction between selection and treatment was controlled by ensuring that the administration of instruments across the groups was kept as similar as possible (Cohen, Manion, & Morrison, 2007). The quasi-experimental design compared control groups, which was taught Mathematics using the conventional teaching methods with experimental groups which was instructed Mathematics using MLS. This design has an advantage over others since it controls the major threats to internal validity except those associated with interaction and history, maturity and instrumentation (Cook &Campbell, 1979, in Wambugu and Changeiywo, 2008).

Solomon's Four Non-equivalent Control Group Design

The design helped to assess the effect of the experimental treatment relative to control conditions, interaction between pre-test and treatment conditions. Also, to assess the homogeneity of the group before administration of the treatment and it offers the benefit of comparison between groups because of the naturally occurring treatment group (Cohen, Manion & Marrison, 2007). Solomon's four-group enables the researcher to make a more complex assessment of the cause of the change in the dependent variable and even tell whether changes in the dependent variables are due to the interactions effect between the pre-test and treatment (Randolph, 2008).

Table 3.1: Solomon's Four Non-Equivalent Control Group Design (as Adapted from Shuttle worth 2009)

Group	Design	Group	Pre-test	Treatment	Post-test
I	Experimental	E_1	O_1	X	O_2
II	Control	C_1	O_3	-	O_4
III	Experimental	E_2	-	X	O_5
IV	Control	C_2	-	-	O_6

Key: E_1 & E_2 - Experimental group

C_1 & C_2 - Control group

O_1 & O_3 - Observation at pretest phase

O_2, O_4, O_5, O_6 - Observation at post test phase

(X) - Indicates treatment

(----) - Indicates the use of non-equivalent group

In Solomon's Four Non-Equivalent Control Group Design the dotted lines signify that the four groups are non-equivalent. X is the treatment where students were taught using MLS.O_1 and O_3 are pre-tests while O_2, O_4, O_5, O_6 are post-tests.

The respondents were randomly organized into four groups. Experimental groups as E_1 and E_2, control group as C_1 and C_2. Experimental groups I and III were taught using MLS while those in the control groups II and IV were taught using conventional teaching method. Prior to treatment only E_1 and C_1 were exposed to pre-test (O_1 & O_3). After two weeks of instruction, all the groups were post-tested (O_2, O_4, O_5 & O_6). The post-test O_5 and O_6 helped the researcher to identify if there were any interaction between pre-testing and treatment. Pre- test and post-test helped in controlling the intervening variables of history and maturation of variables with the research period.

3.3 Location of the Study

The study was conducted in Machakos County in Machakos sub-county. The Global positioning of the county is on the latitude 1^0 29' 59.99''S and longitude 37^0 14' 60.00''E. The choice was made because of its poor performance in mathematics. This sub-county was chosen on the basis of a report from the Sub-County Director of Education Office Machakos as seen in Table 1.1, which observed that learners have been performing poorly in KCSE examinations in Mathematics. There was also little investigation of this kind that has been conducted in Machakos sub-county and therefore the findings of this study may be beneficial to the Mathematics teachers. Accessibility to the schools sampled was taken into consideration.

3.4 Target Population for the Study

The target population of the study was all Form two students in 36 co-educational public secondary schools in Machakos Sub-County. Information from the Ministry of Education shows that there are 44 public and 17 private secondary schools making a total 61. Amongst these 5, 8 and 48 are boys, girls and mixed secondary schools respectively. Non co-educational public secondary schools are 8 (4 boys and 4 girls) and 36 public mixed schools. Among the private schools there are 5 single sex secondary schools (1 boy and 4 girls) and 12 mixed schools. The distribution of schools by category in the sub-county is as shown in Table 3.2 below.

Table 3.2: Number of schools in Machakos Sub-County

Schools	Boys	Girls	Mixed	Total
Public	**4**	**4**	**36**	**44**
Private	**1**	**4**	**12**	**17**
Total	**5**	**8**	**48**	**61**

Source: Sub-County Director of Education Office, Machakos (2021)

3.5 Sampling Techniques and Sample Size

The sample is regarded as the representative of the population when the statistical inferences about the population can be made from the respondents of the sample. When dealing with people, it can be defined as a set of respondents (people) selected from a large population for the purpose of a survey or study.

The sampling techniques used in this study include: purposive sampling and simple random sampling. Out of all the schools both public and private secondary schools the public secondary schools were purposively sampled and out of all these public secondary schools mixed secondary schools were purposively sampled. Two Mixed public secondary schools were then sampled through simple random sampling among those with at least two streams. Two form two streams were randomly sampled from each of the sampled schools. Out of the two sampled streams from each school, random assignment was done to allocate one stream to the treatment group and the other to the control group, as shown in Table 3.3.

Table 3.3: The final Sample Size

Instructional groups	Boys	Girls	Teachers	Total
B-MLS	40	40	0	80
Control group	40	40	2	82
Total	80	80	2	162

Each of the sampled school had one form two stream serving as a control group and the other as an experimental group (B-MLS). The researcher assumed that each stream had approximately a total of 40 students, such that, 20 are boys and 20 are girls. This gave a total of 40 boys and 40 girls in each of the control and experimental groups from the two secondary schools. The total number of boys would be at least eighty (80) and that girls would also be at least eighty (80), giving a grant total of about 160 students.

Finally, the Mathematics teachers of the stream that acted as the control group in each school were purposively sampled. These particular teachers were involved because the study required the teacher who had been teaching a given class to continue teaching the same class during the period of the study. These teachers were teaching the control groups while the researcher was teaching the experimental groups to maintain uniformity in the MLS.

3.6 Research Instruments

Different tools for gathering an assortment of statistics were employed. These included the:

a) Questionnaire on attitude towards mathematics

b) Mathematics achievement tests

c) Misconceptions analysis guide

d) Questionnaire on self-efficacy

These instruments were designed in relation to the research objectives. The conditions under which the instruments were administered were kept as similar as possible across the schools in order to control instrumentation and selection.

Description and Development of Tools

a) Questionnaire on Attitude towards Mathematics

The questionnaire consisted of the Scale of Attitude towards Mathematics which was developed and standardized by Bedi (1992). It was administered to both the control and the experimental before and after the mastery learning intervention.

Description of the Tool

Bedi (1992) prepared the attitude scale by the method summated rating. For the construction of the scale, a total of 59 items were chosen on various dimensions of the prescribed content of mathematics. That is, the General Mathematics, Mathematics teacher, Classroom behavior and Mathematics symbols. For the formulation of the statements, items from various previously constructed tools on attitude, that is, Solanky (1992), attitude of first generation towards education; Shukla (1974), Status of Mathematics teaching and learning; Shanma (1975); Attitude towards science and scientific career, Anand (1984), Attitude of teachers towards students; was collected and tried out on form two students. See appendix II.

Scoring

This was a self-rating scale. Each item of the scale was followed by a five-point scale with the weightage from 0-4. The five-point scale was arranged in a straight line, as the rater was asked to record his or her judgments along the line by marking a tick (√) on the appropriate place, he/she thinks best represents his/her agreement or disagreement with the statement. The maximum possible score was 84, showing a very positive attitude towards mathematics. Each statement was marked with only one tick (√). The attitude test was administered to both the treatment and the control groups before and after the teaching of the selected unit.

b) Mathematics achievement Tests

Mathematics tests were constructed to test the students' knowledge for both control and experimental groups. This was done before and after the mastery learning strategy intervention. The topic that was being taught at that point in time in the school curriculum was algebra. Further, this was a topic of interest to the researcher, as mentioned earlier, because algebra is one of the basic foundations of mathematics. The Mathematics tests administered as the entry behavior test was constructed from what they had already learned in form one algebra classes. See appendix IIIA. After the mastery learning intervention, where algebra was taught to the form two classes, a post-assessment test was given to both experimental and control groups. See appendix IVA.

Below is the Mastery Learning Instructional Model that was adapted by the researcher:

Mastery Learning Instructional Model

Most of the researches investigating mastery model implementations have demonstrated that when mastery model was implemented, students achieved higher levels of performance on objectives – referenced post-tests and increased the amount of instructional time spent in active learning (Harrison and Harrison,1975; Torshen, 1977). The advantages such as higher achievement in mathematics, increased interest, development of positive attitude, etc. of conducting mastery model implementation research in classrooms and other natural settings far outweigh the disadvantages (Lee et al 1971; Torshen, 1977).

Designing Mastery learning Instructional Package

Designing of Mastery Learning Instructional Packages as discussed under the Mastery Learning Components is outlined below.

Mastery Model Component I (Objectives)

The selected content was divided into five units of related concepts where each unit had its own objectives.

Mastery Model Component II (Pre-assessment)

Measuring the Entry Behaviour / pre-requisite skills is equally important as measuring of terminal behavior, (DeCecco, 1986). Entry Behavior described the behavior the students must possess before they can acquire particular new terminal behavior. It is the present status of the student's knowledge and skills in reference to a future learning status the teacher wants them to attain. Entry Behavior consisted of two main components. These included first, specification of the assumptions about the learner, where the instructional units were designed for form two class students, both boys and girls. The students were from Mixed Public Schools and the content (algebra questions) was limited to a segment of form one mathematics syllabus. Then, determination of the pre-requisite skills acquired by the learners.

Pre-requisite skills of the Students

Specification of pre-criterion test/pre-requisite skills assumed that the learners had studied and covered the form one Mathematics syllabus in algebra. Content for pre-assessment test have been given in appendix IIIA.

Mastery Model Component III (Instructions)

The role of the teacher in Mastery Learning Strategy is to formulate specific instructional objectives related to the learning tasks and sequencing the learning units. The teacher was also responsible for designing the instructional materials and other alternative materials and presenting it in such a way that the participation of the students was maximum (Block, 1974). The teacher also specified what was to be learned and how it would be learned. It was the teacher's responsibility to assess students' progress and provide appropriate feedback or remedial work (Gagne, 1965).

The teacher was expected to provide alternative learning opportunities and test whether the final learning criterion (learning outcomes) had been achieved or not.

Before preparing the lesson plan for Bloom's mastery learning, selected subject matter was analysed and sequenced unit-wise. Then the teacher prepared lesson plans and conducted the lessons as per the lesson plan. This applied to the treatment group only. The teacher in the control group employed the regular procedure in conducting the lesson.

Mastery Model Component IV (Diagnostic Assessment)

While the instruction was in progress, a diagnostic mastery test was administered to the students in order to determine the next course of action. For this purpose, some kind of evaluation that could provide immediate and continuous information regarding the students' progress during instruction was required. In this respect, formative evaluation was found to be the most useful (Airasian, 1969). Since a formative instrument was administered at the close of unit, it therefore provided an in-depth picture of what skills each student had or had not mastered (Block, 1971). Consequently, formative evaluation suggested in what ways students' original instruction must be supplemented if he was to complete his learning before proceeding on to a new instructional unit. The criterion referenced tests were developed on each unit for the purpose of formative evaluation.

For each of the five units, five separate formative tests were prepared by the researcher. These were oral questions/assignment that were meant to establish whether the students have learned or not. The oral questions took about 10 minutes. The tests consisted of short mathematical statements where each unit consisted of six such statements. More than one item for each objective in every statement of unit test was developed. The items developed by the investigator was shown to four teachers who were teaching mathematics in secondary schools but not participating in the teaching of the control groups. They were required to give their views about the formative tests generated. Three educational experts were also consulted for their views regarding the items. After this the items generated were tried out (piloted). See appendix IIIC

Mastery Model Component V (Prescription)

The prescription was administered on the basis of diagnostic assessment recommendations. Therefore, if a student did attain mastery enrichment materials were provided and if the student did not attain mastery remedial instruction was recommended

Enrichment Materials/ Remedial Instruction

Individual differences account a lot in the learning environment of the child. This called for proper scrutiny of the child in order to bring them together at par in the learning environment. Some students reached mastery level earlier than the others while others tend to lag behind. This called for proper remediation and enrichment packages, which were prepared in advance in readiness for administration. Enrichment materials were used for early masters while remedial instruction applied to those students who had not mastered the concepts. Some of the enrichment materials were extracted from KNEC past papers and some from form two Mathematics textbooks which were not part of the main text book. See appendix IIIC. The procedure adopted for the purpose of remedial instruction included extensive use of examples/exercises and tutorials for those students who lacked knowledge essential for the unit.

Mastery Model Component VI (Post-Assessment)

The primary purpose of post-assessment was to grade students according to their achievement of the objectives in both control and treatment groups. This was developed on the entire content of five units for the purpose of summative evaluation. Summative evaluation was done at the end of instruction. Summative evaluation is final and the grades assigned are likely to follow the students throughout the scholastic career (Block, 1971; Ebel, 1979; Montgomery, 1994). See Appendix IVA.

c) Misconceptions Analysis Guide

The two groups were subjected to errors and misconception assessment test before and after the intervention or MLS. The competence tests (see appendices IIIA and IVA) were structured in a way that did reveal various errors and misconceptions that the students had. These areas were identified and the researcher recorded their frequency. These included errors in expansion of Mathematical expressions, difficulties in the retrieval of the correct mathematics rules, incorrect interpretation of word Mathematical problems, flawed conceptual knowledge of Algebra and misconception in the dual nature of Mathematical notations as processes and objects. See appendix IVC.

d) Questionnaire for Students on Self-Concept

The purpose for questionnaire for the students was to assess the learners' self-concept which includes self-image, self-identity, self-esteem before and after the intervention or MLS. The student questionnaire reflected a five likert scale where the students ticked against the square of the question a choice marching their self-concept attributes from five given responses which included Strongly Agree (SA), Agree (A), Not Sure (NS), Disagree (D), and Strongly Disagree (SD). The instrument had a total of 15 closed-ended questions items adopted from National Foundation for Educational Research of the University of London. The minimum score for each item was 1(one) and the maximum score for each item was 5(five). The results were then labeled and analyzed by the researcher. See Appendix V.

3.7 Piloting of Instrument

The purpose of conducting the pilot study was to check on the suitability and clarity of the questions on the instruments designed, relevance of the information being sought and the language used to test the reliability of the instruments. It also helped the researcher to be familiar with the administering of the instruments, logistics of research, school schedules for the study and challenges the researcher may face during the groundwork of the study. Piloting was also done in order to detect any unforeseen errors that would have affected the final results. The instruments were pilot-tested to a section of respondents in one randomly selected mixed secondary school outside Machakos before being used for the actual data collection. 16 participants representing 10% of the sample size were selected from elsewhere in Makueni County public mixed secondary schools at random but their responses were not considered in the final data. The exclusion of participants in the pilot test from the actual study was to help eliminate bias in the final findings of the study since they were not part of the study population and would have prior knowledge of the required information (Feeley et al., 2009). Makueni County is in the neighborhood of Machakos and the performance in Mathematics is equally poor. Piloting was done to ascertain reliability and Validity of the instruments. The instruments were then amended before the actual collection of the data.

3.7.1 Validity

The validity of the test instrument is equally important as its reliability. If a test does not serve its intended function well then it is not valid. It is said to be valid if it measures what it is supposed to measure. The study adopted content validity which indicated whether the test items represent the content that the test is designed to measure. It also addressed how well the content of the test samples the subject matter. The domain involved learned knowledge and skills. This content validity is commonly used in achievement tests (Wolf, 1982). The content validity was determined by comparing the items in a test with the content and objectives of a particular domain to see how well they match, as it is essential for a valid test to reflect the content of a particular domain.

The Mathematics test was prepared using forms one and two mathematics syllabus. Five Mathematics teachers in secondary schools and five experts from School of Education of Machakos University stated their opinions and judgments regarding the suitability of the test items. The face and Construct validity of Students Questionnaire was appraised by 3 experts from School of Education of Machakos University.

3.7.2 Reliability

Ensuring reliability is a prerequisite of constructing a good test. Kothari (2007) also argues that, instrument reliability is the degree to which scores obtained from an instrument are consistent. If a test is reliable all the items should correlate with one another. Mugenda and Mugenda (2006) defined reliability as a measure of the degree accuracy in giving similar outcomes when a measuring procedure is carried out a number of times. Reliability in research is influenced by random error. Random error is the deviation from a true measurement due to factors that have not been effectively addressed by the researcher. The researcher used the split-half technique (Nkpa,1997). The test and the questionnaires scores were divided into two halves: scores for odd-numbered items and scores for even-numbered items. Then the correlation between the two halves was determined by using Spearman Correlation Coefficient Formula. Thus: $r = 1 - \frac{\sum d^2}{n(n^2-1)}$

Where r = Spearman coefficient

n = number of items in the tool

$\sum d^2$= sum of the square deviations of the variables

The Correlation Coefficient for the Mathematics test and that of the questionnaire were 0.79 and 0.72 respectively. Thus, the instruments were reliable.

3.8 Data Collection Procedures

The researcher sought for an introductory letter from The School of Post Graduate Studies of Machakos University, authorization letter and research permit from National Commission for Science, Technology and Innovation (NACOSTI). These documents enabled the researcher to secure an authorization letter from The County Commissioner and County Director of Education, Machakos County. These letters introduced the researcher to secondary schools' principals and Mathematics teachers of the sampled schools seeking consent to carry out research and informing them on the role to play.

Conducting the Experiment

The experiment was conducted in three phases. First, the administration of the pretest entry behavior, then instructional program was conducted and finally the administration of the posttest

1) **Administration of the Pretest**

Criterion/Achievement test (a Pre-test) was administered to both the experimental and control groups to ascertain if the two groups were comparable and have the same entry characteristics before the treatment. Separate answer sheets were provided. Scoring was done to obtain the information regarding previous knowledge of the students. One hour and twenty minutes was given to complete the test.

Also attitude and self-efficacy questionnaires were administered to both groups before teaching to ascertain if the two groups are comparable and have the same entry characteristics before the treatment.

2) **Conducting the Instructional Program**

Blooms mastery learning strategy believes that it is the task of the teacher to design his/her instruction so that all who can learn well, do learn well (Block, 1974). The mastery learning strategy group was taught directly by the investigator while the control group was taught by their regular Mathematics teacher in the conventional way.

For Treatment Group

The investigator taught the treatment group following the guidelines in the MLS-Instructional packages developed in advance. New stimulus material was presented and chalkboard was utilized for working out calculations. Content was recapitulated and summarized at the moderate intervals at the same time corrective feedback or confirmations was provided whenever needed. Unit criterion (formative) test was conducted, at the completion of each unit. Further questions were used as alternative/corrective instructions and enrichment materials was provided for early masters of the content.

For Control Group

The regular Mathematics teacher taught the control group in the conventional way following their own lesson plan. Objectives and content for each lesson was provided to their Mathematics teacher by the researcher. The control and the treatment group were both taught the form two algebra. No unit criterion test was conducted after the completion of each unit as was the case with the treatment group. Further, the time schedule followed for the control group was similar to that of the treatment group.

3) **Administration of the Posttest**

According to the school timetable Mathematics is normally taught every day. So, the topic was taught every day for a period of 10 days, that is a period of two weeks, and the Criterion Referenced Test (CRT)-summative test was administered to control and treatment groups the last lesson at the end of the two weeks. This was done after exposing the experimental group to mastery learning and the control group to conventional teaching method. Answer sheets were scored according to their prescribed scoring keys.

Also attitude and self-efficacy questionnaires were administered to both groups after the intervention. This was done the following day after the summative test was administered so as to give students time to relax. Since all these procedures could not fit within the 10 days the attitude and self-efficacy questionnaires were administered on a Saturday so that the school programme is not interfered with. The data thus obtained was subjected to statistical analysis using SPSS.

3.9 Data Analysis

The data collected was processed and analysed by the researcher. The Z scores test statistics, Analysis of Variance (ANOVA) and Chi-Square were used to test whether the two groups' level of competence test achievement in Mathematics, attitude towards mathematics, magnitude of errors and misconceptions committed and level of self-efficacy differed significantly at $\alpha = 0.05$ significance level and thereafter determine the relevance of treatment or MLS.

3.9.1 Testing Hypothesis about the Difference between Two Proportions

Let p_1 *and* p_2 be the sample proportions obtained in large samples of sizes *n1* and *n2* drawn from respective populations having proportions π_1 *and* π_2. We can test the null hypothesis that there is no difference in the population proportions, *i.e.,* $H_0 : \pi_1 = \pi_2$

This was done by testing the hypothesis;

$$H_0 : \pi_1 = \pi_2 \quad versus$$
$$H_0 : \pi_1 \neq \pi_2$$

To test the above hypothesis, the test statistic was computed:

$$z = \frac{(p_1 - p_2)}{\sqrt{p(1-p)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}, \text{ where } p = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}.$$

The statistical inference conclusion is drawn such that if the calculated value of $|z| > z_{\alpha/2}$, then reject H_0, otherwise the H_0 is rejected.

3.9.2 Testing Hypothesis about the Difference between Two groups through ANOVA

The Analysis of Variance (ANOVA) table for single response variable is summarized in Table 3.4 below

Table 3.4: ANOVA Table Before intervention

Source of variance	Sum of Square	df	Mean Square	F_c	F_s	Pr(>F)
Between Groups	SSB	*k-1*	MSB	F_c	F_s	P-Value
Within Groups	SSW	*n-k*	MSW			
Total	SST	*n-1*				

Where;

SSB Sum of the squares between the groups

SSW-Sum of the squares within the groups

SST- Total sum of the squares

MSB-Mean square between the groups

MSW-Mean square within the groups

n-Sample size

k- Number of groups

F-Fisher distribution

3.9.3 Testing Hypothesis about the Difference between Two groups through Chi Square

The value of the chi-square test-statistic is given by

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Where:

χ^2 = Pearson'' cumulative test statistic, which asymptotically approaches a χ^2 distribution

O_i = an observed frequency;

E_i = an expected (theoretical) frequency, asserted by the null hypothesis;

n= the number of cells in the table.

A decision was made after comparing the value of the test statistic to the critical value ofχ^2_α with degree of freedom = (r –1) (c –1) where “r” and “c” are the number of rows and columns in a contingency table. The null hypothesis was rejected if the calculated chi-square value is greater than the standard chi-square value i.e.$\chi^2_\alpha > \chi^2_t$ otherwise ($\chi^2_\alpha < \chi^2_t$) we fail to rejectH_o at the stated level of significance (5%) for this study. The observed and the expected values for this study were entered as in table.

3.10 Ethical Consideration

Research involves learning from human beings and their dignity must be protected at all levels. Respondents are people and cannot be reduced to objects, hence calling for their protection. According to Christians (2000) informed consent means that respondents should freely agree to participate based on fully and open facts. The researcher ensured that participants act voluntarily for they have freedom and a right to choose to participate or not. According to Creswell (2014) individuals participating in the study need to know the purpose and the aims of the research and how the research could be used. In this research the purpose of the study was disclosed to the participants by the researcher. They were also assured of the confidentiality and anonymity on the information given by use of codes such as school ‘x’, student ‘y’, teacher ‘R’ for concealing respondents’ identities and that it will be used only for the purposes of the study. The respondents were also made aware that the information to be gathered will help the teachers and teacher trainers to improve the teaching and learning of Mathematics.

CHAPTER FOUR

PRESENTATION OF FINDINGS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the study findings, interpretation and discussion of results. This is done following the order of objectives. For each objective, descriptive findings are presented followed by inferential statistics where applicable and a discussion of the findings.

The study was designed to compare the competence of students' taught Mathematics using Mastery Learning Strategy (MLS) with students taught using the Conventional Group Learning (CGL) and to investigate the relationship between students' attitudes towards Mathematics, their self-concept and their level of Mathematical achievement per gender. The study was guided by the following objectives:

i. To compare the level of achievement on a Mathematics competence test of students taught using MLS and those taught using CGL in form two classes.

ii. To determine whether there is a difference in attitude towards Mathematics between form two students taught using MLS and those taught using CGL.

iii. To determine whether there is a difference in the type of misconceptions in Mathematical algebra between form two students taught using MLS and those taught using CGL.

iv. To determine whether there is a difference in self-efficacy between form two students taught using MLS and those taught using CGL.

4.2 Questionnaire Response Rate

Two mixed public secondary schools were randomly sampled among those with at least two streams. Two form two streams were randomly sampled from each participating school which had more than two streams. Out of the two sampled streams from each school, random sampling was done to allocate one stream to the treatment group and the other to the control group.

Table 4.1, Table 4.2 and Table 4.3 give the summary of the participants' distribution per group, gender and age respectively.

Table 4.1: Students in mixed Public Secondary Schools

Classes	Frequency	Percentage
Experimental	60	39.0
Control	94	61.0
Total	154	100.0

The study engaged one hundred and fifty-four (154) respondents out of the targeted sample of one hundred and sixty (160) participants in a mixed public secondary school. The control group constituted of 94 students making 61% while the experimental group was made up of 60 students making 39% of the total respondents. Therefore, the response rate was 96.25% leaving only 3.75% chance for nonresponse bias. The high response rate enhanced the reliability and validity of the study findings.

Table 4.2: Distribution of Students by Gender

Gender	Frequency	Percentage
Male	90	58.4
Female	64	41.6
Total	154	100.0

There were 90 and 64 boys and girls respectively who participated in the study making 58.4 % and 41.6% respectively. These were approximately equal in number in a mixed school. This helped to control the classroom environment.

Table 4.3: Distribution of Students by Age

	F	%
10-12 years	-	0.0
13-14 years	35	22.7
15-16 years	111	72.1
Over 16 years	8	5.2
Total	**154**	**100**

Findings from Table 4.3 on students' age shows that 0.0% were aged 10-12 years, 22.7% were aged 13-14 years, 72.1% were aged 15-16 years and the remaining 5.2% were aged 16 years and above. These findings mean that majority of form two students who were approximately of the same age bracket were involved in the study. Therefore, the learners' age and hence their class meant that they could handle the form two mathematics. That is, this determined what they were taught.

4.3 Students' Level of Achievement on a Mathematics Competence Test

The first objective sought to establish whether there is a difference in the level of achievement on a Mathematics competence test of students taught using MLS and those taught using CGL in form two classes. In order to examine the degree to which mastery learning strategy influenced the learning of Mathematics as compared to the conventional group learning, the level of achievement on a Mathematics competence test was conducted for both groups before the mastery learning strategy intervention method was rolled out. There after the MLS intervention another test of the same difficult level was conducted to the same students as discussed in the following sections. The collected data was analyzed using descriptive and inferential statistics.

4.3.1 Students' Level of Achievement before the Intervention

The participating students were subjected to an entry competence test prior to mastery learning strategy intervention and their performance was recorded as summarized in Tables; 4.4, 4.5 and 4.6 and in Figure 4.1.

Table 4.4: Students' Score in Mathematics before intervention

Classes	N	Mean	Std. Deviation	Std. Error Mean	CI for the population Mean
Experimental	60	27.58	16.44	2.86	24.71- 30.44
Control	94	26.36	14.18	2.36	24.00- 28.72

The findings presented in Table 4.4 indicated that the mean score for the control group was 26.36 with a standard deviation of 14.18 and a confidence interval for the population mean of 24.00 to 28.72. The experimental group means score for the same examination was 27.58 with a standard deviation of 16.44 and a confidence interval for the population mean of 24.71 to 30.44. The mean score for the control and the experimental groups were close to one another and so were the standard deviation implying that they were at the same level in as far as their achievement in Mathematics test was concerned. These findings reveal that, before the MLS intervention there was no significant difference in the Mathematics achievement tests score between the two groups. Any differences observed after the intervention would be attributed to the effect of MLS.

A boxplot was constructed to display the distributional characteristics of the group's scores as well as the level of the scores per group as shown in the figure below.

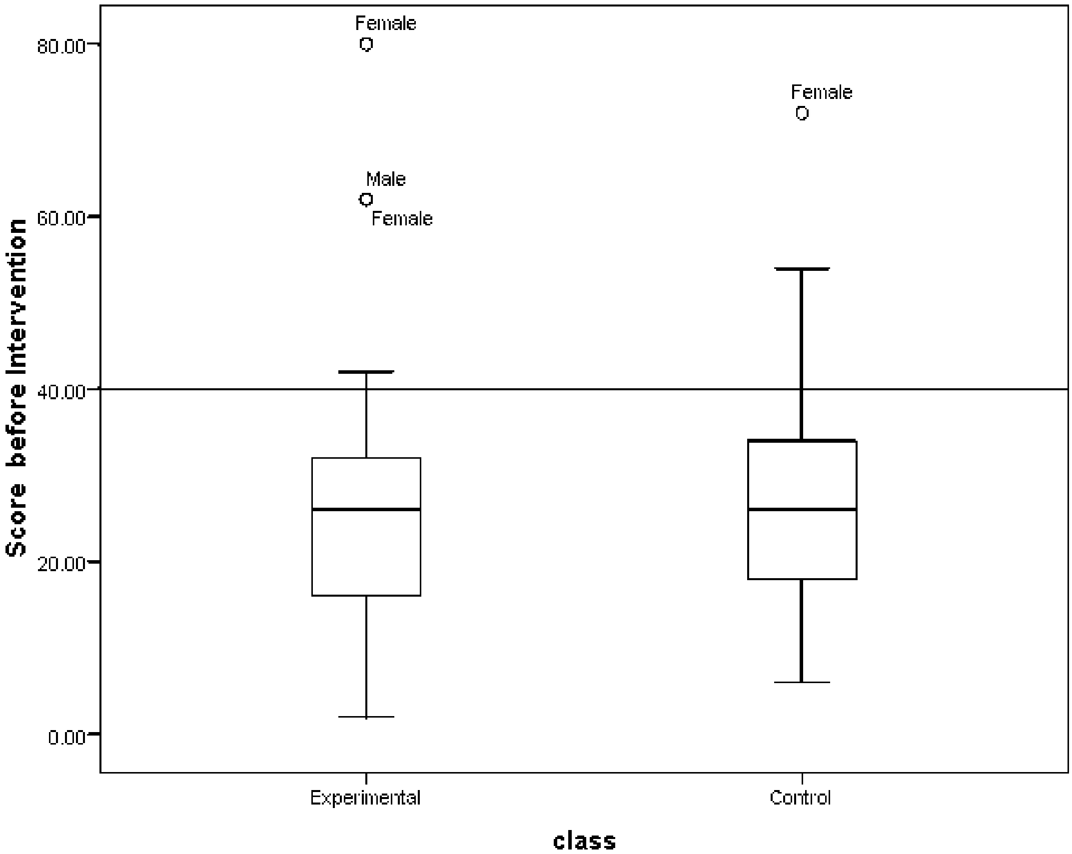

Figure 4.1: Boxplot before Intervention

By inspection the boxplot indicates that the medians which were generally close to the average were almost all at the same level. This suggested that overall students score was close with one another. The whisker for the control group is a bit elongated implying the students' score was quite dispersed in that group.

The Analysis of Variance before the MLS Intervention

To establish if there is some significant difference in the level of achievement on a mathematics competence test of students taught using Mastery Learning Strategy and those taught using Conventional Group Learning in form two classes the analysis of variance was conducted for both the control and the experimental group before the MLS intervention. Table 4.5 gives the summary findings.

Table 4.5: ANOVA Table Before intervention on Mathematics Achievement Tests

Source of variance	Sum of Square	df	Mean Square	F_c	F_s	Pr(>F)
Between Groups	20.585	1	20.585	0.1995	3.90	0.743
Within Groups	15682.366	152	103.173			
Total	15707.768	153				

Based on the variation between sample means to the variation within the samples ratio symbolized by F and the P-value, statistically there was no significant difference in performance between the control group and the experimental group at the entry level. This was because the F computed value 0.1995 was less than the F standard critical value 3.90 at $\alpha = 0.05$ and $(1,152)$ degrees of freedom. While the p-value 0.743 was greater than 0.5 implying the null hypothesis there is no significant difference in the achievement of Mathematics competence test of form two students who were taught using the mastery learning strategy (MLS) and those who are taught using the conventional group learning (CGL) was accepted at $\alpha = 0.05$.

The two-way analysis of variance was conducted to test the interactions effect of the independent variables the MLS and the CGL on the response variable the Mathematics achievement. The findings are summarized in Table 4.6.

Table 4.6: Two Way ANOVA Tests of Between-Subjects Effects

Variance Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corr. Model	50.639[a]	3	16.880	0.162	0.976	0.003
Intercept	46684.165	1	46684.165	447.269	0.000	0.749
Class	25.076	1	25.076	0.240	0.748	0.002
Sex	1.313	1	1.313	0.013	0.941	0.000
Class * Sex	28.551	1	28.551	0.274	0.732	0.002
Error	15656.434	150	104.376			
Total	65577.000	154				
Corrected Total	15707.072	153				

Based on the results in Table 4.6 there was no significant interaction effect (class*sex: sig=0.732) statistically. Hence there was no significant difference in the effect of gender on the examination performance for males and females. There was no significant main effect for any of the independent variables given that the significant values for both the class and sex were 0.748 and 0.941 both greater than 0.05. The computed F-values for class and sex were 0.240 and 0.013 respectively which were both less than the standard F-value $\left(F_{1,150} = 3.90\right)$ at $\alpha = 0.05$.

Based on (Gagne' & Paradise,1961; Atkinson, 1968) research findings it is necessary to validate the prior learning's that were prerequisite to the specific learning task which the learner faced. These behaviors should be identified and measured prior to instruction. The behavior includes Cognitive entry and affective entry behaviors which this study assessed before and after the intervention.

4.3.2 Chi-Square Analysis on Groups' Mathematics Competence Test

To confirm the relationship between the control and the experimental groups in as far as the score in the Mathematics test is concerned a Chi-square test was conducted between the control and the mastery learning strategy group's level of competence test difference in Mathematics before the intervention. The observed and the expected values were entered as in Table 4.7.

Table 4.7: Contingency Table before MLS Intervention in Mathematics Achievement Test

Exam Performance	Count	Class		Total
		Experimental	Control	
Failed	Observed	20	52	72
	Expected	20.3	51.1	71.4
Passed	Observed	40	42	82
	Expected	39.7	42.9	82.6
	Total	60	94	154

Computed Chi-Square=0.022, P-value=0.883

The calculated Chi-Square value was 0.022 which is less than the tabulated chi-square value at 5% significance level with 2 degree of freedom (3.84). Therefore, there was statistically no significant difference with regard to competence test performance in Mathematics. Although the control group had more students failing compared to the group taught using the mastery learning strategy, the difference was not statistically significant at $\alpha = 0.05$. The P-value of 0.883 confirmed the chi-square results findings. Therefore, the calculated Chi-Square value obtained before the intervention confirmed that there was statistically no significant relationship between the control and the experimental groups in as far as the score in the Mathematics achievement test is concerned. That the two groups were at the same level in as far as their achievement in Mathematics is concerned. This can be attributed to the fact that the two groups were taught Mathematics using the conventional method.

4.3.3 Students' Level of Mathematics Achievement Test after the MLS Intervention

The participating students were subjected into an exit competence test after the mastery learning strategy intervention and their performance was recorded as summarized in Tables; 4.6, 4.7 and 4.8 and in Figure 4.2.

Table 4.8: Students Score after the MLS Intervention in Mathematics Achievement Test

Classes	N	Mean	Std. Deviation	Std. Error Mean	CI for the population Mean
Experimental	60	28.27	17.96	3.13	25.15- 31.40
Control	94	18.36	17.34	2.89	15.47- 21.25

The findings in Table 4.8 indicated that the mean score for the control group reduced to 18.36 from 26.36 with a standard deviation of 17.34 and a confidence interval for the population mean of 15.47 to 21.25. The experimental group's mean score for the same examination improved by 0.69 to 28.27 with a standard deviation of 17.96 and a confidence interval for the population mean of 25.15 to 31.40. An improvement in the mean score of the Mathematics achievement test was observed with the experimental group after the intervention. While in the control group, which was not exposed to the MLS, their mean score in Mathematics test dropped by 8.0. The control group was taught by conventional method which as seen above could be concluded that there was no improvement in as far as the learning of Mathematics is concerned.

A boxplot was constructed to display the distributional characteristics of the group's scores as well as the level of the scores per group after the intervention.

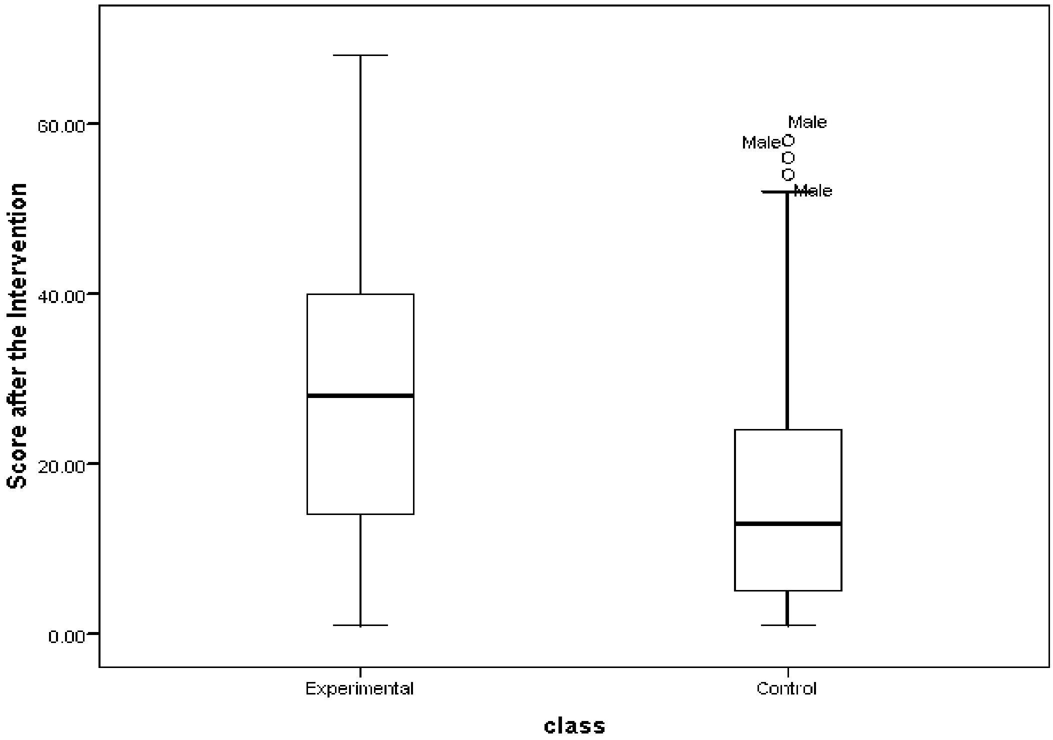

Figure 4.2: Boxplot after MLS Intervention

Based on figure 4.2 results, the medians which were generally close to the average indicated a significant dispersion between the two groups, with the experimental group being higher. The upper side whisker for both the groups were a bit elongated implying the top 25% of the students' score was quite dispersed in both groups.

The Analysis of Variance after the MLS Intervention

To establish if there was some significant difference in achievement on a Mathematics competence test the analysis of variance was computed for both the control and the experimental group after the MLS intervention. Table 4.9 gives the summary findings.

Table 4.9: ANOVA Table after the MLS Intervention in Mathematics Achievement Test

Source of variance	Sum of Square	df	Mean Square	F_c	F_s	Pr(>F)
Between groups	1691.439	1	1691.439	12.334	3.90	0.023
Within groups	20844.851	152	137.137			
Total	22536.290	153				

The variation between sample means to the variation within the samples ratio (F) and the P-value, indicated that statistically there was a significant difference in performance between the control group and the experimental group at the exit level. This was because the F computed value 12.334 was greater than the F standard critical value 3.90 at $\alpha = 0.05$ and $(1,152)$ degrees of freedom. While the p-value 0.023 was less than 0.05 implying that we reject the null hypothesis stating that there is no significant difference in the achievement of Mathematics competence test of form two students who were taught using the mastery learning strategy (MLS) and those who are taught using the conventional group learning (CGL) at $\alpha = 0.05$.

Two-way Analysis of Variance after the Intervention

The two-way analysis of variance was conducted to test the interactions effect of the independent variables on the response variable after the mastery learning strategy intervention. The findings are summarized in Table 4.10.

Table 4.10: Tests of Between-Subjects Effects after the MLS Intervention

Variance Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corr. Model	1878.120[a]	3	626.040	4.546	0.127	0.083
Intercept	34141.051	1	34141.051	247.900	0.000	0.623
Class	1839.770	1	1839.770	13.359	0.019	0.082
Sex	34.623	1	34.623	0.251	0.742	0.002
Class * sex	154.197	1	154.197	1.120	0.489	0.007
Error	20658.170	150	137.721			
Total	59360.000	154				
Corr. Total	22536.290	153				

Based on the result findings there was no significant interaction effect (class*sex: sig=0.489). Hence there was no significant difference in the effect of gender on the examination performance for males and females after the introduction of MLS. However, there was a significant main effect for one independent variable (class), given that its significant value was 0.019, which is less than 0.05 and the computed F=13.389 which is greater than the standard F-value $\left(F_{1,150} = 3.90\right)$ at $\alpha = 0.05$. On the other hand sex was not significant given (sig= 0.742) which is greater than 0.05 and the computed F=0.109 which was less than the standard F-value $\left(F_{1,150} = 3.90\right)$ at $\alpha = 0.05$.

Therefore, there was a significant difference in scores after the mastery learning strategy intervention. These findings were in agreement with Cronbach and Snow (1969), who emphasized on the fact that improving the quality of instruction can optimize the learning of particular learners. It confirmed that mastery learning strategy (MLS) yields better retention and transfer of material, yield greater interest and more positive attitude in various subjects than Non-Mastery Learning Approaches as earlier documented by Ngesa, 2002; Wachanga and Gamba, 2004 and Wambugu, Changeigwo, 2007 and Davrajoo, et al (2010). The study findings were in tandem with Wibler et al (1981) and Wambugu & Changeiywo (2007) findings who opined that MLS helps the students to acquire prerequisite skills to move to the next unit. Moreover Hutcheson (2015), Tukur *(*2018) and Uchechi, Ezinwanyi and Ihendinihu (2013) studies revealed that there is a significant effect on the academic and Mathematics achievement respectively for the students who were exposed to mastery learning strategy.

Mastery learning strategy (MLS) can help the teacher to know student's area of weakness and correct it thus, breaking the cycle of failure. By Fuchs, Fuchs and Tindal, 1986 research findings mastery learning resulted in better scores with the use of alternative procedures.

Both genders competed equally on the Mathematics competence test. This meant that there was no significant difference in their performance. According to Arlin and Webster (1983) study on mastery learning strategy results showed that Mastery Learning Strategy is beneficial to both boys and girls. This finding was in agreement with the study findings where the gender was not a significant factor at $\alpha = 0.05$.

A Chi- Square analysis after the MLS Intervention

To confirm if there was some significant difference in the achievement on a Mathematics competence test Chi- Square analysis for the performance of the two groups was also conducted after the MLS intervention. The overall score for the two groups was determined which was 24.01 and the student who scored less than the average score was classified as failed otherwise it was a pass regardless of the group. Table 4.11 gives the summary of the Chi-Square analysis.

Table 4.11: Contingency Table after the MLS Intervention in Mathematics Achievement test

Exam Performance	Count	Class		Total
		Experimental	Control	
Failed	Observed	13	74	87
	Expected	27.9	59.1	87.0
Passed	Observed	47	20	67
	Expected	32.1	34.9	67.0
	Total	60	94	154

The Table 4.11 above gives the number of students in each category. Like there are 13 out of 154 students in the experimental group who are on the observed frequency and so on. The calculated chi-square value was 10.459 which was greater than the tabulated chi-square value at 5% significance level with 2 degree of freedom (3.84). Therefore, there was statistically significant difference with regard to competence test performance in Mathematics whereby the control group had more students failing 74(85%) compared to the group taught using the mastery learning strategy which 13(15%) students scoring below average. The P-value of 0.001 confirmed the results findings

The Chi-Square confirmed the results findings that the students who were taught Mathematics using the mastery learning strategy had a significantly higher score than the conventional group after the MLS intervention. Hence, the Null hypothesis which stated that there is no significant difference in the achievement of mathematical competence test of form two students who were taught using the mastery learning strategy (MLS) and those who are taught using the conventional group learning (CGL) was rejected by the study. These findings indicate that there is a strong correlation among the variables both dependent and independent.

4.4 Students Attitude towards Mathematics

The second objective sought to establish whether there is a difference in attitude towards Mathematics between form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning. The students were subjected to likert scaled questionnaire before and after the intervention to reveal and establish their attitudes towards Mathematics. The basic premise underlying this study was that the students had the capacity to learn and change and wants these things to happen regardless of past performance.

4.4.1 Attitude before the Mastery Learning Strategy Intervention

The attitude test towards Mathematics for the students before the intervention through the mastery learning strategy was conducted through the questionnaire whose statements are summarized in Table 4.12. The students were supposed to Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) or Strongly Disagree (SD).

Table 4.12: Students Attitude Tests

Attitude Test Statements	SA	A	U	D	SD
Home memories preoccupy during math lessons	16	18	31	31	58
Learning math is a waste of time	9	2	31	40	72
I use math time to do other subjects	2	9	25	29	89
I don't bother why I fail math CATs	74	27	40	9	4
I don't utilize library for math text books	31	38	30	31	24
There's no useful math information	89	31	27	3	4
I do math only because it's compulsory	27	18	25	27	57
Math lessons should be shortened	4	5	29	31	85
I don't like max math questions from teachers	49	40	29	20	16
I don't discuss math questions after the lesson	59	39	25	24	7
I don't ask concept clarification	45	33	29	33	14
I don't keenly attend to math teachers	87	40	21	4	2
Studying math brings headache and tiredness	11	4	29	25	85
I don't share math challenges to my relatives	40	22	40	23	29
I don't study math at home	25	18	27	22	62
Math classes bore	4	0	31	27	92
New math problem solving strategies don't stimulate me	40	31	49	20	14
I am absorbed into other world during math lessons	11	11	40	31	61
I tease my math teachers with questions	11	2	36	49	56
It's not easy to score high in math	67	45	29	11	2
I do math homework after other subjects	57	30	40	11	16
Total	**776**	**463**	**663**	**501**	**849**

Based on the students' response to statements items in table 4.9, they strongly disagreed most times than any other response. The highly disagreed statement by 57% of the respondents was the use of Mathematics time to do other subjects, followed by 55% of the respondents who strongly disagreed with the statements; Mathematics lessons should be shortened and the statement studying Mathematics brings headache and tiredness.

Most students 57% and 56% strongly agreed with the statements that; there is no useful Mathematics information and I don't keenly attend to Mathematics teachers respectively. Based on the students' response it was possible to categorize the student into either having a positive or negative attitude towards Mathematics and then comparing the performance of each category.

Further, majority of the students, that is, 58%, 72% and 77% disagreed with the statements that home memories preoccupy them during Mathematics lessons, that learning Mathematics is a waste of time and that they use Mathematics time to do other subjects respectively. 17 % disagreed that Mathematics lessons should be shortened and 9% disagreed that Mathematics classes are boring. This was an indication of the positive attitude towards mathematics. On the other hand, 12% did agree that during Mathematics lesson they are preoccupied with home memories, that learning Mathematics is a waste of time and they use Mathematics time to do other subjects. Though a small number these students showed no interest in learning Mathematics. Out of the students who disagreed with the statements that Mathematics is a waste of time and that they use Mathematics time to do other subjects only 17% and 9% disagreed with the statements that they do Mathematics after other subjects and that it is not easy to score high in Mathematics respectively.

This can be interpreted that majority of the students in that group had a positive attitude. Very few, 4%, in that group who disagreed with the statement that they do not keenly attend to Mathematics teachers. Again 9% disagreed with the statement that they don't bother why they fail Mathematics CATs and 4% disagreed with the statement that indicated that there's no useful Mathematics information. In the same vein 23% disagreed that they don't like Mathematics questions from teachers and 20% disagreed with the statement that they don't discuss Mathematics questions after the lesson. This implied that more students actually agreed with the statements that they do not discuss Mathematics questions after the lesson, that they do Mathematics homework after other subjects, that they don't bother why they fail Mathematics

CATs and no wonder they concur with the statement that it's not easy to score high in Mathematics. As a result, these students do not ask for concept clarification or share Mathematics challenges with the relatives neither do they find the new Mathematics problem solving strategies stimulating to them.

It's also observed that there is a positive disposition at the start but this gradually turns around and the consequences are dire. If MLS produces positive attitude then the factors lowering the level of commitment can be investigated. The students also need mentoring, orientation and practice. In every statement about 11 to 22 students have remained undecided due to something that needs to be probed in order to establish the factors leading to the statement. These may possibly not be attending classes or there could be another reason. These students will, therefore, need to be mentored or cancelled on the importance and the value of Mathematics.

These findings were further categorized as either positive or negative for both the control and the experimental groups as indicated in the following section.

4.4.2 The Proportions of the Students with negative Attitude Prior to MLS Intervention

To establish if there is a difference in attitude towards Mathematics between form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning the analysis of the student's attitude towards Mathematics was conducted using each student response on the questionnaire items prior to the mastery learning strategy introduction. The result findings are summarized in Table 4.13.

Table 4.13: Attitude towards Mathematics per Class

Attitude	Class		Total
	Experimental	Control	
Negative	27	47	74
Positive	33	47	80
Total	60	94	154

The results after carrying out the computation to determine the attitude of the respondents towards mathematics are given in Table 4.13. The number of students with a negative attitude from the experimental class was 27 out of 74 randomly sampled students forming 36.4% while those with a negative attitude from the control class was 47 out of 80 randomly sampled students' constituting 58.3%. Taking the hypothesis that there was no significant difference in the attitude towards Mathematics between the two samples of the students, i.e., $\pi_1 = \pi_2$. Z statistics was used to test the hypothesis;

$$H_0 : \pi_1 = \pi_2 \ \ versus$$
$$H_1 : \pi_1 \neq \pi_2$$

The computed value of z=-2.72 was greater than the critical value of z = 1.96 at 5% level of significance, therefore, hypothesis is rejected. Hence, there is significant difference in attitude between the control and the experimental class with the control group having the higher proportion of students with negative attitude towards Mathematics compared to the experimental group.

4.2.3 Attitude Test per Gender prior to MLS

The analysis of the student's attitude towards Mathematics per gender was conducted and Table 4.14 gives the distribution of the attitude per gender.

Table 4.14: Attitude per Gender

Attitude	Gender		Total
	Male	Female	
Negative	54	20	74
Positive	36	44	80
Total	90	64	154

The number of male students with a negative attitude was 54 out of 90 randomly sampled male students forming 73% of the students with a negative attitude towards Mathematics compared to 20 out of 64 randomly sampled female students constituting 27% of the students with negative attitude towards Mathematics from the sample. Taking the hypothesis that there was no significant difference in proportion of the students with a negative attitude towards Mathematics between the two gender samples of the students, i.e., $\pi_1 = \pi_2$. Z statistics was used to test the hypothesis;

$H_0 : M_1 = F_2$ *versus*
$H_1 : M_1 \neq F_2$

The computed value of z=29 was greater than the critical value of z = 1.96 at 5% level of significance, therefore, hypothesis is rejected. Hence, there is a significant difference in attitude between the male and the female students.

A significant proportion of 60% of the male students had a negative attitude towards Mathematics compared to 31% of their counterpart female students, where male students had a higher percentage. The main reason why the male students had a higher percentage of the negative attitude compared to the female students is the fact that the male students were more in number (58.4%) compared to the female students (41.6%).

4.4.4 The Proportions of the Students with negative Attitude post the MLS intervention

It is worthwhile to note that although there was a significant difference in attitude between the two groups before the treatment the study however proceeded with the treatment to find the extent of its impact. So, to establish if there is still a difference in attitude towards Mathematics between form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning the analysis of students with the negative attitude towards Mathematics was conducted per class. Table 4.15 gives the summary of the students' distribution per class and the attitude distribution after the MLS intervention.

Table 4.15: Students' Attitude per Student

	Class		
Attitude	Experimental	Control	Total
Negative	6	22	28
Positive	21	20	41
Total	27	42	69

The number of students with a negative attitude from the experimental class was 13 out of the 74 randomly sampled students forming 19.7% of the students with a negative attitude towards Mathematics after the MLS implementation. The control class had 53 out of the 80 randomly sampled students constituting 80.3% of the students having a negative attitude towards Mathematics after the MLS intervention. Taking the hypothesis that there was no significant difference in the attitude towards Mathematics between the two samples of the students from the two classes, i.e., $\pi_1 = \pi_2$. Z statistics was used to test the hypothesis;

$H_0 : \pi_1 = \pi_2$ *versus*

$H_1 : \pi_1 \neq \pi_2$

The computed value of z = -6.103 was greater than the critical value of z = 1.96 at 5% level of significance, therefore, the null hypothesis was rejected. Hence, there was significant difference in attitude between the control class and the experimental class, whereby the control class had the higher percentage of the students with a negative attitude towards Mathematics after the MLS implementation.

An improvement of 18.8% of the students was noted from negative attitude to positive attitude towards Mathematics among the students in the experimental class. Initially 36.4% students had a negative attitude but after the MLS intervention the percentage reduced to 17.6%. These findings are in tandem with Emin (2005) results after investigating the effects of mastery learning and cooperative, comparative and individualistic learning environment organizations on achievement and attitudes in Mathematics on 158 students in mathematics. His results indicated that mastery learning improved students' achievement and yields greater positive attitudes.

4.4.5 Attitude test per Gender post MLS intervention

The analysis of students with the negative attitude towards Mathematics was conducted per gender. Table 4.16 gives the summary of the students' distribution per class and the attitude distribution.

Table 4.16: Attitude per Gender post MLS intervention

	Gender		
Attitude	Male	Female	Total
Negative	50	18	68
Positive	40	46	86
Total	90	64	154

The number of male students with a negative attitude was 50 out of the 90 randomly sampled male students forming 73.5% of those with a negative attitude while from the female students was 18 out of the 64 randomly sampled female students constituting 26.5%. Taking the null hypothesis that there was no significant difference in the attitude towards Mathematics between the two samples of the two gender of the students, i.e., $\pi_1 = \pi_2$. Z statistics was used to test the hypothesis;

$$H_0 : M_1 = F_2 \ \ versus$$
$$H_1 : M_1 \neq F_2$$

The computed value of z=4.148 was greater than the critical value of z = 1.96 at 5% level of significance, therefore, the null hypothesis was rejected. Hence, there was a significant difference in attitude towards Mathematics between the male and the female students with male students having higher percentage. A significant proportion of 56% of the male students had a negative attitude towards Mathematics compared to 28% of their counterpart female students.

4.4.6 Chi-Square Analysis on Groups' Attitude post the MLS Intervention

To confirm if there was some significant difference in the attitude towards Mathematics a Chi-square test was conducted between the control and the mastery learning strategy group's attitude difference after the intervention. The observed and the expected values were entered as in table 4.17.

Table 4.17: Contingency Table on Attitude Proportions post the MLS Intervention

		Attitude		
Class		**Negative**	**Positive**	**Total**
Experimental	**Observed**	13	60	**73**
	Expected	31.9	41.7	**73.6**
Control	**Observed**	54	27	**81**
	Expected	35.1	45.3	**80.4**

Total	**67**	**87**	**154**

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} = \frac{(13 - 31.9)^2}{31.9} + \cdots + \frac{(27 - 45.3)^2}{45.3} = 35.48$$

The calculated chi-square value was 35.48 which was greater than the tabulated chi-square value at 5% significance level with 2 degree of freedom (3.84). Therefore, there was statistically significant difference with regard to attitude towards Mathematics whereby the control group had more students with negative attitude compared to the group taught using the mastery learning strategy.

Table 4.18: Chi-Square and P-value Table on Attitude Proportions post the MLS Intervention

Test statistics	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	35.470[a]	1	0.000		
Continuity Correction[b]	34.556	1	0.000		
Likelihood Ratio	37.355	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	36.231	1	0.000		
N of Valid Cases	154				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.35.

b. Computed only for a 2x2 table

Based on the P-values (0.000) which was less than the critical value 0.05, the null hypothesis which stated that, there is no significant difference in attitude towards Mathematics of form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning was rejected at $\alpha = 0.05$ and the conclusion was there was statistically a significant difference between the two groups with regard to their attitude towards Mathematics. These findings reveal that there is a strong correlation among the variables both dependent and independent.

According to many researchers in the field, the positive or negative attitude of students affects their success levels in Mathematics classes in a positive or negative way (Peker & Mirasyedioğlu, 2003). Perhaps the most important factor which influences Mathematics success levels of students is the students' attitude towards Mathematics classes. As educators we always seek to improve the student learning experience. One way to tackle this issue is to consider students' attitudes towards Mathematics. In the studies conducted so far, it has been suggested that students with higher positive attitudes towards Mathematics also have higher levels of success (Peker & Mirasyedioğlu, 2003; Çanakçı & Özdemir, 2011).

Motanya (2018) in his study discovered a direct relationship between performance in Mathematics and the attitude of a student. Student with positive attitude perform well in Mathematics while those with negative attitude perform poorly and they even lack basic Mathematical concept. A study by Davrajoo, et al (2010) investigated the effect of Algebraic Mastery Learning Module usage on Mathematics achievement. The preliminary findings of this study provided evidence that the construction and mastery of the algebraic concepts assist students towards positive attitude in Mathematics learning.

Tukur *(*2018) conducted a study on the effect of mastery learning strategy in enhancing the academic achievement of Mathematics in Nigeria. The results exemplified that there is a significant relationship between the students' attitudes toward Mathematics and their academic achievement in Mathematics. The results, therefore, indicated that mastery learning improved students' achievement and yields greater positive attitudes.

4.5 Student's Misconceptions in Mathematical Algebra

The third objective sought to establish whether there is a difference in the type of misconceptions in Mathematical algebra between form two students taught using MLS and those taught using CGL. The respondents were subjected into several Mathematics algebraic tasks in order to identify the kind of errors that are commonly made. Table 4.19 gives the summary of the common misconceptions frequencies observed before and after the mastery learning strategy intervention.

Table 4.19: Mathematics Algebraic Misconceptions

	Experimental Class Misconceptions Frequencies	
	Before MSL	**After MSL**
Duality of Mathematics	37	34
Expansion of Mathematics expressions	35	35
Conceptual understanding	38	35
Retrieval of the correct Mathematics rules	36	36
Word Mathematical problems	42	41

There was 8% reduction on the duality of Mathematical concepts errors, which was the highest improvement noted followed by 7.9% reduction on the conceptual understanding errors. Last improvement was of 2.4% reduction of word Mathematical problem errors.

There was, in general, a minimal change in the reduction of the errors and misconceptions, which could be due to Ben-Zeev (1998) argument that errors are logically consistent and rule based rather than random and therefore students construct their misconceptions from their experiences and they find it very difficult to give them up.

The word problems have traditionally been the most difficulty to many algebra students. The major difficulty for students in solving algebraic word problems is translating the story from natural language into appropriate algebraic expressions (Bishop, Filloy, &Puig, 2007). This process involved assigning variables, noting constants, and representing relationships among variables. Among these processes, relational aspects of the word problem was particularly difficult to translate into symbols. Here the student assumed that the order of the key words in the problem statement would map directly into the order of symbols appearing in the equation. This was consistent with what Chalklin (1989) referred to as the direct-translation problem solving which is a phrase-by-phrase translation of the problem into variables and equations. For those who committed this error, the "=" symbol did not mean to represent a Mathematical relationship. Instead, for them, it simply separated the two groups (Clement, 1982). In some cases, the students failed to apply the symmetric relation and the transitive relation of an equal sign when solving an algebraic equation. Correction of these misconceptions can lead to improvements in equation solving skills (Booth & Koedinger, 2008).

If 3 apples and 2 bananas are sold, what does 3a+2b represent? Students displayed lack of understanding of the unitary concept when dealing with variables. This is a basic arithmetic concept and students wrote $5ab$ which was a serious misconception of adding unlike terms. In addition to the incorrect addition of unlike terms, the students regarded a as the label for apples and b as the label for bananas, rather than the unit price of an apple and the unit price of a banana and regarded a and b as prices of item.

Another error in algebra can be understood in the light of the duality of Mathematical concepts as processes or objects, depending on the problem situation and on the learner's conceptualization. One of the most essential steps in learning Mathematics is objectification: making an object out of a process. Due to this dual nature of Mathematical notations as processes and objects (Irawati and Ali, 2018), students encounter many difficulties. For instance,5x+4 stands both for the process 'add five times *x* and four' and for an object as 5x+4. This dual conception causes students to confuse between 5x+4 as a process or as an object. They simplify 5x+4 as 9x when 5x+4 is actually an object (for example, in a final answer).

It was also observed that students expanded $(a + b)^2$as $a^2 + b^2$ or $3(a + b)^2$ as $3a^2 + 3b^2$. This is viewed as emanating from the application of the distributive law intuitively. The formal distributive property of multiplication over addition is deeply deposited in their mind so that they intuitively misapply the rule in similar situations. In here the student was said to have used a known rule inappropriately, and incorrectly adapts a known rule so that it can be used to solve a new problem. The examples for these categories again emanated from the overgeneralization of the distributive law (Luka, 2013). Also, Booth, Barbieri, Eyer, and Blagoev (2014) observed that students start $(y+4)^2$correctly when they expanded. They worked the problem as (y+4) (y+4). The misconception appeared in the second step where they wrote y^2+ 16 as a final answer.

This would mean that, errors are not random but are logically consistent and rule based. This study confirmed earlier conclusions by; Norton & Irvin, 2007; Stacey &

Chick, 2004 that students may find many algebraic problems difficult to solve because most of them require understanding of conceptual aspects of fractions, negative numbers and equivalence.

Most students, though they may have no or least difficulties in working with fractions, they do experience difficulties when dealing with algebraic fractions. For instance, many common errors in simplifying algebraic expressions seem to be instances of the retrieval of correct but inappropriate rules (Luka, 2013; Matz, 1980). For example, students incorrectly misapply $\frac{ax}{bx} = \frac{a}{b}$ into expressions like $\frac{a+x}{b+x}$ to get $\frac{a+x}{b+x} = \frac{a}{b}$. This is an application of a known rule to an inappropriate situation by incorrectly perceiving the similarities of the two situations. Students may find many algebraic problems difficult to solve because most of them require understanding of conceptual aspects of fractions, negative numbers and equivalence (Norton & Irvin, 2007; Stacey & Chick, 2004).

Therefore, it is necessary to have correct conceptual knowledge in order to develop correct procedural skills. Work in Algebra has established that students with stronger conceptual knowledge are better at solving equations, and are able to learn new procedures more easily than peers with flawed conceptual knowledge. The short period exposure of the students to MLS may not have been enough to diagnose and correct all those errors and the misconceptions.

4.6 Self-efficacy

The fourth objective sought to establish whether there is a difference in self-efficacy between the students taught using Mastery Learning Strategy and those taught using Conventional Group Learning in form two classes. Self-efficacy level test was carried out among the students using the likert scaled questionnaire. Table 4.20 gives the summary of the status of the students' self-efficacy per class.

Table 4.20: Self-Efficacies per Class

Self-Efficacy	Class		Total
	Control	Experimental (MLS)	
High	65	40	105
Low	40	09	49
Total	105	49	154

Based on the self-confession as reflected in the completed questionnaire the respondent could be categorized into two groups; those with a strong, positive belief that they had the capacity and the skills to achieve their goals, termed as having high self-efficacy and those who did not have, termed as having low self-efficacy. Slightly more than half, 65 (62%) of the control class had high self-efficacies elements. However, the experimental class had a higher percentage of 81.6% (40).

About less than half, 44.8% of the control class confessed role performance affected their mathematics performance. However, the class taught using the MLS had a higher percentage of 95.9%. The self-identity presence was quite evident to 91.8% of the students taught using MLS compared to 68.6% of the students taught using the conventional methods. About half, 53.3% of the students taught using the conventional methods had a positive self-image compared to 89.8% of the students taught using the MLS. Slightly more than half, 60% of the control class had clear set self-efficacies elements. However, the experimental class had a higher percentage of 91.8%.

Taking the null hypothesis that there was no significant difference in the level of self-efficacy towards Mathematics between the two samples of the students, i.e., $\pi_1 = \pi_2$. Z statistics was used to test the hypothesis;

$$H_0 : MLS = Conventional \quad versus$$
$$H_1 : MLS \neq Conventional$$

The computed value of *z*= -4.587 was greater than the critical value of *z* = 1.96 at 5% level of significance, therefore, the null hypothesis was rejected. Hence, there was a significant difference in self-efficacy towards Mathematics between the class taught by MLS and the class taught using the conventional method with the students taught using the MLS having higher self-efficacy.

These findings were in tandem with Green, et, al (2006), report that indicated that positive self-concept is an extremely important goal for educational programs to promote and help to link positive outcomes including higher academic achievement and effort. The study findings confirmed; Hendy, Schorschinsky, and Wade, (2014) recommendations that MLS should be deployed as a teaching strategy to boost self-efficacy of the students in Mathematics achievement. These findings were also in line with Faithi-Ashtiani *et al*, (2007) documented findings that academic achievement of students with low self-esteem is perceptibly less than the average of those with high self-esteem.

4.6.1 Chi- Square Analysis on Self-efficacy

To confirm if there was some significant difference in Self-efficacy among the control and the experimental groups, Self-efficacy analysis was carried out among the respondents using the Chi-Square test statistics. Table 4.21 gives the summary of the observed and the expected values of the respondents' self-efficacy per class.

Table 4.21: Contingency Table on Self Efficacies per Class

Class		Self-Efficacy		Total
		Clearly Set	**Not Clear**	
Experimental	**Observed**	45	4	**49**
	Expected	34.7	14.2	**48.9**
Control	**Observed**	64	41	**105**
	Expected	74.3	30.8	**105.1**
Total		**109**	**45**	**154**

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} = \frac{(45 - 34.7)^2}{34.7} + \cdots + \frac{(41 - 30.8)^2}{30.8} = 15.2$$

The calculated chi-square value was 15.2 which was greater than the tabulated chi-square value at 5% significance level with 2 degree of freedom (3.84). Therefore, there was statistically significant difference with regard to self-efficacy towards Mathematics whereby the group taught using the MLS had a bigger proportion of the students with clearly set self-efficacy compared to the group taught using the conventional ordinary methods

Table 4.22: Chi-Square and P-value Table on Self Efficacies

Test statistics	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	15.228[a]	1	0.002		
Continuity Correction	17.740	1	0.005		
Likelihood Ratio	20.822	1	0.001		
Fisher's Exact Test				0.002	0.002
Linear-by-Linear Association	19.120	1	0.003		
N of Valid Cases	154				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.35.

b. Computed only for a 2x2 table

Based on the P-values (0.002) which was less than the critical value 0.05, the null hypothesis that there is no significant difference in self-efficacy between form two students taught using Mastery Learning Strategy and those taught using Conventional Group Learning was rejected at $\alpha = 0.05$ and the conclusion was there was statistically a significant difference between the two groups with regard to their self-efficacy towards Mathematics. It is particularly exciting to note that teaching strategies used in the classroom can and do make a difference to students' self-efficacy (Fencl and Scheel, 2005). This was the case in this study where MLS had a positive impact in teaching Mathematics on student's self-efficacy. Bandura also noted that "The most effective way of developing a strong sense of efficacy is through mastery experiences,"

4.7 Overall Findings of the Study

The overall findings of this study on "effects of mastery learning strategy on Mathematical competence among secondary school students" is that mastery learning has a positive impact on students' Mathematics competence, their attitude towards Mathematics and their self-efficacy. It is also a sure remedy on errors and misconceptions particularly in algebra. According to

Uchechi, Ezinwanyi and Ihendinihu (2013) studies revealed that there is a significant effect on Mathematics achievement for the students who were exposed to mastery learning strategy. Motanya (2018) in his study discovered a direct relationship between performance in mathematics and the attitude of a student. Meaning that the most important factor which influences mathematics success levels of students is the students' attitude towards Mathematics classes. Students need a positive attitude to succeed Mathematics. This is achievable through mastery learning strategy. Teaching strategies used in the classroom can and do make a difference to students' self-efficacy (Fencl & Scheel, 2005). In the current study Mastery Learning Strategy had a positive impact in teaching Mathematics on student's self-efficacy which is developed through mastery experiences**.**

On errors and misconception, the quantitative analysis of the data showed that the students had most difficulties in answering questions on word problems which had a 2.4% reduction of word mathematical problem errors followed by expansion of Mathematics expressions. It was noted that students had misconceived notions due to a variety of reasons. Among them, misuse of rules, confusion with previously learned concepts, problems with the structure of algebra, problems with signs and brackets. The short period exposure of the students to MLS may not have been enough to diagnose and correct all those errors and the misconceptions. To alleviate the errors and the misconceptions the students will need a longer exposure to mastery learning strategy.

With mastery learning strategy in place the overall performance in Mathematics and in particular at the national level will likely be improved.

CHAPTER FIVE

SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary, conclusions and recommendations arising from the analysis conducted. This was done in line with the study objectives. The study was carried out to assess the effect of mastery learning strategy on Mathematical competence among secondary school students in Kenya

5.2 Summary of the Findings

The study had four objectives aimed at investigating the effect of mastery learning strategy on Mathematical competence among secondary school students in Machakos County. The specific objectives of the study were to investigate whether there was a difference in the level of achievement on a Mathematics competence test of students taught using MLS and those taught using CGL in form two classes, establish whether there was a difference in attitude towards Mathematics between form two students taught using MLS and those taught using CGL, determine whether there was a difference in the type of misconceptions in Mathematical algebra and self-efficacy between form two students taught using MLS and those taught using CGL.

5.2.1 The level of Achievement on a Mathematics Competence Test of Students taught using MLS and those taught using CGL.

The study sought to establish the effect of Mathematics achievement between students taught through MLS and those taught through CGL. The results indicated that the entry competence test prior to mastery learning strategy intervention showed no significant difference in the score between the two groups where the control had a mean score of 26.36 while the experimentally had a mean score of 27.58. The analysis of variance conducted for both the control and the experimental group showed that statistically there was no significant difference in performance between the control group and the experimental group at the entry level. This was because the F computed value 0.1995 was less than the F standard critical value 3.90 at $\alpha = 0.05$ and $(1,152)$ degrees of freedom. While the p-value 0.743 was greater than 0.5 implying the null hypothesis was true at $\alpha = 0.05$. A Chi-square test was conducted between the control and the mastery learning strategy group's level of competence test difference. The test confirmed that there was statistically no significant difference with regard to competence test performance in Mathematics at a P-value of 0.883. The exit competence test after the mastery learning strategy intervention results showed that the mean score for the control group reduced to 18.36 from 26.36 with a standard deviation of 17.34 and a confidence interval for the population mean of 15.47 to 21.25. The experimental group's mean score for the same examination improved from 0.69 to 28.27 with a standard deviation of 17.96 and a confidence interval for the population mean of 25.15 to 31.40. The two-way analysis of variance showed that there was a significant difference in scores after the mastery learning strategy intervention. Chi- Square analysis for the performance of the two groups was also conducted and the test findings confirmed that there was statistically significant difference with regard to competence test performance in Mathematics after intervention. The P-value of 0.001 confirmed the results findings. It was evident that students taught using MLS performed better in Mathematics than those taught through CGL. These results led to the rejection of null hypothesis that there was no significant difference in the Mathematical competence of students exposed to mastery learning strategy (MLS) and conventionally taught group (CGL).

5.2.2 Attitude towards Mathematics between Students taught using MLS and those taught using CGL.

The study also sought to establish the effect of attitude towards learning of Mathematics between students taught through MLS and those taught through CGL. The analysis of the student's attitude towards Mathematics was conducted using each student response on the questionnaire items prior to the mastery learning strategy introduction and after.

Slightly more than half of the students (57%) strongly disagreed with the statement that they use Mathematics time to do other subjects, followed by 55% of the students who strongly disagreed with the statements that Mathematics lessons should be shortened because Mathematics brings headache and tiredness. Similarly, 57% and 56% of the students strongly agreed with the statements that; there was no useful Mathematics information and didn't keenly attend to Mathematics teachers respectively.

The z-statistical test was done which showed that there was significant difference in proportion of the students with a negative attitude between the control and the experimental class with the control group having the higher proportion of students with negative attitude towards Mathematics compared to the experimental group of students. The computed z value ($|-2.72|$) being greater than the critical value of z = 1.96 at 5% level of significance the null hypothesis was rejected. Once the mastery learning strategy was implemented for the experimental class, the analysis of students with the negative attitude towards mathematics was conducted again per class, and the students with a negative attitude from the experimental class was 19.7% while in the control class had risen to 80.3%. The z score test was once against conducted and the computed z value (|-6.103|) was greater than the critical value of $z = 1.96$ at 5% level of significance, therefore, the null hypothesis was rejected, implying that the difference in attitude towards Mathematics between the control class and the experimental class was significant after the MLS implementation.

A Chi-square test was conducted to establish if there was a significant group's attitude difference between the control and the mastery learning strategy groups. The calculated chi-square value 35.48 was greater than the tabulated chi-square value 3.84 at 5% significance level with 2 degree of freedom. The Chi-square test statistics therefore confirmed that there was statistically significant difference with regard to attitude towards mathematics, whereby the control group had more students with negative attitude compared to the group taught using the mastery learning strategy. Therefore based on both the calculated Chi-square value and the P-values (0.000) which was less than the critical value 0.05, the null hypothesis was rejected at $\alpha = 0.05$and the conclusion was that there was statistically a significant difference between the two groups with regard to their attitude towards Mathematics.

Although a significant difference in attitude towards Mathematics in both control and experimental groups was registered before and after the MLS intervention, a tremendous improvement of and a huge shift of the students was noted from negative attitude to positive attitude towards Mathematics among the students in the experimental class.

Additionally, a significant proportion of 60% of the male students had a negative attitude towards Mathematics compared to 31% of their counterpart female students, where male students had a higher percentage.

5.2.3 The Misconceptions in Mathematical Algebra between the Students taught using MLS and those taught using CGL.

The third objective of the study sought to examine the misconceptions in Mathematics between students taught using MLS and those taught using CGL. The misconceptions evaluated included duality of mathematics, expansion of mathematics expressions challenges, conceptual understanding, retrieval of the correct Mathematics rules and mathematical word problems.

The analysis of the students' misconceptions was done before and after the MLS intervention and there was 8% reduction on the duality of Mathematical concepts errors, which was the highest improvement noted followed by 7.9% reduction on the conceptual understanding errors. The last improvement was of 2.4% reduction of word Mathematical problem errors.

5.2.4 Difference in Self-Efficacy between Students taught using MLS and those taught using CGL.

The study investigated the effect of mastery learning strategy on students' self-efficacy and found out that 62% of the students in the control group had a positive self-efficacy but the experimental group had a higher percentage of 81.6 %. The difference was statistically significant at 5% level of significance given that the computed z value ($|-4.587|$) was greater than the critical z value ($|1.96|$) implying that there was a significant difference in self-efficacy towards Mathematics between the class taught by MLS and the class taught using the conventional method with the students taught using the MLS having higher self-efficacy.

Further Chi-square tests analysis confirmed the significant difference in self-efficacy towards Mathematics between students taught using MLS and those using CGL. A computed Chi-square value of 15.2 and a P-value of 0.002 surpassed the critical values of 3.84 and 0.05 respectively. Hence statistically there was a significant difference between the two groups with regard to their self-efficacy towards Mathematics.

5.3 Conclusions

The Mastery Learning Strategy unlike the Conventional Group Learning is designed towards making learners to perform beautifully well in an academic task. Mastery learning involves frequent assessment of students' progress and it also provides corrective instruction and emphasizes on all participation, feedback and reinforcement. Students who do not achieve mastery receive remediation through tutoring, peer monitoring, small group discussions, or additional assignments, thus, reducing the achievement gaps between varying groups of students. Mastery of each unit is shown when the students acquire the set pass mark of a diagnostic test. Hence Mastery learning strategy (MLS) can help the teacher to know student's area of weakness and correct it thus, breaking the cycle of failure. The theory of mastery learning is, therefore, based on the simple belief that all students can learn when provided with conditions (instruction and time) that are appropriate for their learning. The instructional strategies associated with mastery learning are designed to put that belief into practice in modern classrooms.

So, based on the study findings and the preceding summary the following conclusions were drawn:

i. The students taught using the MLS showed a better and significant difference in mathematics achievement tests as compared to those taught using CGL. Therefore, the students are more likely to improve and excel in Mathematics if MLS is adopted in Mathematics classrooms.

ii. The negative attitude, which is an emotional disposition the students have on Mathematics learning, was significantly diffused through the MLS implementation. Thereby leading to higher levels of achievement.

iii. There was a positive change in the reduction of errors and misconceptions in Mathematics after the MLS implementation. Albeit the change was not statistically significant, the MLS sat the right direction of reducing errors and misconceptions in Mathematics. The slow pace of reducing the errors and misconceptions in Mathematics could be attributed to the fact that the students find it difficult to give up upon the errors they construct.

iv. The MLS intervention built the students' self-efficacy which led to an improvement in Mathematics performance as indicated in the students' exit performance after the MLS implementation that brought mastery experiences**.**

Therefore, MLS is an effective teaching method, which Mathematics teachers should be encouraged to use and should be implemented in all teacher education programs in Kenya.

5.4 Recommendations

Based on the study findings and the preceding conclusions, the following are recommended.

5.4.1 Policy Recommendations

i. It was noted that students improved significantly in competence test after the implementation of the Mastery Learning Strategy (MLS). Therefore, both the teachers and the learners should be exposed to MLS which helps the teacher to know student's area of weakness and correct it thus, breaking the cycle of failure in Mathematics.

ii. The mastery learning strategy implementation impacted the negative attitude towards Mathematics significantly. The positive attitude towards Mathematics motivates the students to learn and improve. Therefore, the mastery learning strategy that focuses and advocates on encouraging a variety way of teacher-student interaction should be practiced in the classroom by the teachers.

iii. The adoption of the mastery learning strategy should be done at early stages of formal schooling since students find it difficult to give up upon the Mathematical errors and misconceptions they construct habitually. The Kenya Institute of Curriculum Development may use the study findings to design appropriate interventions that will help improve the students' performance in Mathematics.

iv. One of the mastery learning strategies is to build and boost the learner self-efficacy, morale and confidence in handling Mathematical challenges and problems. It is recommended that the teachers of mathematics should be taken through the mastery learning strategy content through in-service training to improve on how to handle especially slow learners in a classroom set up.

v. The Kenya Institute of Curriculum Development needs to introduce and develop a programme for the induction and mentorship of mathematics teachers on the implementation of MLS.

vi. The study further recommended an induction of teachers on MLS as a remedy to errors and misconception.

5.4.2 Recommendations for Further Research

i. Since the studies were conducted on single level of study. The same should be done continuously and at different stages of formal training and development to establish the validity, reliability and authenticity of the research findings.

ii. The study can be replicated in other counties in order to give a reflection of the whole country. This will facilitate better decision making on ways of improving Mathematics competence among the students.

iii. The investigation of this study was carried out for Mathematics performance. It can also be carried out for other subjects in the school curriculum and more variables may be included since there is enormous scope and need for further work in all areas of the curriculum.

iv. The investigation of the students' errors was carried out in four areas of algebra, namely variables, expressions, linear equations and word problems. Many areas in algebra still need to be researched.

v. Since few studies in Mastery Learning Strategy on mathematics have been carried out in Kenya, there is enormous scope and need for further work especially in areas like indices, logarithms and trigonometry which are part of the basic foundations in Mathematics.

vi. The investigation of the students' attitude towards Mathematics had a lot of statements where students were undecided. This should be followed up by another research to establish the reason.

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APPENDICES

APPENDIX I: Letter of Introduction to the Principal

P.O BOX 136- 90100,

MACHAKOS.

Date: ________

THE PRINCIPAL,

P.O BOX ______

MACHAKOS.

Dear Sir/ Madam,

RE: REQUEST TO CARRY OUT RESEARCH IN YOUR SCHOOL

I am a student at Machakos University pursuing a degree course in education. As part of my course, I am expected to carry out a research on the topic: **an assessment of the impact of mastery learning strategy on mathematical competence among secondary school students in Machakos sub-county, Kenya.**

I promise to abide by the rules in your school and treat the information sourced with confidentiality. Attached find copies of my abstract and a letter from the university.

Yours faithfully,

Mary Mbathe Mulungye,

REG NO: E83-12721-2017

APPENDIX II: Mathematics Students' Questionnaire on Attitude

Hallo, my name is Mary Mulungye a post graduate student at Machakos University undertaking a study titled **"Effects of mastery learning strategy on mathematical competence among secondary school students in Machakos County, Kenya".** I would like your cooperation in order to gather data related to the study topic. Various questions have been developed and require your response. Thanks in advance'

The attitude scale deals with some of the statements depicting attitude towards mathematics. We are interested in knowing your valuable views about mathematics. You may agree with some of the statements or disagree with others. After reading a statement carefully, decide whether or not you agree with it. This is not a test. There is no right or wrong answer. If you strongly agree with a statement put a tick mark against SA(0), if agree then against A(1), if undecided then against U(2), if disagree then against D(3), and if strongly disagree then put a tick mark against SD(4).You are required to give your free and frank opinions. Please tick (✓) against the box provided against the statement you agree most with.

SECTION A: General information

1. Gender

   Male ( ) Female ( )

2. How old are you

   10 – 12yr ( ) 13 – 14 yrs ( ) 15 – 16 yrs ( ) Over 16- ( )

3. Name
4. School

ATTITUDE SCALE TOWARDS MATHEMATICS

s/n	STATEMENT	SA	A	U	D	SD
		0	1	2	3	4
1.	While attending the Mathematics period l generally recall the memories of my home.					
2.	While learning Mathematics, l find that time is generally wasted.					
3.	I do other subjects work, while Mathematics period is going on.					
4.	I do not wish to know the reasons from the teachers when l fails in my CAT's.					
5.	I do not consult the library for more Mathematics books.					
6.	Mathematics does not provide useful information.					
7.	I study Mathematics because it is a compulsory subject.					
8.	I often think Mathematics period should be shortened.					
9.	I do not always want my Mathematics teacher to ask maximum questions from me.					
10.	I do not discuss Mathematics questions with my friends after the class is over.					
11.	When l do not understand some concepts in Mathematics lesson, l do not ask my teachers.					
12	I do not listen to my Mathematics teacher very attentively.					
13	Whenever l study Mathematics l feel headache and tiredness.					
14	I do not ask my parents, brother, sister or other family members regarding Mathematics problems.					
15	I do not study Mathematics at home.					
16	Mathematics classwork bores me.					
17	I am not highly stimulated, when l learn about new strategies in solving Mathematics problems.					
18	I am totally absorbed in another world, whenever l am working on Mathematics.					
19	I always ask questions to tease my Mathematics teacher.					
20	It is not very easy to score high marks in Mathematics.					
21	I prepare to do Mathematics homework after doing other subjects at home.					

APPENDIX IIIA: Form 2 Students' Pre-Test on Algebra

Hallo, my name is Mary Mulungye a post graduate student at Machakos University undertaking a study titled **"Effects of mastery learning strategy on Mathematical competence among secondary school students in Machakos-County, Kenya".** I would like your cooperation in order to gather data related to the study topic. Various questions have been developed and require your response. Thanks in advance'

SECTION A: General information

1.Gender

Male ( ) Female ( )

2.How old are you

10 – 12yr ( ) 13 – 14 yrs ( ) 15 – 16 yrs ( ) Over 16-18 yrs ( )

5. Name
6. School

Mathematics Competence- Based Test

Instructions:

Attempt all the questions Time: 40 minutes

1) Simplify the following expressions

a i) 3a + a

ii) 3x+2

iii) 28b -21b

b) 5x – 2x + x

c) 3a + b – 2a + 3b

d) $\frac{1}{2} \times 8t - 2 \times \frac{1}{2}t - \frac{1}{2}t$

e) 29b + 20

2) Expand the following expressions

a) x(a + 2)

b) $(a + b)^2$

c) $\sqrt{a^2 + b^2}$

d) x – (2y + 3z)

3) Expand and simplify the following expressions

a) x + (x – 3y)

b) 3 + 7(2x – 5)

c) 8a – 3(2a + b) – 2b

4) Simplify the following

a) $\frac{x^4y^2}{x^2y}$

b) $\frac{3x^4.2x^3y}{12x^6y^2}$

c) $\frac{28b-20d}{4bd}$

d) $\frac{a+x}{b+x}$

e) $\frac{x}{5} + \frac{x}{7}$

f) $\frac{3y}{x} - \frac{2}{y}$

g) $3xy + \frac{2}{3x}$

h) $\frac{a+4}{2} - \frac{a-1}{3}$

5) Factorise the following

a) i) $a^2b^2 - ab^2$

ii) $3a^2-9a$

iii) 54-81a

iv) ax+4a

b) i) a^3+a+a^2+1

ii) $x^2-x+xy-y$

iii) $x^2-ax+bx-ab$

6) Mwangi has x cows and y goats. He buys ten more cows but sells 5 goats.

(a) How many cows has he now?

(b) How many goats has he now?

7) A book costs b shilling and a pen p shilling less than a book. A shopkeeper buys 20 books and 10 pens. What is the total cost?

APPENDIX IIIB: Scoring key for Entry Behaviour-Competency Test

1a) i) 3a+ a = 4a

ii) 3x + 2 = 3x + 2

iii) 28b-21b =7b

b) 5x-2x+x = 4x

c) 3a+b-2a+3b =a+4b

d) ½ x8t-2x ½ t- ½ t = 4t-t- ½ t

$=\frac{5}{2}t$

a) 29b-20d = 29b – 20d

2 **a)** x (a+2) = xa + 2x

b) $(a + b)^2 = a^2 + 2ab + b^2$

c) $\sqrt{a^2 + b^2} = \sqrt{a^2 + b^2}$

d) x – (2y + 3z) = x – 2y – 3z

3 a) x+ (x-3y) = x+ x -3y

= 2x-3y

b) 3+7(2x-5) = 3+14x-35

= 14x +32

c) 8a-3(2a+b) – 2b=8a-6a-3b-2b

= 2a-5b

4a) $\dfrac{x^4y^2}{x^2y} = x^2y$

b) $\dfrac{3x^4\ 2x^3y}{12x^6y^2} = \dfrac{6x^7y}{12x^6y^2} = \dfrac{1x}{2y}$

c) $\frac{28b-20d}{4bd} = \frac{4(7b-5d)}{4bd} = \frac{7b-5d}{bd}$

d) $\frac{a+x}{b+x} = \frac{a+x}{b+x}$

e) $\frac{3y}{x} - \frac{2}{y} = \dfrac{3y^2 - 2x}{xy}$

f) $3xy + \frac{2}{3x} = \dfrac{9x^2y + 2}{3x}$

g) $\frac{a+4}{2} - \frac{a-1}{3} = \frac{3(a+1)-2(a-1)}{6}$

$= \frac{3a+3-2a+2}{6} = \frac{a+5}{2}$

5a i) $a^2b^2-ab^2 = ab^2\ (a-1)$

ii) $3a^2-9a = 3a\ (a-3)$

iii) $54-81a = 9(6-9a)$

$= 27(2-3a)$

iv) $ax+4a = a(x+4)$

b) i) $a^3+a+a^2+1 = a(a^2+1) + 1(a^2+1)$

$= (a^2+1)\ (a+1)$

ii) x^2-x + xy –y = x(x-1) + y (x-1)

=(x-1) (x+y)

iii) x^2-ax+bx-ab = x(x-a) + b(x-a)

= (x-a) (x+b)

6. Number of cows = x

Number of goats = y

a) Now number of cows = x+10
b) Now number of goats= y-5

7. Cost of book = shb

Cost of pen= sh (b-p)

Cost of 20 books =sh 20b

Cost of 10 pens = sh 10(b-p)

Total cost = 20b +10(b-p)

APPENDIX IIIC: Enrichment Questions

The enrichment questions were selected and administered at various intervals as per the need of the students. These questions include;

1. a) Expand and factorise the following expression

   $(2a + b)^2 – (a - 2b)^2$

   b) Simplify

c) $i)\sqrt{x^2} + \sqrt{y^2}$

   ii) $\sqrt{x^2 + y^2} + \sqrt{x^2 - y^2}$

2. Simplify the expression

   a) 2(2a – 3b) – 3(a – 2b +2c) – 4(b – 2c – a)

   b) 5(3x – y) – 2(2x – y + z) – 3(y + 2z – x)

3. Solve

   a) $\frac{2}{3x} - \frac{1}{4} = \frac{5}{12x}$

   b) $\frac{x}{2} - \frac{3}{x} = 15$

4. a) Simplify the following quadratic expression by expanding, collecting terms and then factorizing completely.

   $15x^2 – 9x – 5 – (3x – 2)^2$

   b) Factorise the following expressions

   i) $26x^2 + 13x – 5$

   ii) $12x^2 – 29x + 14$

5. Mwaura now is twice as old as his daughter and four times as old as his son. In eight years' time Mwaura's age will be equal to the sum of the ages of his daughter and son. Determine Mwaura's present age.

APPENDIX IVA: Form 2 Students' Post-Test on Algebra

Hallo, my name is Mary Mulungye a post graduate student at Machakos University undertaking a study titled **"Effects of mastery learning strategy on Mathematical competence among secondary school students in Machakos-County, Kenya".** I would like your cooperation in order to gather data related to the study topic. Various questions have been developed and require your response. Thanks in advance'

SECTION A: General information

1.Gender

Male ( ) Female ( )

2.How old are you

10 – 12yr ( ) 13 – 14 yrs ( ) 15 – 16 yrs ( ) Over 16-18 yrs ( )

3.Name

4.School

Mathematics Competence- Based Test

Instructions:

Attempt all the questions

1) Simplify

a) 3x+2

b) 4a+2b

2) Expand the following

a) $(x + y)^2$

b) $\sqrt{a^2 + b^2}$

c) $x(x^2 + 3)$

d) $(2x - 3)(x + \frac{1}{2})$

e) $(p - 2q)(p - 2q)$

f) $8(n + 1)(n - 1)$

3) Use the identity $(a - b)^2 = a^2 - 2ab + b^2$ to find the value of 97^2.

4) Factorise completely

   a) $x^3y^2 - 4xy^4$

   b) $x^2 + 9x + 14$

   c) $4x^2 - 25y^2$

   d) $(3x - 2y)(4x + 3y) - (3x - 2y)^2$

   e) $10x^2 - 11x + 1$

5) Form the quadratic equation whose roots are $x = -2$ and $x = 3$.

6) Two numbers are such that one of them is three more than the other and their product is 10.

   a) Form an equation.

   b) Solve it to find the two numbers.

7) Solve the following quadratic equations by the factor method

   a) $x^2 + 7x + 10 = 0$

   b) $x^2 + x - 2 = 0$

   c) $(x - 3)^2 - 9 = 0$

   d) $8x^2 + x - 7 = 0$

8a) $\frac{a+x}{b+x}$

b) $\frac{3y}{x} - \frac{2}{y}$

8) Simplify the following expressions

$$\frac{2a^2 - 3ab - 2b^2}{4a^2 - b^2}$$

9) A bananas costs b shilling and an apple a shilling less than a banana. A shopkeeper buys 10 bananas and 12 apples. What is the total cost?

10) Write an algebraic expression for the relationship “there are six times as many students as teachers at the school.

APPENDIX IVB: Scoring Key for Post-Test

1.a) $3x + 2$

b) $4a + 2b$

2. a) $(x + y)^2 = x^2 + 2xy + y^2$

b) $\sqrt{a^2 + b^2} = \sqrt{a^2 + b^2}$

c) $x\,(x^2 + 3) = x^3 + 3x$

d) $(2x-3)\,(x + ½) = 2x^2 + x - 3x - \frac{3}{2}$

$= 2x^2 - 2x - \frac{3}{2}$

e) $(p-2q)\,(p-2q) = p^2 - 2pq - 2pq + 4q^2$

f) $8(n+1)\,(n-1) = 8(n^2 - n + n - 1)$

$= 8(n^2 - 1)$

$= 8n^2 - 8$

3.) $97^2 = (100-3)^2$

$= 100^2 - 2\times100\times3 + 3^2$

$= 10000 - 600 + 3$

$= 9,409$

4. a) $x^3y^2 - 4xy^4 = xy^2(x^2 - 4y^2)$

$= xy^2(x-2y)\,(x+2y)$

b) $x^2+9x+14 = x^2+7x + 2x+14$

$= x(x+7) + 2(x+7)$

$= (x+2)(x+7)$

c) $4x^2 - 25y^2 = (2x)^2 - (5y)^2$

$= (2x+5y)(2x-5y)$

d) $(3x-2y)(4x+3y) - (3x-2y)^2 = (3x-2y)(4x+3y-1)$

e) $10x2-11x+1 = 10x^2-10x-x+1$

$= 10x(x-1)-1(x-1)$

5) $x=-2 \longrightarrow x+2=0$

$x=3 \longrightarrow x-3=0$ therefore, $(x+2)(x-3) = 0$

$x^2-x-6 = 0$

6) Let the number be x

Let the other number be $x+3$

Their product is $x(3+x) = 10$

a) $x(x+3) = 10$

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

b) $x^2+5x-2x-10=0$

$x^2+5x-2x-10=0$

$x(x+5)-2(x+5) = 0$

$(x-2)(x+5)=0$

$x-2=0$ and $x=5=0$

Therefore $x=2$ $x=-5$

Other $2+3=5$ $-5+3=-2$

$=(x-1)(10x-1)$

7. a) $x^2+7x+10=0$

$x^{2+}5x+2x=10=0$

$x(x+5)+2(x+5)=0$

$(x+2)(x+5)=0$

$x=-2$ $x=-5$

b) $x^2+x-2=0$

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

$x(x+2)-1(x+2)=0$

$(x-1)(x+2)=0$

$x=1$ or $x=-2$

c) $(x-3)^2-9=0$

$(x-3+3)(x-3-3)=0$

$x(x-6)=0$

$x=0$ $x=6$

d) $8x^2+X-7=0$

$8x^2+8x-7x-7=0$

$8x(x+1) – 7(x+1) = 0$

$(8x-7)(x+1) = 0$

$x = \frac{7}{8}$ $x = -1$

7. $\frac{2a^2-3ab-2b^2}{4a^2-b^2} = \frac{2a^2 – 4ab + ab - 2b^2}{(2a-b)(2a+b)}$

$= \frac{2a(a-2b) + b(a-2b)}{(2a-b)(2a+b)}$

$= \frac{(2a+b)(a-2b)}{(2a-b)(2a+b)}$

$= \frac{a-2b}{2a-b}$

9)Cost of a banana is sh b cost of 10 bananas is sh10b

Cost of an apple is sh b-a Cost of 12 appes is sh 12(b-a)

Total cost = sh[10b + 12(b-a)

= sh (22b-12a)

APPENDIX IVC: Tool for Misconceptions

The misconceptions and errors were identified from the Mathematics achievement tests that was administered earlier. The frequency on the errors and misconceptions were recorded by considering the following questions in each of the four areas of misconceptions.

Pre-test

A) Duality

1a) ii. 3x + 2

e) 29b + 20

B) Expansion and use of negative and positive signs

2.b) $(a + b)^2$

c) $\sqrt{a^2 + b^2}$

d) x – (2y + 3z)

3.c) 8a – 3(2a + b) – 2b

C) Algebraic fractions (conceptual understanding)

4) Simplify the following

d) $\frac{a+x}{b+x}$

e) $\frac{x}{5} + \frac{x}{7}$

f) $\frac{3y}{x} - \frac{2}{y}$

g) $3xy + \frac{2}{3x}$

g) $\frac{a+4}{2} - \frac{a-1}{3}$

D) Mathematics word problem

6) Mwangi has x cows and y goats. He buys ten more cows but sells 5 goats.

(a) How many cows has he now?

(b) How many goats has he now?

7) A book costs b shilling and a pen p shilling less than a book. A shopkeeper buys 20 books

and 10 pens. What is the total cost?

Post-Test

A) Duality

1.a)3x + 2

b) 4a + 2b

B) Expansion and use of equality, negative and positive signs

2.a) $(x + y)^2$

c) $\sqrt{a^2 + b^2}$

b) $x^2 + 9x + 14$

d) $(3x – 2y)(4x + 3y) – (3x – 2y)^2$

e) $10x^2 – 11x + 1$

C) Algebraic fractions (conceptual understanding)

8a) $\frac{a+x}{b+x}$

$b)$ $\frac{3y}{x} - \frac{2}{y}$

D) Mathematics word problem

9) A bananas costs b shilling and an apple a shilling less than a book. A shopkeeper buys 10 bananas and 12 apples. What is the total cost?

10) Write an algebraic expression for the relationship “there are six times as many students as teachers at the school.

APPENDIX V: Students' Self-Efficacy Questionnaire on Mathematics

Hallo, my name is Mary Mulungye a post graduate student at Machakos University undertaking a study titled **"Effects of mastery learning strategy on Mathematical competence among secondary school students in Machakos County, Kenya".** I would like your cooperation in order to gather data related to the study topic. Various questions have been developed and require your response. Thanks in advance'

This is not a test and there are no correct or wrong answers. The purpose of this questionnaire is to get your opinion on your self-efficacy in mathematics. It is important that you give your honest view. Read the items with care in order to understand before making your choice. Please tick (✓) against the box provided against the statement you agree most with.

SECTION A: General information

1. Gender

   Male ( ) Female ( )

2. How old are you

   10 – 12yr ( ) 13 – 14 yrs ( ) 15 – 16 yrs ( ) Over 16-18 yrs ( )

3. Name
4. School

SECTION B: Learners' Self Concept

What is your opinion on the given statements on self-concept when learning mathematics in your school? Put a tick (✓) in the box provided against the statement

Key: (S A) – Strongly agree (A) – Agree, (NS) – Not sure (D) – Disagree, (Ds) - Strongly disagree .please put one tick (✓) as appropriate.

	STATEMENTS OF SELF-EFFICACY	SA	A	NS	D	SD
	Scale 1:Self –Image	5	4	3	2	1
1	Success in the life of a student is achieved through positive thinking.					
2	The use of mastery learning strategy enhances the way I see myself.					
3	The use of mastery learning strategy provides a good learning environment for me.					
	Scale 2:Self-Identity					
4	I perform well because I believe in my ability.					
5	Mastery learning strategy stimulates my coming up with new ideas which makes me proud of mathematics.					
6	The style of thinking and working in mathematics makes me like the subject.					
7	Learning Mathematics occurs when I am actively involved in finding out.					
	Scale 3:Self Esteem					
8	My liking of mathematics is improved by Mastery learning strategy which I enjoy most.					
9	Feedback/corrections and reinforcement based learning builds my confidence.					
	Scale 4:Role Performance					
10	The teachers' response to my question in class when am performing a practical activity affects my achievement.					
11	I believe that participation in learning develops knowledge which guarantees me the highest level of development.					
12	My mathematics teacher has played an important role in boosting my performance in Mathematics.					

APPENDIX VI: Letter of Introduction to NACOSTI

MACHAKOS UNIVERSITY
OFFICE OF THE DEAN GRADUATE SCHOOL

Telephone:254-(0)735247939, (0)723805929
Email: graduateschool@mksu.ac.ke
Website: www.machakosuniversity.ac.ke

P.O Box 136-90100
Machakos
KENYA

REF. MksU/GS/SS/011/VOL.1

7th July, 2021

The Director,
National Commission for Science, Technology and Innovation,
P.O Box 30623,
NAIROBI.

Dear Sir,

RE MARY MBATHE MULUNGYE (E83/12721/2017)

The above named is a PhD student in the second year of study and has cleared course work. The University has cleared her to conduct a research entitled: **"The Effects of Mastery Learning Strategy on Mathematical Competence among Secondary School Students in Machakos Sub-County, Kenya.**

Kindly assist her with a **Research Permit** in order to undertake the research.

Thank you

DEAN OF GRADUATE SCHOOL
136 - 90100, MACHAKOS
07 JUL 2021
MACHAKOS UNIVERSITY

DR. KIMITI RICHARD PETER, PhD
DEAN GRADUATE SCHOOL

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APPENDIX VII: NACOSTI Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **785838**

Date of Issue: **09/August/2021**

RESEARCH LICENSE

This is to Certify that Ms.. MARY MBATHE MULUNGYE of Machakos University, has been licensed to conduct research in Machakos on the topic: The Effects of Mastery Learning Strategy on Mathematical Competence among Secondary School Students in Machakos Sub-County, Kenya. for the period ending : 09/August/2022.

License No: **NACOSTI/P/21/12229**

785838

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APPENDIX VIII: Location of Study

APPENDIX IX: Similarity Index

EFFECTS OF MASTERY LEARNING STRATEGY ON MATHEMATICAL COMPETENCE AMONG SECONDARY SCHOOL STUDENTS IN MACHAKOS COUNTY, KENYA

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