MATHEMATICAL MODELLING APPROACHES AND THE LEARNER'S CONCEPTUAL UNDERSTANDING OF MATHEMATICS AT SECONDARY SCHOOL LEVEL IN KISII COUNTY, KENYA

BY

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DECLARATION

This thesis is my original work and has not been presented in any other university fo consideration. This research thesis has been complemented by referenced sources dul acknowledged. Where text, data (including other spoken words), graphics, pictures or table have been borrowed from other sources including the internet, these are specificall accredited and reference cited in accordance to anti-plagiarism regulations.

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DEDICATION

I dedicate this piece of work to my parents who borne several adversities to have me go to school and to my wife not only for her perseverance during my absence and long overnight burning of candles but also her tireless encouragement while undertaking this study.

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LIST OF ABBREVIATIONS

CCSSM	Common Core State Standards of Mathematics
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
LA	Learner’s Achievement
MAA	Mathematical Associations of America
MM	Mathematical Modelling
MoE	Ministry of Education
NCF	National Curriculum Frameworks
NCTM	National Council of Teachers of Mathematics
SMASSE	Strengthening of Mathematics and Sciences in Secondary Education
SMP	Standard for Mathematical Project
TIMSS	Trends in International Mathematics and Science Studies
TSC	Teachers Service Commission
TSM	Text book School Mathematics

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ABSTRACT

Research has shown that Mathematical Modelling promotes teaching and learning of mathematics in secondary schools. This is because Mathematical Modelling, when applied, it mathematizes real-world situations with the aim of seeking a solution for the initial problems hence making the subject relevant to students resulting to better performance in the subject. The purpose of this study was to investigate Mathematical Modeling and the learner's conceptual understanding of mathematics at secondary school level in Kisii County, Kenya. The objectives of the study were: to establish mathematical teachers' knowledge in Mathematical Modelling; to determine the extent to which teachers apply Mathematical Modeling in teaching mathematics; and to establish the relationship between Mathematical Modelling and learners' performance in mathematics. The study was pegged on Constructivism theory which draws its arguments from Piaget's cognitive theory and Vygotsky's social critical theory that emphasizes on the active role of learners in building understanding and making sense of the world. A convenient sample of two hundred and seventy students and forty mathematics teachers from ten sampled schools in Kenyenya Sub-County, Kenya participated in the study. Mixed method research design was used to collect data for the study. Data was collected from teachers and students using questionnaires, classroom observation schedule and interview schedules. Both descriptive and inferential statistics was used to analyze quantitative data collected from teachers and students. The research study revealed that more than 75% of teachers have no adequate knowledge in Mathematical Modelling approach as an instructional strategy. Majority of teachers are not familiar with Mathematical Modelling approach. Most Teachers rely on traditional mathematics teaching approach which is teacher-centered whereby a teacher expect students to follow a particular procedure to produce one right answer. The study also revealed that almost all teachers (85%) entirely depend on mathematics text books when teaching a mathematics whereas inclusion of modelling task in students' activities is not given any substantial attention by teachers. Less than 25% of teachers engage students in groupwork and mathematics learning activities in class. The study also revealed that Mathematical modelling instruction had a positive impact on student's achievement in mathematics performance. A single class of 44 form two students exposed to mathematical modelling instruction had a positive change in the performance of mathematics test administered to them as compared to the test they did before Mathematical Modelling instruction. The study therefore recommends to the ministry of education (MoE), Teacher service commission (TSC) and Kenya Institute of Curriculum Development (KICD) to train teachers on Mathematical Modelling. Teachers to attend in-service training programs to deepen their knowledge on Mathematical Modelling. Equally, Mathematical Modelling to be implemented in secondary school mathematics classrooms and Kenya Institute of Curriculum Development (KICD) to infuse Mathematical Modelling skills as an outcome for secondary school mathematics curriculum.

CHAPTER ONE

INTRODUCTION

Students' learning experience in mathematics class influence their cognitive involvement in the learning cycle determining to a great extent the amount and nature of gained information which consequently impact students' achievement in mathematics. The formulation of these is as a result of beliefs and attitudes formed by the student towards the subject emanating from learning experience in mathematics class. This chapter highlights the background to the study, statement of the problem, research objectives, research questions, significance of the study, the limitation and delimitations of the study, assumptions of the study and lastly theoretical and conceptual frameworks of the study.

1.1 Background of the Study

Mathematics has always been recognized as one of the most important disciplines meant at steering economic and technological advancement of any society. It is clear in this inexorably mechanical and worldwide society that accomplishment in arithmetic will majorly affect students' career yearnings, their function in the general public and even their feeling of individual satisfaction (Malcom, 1999, p. 8-13). Likewise, Hunt (1996) contend that in the expansive areas of our general public, research networks and government bodies, there is bountiful affirmation that mathematics capability is basic for passage into the workforce.

The Kenyan government has perceived the significant role mathematics plays in her establishment of logical and mechanical information that is essential in socio-economic development towards its achievement of vision 2030, has made mathematics teaching and learning compulsory in both primary and secondary education under the 8.4.4 system of education. The government has also struggled to provide trained mathematics teachers in every school so as to curb the surging students-teacher ratio gap. Despite this important role the Kenyan government has played, there has always been poor performance in the subject at national examinations level over the years (Aduda, 2003); this is demonstrated on Table 1.1.

Table 1.1 National KCSE Performance in Mathematics by the Year

Year	2012	2013	2014	2015	2016	2017
Mean marks score percentage	21.13%	23.04%	23.75%	23.95%	26.9%	27.32%

Source: KNEC, 2017

Performance in Mathematics as reflected on table1.1 has remained poor over years country wide. The same trend was noted in Kenyenya sub-County over the years as depicted in the last Five years of KCSE results since 2013 with a mean score of 2.8435, 2.7340 mean score in 2014, and 2.9356 mean score in 2015 which shows some slight improvement though still below average (Sub-county E.O. Kenyenya Sub-county, 2017). In the years 2016 and 2017, the average mean score was 2.8753 and 2.9321 respectively which is also below average. The analyzed results are given in Table 1.2.

Table 1.2 Kenyenya Sub-County KCSE Mathematics Means Score By Year

YEAR	2013	2014	2015	2016	2017
MEAN SCORE	2.8435	2.7340	2.9356	2.8753	2.9321
MEAN GRADE	D	D	D	D	D

Source: Education officer, Kenyenya sub-county, 2017

Given the poor performance of the subject locally and nationally, there was a need to address the problem in Kenyan secondary schools. Poor outcomes in mathematics have been credited to different causes going from poor teaching strategies to psychological factors, for example, the poor attitude of learners towards the subject. Taught in mathematics are frequently educated with no considerable reference to their applications, in actuality, circumstances, in this way making the subject boring subsequently resulting students to develop a negative attitude towards the subject. Other factors which have been raised include students' experience in mathematics class, teacher's perception of mathematics, cultural, facility and learning equipment in mathematics (KNEC, 2006 and SMASSE, 2008). However, the most prime factor that influences teaching and learning of mathematics is students' experience in mathematics class which consequently influences student's achievement in mathematics.

Burton (2000) noticed that positive attitude towards mathematics assume a significant function towards science accomplishment and subsequently, instructors' encouraging philosophy should fuse uphold structures for learners learning climate. NCTM (2000) distinguishes the cycle guidelines of critical thinking which incorporates thinking and confirmation, portrayal, correspondence, and associations as ways learners ought to be occupied with learning arithmetic substance in order to create both procedural familiarity and reasonable comprehension of science. Learners occupied with critical thinking, for example, Mathematical Modeling (MM) manufacture numerical information and comprehension by wrestling with and tackling authentic issues, instead of finishing routine activities. These assists with building associations among mathematics and different teaches by applying arithmetic to real-world circumstances. Accordingly, by taking part in these cycles, understudies become dynamic students of mathematics.

Blum (2000) noticed that Mathematical Modeling (MM) as an instructional methodology in mathematics educating has gotten progressively significant in the school mathematics curriculum of numerous nations. Enthusiasm for this region has filled altogether over the most recent twenty years animated by the various and assortment of studies and exploration work done on the learning and instructing of Mathematics. Additionally, International Congress on Mathematical Education (ICME, 2012) report that numerous nations over the world, for example, US's as of late dispatched educational program, the Common Core State Standard of Mathematics (CCSSM, 2010), India's National Curriculum Framework (NCF, 2005) have underscored on the significance of MM in instructing and learning of arithmetic in their educational plan and this has had positive effect on understudies' numerical presentation in these nations.

As indicated by Guideline for Assessment and Instruction in Mathematical Modeling Education (GAIMME) (2016, p. 8-28) MM is a cycle wherein understudy use science ideas and strategies learned in class to speak to, break down, cause forecasts or in any case to give knowledge into genuine marvels. The open idea of MM gives undertakings that advances thinking and critical thinking. Understudies can participate in numerical talk in small and large groups as they figure out mathematics of real-world situations.

MM advances both procedural and unique aptitudes with calculated understanding because of displaying measure and the individual commitment with the issue (Lesh and Zawojewski, 2007, p. 763-804). Simultaneously, students in MM, as a cycle of learning mathematics, are tested to build up their numerical deduction, for example, to depict, relate, change and to sum up data that goes past explicit numerical substance or aptitudes (Swan et al., 2007). Gathering work, class conversations and collaboration are particularly supported during MM exercises. Students are needed to explain their plans to build up their argumentation and relational abilities in a numerical setting while at the same time working with peers when solving MM task (English, 2003, pp. 3-18).

Kaiser (2007, p. 104) likewise contends that by changing over issues into the way toward taking quantifiable information and demonstrating definition, MM instructing can meet the individual capacities of numerous understudies when contrasted with customary techniques for educating. MM underpins the learning of valuable abilities and methodology in arithmetic that assists with creating coherent reasoning, problem solving (PS) aptitudes and students' talk. Rather than commonplace critical thinking rehearsed in science class, the methodology has significant mathematical thoughts and connections installed inside the difficult setting and understudies inspire this as they work through the issue (English, 2007, p. 139-156). In this manner, rather than word issues in which students are essentially needed to apply mathematical control aptitudes learned in class, in MM approach, the specific arrangement way is hazy and may include making suspicion that lead understudies to utilize mathematical abilities and think about whether they were defended in doing as such.

The foregoing leads to better understanding of mathematics concept learned in class. National Research Council (1999) in USA post that students' accessibility to new information and linking it to previous knowledge or prevailing neuronal webs as they wrestle with multifaceted hitches and testing of new ideas thus neuronal networks are extended and strengthened while in this approach of learning. As much as the practice is a fundamental advance in creating proficient cycle through the mind, direct guidance alone does not normally bring about more profound learning and comprehension of mathematical ideas, this is because of the fact that teaching and learning utilizing course reading simply help learners to take in new information. In any case, when learners are occupied with critical thinking, for example, MM, they have occasions to make the association across numerical regions notwithstanding finding out about applications outside of mathematics classrooms leading to better performance of the subject (NCTM, 2000). Thus, because of this there was a need to carry out a study in Kenyenya Sub-county in relation to teaching and learning of mathematics using MM as an instructional strategy.

1.2 Statement of Research Problem

Mathematics performance in Kenyan secondary schools has always been poor over the years, this is revealed in KCSE results from 2012 to 2017 on the background of this study where performance on the national examination has always been below 30% on average for six consecutive years. Various studies have attributed this poor performance in mathematics to makes going from poor teaching strategies to psychological elements like the poor attitude of learners towards the subject. Nevertheless, a number of studies have also pointed out that teaching the subject using Mathematical Modelling approach could lead to better performance in the subject. This is because MM can meet the individual abilities of many students as compared to traditional method of teaching (English, 2007). MM promote student's mathematics procedural skills proficiency and conceptual understanding of mathematics since it acts as a bridge between students' abstract mathematics and students' extra mathematical domain hence making students to see mathematics as a useful tool in solving their day today issue in life. This study sought to provide empirical evidence and understanding on the practice of MM approaches in Kenyenya sub-county secondary schools in relation to teacher's knowledge and extent of applying MM in teaching and learning of mathematics. Additional information on students' learning orientation of mathematics concept through MM approaches and teacher's approaches of students' work was also sought to be investigated.

1.3 Objectives of the Study

The study sought to achieve the following objectives:

(a) To establish mathematics teachers' knowledge in mathematical modelling.

(b) To determine the extent to which mathematical modelling is used in teaching and learning of mathematics in secondary schools in Kenyenya Sub-County.

(c) To establish the relationship between mathematical modelling approach and student's performance in mathematics.

1.4 Research Questions

The study attempted to answer the following research questions:

(a) What do mathematics teachers know about Mathematical Modeling?

(b) What extent is Mathematical Modeling used in teaching and learning of mathematics?

(c) What is the relationship between the use of Mathematical Modeling and student's performance in mathematics?

1.5 Significance of the Study

It is expected that the findings of the study will help to disclose whether or not there is a need for modification of teaching and learning materials used by teachers and students in order to improve performance of mathematics. It is hoped that the findings of the study will help curriculum formulators to establish whether or not there is a need to emphasis on use of MM approach in teaching and learning of mathematics. The outcomes of the study will also help the Ministry of Education and other policy formulators in deciding on whether or not there is a need in planning for further development of teaching as a profession during training of mathematics teachers.

1.6 Limitations of the Study

Class intervention on pre mathematical modelling and post mathematical modelling stage required substantial period of time in administration of data collection instruments but this was not possible because schools were in a rush to cover the syllabus. Therefore, school administrators were not ready to extend more time to the researcher. There was also issue of some respondents failing to complete the questionnaire due to fear or lack of being committal even after the researcher explained the importance of completing the questionnaires.

1.7 Delimitations of the Study

MM is a multifaced process which usually requires syllabus design, selection of instruction materials, learning course and evaluation, but this study confined itself to application of MM in teaching and learning mathematics in secondary schools because all the aforesaid processes subsequent to MM were beyond the scope of the study.

MM as an instruction tool in mathematics can be applied in teaching mathematics in all levels of institutions ranging from primary to tertiary level but this study confined itself to form two in secondary schools.

1.8 Research Assumptions

This study was guided by the following assumptions:

(a) Teachers' knowledge in MM approach influence the extent at which the MM approach is used as a teaching strategy in teaching mathematics in secondary schools.

(b) There is a positive relationship between MM approach as an instruction strategy in teaching mathematics and students' performance in mathematics.

1.9 Theoretical Framework

This study was anchored on constructivism theory which draws heavily its arguments from Piaget's Cognitive Theory and Vygotsky's' Social critical theory. This theory stresses the dynamic part of the understudy in building their comprehension and sorting out the world (Eggen and Kauchak, 2007). Constructivism contends that information results from an individual development of the truth and that information obtaining happens through the persistent making of decides and speculations that clarifies what is watched. The need to make new principles and detail new speculations happens when understudies are tested with groundbreaking thoughts and novel perceptions (Brooks, 1990).

This theory further contends that information cannot be sent and teachers cannot just give understudies information. Rather, understudies' information must be developed as far as they could tell. The part of the educator is to encourage the learning cycle by instructing in manners that make data important and pertinent to understudies, by giving learners occasions to find or apply thoughts themselves (Slavin, 2006). This is seen in MM approach since it involves students' application of formal mathematics to extra mathematical domain hence making sense of the real-world situation. Through MM learners will have the option to make new mathematical knowledge by thinking about their physical and mental activities. Mathematical ideas will be made meaningful when learners will integrate them into their existing structures of knowledge and mathematics will not anymore be viewed by students as an abstract subject.

The role of a teacher under MM, as a teaching approach, is that of a facilitator/guider. A teacher selects or develops a MM task according to instruction goal, organizes learners during MM activity into groups and monitors their progress while working on the activity to look for a solution. The teacher is likewise entrusted to consider how comfortable learners are with the context and mathematics concepts they trust learners to use on MM tasks during mathematics teaching. As students engage in MM activity, a teacher monitors their progress and addresses misconception, answer questions, provides suggestions, have students share their progress and receives peer feedback. This in essence helps students to build their understanding.

Learning is a social cycle wherein kids develop into the scholarly existence of everyone around them (Bruner, 1986). Mathematical thoughts and certainties, both being used and insignificance are helpfully settled by the individuals from a culture. Hence, the constructivist homeroom is viewed as a culture wherein learners are included in revelation and creation as well as in a social talk including clarification, exchange, sharing, and assessment. The constructivist theory further expresses that when an instructor requests that understudies utilize set numerical techniques; the sense-production movement of understudies is truly diminished. learners will in the general copy the techniques methodically with the goal that they can seem to accomplish the teacher's objectives. Their convictions about the idea of science changes from reviewing mathematics as sense-production to survey it as learning set systems that have neither rhyme nor reason.

Generally, this theory arranges the learning of science through the perspective of investment as opposed to the procurement of information alone from educators. Through MM approach, students will be able to acquire and construct their own mathematics knowledge through their own understanding hence change of their attitude towards mathematics resulting to better performance in the subject.

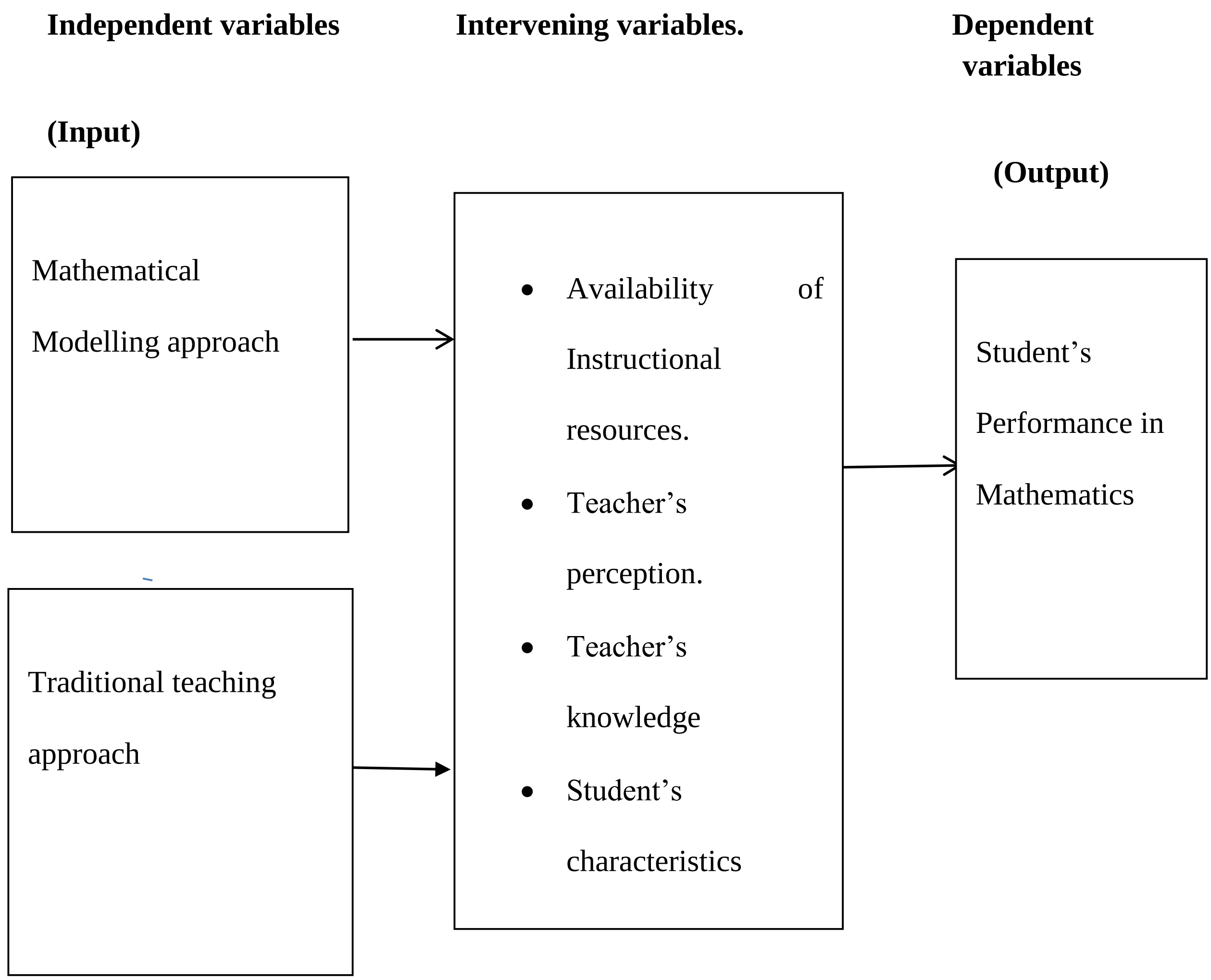
1.10 Conceptual Framework

Students' achievement in mathematics is influenced by instructional strategy adopted by the teacher in a mathematics class coupled with availability of instructional resources, teachers' characteristics and students' characteristics. Thus, in this scenario, student's performance in mathematics will depend on instructional strategy adopted by the teacher in mathematics class. Whereby instructional strategy could either be participatory approach advocated in MM approach, where students learn by constructing their own knowledge while the teacher acts as a facilitator in learning mathematics or the traditional approach adopted by the teacher where students learn through acquisition of knowledge whereby a teacher controls learning through formulaic method of instruction and students learn through mimicking of formulas and procedures in mathematics. In this category, a teacher requests that learners utilize a specific arrangement of numerical techniques and learners follow the procedure to arrive at an expected particular solution.

In this setting, equally students' performance in mathematics can also be influenced by teacher's characteristics such as a teacher's content knowledge, attitude of a teacher towards the subject matter and a teacher's preparedness to teach mathematics. Preparedness to teach by a teacher involves a teacher's possession of professional knowledge in instructional strategy adopted and documents such as a lesson plan, schemes of work and class notes. On the other hand, students' characteristics involve students' entry behaviors such students' cognitive level in mathematics learning, students' attitudes towards the subject and students' motivation toward the subject.

The other factor which is likely to influence achievement in mathematics is availability of instructional resources. Reliable and well-prepared instructional resources will influence students' achievement in mathematics as compared to a situation where there are no instructional resources. This is because availability of instructional resources will save time and give both teachers and students ample time when learning. This scenario can be presented diagrammatically as shown in Figure 1.1.

Figure 1.1: Conceptual Framework



Source, Researcher (2020).

1.11 Operational Definition of Terms

Affective: These are Beliefs (confidence and values) and attitudes that are likely to influence one's cognitive involvement in learning process.

Conceptual knowledge: This is understanding of concept and recognizing their applications in various situations. It goes beyond manipulation of a mathematics problem but transfer of skills acquired to non-familiar situations.

Cognitive: Achievement in learning process that results from experience.

Extra mathematical domain: Mathematics drawn from real world situation, mathematics that includes observing a circumstance, guessing connections, applying numerical investigations, acquiring numerical outcomes.

Mathematical modeling: A procedure or process whereby learners apply numerical ideas learned in class to new and new circumstances.

Mathematization: Process of representing real world problem into mathematical term and establishing relationship and structure that exist in the problem in mathematical format.

Modeling task: Mathematically-rich issue that connect with students in numerical intuition, drawing upon recently learned information and supporting their comprehension of numerical ideas presently being secured.

Mathematical model: This is the disentanglement or reflection of a real-world problem into a numerical issue. The mathematical problem would then be able to be unraveled utilizing any realized procedure to get an answer.

Mathematical world: This comprises of all the concepts and tools employed in mathematical thinking such as theorems, conjectures, symbols, operations and algorithms.

Procedural knowledge: includes the capacity to tackle numerical issues through the control of numerical aptitudes.

Pure mathematics: Closed word problems that involve formulas, procedures and algorithms.

Real life: Refers to situations that emanates from one's environment that require solutions that involve mathematical knowledge.

Real world: Refers to all the situations and events that make up daily life.

Traditional teaching: Refers to teacher-centered, lecture-based classes which focus on the repetition of similar exercises, closed problems and memorization of formulas and algorithms.

1.13 Organisation of the Study

This study is organised in five chapters as follows:

Chapter one: Covers background of the study, statement of the problem, the research objectives and questions, significance of the study, limitations and delimitations of the study, research assumptions, theoretical framework guiding the study, conceptual framework, and operational definitions of terms.

Chapter two: Consists of the literature review related to this study which is subdivided into different sub headings: introduction, meaning of mathematical modelling, Mathematical Modelling process, reasons for using Mathematical Modelling in teaching and learning of mathematics, teacher' knowledge in Mathematical Modeling approach, teachers' perception in Mathematical modelling approach, extent to which teachers use mathematical modelling in teaching mathematics, and the connection between mathematical modelling and students' performance in mathematics..

Chapter three: Covers methodology which is sub divided into research design, location of the study, target population, sampling and sample size, research instruments, piloting of research instruments, data collection techniques, data analysis, presentation, and logical and ethical consideration.

Chapter four: Consists of data analysis methods and procedures. The results of data analysis are presented and the results of research findings are given to answer the research questions.

Chapter five: summarizes the study. The findings are discussed together with their implications. Conclusions are drawn and recommendations made thereof.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

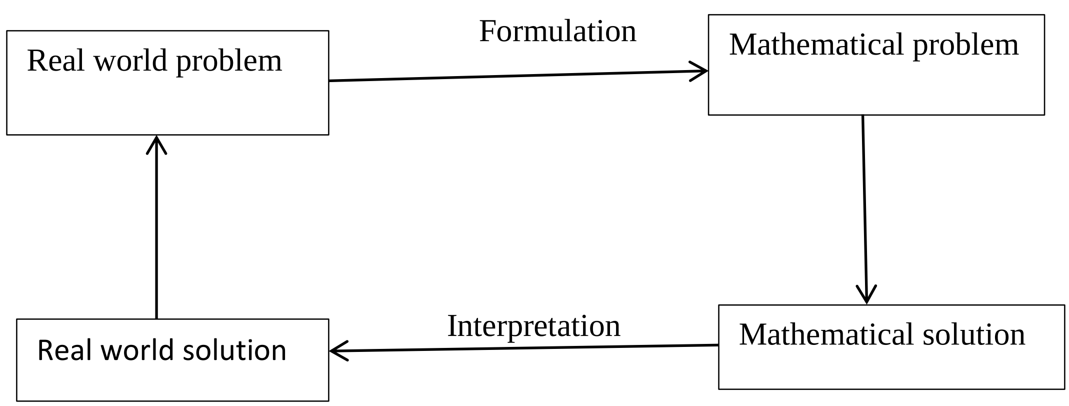
The literature reviewed under this chapter includes meaning of MM, MM process, importance of MM in teaching and learning of mathematics, Extent of application of MM in teaching and learning mathematics, teachers' perception on applications of MM in teaching mathematics, teachers' knowledge in MM, relationship between MM and students' achievement in mathematics, and summary of the literature review.

2.1 Meaning of Mathematical Modelling

As indicated by Haines and Crouch (2007, pp. 417-424), MM is a repetitive cycle in which genuine circumstances are converted into mathematical language, explained utilizing known arithmetic strategies planned and the arrangement tried back inside genuine framework. Then again, NCTM (2000, p. 303) characterizes MM as an instructing approach that includes distinguishing and choosing pertinent highlights in true circumstance speaking to those highlights emblematically, investigating and thinking about the model and the attributes of the circumstances and thinking about the precision and constraint of the model.

The USA educational plan, the Common Core State Standards of Mathematics (CCSSM, 2010) then again, characterizes MM as the way toward applying ideas learned in class to true circumstance and the utilization of Mathematical Model to examine circumstances, making determination and making expectations. This guidance approach is more than essentially giving learners a word issue. It is a numerical cycle that includes watching circumstances, guessing connections, applying numerical investigation, acquiring numerical outcome and deciphering the model (Lingerfiard, 2006, pp. 96-112). Ang (2009) also portrays MM as a cycle of speaking to genuine issues into numerical terms trying to discover answers for issues. A mathematical Model for this situation is considered as a rearrangements or reflection of a true issue or circumstance into a numerical term. The mathematical issue acquired at that point is tackled utilizing whatever realized numerical procedures to get a mathematical solution. The solution is then deciphered and converted into true solution. This scenario is demonstrated in figure 2.1.

Figure 2.1 A Simplified View of the Process of Mathematical Modeling



Source: Ang (2009).

MM task then again as per Ang (2009), is any mathematically rich issue that connects with learners in numerical intuition, drawing upon recently learned information and supporting their comprehension of the mathematically ideas at present being secured. While then again, as per Breen and O'Shear (2010) a MM talks should challenge the learners' interest, support both free reasoning and collective conversation and give huge numerical thoughts and topics. The errands should expand on learners' past information and empower the arrangement of novel thoughts and ideas.

As per GAIMME (2016), the open idea of MM normally gives tasks that advance thinking and critical thinking. Learners get occupied with mathematical talk in little and enormous gatherings as they sort out science of this present reality circumstance and the association that exist between the two. As understudies deal with MM task, teachers screen their work by taking notes of systems utilized, the suppositions learners are making, mathematical opportunities that emerge and puts learners stalls out. As understudy progress, teachers once in a while refocus by uniting the entire class to address misinterpretations.

It is common to confuse MM and PS. However, MM approach is not problem solving (PS). MM requires more than PS tools to be successful. PS process provides strategies to overcome obstacles as students move from the beginning to the end of the problem (Ferri, 2006, pp. 86-95). In PS students have only a few approaches to choose from and each student proceeds to the same solution. The solution in most cases is a short numerical answer to a well-defined question about a pre-mathematical situation (Lesh et al., 2006.). In PS, proficiency is measured in the student's mastery of mathematical skills, efficiency of selected method and accuracy of solution. While MM, on the other hand, is also a process with suggested path but MM tasks are designed for students to use mathematics to understand and make sense of the real-world phenomenon. Successfully MM incorporate PS heuristics in a few stages of MM process but it also relies on mathematics thinking to generate representation and knowledge of real world to identify relationships.

2.2 Mathematical modeling process

According to NCTM (1989), there are five basic stages in MM process that a student can follow to arrive at a solution in real world terms and these steps are as follows:

(a) Identify and simplify the real-world problem situation.

(b) Build a mathematical model.

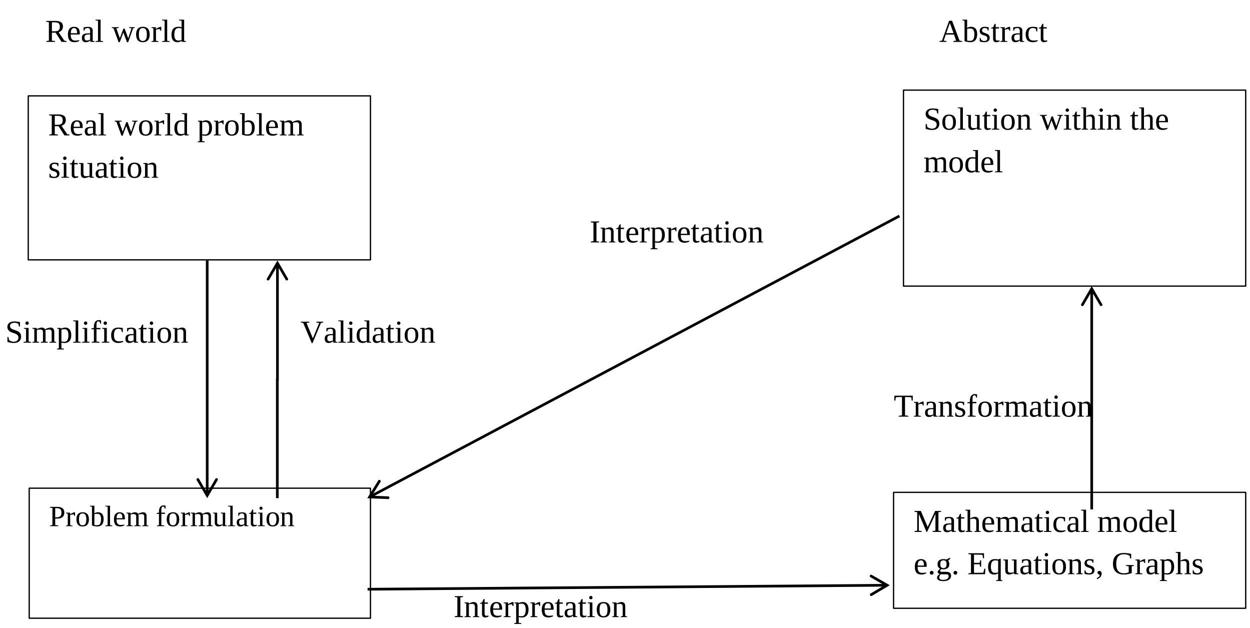
(c) Transform and solve the model.

(d) Interpret the model.

(e) Validate and use the model.

(f) This is shown on figure 2.2.

Figure 2.2 Mathematical Modeling process



Source: NCTM (1989)

Stage one: Students distinguish an issue to be unraveled in reality circumstance, and state it in its most exact structure as could reasonably be expected. This is done through numerically watching, examining and talking about regarding it. They consider what data in the given circumstance is significant or not. Hence, they rearrange the circumstance by disregarding less significant segments from the outset. This cycle additionally incorporates the activity of determining in light of the fact that understudies indicate conditions and suppositions identified with the circumstance so as to consider and utilize them in the subsequent stage, construct a numerical model.

Stage two: It is also known as mathematizations stage. Learners make an interpretation of the issue into science terms by making numerical portrayals of determined parts of the issue and the connections among them. Learners characterize factors, build up documentation, and plainly distinguish some type of numerical relationship and structures, for example, making diagrams and composing of conditions. These mathematization endeavors in the end empower understudies' structure of a numerical model.

Stage three: Also referred as transformation stage. Learners investigate and control the model to discover numerically critical answers for the distinguished issue. This progression is generally natural to learners. The model from second step is illuminated, and the appropriate response is perceived with regards to the first issue. The understudies may need to additionally rearrange the model on the off chance that it cannot be illuminated.

Stage four: Referred as interpretations or translations stage. In this stage understudies do their numerical outcome that is reached with regards to numerical model back to the ordered genuine issue circumstance. At that point, they test and assess whether the arrangement is significant for the issue to be illuminated. At the end of the day, they test if their answer made through a model bodes well or not in the predefined issue setting. (Zbiek and Conner, 2006, pp. 89-112).

Stage five: Also known as verification stage. In this stage understudies consider the legitimacy and handiness of the made model as far as true circumstance other than tending to the recognized issue. This progression expects understudies to test if expectations and ends came to through the model are significant and substantial in reality circumstance. Along these lines, the model is assessed concerning its consistency with its foreordained explicit reason (Zbiek and Conner, 2006, pp. 89-112).

2.3 Importance of MM in learning and teaching of Mathematics

Rewards of applying MM in teaching and learning mathematics have been referred to by various late exploration articles in mathematics education. As indicated by Blomhøj (2004), there are three fundamental explanations behind applying MM as a coordinated methodology in educating and learning Mathematics in secondary school level:

(a) MM overcomes any issues between students' real-life circumstances (critical thinking) and understudies' theoretical science world. It propels the understudies' learning of arithmetic, gives direct intellectual help for the students' conceptions and it places mathematics in the way of life as a method for portraying and comprehension of real-life situations.

(b) In the improvement of profoundly innovative social orders, abilities for setting up, breaking down and scrutinizing, MM are vital. This is the conditions of both from a person's stance comparable to openings and difficulties in training and work power and from a social point of view corresponding to the requirement for an adequately instructed labor force in the work market.

(c) Mathematical models of assorted sorts and multifaceted nature assume significant parts in the working and shaping of the social request dependent on high innovations. Hence, the advancement of a specialist just as a layman capability to evaluate numerical models and the manner in which models and model outcomes are utilized in dynamic, are getting basic for the keeping up and promoting improvement in real-world situations throughout everyday life.

Blum et al. (2007) on the other hand, posits that MM is being used more often to express all sorts of connections made between the mathematical domain and the extra-mathematical domain. Nevertheless, the approach is used in the transition from the extra-mathematical domain to the mathematical domain, whereas application focuses on the well-regarded transition. Boaler (2001, pp. 121-127) similarly, argues that MM approach inspires learners to participate in mathematics in three ways:

(a) The real-world situation appeal to some students, students want to continue to study Mathematics because MM fronts new mathematics situations when solving MM task in Mathematics.

(b) The methodology encourages learners to make connections among arithmetic and build up a more profound calculated comprehension of mathematics ideas

(c) MM tasks allows for many diverse strategies with built-in requirements for communication within mathematics world.

Learners utilizing MM, then again, have been found to outflank learners utilizing the conventional methodology on issues that require detailing an arithmetical model of quantitative relationship and consequences of mathematical calculations (Fey et al., 2000). According to Biembengut and Hein (2010, pp. 481-490) MM empowers a more profound appreciation of numerical thoughts and trains learners to reflect, decipher and define an arrangement when given a non-customary issue. At the point when utilized adequately the methodology will urge learners to quit seeing mathematics as a strategy or system and begin seeing it as a device to tackle issues.

As indicated by NCTM (2000), learners ought to figure out how to apply the science substance and strategies learned in class to various circumstances. The capacity to apply information is a fundamental expertise in higher learning and in the work environment. This is on the grounds that zeroing in on thinking as opposed to repetition methods will not trouble educators in instructing arithmetic but instead will produce more engaged students. They further contend that numerous current change suggestions in the arithmetic world qualities MM of wonders as one of the most remarkable employment of science, and underline on MM and contextualized critical thinking over the mathematics education program.

Doruk and Umay (2011) battle that MM positively affects learners' capacity to move their learning into genuine circumstances. Subsequently, it tends to be construed that moving science into genuine is straightforwardly associated with MM. This is because of the way that MM gives an assortment of the procedure to learning arithmetic, it upgrades understudies' abilities to apply mathematics, in actuality, just as leads understudies to contemplate their learning.

Interestingly with numerous study hall mathematics teaching strategies, MM advances issue presenting, just as, problems solving primarily because they inspire continued posing of inquiries and presenting of guesses (Brown and Walter, 2005). As, all things considered, circumstances, displaying exercises regularly include data that may be deficient, vague or indistinct with something over the top or too little information. All these arguments for inclusion of MM in teaching of mathematics shows that MM will help to fulfill the objectives of secondary school mathematics in Kenya as outlined by the KIE (2002).

2.4 Teachers' Knowledge in Mathematical Modelling approach

Although teachers have teaching and learning materials and resources in form of textbooks containing assortments of MM activities, inadequate knowledge in MM according to Ball (2000) may hinder the potential teacher of MM from structuring and engaging his/her students with meaningful and effective MM learning activities. MM requires a prospective teacher to be qualified both in MM competence and pedagogical knowledge. Proficiency in MM teaching should be mirrored in what a teacher can do and what they see in teaching, learning and PS circumstances so that their intercessions, while their students engross in MM, will be effective (Lesh & Lehrer, 2003, p. 111).

MM approach requires teachers to use non-traditional teaching technique which may be new for many teachers. This is for the reason that teachers are possibly to come across various ways of students' thinking and encounters that learners may have when teaching mathematics through MM (Doerr and English, 2006, pp. 5-13). Effectiveness in MM approach expect instructors to snoop to, understand and decipher learners' differing thinking routes so as to react with helpful outlines. Educators also need another academic way to deal with learners in a circumstance to decipher, clarify, legitimize and assess the propriety of their reasoning ways instead of give them clarifications and assess the models. This kind of new instruction strategy may introduce pedagogical practices that teachers are not prepared to adopt in mathematics class. Doerr (2007, pp. 69-78) lists some pedagogical techniques that a teacher will need to possess so as to implement MM approach in a mathematics class and these includes:

a) To be able to listen for anticipated ambiguities.
b) To offer useful representation of students' ideas.
c) To hear unexpected approaches.
d) To support students in making connections to other representations.

High level tasks such as MM do not lead students to answer questions in the same way like low-level tasks. Teachers needs to be able to anticipate multiple ways to approach a problem and connect difficult ideas (Smith & Stein, 2011). Strategies for high cognitive demand tasks and for mathematical discourse may also apply to teaching MM. In addition, there is a framework for teaching that is specifically oriented towards teaching MM.

Teachers also need to know that MM tasks can be examined by the cognitive demand required by the students, Stein and Smith (2011) categorizes tasks into four levels: memorizations and procedure without connections make up lower-level demands while method with connections and doing arithmetic contains the high - level requests. High-level intellectual interest tasks include making associations, dissecting data and reaching inferences. MM tasks as activities requires students to use complex non-algorithmic thinking along with relevant knowledge and experience as tasks with high cognitive demand (Asempapa, 2015). Engaging students in complex thinking tasks in conjunctions with high level thinking requires teachers to start with a high cognitive demand task. Notwithstanding, choosing and setting up significant level tasks well does not ensure learners commitment at an elevated level yet beginning with a decent task does (Smith & Stein, 2011).

Additional to mentioned requirements on teachers' knowledge, teachers also need mathematical and communicational competencies, which is referred to as MM abilities or competencies (English & Fox, 2005, pp. 321-328). MM competence are skills and abilities to perform modeling process appropriately and goal oriented as well as willingness to put these into action. According to Maaß (2006, p. 117) there is a consensus that MM competence include certain sub-competence among them recognizing relevant variable, constructing relationship between variables, choosing appropriate mathematical notations, reflecting and applying appropriate formulae and generalizing or extending the solution.

Chazan and Ball (1999) then again, set that accommodation of MM in class requires a more versatile numerical style of guidance wherein educators needs to comprehend the association of numerical thoughts in an assignment and adjust their educational procedure to enhance the usage of the undertaking. Educators' information in MM directions can decide to a huge degree how instructors see and react to educational plan advancement endeavors to impact MM learning encounters in auxiliary science prospectus. MM information goes past knowing MM as a technique in instructing science. It requires understanding the mind boggling transaction among parts of different types of instructors' information in MM educating and learning climate.

While utilizing MM as a showing technique, probably won't be workable for forthcoming educators to connect with each understudy separately and right the entirety of their wrong thoughts and approach created while taking care of MM task, study hall conversations are crucial piece of MM. During such situations, an educator needs to figure out how to be a facilitator as opposed to a talk. This is on the grounds that homeroom conversation is a period for understudies to consider the quality and shortcoming of thoughts introduced and choose the best or most sensible arrangement (Inoue, 2011, pp. 5-23)

Then again, educators' arrangement programs in science instructing may not continually achieve an improvement in imminent instructors' information on understudies' reasoning. Feiman (2001), set that educators' planning program faces a few suffering issues as they are traditionalist with shallow educational plan that isolates hypothesis and practice in this manner most instructors can't conform to requesting present day approach of training arithmetic supported in MM technique. An investigation done by Stillman and Brown (2011, pp. 385-395) to research proficient capability of 73 pre-administration auxiliary school science educators in Australia with respect to instructing of MM, uncovered that lion's share of instructors had insufficient information in recognizing understudies' solid or frail focuses for a specific understudy's reaction. Educators gave off base examination on understudies' work. Dispersion of educators' reaction to understudies' work among instructors contrasted practically half (43%) of preservice educators in the 4-year program couldn't give sufficient assessment of understudies' work contrasted with under 24% in the 1-year program.

Also, Son (2013, pp. 49-70) examining how rudimentary imminent educators decipher and react to understudy' added substance thinking mistake on idea of proportion and extent in USA, discovered that while the greater part of the taking an interest planned instructors distinguished system based-blunder, just few instructors had the option to decide the mistake originating from theoretical part of similitude. In like manner, Widjanja (2013, pp. 583-593), who gave occasions to pre-administration auxiliary teachers in Indonesia to encounter being modelers, comparably found that instructors needed information in MM particularly in expressing presumptions and certifiable contemplations for making connects to MM towards approval of the suitability of the model.

2.5 Teachers’ Perception of Mathematical Modelling approach

Thompson (1992) acknowledged that there is support in literature for the claim that teacher’s perception influence classroom practice in mathematics. Teacher’s intuition acts as a filter through which teachers interpret and ascribe meaning to their experience as they interact with learners and the subject matter. Leder et al. (2002) similarly, argues that there is a strong relationship between teachers’ perceptions and their practice in mathematics classroom, especially in the connection with MM. while Kaiser (2006) on the other hand, concludes that depending on MM perception held by a teacher it’s more or less likely that they build up obstacles during the application of MM while teaching and learning mathematics in class.

Kaiser and Maaß (2007) in their study found out that MM did not play a substantial role in the teachers' perception in the teaching of mathematics as a discipline. However, teachers were found to have altered and espoused application-oriented beliefs in line with their prevailing mathematical discernments while on the other hand, Blum and Niss (1991, pp. 37-68) in their study discovered that teachers found MM to be very intricate and necessitated other transformations of teachers' knowledge in MM instructions.

De Oliveira and Barbosa (2013) categorized encounters of teachers' MM involvements into three key areas:

(a) Deciding on what to do; This is a situation where mathematics teacher is unable to make decision on direction mathematics lesson is heading to when applying MM in class.
(b) Students' involvement; Occurs during MM teaching where the teacher is expecting his/her students to be tangled in the lesson but they end up becoming unresponsive and detached.
(c) Students' dominations of mathematical content; This is a scenario where mathematics teacher is expecting his/her student to have some ideas on mathematical content to be learned but the student act unexpectedly opposite of the teachers' aspirations.

Biembengut and Hein (2010, pp. 481-490) postulates that majority of teachers are not mollified with equivocalness in the classroom and thusly need practice on building up the abilities expected to take learners through MM tasks without furnishing them with an excessive amount of help. This is because of the way that most of instructors destabilize the unpredictability of an errand by providing learners with an excess of sponsorship and explanation as opposed to requiring the learners to advance numerical intuition by giving their own clarifications.

Blum and Niss (1991, pp. 37-68) came up with impediments from the instructional perceptions, student's standpoint and also from the teachers' perceptions. The various illustrations presented in this scenario is that teachers are habitually of the view that there is neither time nor space to embrace MM approach in an already packed syllabus. Teachers are not convinced that MM belongs to mathematics instruction at all this because MM borrows heavily from other disciplines that outside mathematics domain. From the students' standpoint, Blum and Niss claims that MM makes mathematics classroom less foreseeable and much more challenging, which is exhibited as a student in-built impediment. Lastly, from the teacher's standpoint, the introduction of MM requires more from the teachers than just pure mathematical knowledge practiced in traditional mathematics classroom for example additional of non-mathematical trainings are obligatory which essentially makes many teachers feel nervous and incapable to deal with applied tasks in mathematics originating from subjects and disciplines that they did not study during mathematics teaching training since they lies outside their field of expertise.

2.6 Extent of Teacher's use of Mathematical Modelling Teaching in High Schools

MM as an instructional strategy has been gaining momentum across the world in recent past, western countries such as the USA Mathematics curriculum, the CCSSM (2010) emphasis to their tutors on the importance of applying MM in teaching and learning mathematics. CCSSM commends that students should be evaluated on their ability to solve a variety of open-ended mathematical tasks that requires variety of approaches in finding solution and multiple solutions. In India, MM was recommended in 2005 by the National Curriculum Framework (NCF). The NCF states that the primary goal of mathematics education is the mathematization of a child's thought process and therefore teaching of mathematics at all levels should be more activity oriented through inclusion of MM (NCF, 2005). While in Singapore, MM began to feature in the school mathematics curriculum framework around 2007. Ang (2001, pp. 62-74) first proposed the idea of introducing MM in Singapore schools since then MM has been a central theme in Singapore's school mathematics curriculum.

In Kenya, MM has been used by researchers to analyze emerging issues in the society for example Nathan et al. (2019) used MM to do stability analysis in a mathematical modal of teenage pregnancy in Kenya incorporating with contraceptive and education. Likewise, MM was also used by Omondi et al. (2019) to study HIV infection in two heterosexual age group in Kenya. However, besides MM used in this various research in Kenya there is no much literature talking about the state of MM practice in Kenyan mathematics classroom. Research in other countries have shown that teachers hardly present students with challenging mathematical tasks that require multifaceted mathematical thinking which requires the application of MM knowledge. Gainsburg (2008) research study set up that instructors' essential objective in utilizing certifiable models is to confer numerical substance as opposed to in showing the understudies to pick a proper strategy and apply different ideas to tackle issues. Then again, the exploration found that when instructors use word issues, they will in general present a cliché answer for understudies, where issues were gathered by the kind of arrangement needed without thinking about elective techniques for comprehending. Instructors' instructional procedure were likewise found to zero in on a specific technique or system instead of on exploring an issue on its application to this present reality. It was uncovered that one explanation most educators don't utilize intriguing undertakings, for example, MM on understudies is dread of over-testing the understudies. Most educators referred to by Gainsburg (2008) for instance believed that understudies couldn't be given testing issues as a result of their lacking numerical abilities. Instructors neglected to perceive how the difficult itself could be a device for guidance. Different reasons gave was that most schools need educating and learning science assets. Dominant part of instructors detailed that they created numerical undertakings from their own or past encounters and they likewise implied this to deficient time and assets as a factor in not utilizing MM approaches in showing science and furthermore MM errands all the more regularly.

Leikin (2003, pp. 297-329) set that instructors depend vigorously on their own science encounters which generally incorporate next to zero MM by any stretch of the imagination, this is on the grounds that a considerable lot of them are awkward with MM issues where there are numerous methodologies for tackling the issue and at times various right arrangements. There is likewise an enormous difference between what educators accept that they do in their homeroom and what they really do. For example, in TIMSS video study done in the USA, it was uncovered that practically all science instructor without avoidance, shown on the polls that they use MM in showing arithmetic in their study hall, however when videoed covertly it was found that they all adhered to conventional technique for guidance. This is the place they expressed a numerical idea or recipe without improvement of confirmation of the arrangement found. Educators were found to show understudies what to do, and afterward doled out comparable issues for training. There were no occurrences where instructors utilized MM (Hiebert and Stigler, 2000, pp. 3-20).

Swetz (1991) post further that teaching MM is difficulty because not only does a teacher need authentic real-world task but the context around the task as well as the mathematics involved need to be accessible and interesting to students. Finding or developing a good MM task is hard and there is no such type of problem or collection of problem, it is a process and should be taught as such. This is because majority of textbook modelling problems consist of word problems that may include few application problems but rarely contains any actual MM tasks. Typical mathematical curricular focuses on students learning a particular skill and will present problems to encourage students to solve them in a certain way (Zbiek & Conner, 2006).

2.7 Relationships between MM and Students' Achievement in Mathematics

2.7.1 Relationships between Affect and Cognitive Domain

As per Papanastasiou and Zembylas (2002, pp55-70) there exists an association between understudies' effect and learners' accomplishment in the arithmetic class (psychological).

Understudies considered as high achievers in science will in general have more inspirational perspectives toward arithmetic than those with lower achievements. Therefore, the discernment learners expand regarding the matter decides by and large the degree of their inclusion and furthermore what will be accomplished in mathematics execution.

As for influence, research has likewise indicated that learners educated in a customary manner (without utilization of MM) comprehend arithmetic as a shut arrangement of images and fixed standards with no space for change and inventiveness. Teaching mathematics without relating it to genuine circumstances enlarges the hole between school science and genuine circumstance henceforth making it harder for learners to value the benefit of contemplating math since to overlook its association with ordinary exercises intends to introduce math to the students as unimportant obligation (Cobern, 1996, p. 579).

2.7.2 Mathematical Modelling and students' achievement in mathematics

According to Lesh and Zawojewski (2007, p. 763), learners' convictions and mentalities toward science are impacted by their encounters in the arithmetic class and in this manner could be affected by changes in the educating and learning approach in mathematics based on this assumptions MM promote positive attitudes towards learning of mathematics in class resulting to better performance in the subject. Researchers on MM approach and influence domain in a diverse manner, to be specific as an adaptable portion of the understudy's critical thinking procedure which changes as the learner travels through the phases of the MM cycle (Lesh & Doerr, 2003, p. 33).

As per Lesh and Doerr (2003, pp. 3-33) MM goes about as a vehicle for instructing and learning science. MM undertakings as genuine issues expect understudies to build up their own numerical thoughts and understudies' working are not limited to brief answers. This since answers for MM includes a progression of demonstrating cycles so as to grow more refined perspectives through testing and amending iteratively. As learners create and asses their model, they participate in critical numerical cycle including depicting, investigating, clarifying and mathematizing items, relations and example. Learners produce depictions, clarifications and developments while dealing with MM undertakings by uncovering, testing and refining their perspective in mathematics.

Rather than traditional mathematics educating and learning, MM can possibly uncover learners' different perspectives through portrayals, clarifications, defenses, and portrayals while participating in MM exercises (Doerr and English, 2006). For instance, through researching third grade learners' mathematics information advancement and thinking measure as they worked with two MM assignments, English and Watters (2005, pp. 58-79) found that MM task helped little youngsters cultivate the improvement of their numerical thoughts and cycle. The researcher observed some critical numerical thoughts that they had not experienced during the class guidelines. Children's rudimentary comprehension of the pace of progress and likelihood thoughts was apparent for the crisis of kids' mathematical thoughts.

Also, English (2007, P. 139) affirms that MM underpins learning of helpful abilities and techniques. It assists with creating intelligent speculation in critical thinking and numerical propensities for the psyche henceforth advancing learners' talk and intelligent conversation. Interestingly with ordinary P.S regular in most homeroom, MM assignments have a significant numerical thoughts and relationship installed inside the difficult setting and learners inspire these as they work through the errand accordingly instead of word issue in which understudies are needed to apply mathematical aptitudes they have quite recently learned in another specific circumstance, frequently in MM circumstance the specific way is hazy and may include making presumptions that lead understudies to utilize a mathematical abilities and consider whether they were defended in doing as such.

MM advances both procedural and dynamic abilities with calculated understanding because of demonstrating cycle and individual commitment with the issue. Simultaneously understudies are tested to build up their mathematical reasoning that is to depict, relate, change and sum up data and go past explicit numerical substance or aptitudes. Gathering work, class conversation and collaboration are particularly energized during MM exercises. Learners explain their numerical thoughts and build up their argumentations and relational abilities in arithmetic setting while at the same time working with partners (Swan, et al. 2007). An examination directed by Sokolowsk (2015) to research the impact of applying MM on reconsidering learners' previously established inclination of the way toward enhancing zone encased by a line of fixed length uncovered that while 86% of learners dishonestly speculated that the rectangular territory encased by the line of fixed length will stay steady before taking part in the lab, the resulting assignment of MM exercises provoked the understudies to address their perspectives. The examination uncovered that MM approach gave plentiful methods for changing learners' discernment to set up firm applied foundation for actuating a more thorough logarithmic way to deal with taking care of issues in mathematical.

2.8 Summary of literature review

From the reviewed literature, evidence accumulated suggest that MM promotes teaching and learning of mathematics in secondary schools. According to Boaler (2001) MM approach helps to motivate students to engage in mathematics in three ways; the real-world situation in MM tasks appeals to some students thus motivating them to want to study mathematics; MM fronts new mathematics situations and help students to make connections among mathematical ideas hence develop deeper conceptual understanding of mathematics; and MM tasks allows student students while working with mathematics to have many different approaches with in-built requirements for communications within mathematical world. This assertion is also supported by Fey et al (2001) who posits that learners utilizing MM have been found to beat learners utilizing a conventional way to deal with issues that requires defining a mathematical model of quantitative relationship and aftereffects of logarithmic estimations.

Comparative sentiments are likewise repeated by English (2007) who clarifies that MM underpins learning of valuable abilities and systems. It assists with creating legitimate intuition in critical thinking and numerical propensities for the psyche henceforth advancing understudies' talk and intelligent conversation. Conversely with average P.S basic in many study halls, MM undertakings have significant numerical thoughts and connections installed inside the difficult setting and learners evoke these as they work through the assignment. However, for MM to be effective teachers must have adequate knowledge in MM since lack of adequate knowledge in MM according to Ball (2000) will inhibit the potential teachers of MM from structuring and engaging students with meaningful and effective learning experience. MM requires teachers to be qualified both in MM competence and pedagogical knowledge. MM capabilities are aptitudes and capacities to perform MM measure fittingly and objective arranged just as an eagerness to put these energetically (English and Fox, 2005). Teachers' knowledge in MM likewise decides to a huge degree how educators see and react to educational program advancement endeavors to impact MM instructing and learning experience. Instructors' discernments go about as a channel through which educators decipher and credit significance to their experience as they collaborate with students and the topic (Thompson, 1992).

The literature reviews further reveals that MM has been used in Kenya in various scientific research for example MM was used by Nathan et al. (2019) to analyze teenage pregnancies incorporation with contraceptive and education in Kenya and also was used by Omondi et al. (2019) to study HIV infection in two heterosexual age group in Kenya. However, besides MM used in these various studies in Kenya there is no literature especially talking about the state of MM practice in Kenyan secondary school classroom. There is a gap in literature concerning MM practice in relations to teachers' knowledge in MM, the extent of teachers' uses of MM in teaching and learning mathematics and the impact of MM on students' achievement in mathematics.

The next chapter presents the methodology that was adopted to collect data for the study to fill the identified gaps.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents information on the research design, location of the study, target population, sampling and sample size, research instruments, piloting of research instruments, data collection techniques, data analysis and presentation and logistical and ethical consideration.

3.1 Research Design

In this study, both quantitative and qualitative methods were used to collect data. The study was conducted using mixed method approach. Mixed method approach is an effective research design since it benefits from both qualitative and quantitative method (Creswell, 2008). Questionnaires (for both teachers and students) and observation schedule were used in the collection of data to respond to objective one and objective two of the study. Students' questionnaires and a single group pre-test and post-test design was used as quantitative method to collect data to respond to objective three of the study. A pre-test was applied to a single class then the class was exposed to MM approach instruction after which a post-test was administered. Thus, there was an opportunity to observe whether there was an effect of MM approach instruction on students' achievement on mathematics test. Students' achievement was compared before and after exposure to MM instruction. The independent variable was instruction based on MM while dependent variable was students' achievement in mathematics test.

3.2 Location of the Study

The study was based in Kenyenya Sub-County in Kisii County, Kenya. The study focused on Kenyenya Sub-County because of its continuous poor performance in the national examination (KCSE). The area was also a location the researcher was familiar with because according to Singleton (1993), an ideal setting for any study is one that is directly related to the researcher's interest. It should also be easily accessible to the researcher and will allow good rapport with the participants for easy data collection.

3.3 Target Population

According to Orodho (2012), target population is any gathering of people who share at least one qualities practically speaking that are important to the researcher. All secondary schools in Kenyenya Sub-County were of interest to the researcher because of their continuous dismal performance in mathematics. The target population thus was all Forty-one (41) secondary schools in Kenyenya sub-county which are all public schools, one hundred and thirty-five mathematics teachers (135) and two thousand six hundred and sixty-five (2665) form two students in secondary schools found in Kenyenya Sub-County formed part of the study (Kenyenya Sub-County Education office, Statistics department, 2017). Table 3.1 shows the target population (N) for the study.

Table 3.1: Population for the Study

Category	Population (N)
Secondary Schools	41
Mathematics teachers	135
Form Two Students	2,665

Source: Kenyenya sub-county Education office, statistics department (2017)

3.4 Sampling and Sample Size

Slavin (1984) sees that because of the impediment of time, assets, and energy, a research can be completed from a painstakingly chosen test to speak to the whole populace. Gall and Borg (2003) posts that in descriptive research, a sample of 10%-30% is acceptable. Thus, out of the forty-one secondary schools in the Sub-County, ten schools were sampled for the study using stratified random sampling technique representing 25% of the sample size of schools sampled for the study. Schools were stratified into two strata, county schools and sub-county schools. The sampling technique allowed the researcher to select schools that had information for in-depth study as per the objectives of the study. These categories were based on the facilities within the institution, number of teachers, entry behavior of students and the gender of students. Two hundred and seventy (270) form two students were sampled for the study representing 10% of sample size using simple random sampling technique and forty (40) mathematics teachers were also sampled for the study representing 30% of sample size. Table 3.2 shows sample size and sampling procedure.

Table 3.2: Sample and Sample Size

Category	Population (N)	Sample (n)	Percentage
Secondary schools	41	10	25%
Mathematics teachers	135	40	30%
Form two students	2665	270	10%

Source: Researcher (2017)

From table 3.2, schools were stratified into two strata: County schools and Sub-county schools from which five schools were sampled from each category using simple random sampling technique for the study. The researcher then sampled 40 teachers and 270 students for the study.

3.5 Research Instruments

The researcher used questionnaires and class observation for data collection for the study.

3.5.1 Questionnaire

Orodho (2012) sets that questionnaires empower the individual controlling them to clarify the motivation behind the investigation and the importance of things that may not be clear. Questionnaires are utilized to get significant data about the population (Mugenda and Mugenda, 2003). The researcher utilized questionnaires since: they can guarantee obscurity; grant utilization of normalized questions; they possess uniform strategies that give energy to subjects to consider reactions; and they are anything but difficult to make sure about. Questionnaires were likewise utilized in light of the fact that they are simpler to finish and the researcher can undoubtedly identify a pattern just by looking at the response (Orodho, 2012). Quantitative data was collected using two sets of questionnaires adapted from Trends in International Mathematics and Science Studies (TIMMS, 2007) namely student's questionnaires (SQ) and teacher's questionnaires (TQ).

3.5.1.1 Students' questionnaires

SQ consisted of four sections: A, B, C, D, and E. Section A focused on extracting students' demographic information, Section B extracted data on student's self-confidence in doing mathematics and values students attach to mathematics whereas section C focused on the attitudes of students towards mathematics. Section D collected data on students' experience of MM in class (See Appendix I).

3.5.1.2 Teacher's questionnaires

TQ was used to collect data on teachers' demographic information, teachers' professional development courses, teachers' use of mathematics textbook, teachers' MM practice in class and outside class and teachers' knowledge in MM (see Appendix II).

3.5.2 Observation Schedule

As per Cohen, Manion and Morrison (2007) observation empowers researchers to assemble live information from normally happening social situations. Robson (2002) clarifies that observation gives a rude awakening since what individuals do may contrast from what they state they do. In this investigation, observation schedule was utilized to gather information from teachers during live mathematics lessons (see Appendix III).

3.5.3 Interview schedule

Mackay (1978) upheld for the utilization of interviews when investigating students' needs. The interview schedule was additionally utilized on the grounds that more point by point data was to be acquired through examining questions. Interview schedule was utilized to gather subjective information from educators saw during live mathematics lesson. The interview schedule for educators were semi-organized (see Appendix VI). Semi-organized inquiries do not offer decisions from which the respondent can choose an answer rather the inquiry is stated to consider singular reactions. This kind of approach gave a serious extent of objectivity and consistency and furthermore permitted testing and explanations (McMillan and Schumer, 2001). Teachers' interview schedules were developed by the researcher under the guidance of experts. Teachers' interview schedules elicited information from teachers about their knowledge in MM and extent to which they apply MM.

3.6 Piloting of Research instruments

Piloting was conducted in two schools which were not part of the study but had similar characteristics to the sampled schools for the study. All mathematics teachers in the two schools and sampled form two students were used in the pilot study to check whether there was a need to adjust the research instruments. The questionnaires, observation schedules and interview schedule were tested out on the selected schools to determine workability, relevance and phrasing of the questions. This section discusses the validity and reliability of the data collection instruments used in the study.

3.6.1 Validity

The study employed content validity. According to Mugenda and Mugenda (2003) the usual procedure in assessing the content validity of a measure is through the use of professional or expert in that particular field.

3.6.1.1 Questionnaires

Teacher and student questionnaires were assumed to be valid since they were adapted from existing questionnaires from TIMSS where they had already been used in collecting data from teachers and students in mathematics and sciences. During the pilot study, minor adjustments were done on questionnaires in consultations with the experts.

3.6.1.2 Interviews

Teachers and students interview schedule were validated by comparing them to corresponding teacher questionnaires which were found to be valid. This kind of comparison is known as convergent validity. Since the two instruments (teacher’s and student’s interview schedules) were equivalent, it was assumed that the interview schedules were valid as they were comparable to the proven validity of the corresponding instruments (Cohen, Manion and Morrison., 2007).

3.6.1.3. Class observation schedule

Classroom observation schedule was validated by comparing it with questionnaires. Adjustments were made on observation schedule in comparison with the questionnaires since the teacher questionnaires and student questionnaires were found to be valid.

3.6.2 Reliability

Since teachers' and students' questionnaires were adapted from existing questionnaires from TIMSS, both questionnaires were taken to be reliable and all other research instruments were compared to them and adjusted so as to be reliable.

3.6.2.1 Interviews schedule

The reliability of interview schedule was tested by comparing it with the corresponding teachers' questionnaires. Teacher interview schedule was compared to teachers' questionnaires and adjustments were done on it to be reliable. After comparison on both questionnaires and interviews schedules and necessary adjustments done the interviews were taken to be reliable.

3.6.2.2 Classroom observation schedule

Reliability of the classroom observation was also determined through a process of repeated usage in two different schools that were not part of the study coupled with adjustment until it was confirmed by the experts in my study that they are reliable.

3.7 Data Collection Techniques

A research permit was obtained from the National Commission of Science and Technology and Innovation (NACOSTI) after presenting an introduction letter of

Approval from Graduate school of Kenyatta University. A copy of the research permit and introduction letter from county director of education (Kisii county) was presented to sub-county director of education Kenyenya sub-county to seek authority to visit the sampled schools for the study.

During the visit of each of the ten sampled schools for data collection, permission was sought from principals before involving teachers and students. After getting permission from principals, the researcher delivered two sets of questionnaires (see Appendix I and Appendix II) which were to be completed by four mathematics teachers per school and twenty-seven form two students from each of the ten sampled schools. The researcher then made prior arrangement with each school when to conduct class observation and interviews during live mathematics lesson in form two class with a class mathematics teacher.

After collection of TQ, SQ and carrying out class observation and interviews with teachers, a single form two class was sampled for MM approach intervention, the researcher conducted a four-lesson using mathematical modelling approach on the topic of gradient and equation of a line to answer research question three of the study.

MM intervention was done with a class of 44 form two students. All the students had already covered the topic on gradient and equation of a line. The main concept on this topic was gradient. The general concept included equation of a line, gradient and variables. Since MM approach was based on this topic it was assumed that all students had a prior knowledge on the concept. During the intervention the researcher guided students and managed the class discussion necessary in MM approach in teaching.

During the first lesson, a pre-test on Gradient and Equation of a line was conducted. Students were given 40 minutes to complete the test. MM tasks on pretest and post-test were appropriate for form two students since these students had successfully covered the topic of gradient and equation of a line. The mathematics problems to be solved were also familiar to all students since all tasks contained basic situations of daily life. However, tasks on both tests were different from traditional non-routine problems since they provided opportunity to students to work in small groups and develop shareable ideas besides that they contained real-life situations and required interpretation of the results rather than making mathematical calculations only which is essential in MM tasks. This is because in a traditional mathematics class, students get engaged in mathematical exercises that usually contain calculations covering a concept taught by their teachers. However, tasks chosen in this case for data collection were beyond simple calculation and required students to think deeply and conceptualize about real-life situations.

In the second, third lesson and fourth lesson, students were given some brief information about MM. This information included the five MM cycles proposed by NCTM (2000). Students were then taken through a number of MM tasks prepared by the researcher where MM steps were followed carefully. Thus, after the researcher had taken students through MM tasks, students were arranged in a group of three and four and then were given MM tasks on gradient and equation of a line to solve as a group. In order to induce class discussion, each group was required to share their results with the entire class. This was to show students that the task given can have different method solution. After class discussion the researcher made his reservations concerning the task.

In the fifth and last lesson the students sat for a post-Mathematical Modelling test on gradient and equation of a line.

3.8 Data Analysis and Presentation

The data got from respondents were recorded in readiness for analysis. Kerlinger (1973) characterizes investigation as classification, requesting controlling and summing up information to get answers to explore questions Both quantitative and qualitative data obtained from respondents was analyzed and presented depending on the objectives of the study as follows:

In objective one, which sought to establish teachers' knowledge in MM in teaching and learning mathematics, quantitative data collected from TQ was analyzed by utilization of descriptive statistics utilizing SPSS version 20 and presented by use of percentages, mean, standard deviation and frequency tables. Data gathered using observation schedule which is qualitative in nature was investigated utilizing conceptual content analysis which is the most appropriate strategy for analysis. Conceptual content analysis is characterized by Creswell (2003) as a method for making inductions by efficiently and impartially recognizing explicit attributes of messages and utilizing similar way to deal with relate patterns.

Objective two, which sought to establish extent to which MM is used in teaching and learning mathematics in Kenyenya sub-county secondary schools, quantitative data collected using TQ and SQ was analyzed by the use of SPSS and presented through percentages, mean, standard deviation and frequency. The information was displayed through frequency tables and charts.

In objective three, which sought to compare the relationship between teaching using MM approach and students' achievement in mathematics, the study used inferential statistics (correlations) to analyze the relationship that exist between MM instruction and students' achievement in mathematics. SPSS was used to analyze the quantitative data obtained from pre-test and post-test where the Paired t-test sample was run with significant (p-value) set at 0.05 to compare the significance level between the two tests.

3.9 Logistical and Ethical Considerations

It is commonly concurred that any exploration including human members must satisfy fundamental moral guidelines. Taking into account this, research morals is critical in any examination. Subsequently, the specialist guaranteed that adequate conduct over the span of the examination study was maintained. As per McNabb (2004), research morals ought to apply at four-stages of research, that is the arranging stage, information gathering stage, the preparing and understanding of information stage and the spread of the examination results stage.

To guarantee that the analyst followed the code of morals, all members were educated regarding the nature and motivation behind the examination. They were guaranteed that lone the individuals who will elect to partake in the exploration will be chosen. They were guaranteed that their interest in the examination was deliberate, and that they reserved an option to decline to partake and the option to end their association whenever without punishment. Members were educated regarding the motivation behind the examination before they consented to participate. In like manner, to evade conceivable damage to the members, information about them stayed private. The names of the members and the names of their schools were not uncovered in the investigation rather codes were utilized rather than their names.

In addition, convention was watched both in acquiring authorization to direct the examination and while mentioning members' consent to be essential for the investigation. Since the examination included instructors and understudies at different secondary schools, formal methods were trailed by mentioning authorization from Kenya's National Commission for Science, Technology and Innovation (NACOSTI) (see Appendix IX) to direct research in schools. At long last, information was not misrepresented and all discoveries announced in the investigation were as uncovered by the consequences of information gathered.

CHAPTER FOUR

FINDINGS, INTERPRETATIONS AND DISCUSSIONS

4.0 Introduction

This study sought to establish mathematical modelling approach and learners' conceptual understanding of mathematics at secondary school level in Kenyenya sub-county in Kisii county, Kenya. In this chapter, data collected is presented, analysed and discussed in regard to the objectives of the study. The study sought information from teachers and students using questionnaires and class observation schedule and interview schedule. Data analysis, presentation of the findings and discussion were guided by the following objectives of the study:

(a) To establish mathematics teachers' knowledge in MM approach.

(b) To establish the extent to which teachers in Kenyenya sub-county uses MM as an instructional strategy in teaching and learning of mathematics.

(c) To establish the relationship between MM approach and students' performance in mathematics.

The findings of the study were discussed in light of literature related to MM approach and learners' conceptual understanding of mathematics in Kenyenya sub-county, Kisii county, Kenya.

4.1 Demographic information of the respondents.

Demographic information has a great bearing on the interpretation of data collected on various objectives of the study. Demographic characteristics of respondents was based on the gender of both teachers and students, teachers' highest qualification and attendance of in-service courses by teachers.

4.1.1 Distribution of respondents by gender

Out of the total number of teachers sampled to participate in the study 30% were female while 70% were male. This is shown on table 4.1

Table 4.1 Teachers' gender composition (n=40)

Gender	Number	Percentage	Valid Percentage
Female	12	30.0	30.0
Male	28	70.0	70.0
Total	40.0	100.0	100.0

From table 4.1, the findings of the study revealed that 70% of the teachers' population in Kenyenya sub-county consisted of male teachers while 30% consisted of female teachers. The high number of male teachers than female teachers could be as a result of more male than female students joining colleges and universities to train as mathematics teachers hence more male teachers than female teachers. Other factors would be more male students preferring to take mathematics related courses than their female colleague students. The finding of the study also revealed that on the other hand, 55.6% of students sampled for the study were male while 44.4% were females. This is shown on table 4.2.

Table 4.2 Students' gender (n=270)

GENDER COMPOSITION				
Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	120	44.4	44.4	44.4
Male	150	55.6	55.6	100.0
Total	270	100.0	100.0	

Table 4.2, discloses that male students consisting of 55.6% of the students' population are more than their female counterparts also consisting of 44.4% of the students' population. Gender disparity in both teachers and students could also be attributed to a high number of male than female students that transition from primary to secondary schools which consequently affect the number of female and male training as teachers. Other factors contributing to disparity is cultural practices, that disadvantage the girl-child in education acquisition as compared to the boy-chid, such as early marriages.

4.1.2 Teachers' highest qualifications

Teachers' qualification, in mathematics teaching as a profession, has a great influence on students' performance in mathematics. According to Leczko-Kerr and Berlier (2002), students taught by qualified teachers scored better in mathematics achievement than those taught by unqualified teachers. Therefore, it's against this background that the researcher sought information on teachers' highest qualification as far as mathematics teaching in high school was concerned. Teachers through TQ were requested by the researcher to indicate their highest academic qualifications. The findings of study revealed that more than 90% of teachers in Kenyenya sub-county are qualified to teach mathematics as far as teacher's professional qualifications is concerned in Kenyan secondary school curriculum. The results are shown on table 4.3

Table 4.3 Teachers' Highest Qualifications

Qualifications	Frequency	Percent	Valid Percent	Cumulative Percent
Untrained graduates	3	7.5	7.5	7.5
Diploma	10	25.0	25.0	32.5
Bachelor's Degree	24	52.5.0	52.5.0	85.0
Master's Degree	6	15.0	15.0	100.0
Total	40	100.0	100.0	

From table 4.3, the data analysis indicates that 92.5% of mathematics teachers' population in Kenyenya sub-county are qualified to teach mathematics in secondary schools while 7.5% are not qualified since they have not met the minimum qualifications to teach mathematics in high schools. From table 4.3, 10% of teachers have a Diploma in education, 52.5% of teachers have a Bachelor's degree in education, 15% have Master's degree while 7.5% of teachers have no professional certification in education. This revelation means that majority of teachers in Kenyenya sub-county are qualified to teach mathematics. However, despite the fact that majority of teachers are qualified, the issue still remains about teachers' teaching approach and teacher-students ratio as informed by the poor performance of mathematics in the sub-county.

4.2 Teacher's Knowledge in Mathematical Modelling

The first objective of the study was to establish mathematical teachers' knowledge in MM approach in teaching and learning of mathematics in Kenyenya sub-county. To establish this objective of the study, the researcher collected data from teachers and students and analysed it based on the following themes.

4.2.1 Teachers' attendance of in-service professional workshops

In-service workshops (inset) are expected to expand instructors' substance information and to assist them with handling their study hall PS in mathematics to boost student' understanding of mathematics concepts. Teachers who devote more time to in-service training programs are more likely to develop better instructional strategies (Parsad et al., 2001). It is against this background that the researcher sought information from teachers to ascertain whether they had attended a pre-service training to improve their mathematical content knowledge and various instructional pedagogies. Thus, based on these views, teachers were requested to indicate on the TQ their attendance of in-service courses on mathematical content knowledge, mathematical pedagogy, students' PS skills and mathematical assessments.

The results of data analysis revealed that more than 60% of teachers had, for the last two years, never attended in-service courses on mathematical content knowledge, mathematical pedagogy, improving students' PS skills and mathematical assessments. This is shown on table 4.4.

Table 4.4 Teacher' In-service Programs (n=40)

Item	Statement	Yes	No	Mean	Std Deviation
1	Mathematics content knowledge	40%	60%	1.60	.503
2	Mathematical pedagogy	20%	80%	1.80	.410
3	problem- solving skills	15%	85%	1.85	.366
4	Mathematics assessment	40%	60%	1.60	.503

From table 4.4, the finding of data analysis shows that 40% of teachers have had a training on mathematics content knowledge while 60% have never had any training on the same for the last two years. On the other hand, less than 20% of teachers attended mathematical instructional pedagogy while 80% have never had an opportunity to attend the same. The same trend is also demonstrated PS, where only 15% of teachers have had opportunity to attend in-service in student PS while 85% have never had a training on the same. It also emerged that 60% of teachers have never had any training in mathematical assessment for the last two years. Inadequate knowledge in mathematical instruction skills act as obstacles in MM approach when teaching mathematics. This is because according to Chazan and Ball (1999), MM approach in class requires a versatile style of guidance where educators needs to comprehend the association of numerical thoughts in an assignment and change their instructive procedures to enlarge the usage of the methodology in-class. Expertise in MM should be replicated in what teachers can do and what they can see in teaching, learning and PS situation so that their intervention, while students engage in MM, will be effective.

Teachers who have adequate knowledge in various instructional strategies like PS are able to come up with strategies to overcome obstacles that crop up as students move from the beginning to the end of MM problems (Ferri, 2006). This study thus, is in line with Widjanja (2013) who found out that teachers who never had an opportunity to attend pre-service training courses lacked adequate knowledge when administering MM approach in teaching mathematics in class. MM approach demands teachers' ability in broad knowledge on various instructional strategy so that a teacher is able to integrate real-world problems into classroom mathematics and in the selection of MM task in class as part of students' mathematics assignment or exercise when teaching mathematics. For effective teaching and learning of mathematics, teachers require content knowledge, pedagogical knowledge and PS solving skills. Teachers' knowledge influences the depth of teaching and in turn the quality of learning. Teachers' adequate knowledge in MM can be supplemented through in-service education and training programmes.

4.2.2 Teacher's use of mathematics textbook in teaching MM

According to Shulman (1986) and Ball (2000), though teachers have materials and resources in form of textbooks containing collections of modeling and application activities, lack of adequate knowledge in MM may inhibit the potential teacher of MM from structuring and engaging students with meaningful and effective MM learning experience. MM requires prospective teacher to be qualified both in modeling competence and pedagogical knowledge thus teachers should not depend entirely on textbooks. Boaler (2002) avers that learners separate their numerical information in formal school science and casual school in regular arithmetic exercises and cannot associate the two. Learners are additionally incapable to tackle issues which require a mix of genuine information and school arithmetic and they neglect to move formal numerical information to real-life problems. However, much textbooks might be at teachers' disposal, mathematics teachers should not entirely rely on textbooks in applying MM approach when teaching mathematics. It's against this background that the researcher sought to find out how teachers use mathematics text books in teaching and learning of MM. The results are as shown on table 4.5.

Table 4.5 Teachers' Use of Mathematics Textbook (n=40)

	Frequency	Percent	Valid Percent	Cumulative Percent
Primary basis	32	80.0	80.0	80.0
Supplementary Resource	8	20.0	20.0	100.0
Total	40	100.0	100.0	

On table 4.5, the findings of the study disclose that 80% of mathematics teachers in Kenyenya sub-county uses mathematics textbooks primarily as their source of information and guidance when teaching mathematics in class while 20% use mathematics textbook as a supplementary source of information when teaching mathematics. Most examples in mathematics textbook might not reflect much on real-world everyday situations that a learner might be familiar with but a teacher who is competent in MM needs to come up with MM task and mathematics textbook used to supplement his ideas or guide him in the selection of tasks. Therefore, this is the reason why teachers with adequate knowledge in MM do not put mathematics textbook at the centre when teaching MM. Skilled teachers in MM are able to draw their examples from students' real world and integrate it during teaching and learning of MM.

This study is in support of Wu (2011) argument that mathematics textbooks employ analogies and symbols and half-explanations that are not realistic with students' real-world experience. Teachers' overreliance on textbook can be deduced as lack of adequate knowledge in MM, MM require teachers to adopt more adaptive styles of instruction this is because according to Zbiek and Conner (2003) majority of textbook modeling problems consist of word problems, they may include few application problems but rarely contain any actual MM task. Typical mathematical curricular focuses on students learning a particular skill and will present problems to encourage students to solve them in a certain way.

Over reliance on the textbook by teachers makes learning of mathematics boring and totally abstract to learners hence making learners to develop a negative attitude towards the subject resulting to poor performance. Inclusion of real-world examples while teaching mathematics makes the subject not only interesting to learners but also meaningful to learners. Teachers' adequate knowledge in mathematical modelling enables them to go beyond textbook and assist learners to see that mathematics is all about their day-to-day activities by ensuring that mathematics is real to students through inclusion of real-life examples from students' immediate environment which might not be the case with most of the textbooks.

4.2.3 Teachers' application of mathematical modelling approach in class

According to Doerr (2007), implementing MM approach in class is not straight forward and teachers need new pedagogical strategies when applying MM approach in class. This is because teachers are probably going to experience different methods of students' reasoning and difficulties that students may have when learning arithmetic through MM approach in class subsequently, instructors need to tune in to students, comprehend and decipher understudies' assorted intuition routes so as to react with helpful introductions.

Also, educators need to gadget new instructive systems to place students in a circumstance to decipher, clarify, legitimize and assess the fittingness of their reasoning ways instead of giving them clarifications. Thus, it is against this background that the study using TQ explored teachers' knowledge in MM strategies in class when teaching mathematics. Teachers were requested to indicate how often they apply various strategies while teaching mathematics in class.

The findings of the study from data analysis revealed that less than 25% of teachers teach students by engaging them in high level mathematics cognitive activities, which is part of MM approach in class, while more than 70 % of teachers said they rarely put into practice the approach or have never engaged students in such kind of activities in class. According to Smith and Stein (2011), teachers need to be prepared not to teach the one correct way to do a problem but rather need to be able to anticipate multiple ways to approach a problem and connect different tasks. This is because high level cognitive tasks such as MM learning activities do not lead students to answer a question on the same way, thus teaching using MM requires teachers to use a different kind of non-traditional approach. The findings of data analysis are shown on table 4.6:

Table 4.6: Teaching using Mathematical Modelling approaches

	Statement	Every almost lesson	About half the lesson	Some lesson	Never	Mean	Std. Deviation
1	Relate what they are learning to their lives	10%	15%	25%	50%	3.15	1.040
2	Decide on their own procedure for solving complex problems	5%	10%	20%	65%	3.45	.887
3	Work on a problem from real -world for which there is no immediately obvious method for solution	0	5%	25%	70%	3.40	.821
4	Work together in small groups to solve non routine problems from real-world to find real-world solutions	5%	20%	30%	45%	3.05	1.050

From table 4.6, the findings of the study show that more than 75% of teachers do not teach by guiding their learners to relate what they are learning in mathematics to their daily lives while only less than 25% of teachers in Kenyenya sub-county guide students to connect mathematics to their daily lives. On the other hand, 15% of teachers allow students to decide on their own way on how to solve complex problems in mathematics while more than 85% of teachers interfere with students when solving complex mathematical problems. Less than 25% of teachers engage their students in MM tasks in class, these MM activities include arranging students in small groups to work together to solve real-world problems or assigning students MM tasks as a class assignment. On the other hand, 75% of teachers have never engaged their students in such kind of activities in class. This could mean that more than 75% of teachers lack adequate knowledge in MM.

In a class where MM is applied in teaching, group work is essential. Group work, class discussion and cooperation are especially encouraged during MM activities. This is because students clarify their ideas and develop their argumentation and communication skills in mathematics context while working with colleagues (Swan et al, 2007). Therefore, a teacher who has adequate knowledge in MM approach is expected to involve students in MM activities such as giving students open mathematical tasks, relating students' mathematics activities to students' daily activities and organising students into small groups to solve tasks that do not have obvious answers. This study, therefore, is in line with Biembengut and Hein (2010) who posited that majority of teachers are not happy with vulnerability in the classroom and consequently need practice on building up the abilities expected to take understudies through MM errands without furnishing them with an excess of help. This is on the grounds that educators sabotage the unpredictability of an errand by furnishing learners with a lot of help and clarification as opposed to requiring the learners to create mathematical speculation by giving their own clarifications.

4.2.4 Teachers' understanding of mathematical modelling

The study sought to establish teachers' understanding of MM as an instruction strategy in teaching mathematics. This is because for a teacher to apply MM in class it requires the teacher, first of all, to know the meaning and process of MM. Teachers will also need to differentiate MM from traditional word problem that is commonly practised in most mathematics classroom. MM activities are less structured than word problems. MM tasks usually lack: clear problem statement; suggested variables; and mathematical statements that will quickly lead to solutions. This deficiency results to a mess problem-solving situation that require students to make their own choice and assumption which can alter the problem-solving process and result in different paths and solution for each student (Maaß, 2006).

Application of MM in class requires a potential teacher of mathematics to have adequate knowledge and understanding of MM before adopting it in class. It's against this background that teachers were required to respond to the questionnaire about their understanding of MM in relation to teaching and learning of mathematics in school. Data analysis of teacher's response revealed that majority of teachers (85%) have no idea of what MM is all about. MM to the respondents was a new term especially as an instructional strategy in teaching mathematics. The results of teacher's response to TQ are indicated on table 4.7.

Table 4.7 Teachers' understanding of Mathematical Modelling (n=40)

Response on meaning of mathematical modeling approaches

Statements	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Teaching based on relating mathematics to its application in real-life situations	6	15.0	15.0	15.0
Teaching based on memorization and recall of facts and procedures	10	25.0	25.0	40.0
Any other	24	60.0	60.0	100.0
Total	40	100.0	100.0	

Table 4.7, shows that only 15% of teachers were able to give out a definition of mathematical modelling, 25% had a wrong definition of the term while 60% had no idea of what mathematical modelling was all about. This could mean that more than 85% of teachers in Kenyenya sub-county had no idea of what MM approach is as an instructional strategy in teaching and learning of mathematics. Lack of knowledge in what MM means that teachers have no knowledge in MM approach is as a teaching strategy in teaching mathematics, Therefore, more than 85% of teachers in Kenyenya sub-county cannot be

in a position to give a definition of MM which means that they have no knowledge in MM.

4.2.5 Teacher's Instructional Approach in Mathematics Class

According to Cohen et al. (2007), observation enables researchers to gather live data from naturally occurring social situations. Thus, it's against this background that the researcher observed ten mathematics teachers to assess their knowledge in MM while teaching mathematics in class. The findings of the study from class observations revealed that teachers relied much of their teaching on the textbooks and most of learning in class was teacher-centred with teachers doing almost every mathematics activity in class. Teaching was less focused on the learner. Students' personal construction of knowledge was given little time in the classes. When teachers gave a task to students to handle, they provided too much support that the task lost the role it was intended to play in students' understanding of concept learned. Almost all teachers observed followed formulaic method of instruction.

Eight out of ten teachers observed by the researcher gave a brief explanation of the concept to be studied followed by an example from the book which did not contain any real-word mathematics problem and then students were assigned a similar task to attempt. There was no instance where teachers used any task that was open and required more than one approach to find a solution. This study therefore is in tandem with Leikin (2003) study which found out that when teachers use world problem, they tend to present a stereotypical solution to the students, grouping problem according to the type of solution required without necessarily considering alternative methods of solving the task.

Teachers' type of instruction focuses the instruction on a particular method or strategy rather than on investigating the problem.

Teachers interviewed also indicated that they have no knowledge of how MM is used in class. However, they have been using application questions in mathematics but they all follow formulaic procedure where the teacher expects a particular answer. They all admitted that they have never used open ended task from real-world which can have multiple approach towards finding a solution in real world using mathematical models and manipulations.

4.3 Extent of teachers' use of Mathematical Modelling in Teaching mathematics

The second objective of the study was to establish the extent to which teachers use MM approach in teaching and learning of mathematics in Kenyenya sub-county. To establish this objective of the study, the researcher collected data from both teachers and students using TQ and SQ and class observation schedule. Collected data was analyzed based on the following themes:

4.3.1 Teachers' method of instruction in a mathematics class.

According to Doerr (2007), there are some strategies that a teacher can put in place while teaching mathematics in class that supports MM approaches, though these teaching practices are not specific to MM approach but they are part of MM. Strategies for high cognitive demand task and for mathematical discourse may apply during MM. In addition, there is a framework for teaching that is specifically oriented towards teaching using MM approach. Thus, it's against this background the researcher sought information from teachers concerning their mathematics teaching strategies in class. This was necessary because the researcher wanted to know how often teachers apply various instructional strategies in a mathematics lesson. Data analysis revealed that more than 70% of teachers in Kenyenya sub-county engage their students in lower-level mathematics learning activities which only demands procedures without connections while less than 25% of teachers only try to involve students in high-level cognitive learning activities. The results are as shown on table 4.8

Table 4.8 Teachers' Mathematical Modelling Approaches in class (n=40)

	Statement	Every almost lesson	About half the lesson	Some lesson	Never	Mean	Std. Deviation
1	Interpreting data on tables, charts or graphs	70%	10%	20%	0	1.60	.821
2	Write equations and functions to represent relationships	65%	15%	15%	5%	1.45	.759
3	Memorize formulas and procedures (reversed)	45%	25%	20%	10%	1.95	1.050
4	Apply facts, concepts and procedures to solve non-routine problems	15%	25%	40%	20%	2.65	.988
5	Explain their answers	5%	15%	30%	50%	3.25	.910
6	Relate what they are learning to their lives	10%	15%	25%	50%	3.15	1.040
7	Decide on their own procedure for solving complex problems	5%	10%	20%	65%	3.45	.887
8	Work on a problem from real-world for which there is no immediately obvious method for solution	0	5%	35%	60%	3.40	.821
9	Work together in small groups to solve non routine problems from real-world	2.5%	12.5%	30%	55%	3.05	1.050

From table 4.8, more than 75% of teachers teach mathematics in class by requiring their students in almost every lesson of mathematics to interpret data on tables, charts and graphs and also in writing equations and functions to represent mathematics relationships.

While 70% of teachers almost in every lesson of mathematics teach by requiring their learners to memorize mathematics formulas and procedures. This means that more than 70% of teachers in Kenyenya sub-county engage their students in low level learning mathematics activities that do not support MM approach as an instruction strategy in mathematics teaching. This study therefore is in line with Silver, et al (2009) study on the analysis of National Board application where teachers were asked to submit a sample lesson that demonstrated a deep level of mathematics understanding and it was established that most lessons submitted by teachers required only low- level rote learning activities.

Teachers' response on questionnaire further disclosed on table 4.8 that less than 40% of teachers require students to apply facts, concepts and procedures to solve non-routine problems and also explain their answers in mathematics lesson in almost every lesson of mathematics while less than 25% of teachers get their students in almost every lesson of mathematics to relate what they are learning in mathematics to their lives outside school and in class to decide on their own procedure for solving complex mathematics tasks. The table also indicates that 80% of teachers in Kenyenya sub-county never involve their students to work on problems for which there is no immediate obvious method for finding a solution nor working together in small groups to solve non-routine problems. Majority of teachers rarely presents their students with challenging mathematical activities that requires deep mathematical thinking. These findings concur with Leikin (2003) argument that teachers rely heavily on their own mathematics experiences which for the most part includes little or no MM at all, this is because many of them are uncomfortable with MM problems where there are multiple approaches for solving the problem and in some cases multiple correct solutions.

4.3.2 Application of Mathematical Modelling in Outdoor Activities

The researcher sought information from teachers concerning application of outdoor MM learning activities in students' assignment. This involves assigning students simple MM activities where teachers ask students to identify a problem in the real-world then translate the problem into mathematical terms using mathematical models. Then using known mathematical algorithms, the student will solve the mathematical problem into mathematical solution after which the students translate the mathematical solution into real-world solution (Ang, 2009). In this activity, students are expected to make genuine choices about what is important and decide what mathematical procedures to apply and then determine whether their solutions are useful within real-world situations

MM activities provide an opportunity for students to develop and practice mathematical related skills hence communicating their understanding and interpretation of the real-world problem into real-world solution. Thus, it's against this background that the researcher wanted to establish the frequency at which teachers apply MM outdoor activities in mathematics class. Data analysis of teachers' response disclosed that only less than 10% of teachers get to involve their students in outdoor mathematical modeling activities while more than 60% of teachers never get to include modeling activities in students' assignment completely. The results of the data analysis are shown on table 4.9.

Table 4.9 Application of Mathematical Modelling Activities in outdoor (n=40)

Item	Statement	Always	Some Times	Never	Mean	Std. Deviation
1	Identifying a problem in real-world and finding real-world solution using mathematics	5%	25%	70%	2.55	.605
2	Finding one or more applications of the content covered in class in real-world to find a solution	10%	15%	75%	2.50	.688

From table 4.9, the mean of teachers giving students mathematics assignment containing MM activities where students are required to identify a problem in real-world and using mathematics to find a real-world solution is 2.55 while standard deviation is 0.605 which means that more than 70% of teachers have never practised it in class. This is also indicated on the table that only 5% of teachers require students to apply mathematics in real-world situation to find real-world solution. On the other hand, table 4.9 shows that only 10% of teachers engage their students in finding one or more applications of the content covered in mathematics class in real-world situations to find a solution in real-world situations while more than 75% of teachers have never applied the approach in their mathematics class. This study concurs with Wu (2011) study which found that many teachers have relied on textbook school mathematics (TSM) where students are made to feel that what is learned in one year can be forgotten in the next year. According to Wu

(2011) TSM employs analogies and metaphor and half – explanations. That most teachers rely on and do not extend mathematical content in class to real world situations. MM approach requires a shift in thinking where teachers use different teaching and learning strategy to extend concept learned in class to real-world situations.

4.3.3 Students' Experience of Mathematics Learning Activities in Class.

This section sought information from students using SQ on how they learn mathematics in class. The intention was to compare and confirm the information given by teachers on the TQ about the extent of using MM approach in the teaching and learning of mathematics in Kenyenya sub-county. Students were requested to indicate whether they strongly agree (SA), agree (A), disagree (D) or strongly disagree (SD) on various mathematics learning activities they practice in class. The results of data analysis revealed that more than 70% of students learn mathematics using lower-level which requires procedures without connections while less than 27% of students learn mathematics using high-level strategies which involves making connections, analysing information and drawing conclusions which supports MM approach in learning mathematics. There is little of learners' involvement in the learning process as everything is done by teachers and students' role is that of taking instruction from teachers and putting them into action. The results are as shown on table 4.10.

Table 4.10 Students' Mathematics learning experience (n=270)

Items	Statement	SA	A	D	SD
1	We interpret data on tables, charts and graphs.	35%	50%	10%	5%
2	We write equation and functions to represent relations.	55%	40%	5%	0
3	We memorize formulas and methods.	40%	30%	25%	5%
4	We listen to the teacher as he/she does everything in mathematics lesson.	30%	25%	26%	19%
5	We explain our answers in mathematics	5%	14%	65%	16%
6	We relate what we are learning in mathematics to our daily life	7%	20%	54%	19%
7	We decide on our own procedure for solving complex problems	15%	16%	41%	28%
8	We work on problems in small groups	17%	21%	40%	22%
9	We work on problems from real-world for which there are no obvious answer	0%	5%	20%	75%

From table 4.10, More than 85% of students participate in a mathematics class by interpreting data on tables, charts and graphs when learning mathematics while 95% of students engages in writing of equations and functions to represent relationships in mathematics. On the other hand, 70% of students learn mathematics through memorisation of formulas and procedures while 55% listen to their teachers as they do everything in class while taking no active part. This means that majority of teachers involve learners in low level rote learning mathematics activities which does not require deductive reasoning in mathematics. This type of learning does not challenge students' mathematical thinking abilities which is the case with MM teaching approach. This is one-way mathematics learning methods where the teacher is the only source of knowledge and does everything in class while the students passively receive knowledge by memorisation of formulas and procedures in mathematics.

Table 4.10 also shows that very few teachers ask their students to explain their answers in mathematics (17%) nor relate what they are learning in mathematics to their daily life (37%) hence mathematics learning in majority of schools in Kenyenya sub-county is teacher-centred. In addition to this, less than 31% of teachers give students problems that require their own way of solving them with a variety of solutions. The same applies to organising students into groups for discussions (38%), where teachers are expected to organise learners in small groups for deeper understanding of concept learned in class. Group work, class discussion and cooperation among students and teachers are especially encouraged during MM, students clarify their mathematical ideas and develop their argumentation and communication skills in mathematical context while working with peers (Lesh & Doerr, 2003). However, this is not possible from table 4.10 where majority of teachers in Kenyenya sub-county secondary schools use traditional methods of instruction characterised by memorisation of formulas and procedures that do not promote students' independence in learning of mathematics, these revelations from students' response also supports Leikin (2003) study which found that teachers rely on their own mathematical experiences when teaching mathematics which in most cases includes little or no MM at all.

4.3.4 Teaching Mathematics Using MM Approach in Class

To confirm and supplement data obtained from questionnaires on the extent of teachers' use of MM in teaching and learning mathematics in secondary schools in Kenyenya sub-county, class observation was conducted. This is because according to Robson (2002) observation provides a reality check because what people do may differ from what they say they do. Data obtained from class observation of ten teachers in ten schools revealed that majority (60%) of teachers followed formulaic method of instruction where teachers stated a mathematical concept showed students what to do and then assigned similar task for practice. There was no instance at which teachers used MM tasks in class either during the lesson development or at the end of lesson as an assignment to students. Class observation also revealed that almost all (80%) teachers organised their lesson in a rather traditional way. Most of the time was covered by the teacher explaining the concept to be studied and students had almost no active role in participation.

Table 4.11 Classroom Observation Feedback (n=10)

Teaching strategy	Frequency of teachers Observed (%)	Frequency of teachers not observed (%)
1. Explaining the concept to be learned	90%	10%
2. Demonstrating to students how the concept learned apply in real-life situation	40%	60%
3. Giving open ended task from real-world situation for student to attempt	0	100%
4. Organising students in groups to work on the task	20%	80%
5. Asking students to give situations where the concept apply in real life	30%	70%
6. Asking students to explain their solutions in real world	10%	90%

From table 4.11, it shows that 90% of teachers were able to explain to their students how the concept taught works in mathematics. However, only 40% of teachers observed were able to link the mathematical concept taught to real-life situation. 60% of teachers did not use real-life situations to link to mathematics taught in class. Table 4.11 also shows that of all (100%) teachers observed in a live mathematics lesson, no one of teachers either attempted nor assigned students an open-ended task from real-world situation that would require MM approach to solve either during lesson development or at the end of the lesson as an assignment. While in group discussion, which is pertinent in MM teaching and learning approach, only 30% of teachers organised students in class to discuss world problems from textbooks as an assignment whereas 70% of teachers teaching was one-way communication with teachers taking centre stage in learning thereby controlling most of the learning activities in class. On the other hand, only 30% of teachers observed required students to relate concept learned in class to real-life situation. However, 90% of teachers never asked their students to translate mathematics solution to real life solutions. Therefore, this study concurs with Gainsburg (2008) who revealed that teachers give students problems to solve expecting a particular solution and that educators will probably bestow numerical substance as opposed to in instructing understudies to pick a fitting strategy and apply different ideas to tackle the genuine issues in the world.

Teachers' lesson observation further revealed that there was over-reliance of teachers on the mathematics textbook when teaching mathematics. From the start of all lessons observed by the researcher to the end, everything teachers were teaching including their examples came from the textbook with little or no connection at all to learners' immediate world which didn't have any MM activities. These might mean that teachers' examples were meant to impart the content taught and not opening the students' mind to choose their own ways of solving problems using concepts covered during the lesson. Teachers presented mathematical tasks to students expecting a particular solution from students without much consideration of alternative methods of solving the same. Therefore, these findings are also in support of Zbiek and Conner (2006) who argued that majority of textbook modelling problems consist of word problems, that may include few application problems but rarely contains any actual modelling tasks.

4.4 Relationship between MM and students' performance in mathematics.

The third objective of the study was to establish the relationship between MM approach in teaching mathematics and students' achievement in mathematics. To establish this objective, the researcher collected data from students using SQ and also carried out a single group pre-mathematical modelling test and post-mathematical modelling test to collect quantitative data on the impact of MM instruction on students' achievement in mathematics. A pre-test was applied to a single class of 44 students, then the class was exposed to MM instructional approach by the researcher after which a post-test was administered. Therefore, there was an opportunity to compare whether there was an impact of MM instructional approach on students' performance in mathematics. Data collected using SQ and pre-mathematical modelling test and post-mathematical modelling test were analysed using the following themes to respond to objective three of the study.

4.4.1 Students' Self-confidence in learning Mathematics.

According to Papanastasiou and Zembylas (2002), there exists a connection between students' belief and attitudes and students' achievement in mathematics. Students considered to be higher achievers in mathematics tend to have more positive attitude towards mathematics than students with low achievement. Subsequently, the opinion students build on the subject determine the level at which they get involved in mathematics and also what will be achieved in the subject. Therefore, it is against this background that the researcher asked students through SQ to indicate their confidence in doing mathematics in class. Data collected from students shows that more than 70% of students in Kenyenya sub-county neither have confidence in learning mathematics nor perform well in mathematics as a compulsory subject. Only less than 30% of students in Kenyenya sub-county can be considered to be confident in doing mathematics as their favourite subject and learn mathematics quickly hence perform better. This result is as shown on table 4.12.

Table 4.12 Students' Confidence in Learning Mathematics

Beliefs	**ITEM**	**LIKERT SCALE**			
		SA	A	D	SD
Self confidence in mathematics	I usually do well in mathematics	5%	21%	20%	54%
	Mathematics is not my favourite subject(reversed)	25%	50%	10%	15%
	I learn things quickly in mathematics	5%	25%	40%	30%

From table 4.12, data analysis indicates that majority (74%) of students in Kenyenya sub-county perform poorly in mathematics as in comparison to 26% of their colleagues. This is because 70% of students don't consider mathematics as one of their favourite subjects of study nor enjoy learning mathematics as quickly as compared to other subjects. This might be as a result of learning experience students undergo in mathematics class that do not motivate their learning of mathematics hence reason why most students lack confidence in learning mathematics. This could be attributed to learning experience students are exposed to in class during mathematics lessons by their teachers. This study therefore concurs with Lesh and Zawojewski (2007) argument that students' beliefs and attitudes toward mathematics are influenced by their experiences in the mathematics class and could therefore be influenced by changes in the teaching approach.

4.4.2 Students' Value in Learning Mathematics

According to Cobern (1996) teaching mathematics without relating it to real-life situations widens the gap between school mathematics and real-life situations hence making it harder for students to appreciate the value of studying mathematics in school. Thus, it was against this background that the researcher collected data from students on their held value in learning mathematics so as to get an idea on students' experience of mathematics. Data analysis revealed that more than 55% of students do not value learning mathematics in school. The results of data analysis are shown on table 4.13.

Table 4.13 Students' Value in Learning Mathematics

Belief	**ITEM**	**LIKERT SCALE**			
		SA	A	D	SD
Students' value in mathematics	Learning mathematics will help me in my future career	25%	35%	25%	15%
	Other subjects are important than mathematics.	5%	30%	40%	25%
	Mathematics is useful in life outside school	25%	30%	30%	15%
	Mathematics is a lot of procedures that have to be memorised.	35%	30%	15%	20%

From table 4.13, 55% of students think that learning mathematics is useful in life outside schools and therefore will help them in their future career while the other 40% feel that learning mathematics will not have any positive impact on their future careers. This means that more than half of the secondary school students in Kenyenya sub-county value mathematics as a subject that they will use in their future career development and opportunity. However, despite more than half of student's population valuing mathematics, 65% of students' population feel that learning mathematics is full of procedures that have to be memorised whereas 35% think that other subjects are more important than mathematics. Hence, this study supports Cobern (1996) argument that learners instructed in a customary manner (without the utilization of MM) comprehend science as a shut arrangement of images and fixed guidelines with no space for change and inventiveness. Teaching mathematics without relating it to genuine circumstances augments the hole between school arithmetic and genuine circumstance subsequently making it harder for understudies to value the benefit of contemplating arithmetic since to overlook its association with regular exercises intends to introduce math to the students as a negligible obligation.

4.4.3 Student's Attitude Towards Mathematics Learning

Attitude is a manner of acting, feeling or thinking that shows someone's disposition or opinion. Students considered as high achievers have positive attitude towards learning mathematics than students with low achievements. Students' attitude towards mathematics are influenced by their experience in mathematics class (Lesh & Zawojewski, 2007). Teachers' teaching approach in class plays significant role in shaping students' attitudes towards mathematics achievement. Learners educated in a conventional manner comprehend arithmetic as a shut arrangement of images and fixed guidelines with no space for change and inventiveness thus restricting understudies' comprehension of what science is and makes it hard for understudies to associate arithmetic to regular problem solving activity (Boaler, 1999). Thus, it's against this background that the researcher collected data from students to evaluate their attitude towards mathematics so as to evaluate their experience in learning mathematics. Students' response on SQ revealed more than 64% of students have negative attitude towards learning mathematics. The results are as shown on table 4.14.

Table 4.14 Students' Attitudes Towards Learning Mathematics

	ITEMS	SA	A	D	SD
	I would like to take more mathematics	12%	24%	22%	42%
Attitude	I enjoy learning mathematics	12%	30%	23%	35%
	Mathematics is a boring subject.	18%	34%	34%	15%

Table 4.14 indicates that only less than 42% of students agree that they enjoy learning mathematics and would wish to take more mathematics while on the other hand more than 56% of students neither enjoy learning mathematics nor ready to take more mathematics in the near future. This means that majority of students in Kenyenya sub-county see mathematics as a boring subject hence the reason why they don't enjoy learning mathematics (44%) which subsequently leads to large number of students deciding against taking any form of mathematics in their future careers. The negative attitude of students towards mathematics could be as a result of poor teaching method in class which leads to students losing interest in the subject leading to negative attitude towards the subject hence low achievement in mathematics. Thus, this study concurs with (SMASSE, 2008) argument that topics in mathematics in Kenyan secondary schools are often taught without any substantial reference to their applications to real life situations, thus making the subject boring hence students developing negative attitude towards the subject leading to low achievement in the subject.

4.4.4 Students' Mathematics Learning Experience in Class

Using SQ, students were requested to indicate their learning activities in class. The purpose of students' response was to evaluate the teaching approach teachers use in class while teaching mathematics. Data analysis revealed that more than 55% of students learn mathematics through traditional method which target low level learning activities which does not support students' cognitive developments. While only less than 27% of students get engaged in higher-level mathematics learning activities which helps to support students' cognitive developments. Higher cognitive learning activities supports MM which promote mathematics learning which leads to change of students' attitudes and beliefs in mathematics leading to higher achievements in mathematics. The result from data analysis are as shown on table 4.15.

Table 4.15 Students' Mathematics Learning Experience (n=270)

Items	Statement	SA	A	D	SD
1	We interpret data on tables, charts and graphs	35%	50%	10%	5%
2	We write equation and functions to represent relations	55%	40%	5%	0
3	We memorize formulas and methods (Reversed)	40%	30%	25%	5%
4	We listen to the teacher as he/she does everything in mathematics lesson (Reversed)	30%	25%	26%	19%
5	We explain our answers in mathematic	5%	14%	65%	16%
6	We relate what we are learning in mathematics to our daily life	7%	20%	54%	19%
7	We decide on our own procedure for solving complex problems	15%	16%	41%	28%
8	We work on problems in small groups	17%	21%	40%	22%
9	We work on problems from real-world for which there are no obvious answers	0%	5%	20%	75%

Data analysis on table 4.15, shows that more than 85% of students learn mathematics through interpretation of data on tables, charts and graphs in mathematics and also by writing equations and functions to represent a function in a mathematics class. The table further shows, on the other hand, that 70% of students learn mathematics through memorisations and listening to their teachers as he/she does everything in class. This type of learning targets low level cognitive ability of students since they cannot reveal students' multiple ways of thinking when students are solving mathematical problems which support students' cognitive development. Therefore, the reason why majority of students have negative attitudes towards mathematics resulting to low achievement. Table 4.16 further shows that less than 27% of students explain their answers in mathematics and also relate what they are learning in mathematics to their daily life. Whereas less than 38% of students learn mathematics by deciding their own ways of solving complex problems in mathematics and organised in small groups to work on problems from real world for which there are no obvious answer in mathematics. This revelation in learning mathematics in class means that majority of teachers use traditional instruction approach which does not support MM nor participatory learning leading to negative attitude of students toward mathematics leading to poor performance.

4.4.5 Impact of MM approach on students' achievement in mathematics test

To collect data on the impact of MM instructional approach on students' achievement in mathematics, the researcher conducted a single group pre-mathematical Modelling test and post-Mathematical modelling test on form two students who were sampled for MM intervention. A form two topic on gradient and equation of a line was picked for the intervention study. All students had already covered the topic with their regular class teacher. Therefore, since MM intervention was based on this topic it was assumed that all students had a prior knowledge on the concept of gradient and equation of a line. Both pre-test and post-test had four questions that contained similar questions in terms of mathematical concept and difficulty level and each test contained problems from real life situations. Each test took 40 minutes to be completed.

The researcher spent 5 class lessons to carry out the intervention. In the first lesson the researcher administered pre-mathematical modelling test to the students. Then three lessons were spent on MM instructions. During MM instructions, the researcher acted as a teacher whereby the lesson was organised in constructivist approach and student-centred approach. Students were taken through MM process on how to solve mathematical problems from real-life situation using mathematical concepts learned in class. Students later were given time to discuss MM task where they were organised in groups of three to four students. The researcher acted as a facilitator and once in a while the researcher intervened in their discussion to correct misconceptions. At the end of the three-mathematics lesson based on MM instructional approach, post-mathematical modelling test was administered.

The score of students on pre-mathematical modelling test and post-mathematical modelling test were first analysed to determine the distribution of the score on a normal curve before doing comparison of the two tests. Normal distribution of the data obtained from the two scores were calculated. The kurtosis and skewness were determined. Data obtained from pre-mathematical modelling test, the kurtosis values was 0.776 and skewness was 0.768. On the part of post-mathematical modelling test, the kurtosis value was 0.0456 and skewness value was -0.768. The results are shown on table 4.16

Table 4.16 Skewness and Kurtosis of Students' Score

Category of test	**N**	**Min**	**Max**	**Mean**	**SD**	**Skewness**	**kurtosis**
Pre-MM test	44	5	26	17	6.62	0.768	0.776
Post-MM test	44	13	34	26	8.33	-0.768	0.045

Since kurtosis and skewness values were between -1 and 1, it was accepted that the data had normal distribution (George & Mallery, 2003). Thus, it was accepted that parametric test assumption was held hence analysis continued with paired t-test analysis to compare the mean score between students' scores on the test before they were exposed to MM teaching approach and after they were taken through MM instructional approach.

In order to compare students' score on the pre-mathematical modelling test and post-mathematical modelling test, paired sample t-test was run with significant (P-value) set at 0.05. Data analysis revealed that there was positive significance difference on students' performance between pre-mathematical modelling test and post-mathematical modelling test. The results are shown on table 4.17.

Table 4.17 T-Test Analysis of Pre-MM Test and Post-MM Test Score

Category of test	**Mean**	**N**	**SD**	**T**	**Df**	**P**
Pre-MM test	17	44	6.62			
Post-MM test	26	44	-8.33	8.886	23	0.000867

From the table 4.17, there was significant difference between pre-MM test and post-MM test (t=8.886 and P<0.05). In order to determine the direction of the difference, the mean value of the test score were compared. The result showed that post-mathematical modelling score were significantly higher than pre-mathematical modelling score. The quantitative and qualitative results show that instruction based on MM has a positive impact on students' achievements in mathematics performance. The t-test analysis between pre-test and post-test analysis concluded that there was statistically significant difference between the two scores.

The increase in students' performance may be due to instruction based on MM approach. MM approach enabled students to think deeply on real-life situation and focus on the conceptual knowledge about mathematical concepts which were presented through MM approach. This examination, thusly, underpins an investigation done by Sokolowsk (2015) to explore the impact of applying MM approach on amending understudies' previously established inclination of the way toward advancing region encased by a line of fixed length. In the examination, it was uncovered that while 86% of learners dishonestly speculated that the rectangular territory encased by the line of fixed length will stay consistent before participating in the lab, the resulting undertaking of MM exercises provoked the understudies to address their perspectives. The examination uncovered that MM approach gives plentiful methods for reexamining learners' discernment to set up firm theoretical foundation for instigating a more thorough logarithmic way to deal with taking care of issues in mathematics.

Group work, as one of the road maps in MM approach, might have also contributed to students' performance in mathematics which probably enabled students to express their ideas more comfortably and also provided them with different method of finding solutions to the tasks given hence better performance in post-Mathematical modelling test than pre-Mathematical modelling test. Therefore, this study concurs with Swan et al (2007) argument that group work, class discussion and cooperation are especially encouraged during MM activities since they help students to clarify their mathematical ideas and develop their argumentation and communication skills in mathematics context while working with colleagues.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of the findings, conclusion and recommendations of the study. The purpose of the study was to investigate mathematical modeling and learners' conceptual understanding of mathematics at secondary schools. The study was guided by the following research objectives:

(a) To establish mathematics teachers' knowledge in mathematical modelling.

(b) To determine the extent to which teachers in Kenyenya sub-county use mathematical modeling as an instructional strategy in teaching and learning of mathematics.

(c) To establish the relationship between mathematical modeling approach and students' performance in mathematics.

These objectives of the study were achieved through the following research questions:

(a) What do mathematics teachers know about mathematical modeling?

(b) To what extent is mathematical modeling used in teaching and learning of mathematics?

(c) What is the relationship between the use of mathematical modeling and learners' performance in mathematics?

5.1 Summary of the findings

The study sought demographic characteristics of the sample population by gender of both students and teachers and teachers' highest academic qualifications. However, of the prime importance were the findings of the study as per the objectives. The summary of the findings is thus presented as follows.

In regards to teachers' highest qualifications, the study found that more than 90% of teachers teaching mathematics in Kenyenya sub-county meet the minimum qualifications to teach mathematics in secondary schools. However, 7.25% of teachers do not meet minimum qualifications thus not qualified to teach mathematics.

In regard to objective one of the studies, the findings of study revealed that more than 80% of teachers have got no adequate knowledge in MM. more than 60% of teachers have never attended in-service courses in mathematical pedagogy, mathematics curriculum, PS nor in mathematical content knowledge for the last 2 years of their teaching service. Inservice course are essential for teachers adopting MM instructional approach in class. This is because according to Ogbonnaya (2007) in-service workshops (inset) are intended to broaden teachers' content knowledge and to help them tackle their classroom PS in mathematics to boost student' understanding of mathematics concepts. Teachers who devote more time in in-service training programs are more likely to develop better instructional strategies (Parsad, Lewis, Farris & Greene, 2001). Similarly, according to Chazan and Ball (1999) application of MM in class requires more of adaptive style of instruction in which a teacher need to understand the connection of mathematical ideas in a task and adjust their pedagogical strategies.

In regard to teachers' use of mathematics textbook, the findings of the study revealed that more than 80% of teachers depend on mathematics textbook entirely in their teaching of mathematics lesson in class. While less than 20% of teachers besides relying on textbooks on their guidance on what to teach, they supplement it with mathematics activities from students' environment that contain MM activities. According to Zbiek and Conner (2003) majority of textbook mathematical problems consist of word problems that include little application of mathematical problems but rarely contains any actual MM task hence reason why it requires that teachers with adequate knowledge in MM will go beyond mathematics textbooks when teaching mathematics.

Concerning teachers' cognizance of MM approach as an instructional strategy in teaching mathematics, the findings of the study revealed that majority of teachers are not familiar with MM approach. Teacher have no idea of what MM is all about. Many teachers were not in a position to give clear details of what MM is nor how the approach is used in mathematics as an instructional strategy. Only less than 15% of teachers were in a position to explain what MM entail as a teaching strategy in mathematics. The findings of the study also revealed that almost all teachers followed formulaic method of instructions where teachers were showing students a mathematical concept to be learned then gave similar mathematics activity and expected student to follow same produce to arrive at a solution as expected by teachers, hardly teachers used open real-world mathematics task in class. No situations in mathematics class teachers ever developed or applied MM approach in their instructions.

On objective two which sought to establish the extent at which mathematics teachers in Kenyenya sub-county uses MM approach in teaching mathematics, the findings of the study revealed that more than 75% of teachers have never put into practice MM approach in class. The high numbers of teachers not practicing MM was deduced to lack of adequate knowledge in MM. Thus, this study concurs with Biembengut and Hein (2010) that the main difficulty with using MM in the classroom is the lack of experience of teachers. Majority of teachers as researches have indicated are not comfortable with uncertainty in the classroom and therefore need practice on developing the skills needed to take students through these tasks without providing them with too much assistance. 80% of teachers were found to be engaging students in low-level cognitive mathematics learning activities which does not support MM approach as an instruction strategy. These activities include students memorizing mathematical formulas and procedures, interpreting data on tables and charts, writing equations and functions to represent a relationship in a mathematical problem. Thus, the study supports Leikin (2003) argument that majority of teachers rely so heavily on their own mathematical experiences which for the most part includes little or no MM at all, this is because many teachers are uncomfortable with mathematical problems that requires multiple approaches for solving problems.

Concerning application of MM in outdoor activities, the finding of the study revealed that less than 10% of teachers engage students in MM learning activities outside class while more than 80% of teachers have never involved students in using MM approach in activities outside class. Thus, the study concurs with Wu (2011) who argues that majority of teachers engage students only on text book school mathematics. That most teachers rely on mathematics text books and do not extend mathematical content in class to real world situations. MM approach requires a shift in thinking where teachers use different teaching and learning strategy to extend concept learned in class to real-world situations.

The finding of study from teachers' observation revealed that almost all teachers followed formulaic method of instructions, where teachers stated a mathematical concept showed students what to do and then assigned similar task for practice. There was no instance at which teachers used MM approach in class either during the lesson development or at the end of lesson as an assignment to students. Teachers were found to be organising their lesson in a rather traditional way where most of the time was dominated by the teachers controlling learning and students had almost no active role in learning. Therefore, this study concurs with Gainsburg (2008) study, that teachers give students problems to solve expecting a particular solution and that teachers' goal is to impart mathematical content rather than in teaching students to choose an appropriate method and apply various concept to solve the real-life problems in the world.

The third objective of the study sought to establish the relationship between MM instructional approach and students' performance in mathematics. The finding of study revealed that more than 80% of students learn mathematics through traditional method approach which consists of following mathematical procedures shown by their teachers and doing similar mathematical activity to arrive at a solution expected by their teachers. Thus, this study concurs with (SMASSE, 2008) argument that topics in mathematics in Kenyan secondary schools are often taught without any substantial reference to their applications to real life situations, thus making the subject boring hence students developing negative attitude towards the subject leading to low achievement in the subject.

In regards to impact of MM approach on students' achievement on mathematics, the study findings reveal that there was slight improvement on students' performance in mathematics test when they were exposed to MM instructional approach. Students' performance in post-mathematical modelling test was higher as compared to their performance in pre-mathematical modelling test. The t-test analysis conducted between the two test, pre-mathematical modelling test and post-mathematical modelling tests concluded that there was statistically significance difference between the two scores ($t=8.886$ and $P<0.05$). where in this case students performed better in the test after MM instruction as compared to before instruction based on MM. This study consequently supports Sokolowsk (2015) study which found that application of MM approach improved revising of students' preconception of the process of optimizing area enclosed by a string of fixed length. In the study, it was revealed that while 86% of learners dishonestly speculated that the rectangular territory encased by the line of fixed length will stay consistent before participating in the lab, the resulting undertaking of MM exercises provoked the understudies to address their perspectives. The examination uncovered that MM approach gives plentiful methods for reexamining learners' discernment to set up firm theoretical foundation for instigating a more thorough logarithmic way to deal with taking care of issues in mathematics.

5.2 Conclusion

This study investigated MM approaches and learners' conceptual understanding of mathematics at secondary school levels in Kisii county, Kenya. This was to be achieved through establishing teachers' knowledge in mathematical modelling, extent at which mathematics teachers use MM approach in teaching mathematics and determining the relationship between MM and students' performance in mathematics. The study concludes that teachers in Kenya secondary schools are not familiar with MM approach as an instructional strategy. Teachers hardly have ideas of what MM is all about. Teachers mainly taught by guiding students through examples and giving them similar exercises in a particular textbook adopted as a coarse book. Teachers neither have adequate knowledge in developing appropriate MM task in class nor manipulating their instruction strategy using MM approach. Therefore, teachers in Kenya rarely apply MM approach when teaching and learning of mathematics. Instruction based on MM approach had a positive influence on students' performance of mathematics. There was improvement on students' performance in mathematics when they were exposed to instruction based on MM approach. Students' performance in mathematics test was higher as compared to their previous performance in similar test before exposure to MM instructions. The t-test analysis conducted between the pre-MM test and post-MM test concluded that there was statistically significance positive difference between the two scores.

5.3 Recommendations

Based on the findings that emerge in this study, the following recommendations can be made:

i. KICD in collaboration with MOE and TSC to conduct in-service courses to train teachers on MM approach as an instructional strategy in mathematics teaching in secondary school level.

ii. KICD to develop and issue instructional materials and teacher guides to teachers on MM tasks and strategies to use when applying MM.

iii. KICD to conduct implementation and supervision of MM instructional approach in secondary school mathematics teaching and learning.

iv. KICD to infuse MM skills as an outcome for secondary school mathematics curriculum.

5.4 Possible Future Researches

This study did not investigate on how MM can be implemented in the existing teaching practice in Kenyan secondary schools and what will be the likely type of challenges and achievements that can be identified in relation to the implementation process. It is therefore suggested that it may be of interest if focus will be on implementation of MM in Kenyan secondary schools. There is also need in future research to be done on requirements for an effective professional development on MM especially for in-service teachers of mathematics in secondary schools in Kenya.

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S.NO…………………….

APPENDIX I: QUESTIONNAIRE FOR SECONDARY SCHOOL STUDENTS

INTRODUCTION

Dear Respondent,

This questionnaire is meant to collect data for a study *investigating on how mathematics is thought in Secondary Schools in Kenya.* You have been selected as one of the respondents and, if you consent to participate, you are kindly requested to be honest with your answers. Please note that any information you give will be treated with utmost confidentiality. On top of this, the information will be used for academic purpose only.

Thank you for your cooperation.

ALBERT OTONDI

Researcher,

Com Tech, Kenyatta University.

Instructions: Please use a Tick [√] against the statement and write in the spaces provided as appropriately.

Key: SA-Strongly Agree; A-Agree; D-Disagree; SD-Strongly Disagree

PART A: Demographic information:

1. Are you a female or a male?
   Female…………………………………… ☐

   Male…………………………………… ☐

PART B: How do you agree with these statements about learning mathematics?

	STATEMENT	SA	A	D	SD
1	I usually do well in mathematics.				
2	I would like to take more mathematics in school.				
3	I enjoy learning mathematics.				
4	Mathematics is not one of my favorite subjects.				
5	Mathematics is a boring subject.				
6	I learn things quickly in mathematics.				

PART C: How much do you agree with these statements about mathematics?

	STATEMENT	SA	A	D	SD
1	Learning mathematics will help me in my future career.				
2	Other subjects are more important than mathematics.				
3	Mathematics is really useful in life outside school.				

4	Mathematics has a lot of procedures that have to be memorized.				

PART D: How often do you do these things in your mathematics lesson?

	STATEMENT	**SA**	**A**	**D**	**SD**
1	We practice adding, subtracting, multiplying and dividing without using a calculator				
2	We interpret data on tables, charts and graphs				
3	We memorize formulas and methods				
4	We explain our answers in mathematic				
5	We relate what we are learning in mathematics to our daily life				
6	We decide on our own procedure for solving complex problems				
7	We listen to the teacher as he/she does everything in mathematics lesson				
8	We work problems in small groups				
9	We write equations and functions to represent relations				

THANK YOU.

S.NO………………….

APPENDIX II: QUESTIONNAIRE FOR MATHEMATICS TEACHERS

INTRODUCTION

Dear Respondent,

This questionnaire is meant to collect data for a study *investigating on how mathematics is thought in Secondary Schools in Kenya.* You have been selected as one of the respondents and, if you consent to participate, you are kindly requested to be honest with your answers. Please note that any information you give will be treated with utmost confidentiality. On top of this, the information will be used for academic purpose only.

Thank you for your cooperation.

ALBERT OTONDI

Researcher,

Com Tech, Kenyatta University.

Instructions:

a. Please use a Tick [√] against the statement and write in the spaces provided as appropriately.
b. Feel free to give any information that is relevant to the study and that may not have been catered for in the questionnaire.

Part A: Demographic information:

1. Are you a female or a male?
   Female…………………………… ☐

   Male……………………………… ☐
2. What is the highest academic qualification you have completed?

   High school certificate (KCSE)…………………………… ☐

   Diploma …………………………………………………… ☐

   Bachelor's Degree……………………………………… ☐

   Master's Degree………………………………………… ☐

   PhD Degree……………………………………………… ☐

   Any other…………………………………………………...

Part B: In the past two years, have you participated in the professional development courses in the following;

	STATEMENT	YES	NO
1	Mathematics contents		
2	Mathematical pedagogy/instruction		
3	Mathematical curriculum		
4	Improving students' problem-solving skills		
5	Mathematics assessment		

PART C: How many lessons per week do you teach mathematics………………

PART D: How do you use a text book (s) in teaching mathematics in class?

1. As the primary basis for my lesson…… ☐
2. As a supplementary resource ………….☐

Part E: In teaching mathematics in class how often do you usually ask students to do the following**:**

	Statement	Every almost lesson	About half the lesson	Some lessons	Never
1	Interpreting data on tables, charts or graphs				
2	Write equations and functions to represent relationships				
3	Memorize formulas and procedures				
4	Apply facts, concepts and procedures to solve routine problems				
5	Explain their answers				
6	Relate what they are learning to their daily lives				
7	Decide on their own procedure for solving complex problems				
8	Work on problem for which there is no immediately obvious method for solution				
9	work together in small groups to solve non routine problems				

PART F: How often do you assign the following kinds of mathematics homework in class?

Statement	**Always**	**Sometimes**	**Never**

1	Gathering data and reporting
2	Finding one or more applications of the content covered

PART G: How often do you include the following type of questions in your mathematics tests or examinations?

	Statement	Always	Sometimes	Never
1	Questions based on recall of facts and procedures			
2	Questions involving applications of mathematical procedures			
3	Questions requiring explanations or justifications			

PART H: When explaining a concept or introducing a new topic in class, where do you get your examples from so as to make students understand? (Thick the appropriate box)

1. Text books. ☐
2. Real life situations. ☐

Briefly explain your response above:

……………………………………………………………………………………………
…

……………………………………………………………………………………………
…

PART I: what is your understanding of **mathematical modeling approach** in teaching and learning of mathematics? (Thick the appropriate box)

1. Teaching based on relating mathematics to its application in real life situations. ☐

2. Teaching based on memorization and recall of facts and procedures in mathematics. ☐

   .
3. Any other

………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………

THANK YOU

S. NO……………

APPENDIX III: OBSERVATION SCHEDULE

Subject: Mathematics. Topic: ……………………………….

FOM: II Date: ………………………………….

Number of learners observed: ……. Time: …………………………………

Sub-topic observed: …………………

School type: ………………

Classroom Observation Feedback (n=10)

Teaching strategy	Frequency of teachers Observed	Frequency of teachers not observed
1.Explaining the concept to be learned		
2.Demonstrating to students how the concept learned apply in real life situation		
3.Giving open ended task from real-world situation for student to attempt		
4.Organising students in groups to work on the task		

5.Asking students to give situations where the concept apply in real life

6.Asking students to explain their solutions in real world

APPENDIX IV. TEACHER'S INTERVIEW SCHEDULE

(a) what is your understanding of Mathematical modelling approach as a strategy in mathematics teaching?

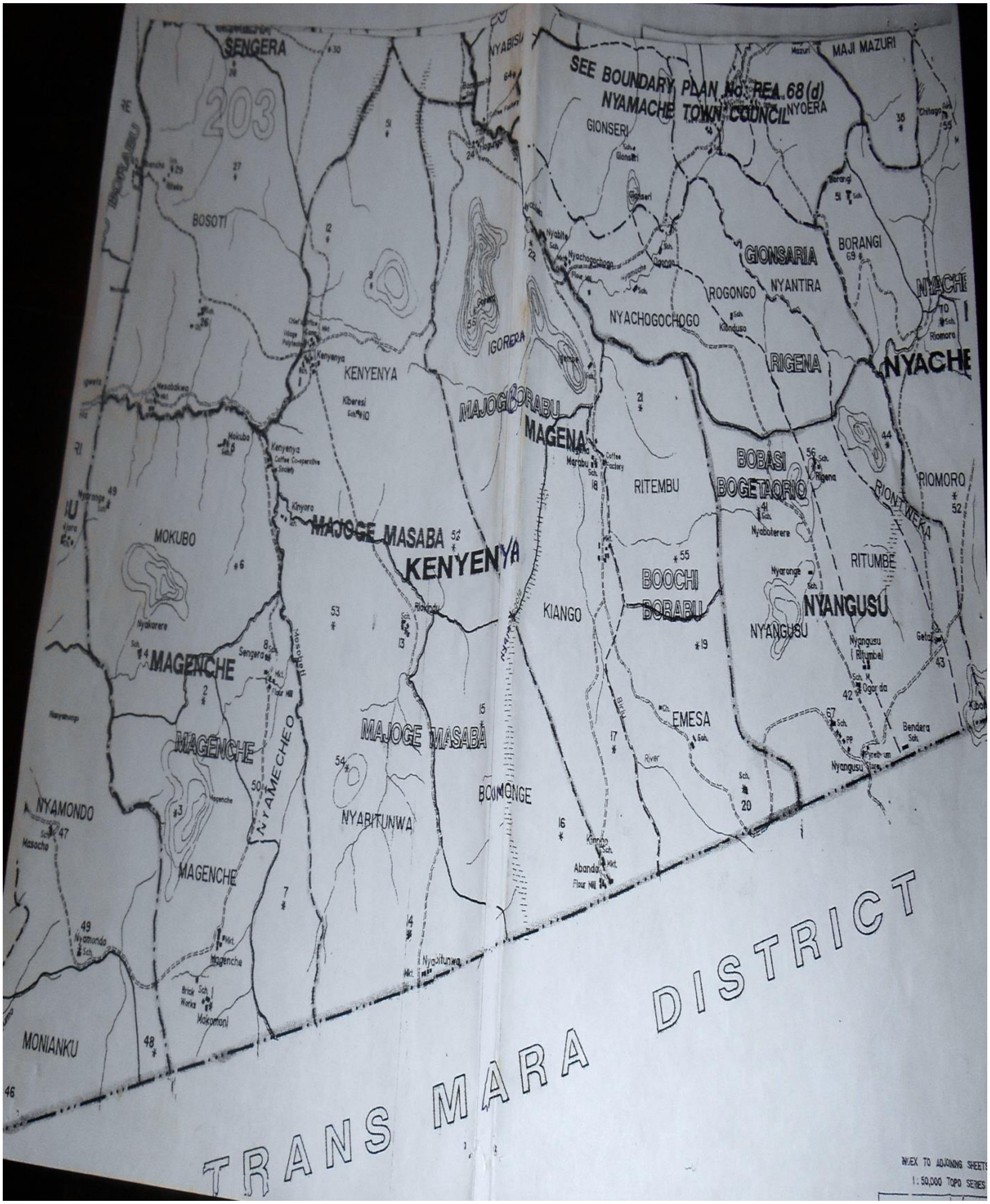
(b) Have you ever used Mathematical Modelling approach in your mathematics lesson?

(If the answer is yes on section (b)). Explain how you conduct it in mathematics teaching.…………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
……………

(c) In your understanding what is the difference between Mathematical modelling approach and traditional teaching approach in mathematics teaching?

Thanks.

APPENDIX V: MAP OF KENYENYA SUB-COUNY, KISII COUNTY, KENYA



APPENDIX VI: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. ALBERT OTONDI
of KENYATTA UNIVERSITY, 2699-40200
KISII,has been permitted to conduct
research in *Kisii County*

on the topic: *MATHEMATICAL MODELING APPROACHES AND THE LEARNER"S CONCEPTUAL UNDERSTANDING OF MATHEMATICS AT SECONDARY SCHOOL LEVEL IN KISII COUNTY, KENYA.*

for the period ending:
23rd March,2017

Permit No : NACOSTI/P/16/35272/9197
Date Of Issue : 30th March,2016
Fee Recieved :Ksh 1,000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 8281

CONDITIONS: see back page

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/16/35272/9197**

Date: **30th March, 2016**

Albert Otondi
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "***Mathematical modelling approaches and the learner's conceptual understanding of mathematics at secondary school level in Kisii County, Kenya,***" I am pleased to inform you that you have been authorized to undertake research in **Kisii County** for a period ending **23rd March, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Kisii County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kisii County.

The County Director of Education
Kisii County.