GEOGEBRA INSTRUCTION SOFTWARE AND ITS EFFECT ON STUDENTS' PERFORMANCE IN MATHEMATICS IN SECONDARY SCHOOLS OF KAKAMEGA CENTRAL SUB-COUNTY, KENYA

By

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Mathematics Education of Masinde Muliro University of Science and Technology.

NOVEMBER, 2017

DECLARATION

This thesis is my original work and has not been presented elsewhere for a degree or any other award.

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of Masinde Muliro University of Science and Technology, a thesis entitled: "Geogebra Instruction Software and its effect on Students' Performance in Mathematics in Secondary Schools of Kakamega Central Sub-County, Kenya".

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ii

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DEDICATION

This thesis is dedicated to my beloved wife Lillian Juliet Awuor for her psychological, social, moral and spiritual support.

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ABSTRACT

Mathematical knowledge and understanding is important not only for scientific progress and development but also for its day-to-day application in social sciences and arts, government, business and management studies as well as household chores. But the general performance in school mathematics in Kenya has been poor over the years. There is evidence that students have problems in understanding and interrelating the symbols and special language structure as used in mathematics. Broad curricula, lack of facilities and inadequate staffing were always cited as the major causes of the problem. Although dismal performance in the subject had almost been accepted as the norm in some schools, the Ministry of Science, Education and technology (MoEST) and other stakeholders felt there had to be an intervention. The study sought to explore the effectiveness of using Geogebra Instruction Software as a pedagogical tool in secondary school mathematics, as contrasted to conventional teaching methods on student's performance in mathematics scores and their creativity. The study was carried out in a real classroom setting that involved comparisons between the treatment and control groups. A Quasi-experimental nonequivalent Solomon- Four fold research design employed involved eight secondary schools in Kakamega Central Sub-County. A total of 20 teachers of mathematics and 240 form two students', randomly sampled (using proportionate stratified random sampling) were enrolled in four intact classes from the selected schools and exposed to the similar contents on the topic of transformations for a period of two weeks. Both descriptive and inferential statistics were used to analyse the data. Descriptive statistics involved the use of means and standard deviations while inferential statistics involved an analysis of variance (ANOVA). The findings of the study showed that the computer instructional software Geogebra as an instruction medium was superior to the conventional methods as regards the students' creativity, attitude and achievements in mathematics at secondary school level. Based on these findings, the researcher recommends that; for quality and optimum learning to occur in present times, an effective instructional approach that the 21st century mathematics teacher should embrace is computer based instructional software. This method not only enhances mastery of content but also improves on learners' retention rate and increases their involvement in problem solving. These factors contribute heavily towards better performance in Mathematics.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
BECTA	British Educational Communications and Technology Agency
CAI	Computer Aided Instruction
CAS	Computer Algebra Systems
CMI	Conventional Methods of Instruction
DGS	Dynamic Geometry Software
DMS	Dynamic Mathematics Software
GIS	Geogebra Instruction Software
ICME	International Conference of Mathematics Education
ICT	Information, Communication and Technology
INSET	In-Service Training
JICA	Japanese International Co-operation Agency
KCPE	Kenya Certificate of Primary Education
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examinations Council
MAT	Mathematics Achievement Test
MCEQ	Mathematics Classroom Environment Questionnaire
MSQ	Mathematics Student's Questionnaire
MTQ	Mathematics Teacher's Questionnaire
MOEST	Ministry of Education, Science and Technology
NACOSTI	National Commission of Science, Technology and Innovation
NCTM	National Council of Teachers of Mathematics
NNS	National Numeracy Strategy
OSS	Open Source Software
QCA	Qualifications and Curriculum Authority
SMASSE	Strengthening of Mathematics and Sciences in Secondary Education
TTA	Teachers Training Agency
UNESCO	United Nations Education, Scientific and Cultural Organisation

CHAPTER ONE

INTRODUCTION

1.1 Overview of the chapter

This chapter deals with the background of the study, statement of the problem, purpose of the study, research objectives and hypothesis, the significance, assumption and scope of the study. It also offers insight to the limitations and theoretical framework behind the study. Finally it gives the operational definitions of terms as used in the study.

1.2 Background of the study

In the recent times, societies have experienced rapid and widespread technological change the world over. Information, Communication and Technology (ICT) permeates our whole life including work, learning, leisure and relationships. Allen (2007) observes that digital literacy undoubtedly plays a significant role in our future lives. Students nowadays live in a world where ICT plays a central role to their daily lives. They enter the classroom not only having encountered rich digital experiences but also being part of a society influenced by new technologies. In order for them to succeed in the digital culture, they need to be equipped not only with basic but also higher-order skills. This experience has been strongly supported by Papert's (1994) assertion that:

> Not very long ago, young people would learn skills they could use in their work throughout life. Today, in industrial countries, most people are doing jobs that did not exist when they were born. The most important skill determining a person's life pattern has already become the ability to learn new skills, to deal with the unexpected. (pg. 2)

Education and in particular mathematics education need to prepare today's learners for their adult lives in today's and tomorrow's world, so that they can contribute in activities not as passive but as active and empowered participants (Pachler,2001). Undoubtedly everyone is empowered by technology and the challenge for education is to develop those human talents that technological tools cannot provide. This calls for a paradigm shift in the teaching and learning process with emerging information and communication technologies. This pressure has made everyone involved to change their roles. ICT and especially computers are considered to be necessary tools in classrooms and their use is mentioned in several of the goals of many National Curricula. Davis (2001) argues that ICT can play many roles in education that will continue to develop ICT aspects of core skills, ICT as a theme of knowledge and ICT as a means of enriching learning. New applications of technology have the potential to support learning across the curriculum and allow effective communication between teachers and learners in ways that have not been possible before. Loveless (1995) asserts that:

"ICT has the potential not only to support the current curriculum but also to enhance the experience and understanding of that curriculum and even extend thinking and learning in new ways" (pg. 87)

Technology therefore provides students with a sense of mastery over their environment; they think about their thinking, check their work and continue reflecting. The use of ICT promotes initiative and independent learning, with pupils being able to make informed judgments and develop the ability to be critical in their choices (DfEE, 1999). This is further corroborated by Loveless (1995) when he states that:

> ICT has the potential to organize and process information, freeing the children to ask questions, look for answers, take risks in exploration and use a wide range of resources for information. They can develop a positive attitude to their work by using real and relevant data and presenting work in a polished and accessible form. A positive experience of ICT in the classroom, developing children's confidence and confidence in working as individuals and with others, should contribute to the general quality of their learning. (pg. 87)

Teaching with ICT in the classroom is thus seen as qualitatively different from the explicit, traditional teaching. While the need for effective use of ICT in teaching subjects across the curriculum is increasing, good practice remains uncommon especially in Kenya

(Ofsted,2001). According to Saye (2010), the traditional method for teaching mathematics has impacted negatively on the students, and this has largely contributed to their poor performance in the subject. In views of Saye (2010), teachers of mathematics usually lecture when they teach their classes. In a Kenyan traditional classroom setting, the teacher religiously observes a routine. This starts with answering questions from the learners homework, then followed by teaching the new concept, and finally giving a homework assignment that students occasionally embarks on in class if time permits. This method is not only boring for students because their only task in the classroom is to passively sit and watch the teacher solve mathematics problems on the board but also inhibits creativity. The student watches, listens, and copies what the teacher does. The student then begins to feel that mathematics is pointless and is of little value to them in real life. No wonder it is a subject they are not only forced to study in school, but one that is useless to them in real life.

The contrast, however, is between the theoretical Mathematics learnt in school and the practical mathematics that our parents use in daily life. In the traditional classroom setting aforementioned, both student and teacher are often frustrated because students' individual needs are unmet. Students generally have difficulty listening and copying problems from the board at the same time, and so when they begin working on assigned problems at their desks, they become frustrated. Although there are attempts by the teacher to move round the room trying to answer student’s questions, this is greatly hampered by lack of sufficient time. Students leave the classroom without having all their questions answered and unable to complete the assignment. The teacher is exhausted from moving about the room in an effort to answer all the questions, and is discouraged by lack of effort to effectively meet the needs of all the students (Saye, 2010).

Consequently, Mathematics teachers today are eagerly trying alternative methods in an effort to reach out to their students. They want their students to solve mathematics problems that they recognize as relevant to their lives, not to listen and watch mathematics being done by the teacher. They want the students to be excited about doing mathematics. They want them to understand mathematics, score highly in the subject, and stay in school. Some effective alternative methods currently in use for teaching mathematics include: cooperative learning, problem solving experiences, use of manipulative, student projects and use of technology. The latter is what this research intends to explore. The basic policy of the Kenyan education sector is shown the policy session paper No.1 of 2005. The paper recognized that two of the problems with the present situation in secondary education are low performance in important subjects including mathematics and science in the final exams for secondary education and also the low school attendance rate. Since the 7th National Development Plan, the Kenyan government has stressed the importance of strengthening mathematics and science in secondary education as a means to promote industrialization and sustainable development. Co-operation with Japanese Government through the Japan International Cooperation Agency (JICA), saw the birth of Strengthening of Mathematics and Science in Secondary Education (SMASSE). The necessity for the In-Service Training (INSET) for mathematics and science teachers in secondary education was specified in the education policy through the active advocacy which came from the project.The SMASSE Team came up with the **A**ctivity, **S**tudent, **E**xperiment, and **I**mprovisation (**ASEI**) movement to upgrade the various aspects of teaching and learning. To achieve the ASEI condition, SMASSE came up with the **P**lan, **D**o, **S**ee and **I**mprove (PDSI) approach to teaching and learning. The ASEI-PDSI approach was however not necessarily introduced into the lessons in the classroom by all the teachers. The SMASSE technical experts in recognition of this (SMASSE Project in Kenya, 2005) observed that:

> There is clearly unsatisfactory situation of mathematics and science within the context of the final examination of secondary education that worried not only the government, but the society in its entirety.

While there were some problems involving the INSET, definite project results did start to show in some statistics. One was seen in the changes in the attitude of students towards the subjects of mathematics and science. In the final KCSE exams for secondary education in 2005, a total of 69,058 students out of the 256,825 students (27 %) chose physics, compared to 38,000 students out of a total of 167,000 students (23 %) in 1998. The proportion of high achievers was raised in mathematics and science by 10%. This is working as an incentive for the policy planning officials to support the project. With regard to the outcome at the school-level, most Principals at the secondary schools interviewed during the field survey said that performance was improving in mathematics and science. They also answered that the students' interest in mathematics and science increased even if INSET did not lead to a direct improvement in the scores. However, the quality of the learning process had clearly improved when comparing the survey results from before and after the SMASSE INSET courses took place. Through the PDSI approach,Climbing Learning approach and Open-ended approach, SMASSE Project has had a positive impact on skills, knowledge and attitudes in the teaching and learning of mathematics and science (SMASSE Project in Kenya, 2005).

There has been significant improvement in performance of science and mathemantics subjects, in the counties where SMASSE has been in operation during the project period. Other than focusing on Kenya, SMASSE focuses on the African region through SMASSE-Western, Eastern, Central and Southern Africa (WECSA) as a regional association of mathematics and science educators. It was started in 2001 for the purpose of strengthening the quality of teaching and learning of mathematics and science in member countries. Member countries have adopted SMASSE's ASEI movement and PDSI approach as a way of improving classroom practice. As a follow-up, SMASSE Kenya personnel conducted Monitoring and Evaluation of application and impact of the principles of ASEI movement and PDSI approach, in the classroom in Malawi, Zambia, Rwanda and Zimbabwe. They also administered lesson Quality of Participation questionnaire to the students in the classes where they observed lessons to assess the quality of learning by SMASSE trained and non-SMASSE trained teachers**.** Mathematics generally is a critical subject in the society. It is no wonder the subject has been made compulsory in the school curriculum in Kenya (Mutunga & Breakel, 1992). This is because students are expected to apply the knowledge of mathematics in both familiar and unfamiliar situations. This is in line with the observation of the 11th International Congress on Mathematics Education in Mexico (ICME II, 2008) that:

> Mathematics is a fundamental part of human thought and logic, and integral to attempts at understanding the world and ourselves. Mathematics provides an effective way of building mental discipline and encourages logical reasoning and mental rigor. In addition, mathematical knowledge plays a crucial role in understanding the contents of other school subjects such as science, social studies, and even music and art. (pg.125)

Literature however indicates that a considerable number of students have inadequate understanding of mathematics and mathematical concepts and skills, which results in dismal performance in end year national examination every year. Students' performance results in Mathematics at (KCSE) from 2011 to 2014 are shown in table 1.1. The table shows the overall mathematics performance by students in both papers in the last four years.

Table 1. 1: Candidates Overall Mathematics Performance at KCSE from 2011 to 2014

Year	Paper	Candidature	Maximum Score	Mean score	Standard Deviation
2011	1		100	14.57	15.42
	2		100	22.63	20.43
	overall	**221,295**	**200**	**37.2**	**35.85**
2012	1		100	14.87	15.73
	2		100	17.04	16.74
	overall	**259,280**	**200**	**31.91**	**31**
2013	1		100	22.71	20.09
	2		100	15.36	15.97
	overall	**238,684**	**200**	**38.08**	**35**
2014	1		100	19.55	19.09
	2		100	19.91	20.74
	overall	**273,504**	**200**	**39.46**	**39.83**

Source: Kenya National Examinations Council (KNEC), 2015; Ministry of Education, Science and Technology (MOEST), 2015)

From the table it is noted that, the overall mean in Mathematics showed a slight improvement in the year 2014 compared to the previous years. However these values are still very low given that about 40% of the candidates scored E-grade.

According to Kenya National Examinations Council report for the year 2009, teachers were indicted for poor performance of the pupils in the Kenya Certificate of Primary Education as a result of inadequate coverage of the syllabus, lack of practice and inability to master simple and basic concepts. In that report given by the Daily Nation of 8/8/2009, Mathematics was poorly done with a mean of 24.62 per cent in 2007 compared to the year 2008's 23.58 per cent. At Secondary school level the Mean score in the year 2009 was barely 2.34 with about half the number of examinees getting mean grades of D- and E. Statistics from the Kakamega County's education office indicates that more than half of the students failed in Mathematics at Kenya Certificate of Secondary Education level by scoring grade D. Kakamega County is actually last in Mathematics performance compared to other counties in Western Part of Kenya. This places a number of students outside the competition arena given that Mathematics is a requirement in most tertiary colleges and a number of university courses. It is therefore imperative for the Kenyan Government not only to implement ICT resources in the classroom but also to ensure that they are effectively used. The government on her part made a milestone on 30th March 2010 when the e-learning was launched by the then President Mwai Kibaki at Kenya Institute of Curriculum Development. With the challenges of implementing ICT aside, mathematics teachers need to change their teaching methodology in tandem with the continually changing learners' and societal needs. According to the study carried out by UNESCO on general issues of teaching in 1992, it was observed that students worked less by themselves and the teacher served as the sole source of information. There is need therefore to focus upon teacher teaching practices in the classrooms and require the development of very different methods of teaching. The primary target is the teacher because according to UNESCO (1992),

"The teacher is the primary source of instruction in most societies and has been recognised as such by most curricula and forms of classroom organization". (Pg.17)

Teachers need to be involved in the actual curriculum implementation in order to cause some change in the mathematics classroom. In this sense and for the aforementioned reasons, this study sought to look at the development of mathematical ideas and concepts through computer based teaching. The main aim of the research was to analyze the role of dynamic mathematics computer software called Geogebra, as a tool in the teaching and learning of mathematics in the Kenyan Secondary schools, by exploring its effectiveness in the implementation of secondary school mathematics. Geogebra is a relatively new software system that integrates possibilities of both dynamic geometry and computer algebra in one tool for mathematics education. It allows a closer connection between the symbolic manipulation and visualization capabilities and dynamic changeability (Hohenwarter & Fuchs, 2004). Introducing Geogebra in mathematics classrooms could be a way of providing opportunities for mathematical investigation, encouraging discussion and group work and generally it can make mathematics a more open and practical subject, which is accessible and manageable to more learners (Hohenwarter & Fuchs, 2004).

There have been no investigations known to the researcher on whether learner's ideas about mathematics are affected by experience and interaction with Geogebra and generally about its effectiveness in teaching secondary school mathematics in Kenya. Since not much has been written about this topic the researcher sought to explore Geogebra's potential and implications in secondary school classroom practice. This exploration and understanding can in part be established by carefully conducting research in the secondary school mathematics classroom. This exploratory study sought to listen to participants and see their perspectives on the topic, thus building an understanding based on their ideas and getting a complex, detailed understanding of the issues interplay.

1.3 Statement of the Problem

Several efforts have been made to improve on the quality of teaching and learning process in mathematics using conventional methods but still considerable number of students (about 40%) get mean grade E, at KCSE (KNEC report, 2016). It is the concern of secondary schools mathematics teachers who use various pedagogical tools to disseminate knowledge as to why good results are always eluding the students especially in the subject Mathematics. In Kakamega County out of 26,898 candidates in mathematics, the mean Score in 2016 was 2.5118 (D-) (KNEC report, 2016). This was a drop compared to 2015 when out of 23135 candidates the mean score was 3.728 (D). Equally in Kakamega Central Sub-county with a candidature of 1926 in mathematics, 1387 students scored mean grade D- and E (Kakamega County Education report, 2016). The sub-county means score in Mathematics was 2.151 (D-). With such poor performance in mathematics the learners transit without the five paramount 21st Century skills (5C's) which are dependent on the subject. A SMASSE survey conducted in 9 districts in 1998 revealed that poor teaching methods and students attitude towards the subject contributed heavily to poor performance. It was observed that most students in our schools are techno-savvy.

A fresh look into Geogebra (computer software) as a pedagogical tool (*in the teaching and learning of Transformations and other areas in geometry*) is the condition necessitating the need to improve Mathematics instruction through innovative approaches that involve the use of computers. The researcher needed to explore its effectiveness and the creativity involved in its implementation in secondary school mathematics. Geogebra presumably, is the tool that would reduce the poor performance in Mathematics at secondary school by improving student's attitude towards the subject, enhancing motivation hence generating interest through sustained creativity. On the other hand, if the study is not done, then we deny the field of mathematics an important input, as far as pedagogy is concerned. The results may continue to be poor and the teachers will continue to use conventional methods which are not counterproductive, and the good results would continue to elude them.

1.4 Purpose of the Study

The purpose of the study was to explore the effectiveness of using Geogebra Instruction Software as a pedagogical tool on the student's creativity, attitude and achievement in secondary school mathematics. It is hoped that the findings of the study will create a paradigm shift in Mathematics pedagogy.

1.5 Research Objectives

The study sought to address the following objectives:

i) Investigate whether there is any significant difference in the achievement of students taught Transformations in mathematics using Geogebra Instruction Software (GIS) and those taught by conventional teaching methods.

ii) To assess whether there is any significant difference in attitude of students towards Transformations when taught using Geogebra Instruction Software (GIS) as compared to those taught using conventional teaching methods.

(iii) To establish whether there is any significant difference in creativity between students taught Transformations using Geogebra Instruction Software and those taught using conventional teaching methods.

1.6 Research Hypotheses

The research sought to test the following null hypotheses:

H_{O1}: There is no significant difference in the achievement of students taught Transformations in mathematics using Geogebra (GIS) and those taught using conventional teaching methods.

H_{O2}: There is no significant difference in attitude towards transformations between students taught using Geogebra Instruction Software (GIS) and those taught using conventional teaching methods.

H_{O3}: There is no significant difference in creativity between students taught Transformations using Geogebra Instruction Software (GIS) and those taught using conventional teaching methods.

1.7 Significance of the study

The study was aimed at providing information with regard to the use of computers as pedagogical tool in secondary schools with respect to the teaching and learning of mathematics in Kakamega Central Sub-County. The research hopes that the information so obtained would serve as a basis upon which the new effective teaching methodology would be implemented. The findings of the study are invaluable to practicing mathematics teachers, school administrators, education planners, mathematics trainers at the Universities and the Kenyan community at large in instituting measures that could bring about a high degree of teaching/ learning experiences. The findings could also serve as a source of information for policy makers, those involved in education research and policy formulation as well as stakeholders in education. The parents, who are heavily laden in terms of education support, would be influenced by these finding as they make decisions on what support programmes their children should have, access and use on daily basis.

1.8 Assumptions of the Study

The study was based on the assumptions that:

i) The students and teachers have had an access to computers.

ii) The schools have readily available and adequate computers for use.

iii) The teachers have employed various teaching methodologies other than use of computers in the classroom.

1.9 Scope of the Study

The study targeted 8 out of 24 secondary schools in the sub-county since Kakamega County was one of the pilot counties during SMASSE piloting in the year 1998. The eight schools chosen were the schools that benefitted from government funding. Although this fact made it feasible in terms of time and financial resources, the results obtained may not apply to all secondary schools in the country. Secondly, some teachers who were key subjects in the study were not in a position to use and manipulate effectively the computers, a tool upon which the conjectures are framed. This however, was overcome by giving orientation to the teachers until they were comfortable. A total of 240 form 2 students of both gender, drawn from the eight schools across the Sub-County participated in the study. The study narrowed on the basic concepts of transformation as this is a prerequisite for advancements.

1.10 Limitations

The study targeted schools that had or could access computers, one of which must be a centre of excellence. This therefore means that particular schools were targeted in the research. This definitely limited the extent to which the results obtained can be generalized to other areas. The study was on the topic of Transformations (I) learnt in Form Two. It was anticipated that it would be easy to locate these schools, however having them to volunteer to participate freely and honestly (owing to technophobia) was a challenge that the researcher anticipated. Although the researcher also anticipated difficulty of getting honest and impartial responses to the data collection instruments, the respondents were however assured of confidentiality of the responses, and that the responses were only used for this research. The study focused on effectiveness of Geogebra on student's creativity and achievement in mathematics. Although teachers with knowledge in computers would be very useful, those without basic knowledge of computer were still involved with the assistance of teachers of computer in their schools.

However students taking computers studies and those without computer knowledge were involved in the study in order to create variety.

1.11 Theoretical Framework

This study was based on the "information processing theory of the late 1950's". The theory is based on the idea that human beings process the information they receive, rather than merely responding to stimuli. This perspective equates the mind to a computer, which is responsible for analyzing information from the environment. According to the standard information-processing model for mental development, the mind's machinery includes attention mechanisms for bringing information in, working memory for actively manipulating information, and long term memory for passively holding information so that it can be used in the future (Gray, 2010). This theory addresses how as children grow, their brains likewise mature, leading to advances in their ability to process and respond to the information they received through their senses.

From 1950's onwards "cognitivists", those who believed in Cognitive Psychology wanted to look at the "interior" mental processes, rather than the observable "exterior" views that behaviorism held. This revolution had a huge impact on theory and research such as human-computer interaction, human factors and ergonomics. Overall, information-processing models helped reestablish internal thought processes. A central metaphor that was adopted by cognitivists at this time was the computer, which served to provide these researchers important clues and directions in understanding the human brain and how it processes information. Many psychologists and researchers believe that the Information Processing Theory was influenced by computers, in that the human mind is similar to a computer. A typical such model is shown in figure 1.

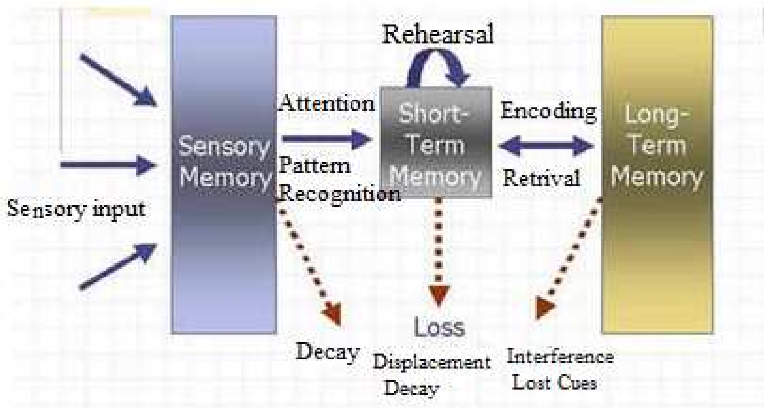

Figure 1: Information processing model

Source*:* http://psychology.jrank.org/pages/334/Information-Processing-Theory.html

The cognitive processes involved include perception, recognition, imagining, remembering, thinking, judging, reasoning, problem solving, conceptualizing, planning and more terms and applications. These cognitive processes can emerge from human language, thought, imagery and symbols. Out of all of these specific cognitive processes, many cognitive psychologists study language-acquisition, altered states of mind and consciousness, visual perception, auditory perception, short-term memory, long-term memory, storage, retrieval, perceptions of thought and much more.

There are four fundamental assumptions – or four pillars – of the information processing approach. These pillars underlying, and support this approach as well as many other cognitive models.

> *Thinking:* The process of thinking includes the activities of perception of external stimuli, encoding the same and storing the data so perceived and encoded in one's mental recesses.

Analysis of Stimuli: This is the process by which the encoded stimuli are altered to suit the brain's cognition and interpretation process to enable decision making. There are four distinct sub-processes that form a favourable alliance to make the brain arrive at a conclusion regarding the encoded stimuli it has received and kept stored. These four sub-processes are encoding, strategization, generalization and automatization.

Situational Modification: This is the process by which an individual uses his experience, which is nothing other than a collection of stored memories, to handle a similar situation in future. In case of certain differences in both situations, the individual modifies the decisions they took during their previous experience to come up with solutions for the somewhat different problem.

Obstacle Evaluation: This step maintains that besides the subject's individual development level, the nature of the obstacle or problem should also be taken into consideration while evaluating the subject's intellectual, problem solving and cognitive acumen.The standard information-processing model has three major components: sensory register, short-term memory (working memory), and long-term memory as shown in figure 2.

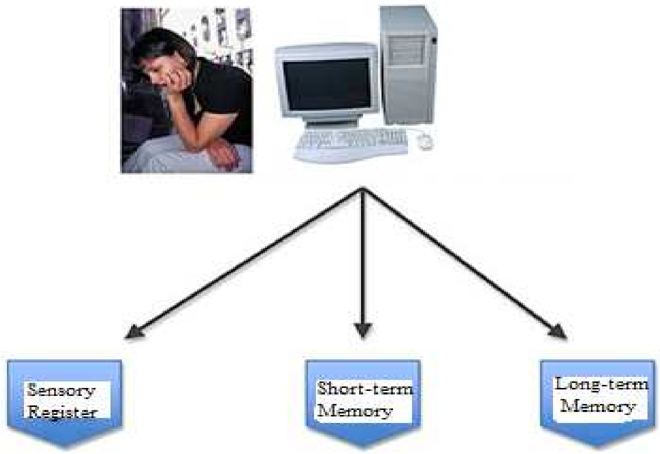

Figure 2: Information Processing Perspective- Computer System

Source: http://psychology.jrank.org/pages/334/Information-Processing-Theory.html

Each sensory system has its own sensory store, which receives and holds, although very briefly, all the external and internal stimuli. The sensory stores hold onto the sensory information long enough so that unconscious processes may operate on these traces to determine whether the input should be brought into the working memory, or discarded.

Working memory is believed to be the center of conscious thought, analogous to the "central processing unit" of a computer, where information from long-term memory and the environment is combined to help solve problems. However, the working memory has a small capacity so that it is not able to attend to much information at a time, thereby limiting the abilities of humans to solve problems. The information processing perspective proposes that as children grow until about 15 years of age, their working memory capacity for verbal/visual information also steadily increases, as demonstrated by improved performance on fluid intelligence tests. Many proponents of the information processing system correlate this increased working-

> memory capacity with increased speed of processing, the speed at which a person can fluently carry out relatively elementary information-processing tasks. It is believed that the physical maturation of the brain that occurs throughout childhood may cause faster processing speeds. This faster processing speed permits faster mental movement from one item of information to another, which improves on one's ability to keep track of a number of different items in working memory at once (Miller, *et.al*,1999)
>
> Long-term memory is the stored representation of all that a person knows. The items stored in long-term memory lie dormant until they are called back into the working memory and thus put to use. Many psychologists believe that the ability to form episodic memories increases gradually throughout childhood due to continued maturation of the brain, particularly in the prefrontal lobes. Proponents of the information processing theory make sense of the development of memory systems, from implicit → semantic → episodic, in terms of childhood developmental needs.

This theory is directly linked to the purpose of the research in that: to find out how the computer software could be used as an aid in learners' understanding of mathematics. Only through significant symbols, for example language and other symbolic tools which humans within a culture share and use to communicate, researchers can become aware of the insiders' perceptions and attitudes and interpret their meanings and intentions (Cohen *et al.*, 2007; Crotty, 1998)

1.12 Conceptual framework

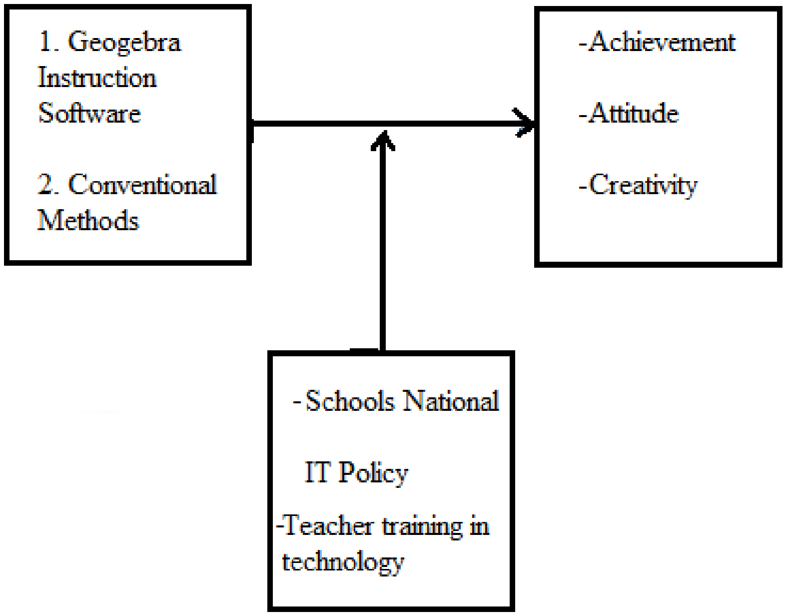

Figure 3: Conceptual framework model

1.13 Operational Definition of terms

The following are the operational meanings of the terms as used in the study;

ICT stands for 'Information and Communication Technology' and as used here refers to (a) the technological equipment available for educational use, (b) associated skills that students and teachers have to acquire.

Educational technology as used refers to the introduction of computers and other technological tools to the classroom environment.

Technophobia is used to refer to fear of technology. It is imagined that when used, technology will take up people's jobs.

Inclusive learning is used to refer to a process of increasing the presence, participation and achievement of all learners

Computer software refers to programmes designed with different purposes in mind.

Geogebra is a Dynamic Mathematics Software (DMS) for teaching and learning mathematics that combines many aspects of different mathematical packages.

Open source software (OSS) is defined as 'software for which the underlying programming code is available to the users so that they may read it, make changes to it, and build new versions of the software incorporating their changes'

Dynamic geometry software (DGS) is a type of software which allows for creation and then manipulation of geometric constructions.

Computer algebra systems (CAS) are designed to facilitate the manipulations of mathematical expressions in symbolic form. CAS can contribute to the development of mathematical knowledge because developing graphic and symbolic reasoning using CAS influences the range and form of the tasks and techniques experienced by students.

Performance entails all that a learner goes through in a structured curriculum namely; creativity, attitude change and achievement.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section discusses the studies of various researchers so as to provide the general background to the present study. In recent years, with the increasing importance of new technologies for everyday life, educational technology has become a cornerstone for government efforts. Governments provide technology to schools and promote the use of ICT in schools across the curriculum in order to improve on students' performances (Wenglinsky, 1998). Bringing ICT into the classroom provokes innovation and change; in the absence of these fundamental changes to the teaching process, schools may do little but speed up ineffective processes and methods of teaching (Leidner & Jarvenpaa, 1995). The recent research indicate that Geogebra has had impact on the attitude of students towards mathematics, creativity involved when handling computers and other technological tools and generally the achievement in mathematics results posted by the students. Geogebra as an instructional tool has been researched on by a number of researchers targeting pupils and students of all ages. The tool has also been exposed to quite a large number of topics in mathematics each producing varied and unique results.

2.2 Instructional methods in Mathematics

In Kenyan secondary school curriculum, Mathematics alongside English and Kiswahili are compulsory subjects. Of the three, many students find mathematics intimidating, difficult to understand and most difficult to master (Bradley, 2008). Equally for teachers, mathematics is most challenging to teach. Partly this is because it has a totally different language for the students to learn. The symbols represent operations. They are interchangeable and require different operations in different situations. The operations are performed in different ways using different formulas. The difficulty of teaching mathematics is compounded by the fact that teachers are held to account for students performance in evaluation. Heavy emphasis is placed on student's scores in standardized tests. Teachers are also held responsible for the student's mastery of required course objectives. Thus, the understanding of mathematics as a natural exploratory process has been overshadowed by the teachers' concern with students solving tasks to get correct answers. The pressure to obtain better scores has resulted in memorization at the expense of reasoning. There is therefore the inability of students to grasp basic concepts and become creative (Bradley, 2008).

Many articles reviewed in various studies make practical suggestions for mathematical instruction. According to Ediger (2001), teaching mathematics requires securing of learners attention, having learners understand what is taught, guiding learners to perceive reasons for learning that which is stated in the objective and sequencing learning opportunities in the teaching of mathematics. Wakefield (2001) gives three principles a teacher should consider when teaching mathematics; encourage the learners to think, encourage the learners to think about thinking, and encourage representations of thinking. Schorr & Koeller-Clark (2003) believe that while students may be allowed to tactile mode with the use of manipulative, elementary math students do not necessarily make the intuitive leap allowing them to connect the concrete items with the symbolic meaning of the objective process. These authors propose a multi-tiered program that encourages teachers to reflect upon their own mathematical concepts and discuss these with a group of peers before planning a mathematical lesson. This practice allows teachers to engage colleagues, some of whom are master teachers, in exploring different ways of relating the mathematical objectives to the students in their schools. However, Ufuktepe & Ozel (2002) improved on Schorr & Koeller-Clark theory by suggesting that music and drama should be integrated into concrete manipulative. Integration of music and drama into traditional mathematics instruction not only reduced stress and anxiety but also improved student performance on unit tests. They further added that building mathematical concepts by making connections of abstract symbols to concrete materials with use of manipulative, music and drama is vital in engaging tactile, auditory and kinesthetic activity during learning. When the five senses are engaged, abstract concepts become more concrete, however connection between conceptual and procedural knowledge remain anathema for students.

Yetkin (2003) alluded that the language of mathematics is different from the verbal language used in everyday communication. He further pointed out that written symbols of mathematics create confusion to many students, and suggested for example, that number lines should be employed in addition to manipulative in an attempt to concretely visualize the abstract symbol. Baker, Gersten and Lee (2003) offer suggestions for supportive activities. They recommended scaffolding components which include providing teachers and students with data on student performance, using peers as tutors or instructional guides, providing clear and specific feedback to parents on their children's success and finally using principles of explicit instruction in teaching mathematics concepts and procedures. Carey (1998) advocated for parent-teacher relationship as a key factor in achieving any educational objective. Parents can reinforce mathematical concepts in many ways. Students are highly motivated and more personally excited about learning when their parents actively participate in the learning process with them. Although a variety of methods are advocated for by researchers to essentially reach out to students, the teacher is the primary decision maker in planning the combination of instructional strategies to accommodate the needs of every learner (Little, 2003). Despite all the aforementioned suggestions, score card in mathematics is still an area of great concern in the world over.

2.3 Computers and Education

The history of education is largely a story of gradual evolution, but education has also had its revolutions. The first use of writing as a tool in teaching transformed education many centuries ago when it freed teachers from the constraints of oral tradition. The invention of printing in the 15th century made books widely available and had a similarly drastic effect on the history of education. Now, in the 20th century, the invention of the computer may have had an equally profound impact on education. According to Kulik & Kulik (1987), educational developers long ago demonstrated that they could program computers to work in schools as drill masters, tutors, testers, and schedulers of instruction. The effectiveness of computer-assisted learning (CAL) has however not been conclusively demonstrated (Parr, 2000). To date, it has been shown to be less effective, on average, than other forms of intervention in education. Generally, computer-assisted learning software is under pinned by an older, neo-behaviourist theory of learning, one that has been displaced in the classroom by more social constructivist views of learning. Computer-assisted learning programs, especially integrated learning systems, are generally costly. Their efficacy and cost effectiveness relative to alternative programs, particularly with respect to reading, is questionable. While comparative research exists with respect to effectiveness, good comparative research in relation to cost effectiveness is lacking.

Results from evaluations of integrated learning systems show highly variable results, with independent evaluations tending to be less favourable. The best results appear to be for basic mathematics skills; there is little evidence of gains in reading. Integrated learning systems, in their current form of neo-behaviourist, mastery learning, support the gaining of basic procedural knowledge. There is evidence that students may not be able to apply such knowledge without teacher intervention and that such knowledge may not generalize to school or system curriculum assessment tasks (Parr, 2000).

Part of the variability in outcome results stems from the different off-system assessment measures used to measure progress and part stems from the differing contexts of implementation. The latter includes characteristics of the student body and organization for implementation including configuration of resources and deployment of personnel. Above all, this latter factor concerns integration, particularly the match between computer-assisted instruction (CAI) or the integrated learning system curriculum content and methods, and that of the school and classroom.

According to research carried by Kulik & Kulik (1987), the computer-based instruction has positive effects on students studying mathematics as shown on Table 2.1

Table 2. 1: Average effect of CBE on students in 199 studies

Outcome measure	Number of studies	Average effect (std.deviation)
Final Examination	199	0.32
Attitude toward instruction	17	0.28
Attitude toward computers	17	0.33
Attitude toward subject	29	0.05
Instructional time	28	68%

Source: Centre for Research on Learning and teaching, The University of Michigan.

From the table it can be seen that:

(i) Students generally learned more in classes when they received help from computers. The average effect of computers in all the 199 studies used was to raise examination scores by 0.32 standard deviations, or from the 50^{th} to the 61^{st} percentile.

(ii) Students also learned their lessons with less instruction time. The average reduction in instructional time in 28 investigations of this point was (100-68) = 32%.

(iii) Students also liked their classes more when they received computer help. The average effect of computer-based instruction in 17 studies was to raise attitude toward instruction scores by 0.28 standard deviations.

(iv) Students developed more positive attitudes towards computers when they received help from them in school. The average effect size in 17 studies on attitude toward computers was 0.33.

(v) Computers did not, however, have positive effects in every area in which they studied. The average effect of computer- based instruction in 29 studies of attitude toward subject matter was near zero (0.05).

Not a lot of such studies have been conducted in our country Kenya and therefore this study offers an insight on the effectiveness of computers in our curriculum.

2.4 Computers and Mathematics Instruction

There has been an increasing awareness that interactions between humans and technologies can facilitate effective teaching and learning (Hennessy *et al.*, 2005). During the 1990s, Information Technology (IT) was the term reserved for computers and other electronic data handling and storage devices used to provide speedy automatic functions, capacity and range. More recently, the word ‘communication’ was incorporated to acknowledge the increase in interaction between people and technology, this is widely known as Information and Communication Technology (ICT). Kennewell (2004) explains that ‘the term ICT covers all aspects of computers, networks (including the internet) and certain other devices with information storage and processing capacity, such as calculators, mobile phones and automate control devices. Thus ICT integrates teaching and learning as a complete activity with a number of features.

Kennewell (2004) points out that some key features that ICT can offer in this respect are speed and automatic functions, capacity, range and interactivity. Deaney *et al* (2006) identify teachers' '*practical theory'* concerning the contribution of ICT to education as:

- Broadening classroom resources and references;
- Enhancing working processes and procedures;
- Mediating subject thinking and learning;
- Fostering more independent learner activity;
- Improving learner motivation towards lessons.

The '*practical theory'* could be seen as a starting point for the development of explicit models of ICT into different subject teaching and learning. Nevertheless, after decades attempting to incorporate technology in education, it is still problematic (Cuban *et al.*,2001). Research therefore suggests further areas for development in terms of the contribution that ICT lends to education including improvements in pedagogical development and teacher training of ICT competence (Ofsted, 2004).

So with the introduction of computers to Mathematics education, one question to consider is whether mathematics education changed when computer was introduced? Hershkovitz & Shwartz (1999) research on the differences between computer-integrated environment and paper-pencil environment and suggested that paper-pencil environment is relatively passive in supporting learning. Current studies have found that there are changes in terms of active engagement with the implementation of computers in mathematics education as computers hold higher efficiency in mathematics manipulation and communication as well as interactivity between teachers, students and mathematics (Hershkovitz *et al*, 2002).

Research, however, indicates that the paper-and pencil environment has simplicity and convenience that cannot be ousted from classroom practices. It can be argued that the inappropriate uses of ICT may potentially block teaching and learning processes in problem solving and justifying, or perhaps create cognitive obstacles in understanding (Yerushalmy, 2005; Arzarello, 2005). Since ICT and paper-and pencil environments have both advantages and disadvantages, it is not advisable to separate but to combine them. The implementation of ICT into mathematics education has been the main direction of current research in the field of mathematics education and ICT (Ruthven *et al*, 2004; Sutherland *et al.*, 2004).

> "Despite official encouragement and enormous investment across the developed world, the global movement to integrate digital technologies into school mathematics has had limited impact on mainstream classrooms" Ruthven *et al*, 2004, Pg 23.

Since the implementation of ICT in classroom practices has been slow, recent studies shift their attention to the role of the teacher as a mediator for appropriate integration of ICT into teaching practices (Becta, 2004; Ruthven *et al.*, 2004; Sutherland *et al.*, 2004). Teachers' pedagogical knowledge in the use of ICT to bolster students' learning requires them to tackle potential problems (Ofsted, 2004). Possible misunderstanding may arise from multiple representations within the software, or improper use of ICT to investigate mathematical ideas (Deaney, *et al.*, 2006). Consequently, the present research focuses on instructional practice incorporating Geogebra in the teaching and learning of mathematics.

2.5 The dynamic mathematics software Geogebra

We look at what it is, why it is different and its relevance in teaching Mathematics.

2.5.1 *What is Geogebra?*

Geogebra is a Dynamic Mathematics Software (DMS) for teaching and learning mathematics that combines many aspects of different mathematical packages (Hohenwarter & Lavicza, 2007). It is a form of freely-available, open-source educational mathematics software that provides a flexible tool for visualizing mathematical ideas from elementary to university level, ranging from simple to complex constructions (Hohenwarter & Jones, 2007). It dynamically joins geometry, algebra and calculus offering these features in a fully connected software environment (Hohenwarter & Lavicza, 2007). It is as easy to use as Dynamic Geometry Software (DGS) but also provides basic features of Computer Algebra Systems (CAS).

2.5.2 *Why is Geogebra different?*

Atiyah (2001) refers to geometry and algebra as '*the two formal pillars of mathematics'*. Geogebra is an attempt to join these pillars, which other packages treat separately, into a single package. The basic idea of Geogebra is to provide a dynamic software that incorporates geometry, algebra, and calculus and treats them as equal partners thus enhancing the teaching of mathematics through enabling learners to gain stronger links between geometry and algebra (Hohenwarter & Jones, 2007; Hohenwarter & Lavicza, 2007). The most notable feature of Geogebra is that it offers two representations of every object: every expression in the algebra window corresponds to an object in the geometry window and vice versa providing a deeper insight in the relations between geometry and algebra (figure 3.0). Geogebra provides the facility to move between the algebra window and the geometry window. On the one hand, the geometric representation can be modified by dragging it with the mouse like in any other dynamic geometry system, whereby the algebraic representation is changed dynamically. On the other hand, the algebraic representation can be changed using the keyboard causing Geogebra to automatically adjust the related geometric representation.

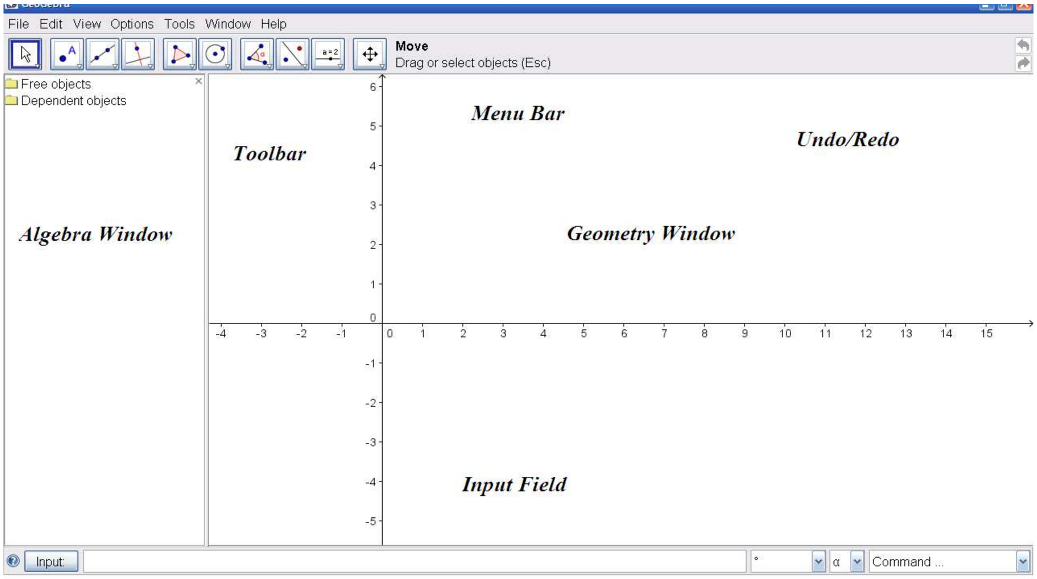

Figure 4: Screenshot from a Geogebra window

2.5.3. *Teaching Mathematics with Geogebra*

Skills, pedagogy and curriculum are the three aspects involved in the use of Geogebra in the classroom. Teachers need to know how it works and how it can be effectively integrated both within the classroom and within the curriculum. Thus, when incorporating Geogebra in the classroom these fundamental features should be taken in mind. Geogebra can be used in many ways in the teaching and learning of mathematics: for demonstration and visualization since it can provide different representations, as a construction tool since it has the abilities for constructing shapes, for investigation to discover mathematics since it can help to create a suitable atmosphere for learning, and for preparing teaching materials using it as a cooperation, communication and representation tool (Hohenwarter & Fuchs, 2004). The success of Geogebra has shown that non-commercial software packages have the potential to influence mathematics teaching and learning worldwide (Hohenwarter & Lavicza, 2007) without governments having to invest a tidy sum of money in supplying schools with software.

2.5.4 Effectiveness of Geogebra in Mathematics Education

The question arises here concerning the impact of Geogebra in mathematics education. This can be answered by exploring how technological changes interact with learning. Modern technology can provide students with a new means to experience mathematical concepts; it is essential for everyone involved in the teaching community to understand if these means affect and how they affect what students learn. Educators need to know the realities and the possibilities for learning in the era of technology. Several educational organizations have started to develop technology-related standards. In the US the National Council of Teachers of Mathematics (NCTM) considers technology as one of their six principles for school mathematics: "Technology is essential in teaching and learning mathematics, it influences the mathematics that is taught and enhances students' learning" (NCTM, 2000, pg. 16). In England the Teacher Training Agency (TTA) offers a rationale for making use of ICT to support children's learning of mathematics. They suggest that technology has the potential to make a significant contribution to their pupil's learning mathematics, because it can help them to:

i) practise and consolidate number skills;

ii) explore, describe and explain number patterns;

iii) take their first steps in mathematical modelling by exploring, interpreting and explaining patterns in data;

iv) experiment with and discuss patterns in number and shape and space;

v) develop logical thinking and learn from immediate feedback;

vi) make connections within and across areas of mathematics;

vii) develop mental imagery and

viii) write simple procedures (TTA, 1999).

Additionally, the Qualifications and Curriculum Authority (QCA) states that: *A sound grasp of technology is essential in modern society; it gives learners' the skills and understanding needed to use technology effectively, every day and in the world of work ahead. Moreover, a sound grasp* *of technology is fundamental to engagement in modern society; it teaches learners how to find information appropriate to a task and to judge the accuracy and reliability of what they find. It gets learners questioning and learning things for themselves and provides a gateway to information and experiences from a wide range of people, communities and cultures* (QCA, 1998). One of the most interesting research fields in mathematics education concerns how to help students come to a 'proper' understanding of mathematics. A great number of teachers and researchers these days try to discover the impact of technology on teaching and learning of mathematics. The British Educational Communications and Technology Agency (BECTa, 2007b) argues that technology '*improves attainment and helps raise standards, supports school improvement and efficiency, strengthens local authority data management and helps to personalize learning'* (pg.15). The use of technology, wherever it is possible in the classroom, makes the teaching process more efficient and strengthens knowledge; there are claims that technology has the potential to enhance cognitive learning, develop problem-solving and higher-level thinking skills and extend physical and mental abilities (Loveless, 1995). Working with technology contributes to the students' use of their mathematical knowledge and stimulates them into making their thinking visible and constructing their own knowledge (Hurme & Jarvela, 2005). Researchers have found evidence of a positive relationship between technology use and educational attainment (BECTa, 2001). Technology can develop children's knowledge, understanding and skills concerning the following factors: finding things out, developing ideas and making things happen, exchanging and sharing information, reviewing, modifying and evaluating work as it progresses (Allen, 2007).

Evidence from research on the impact of technology on intermediate outcomes, such as motivation, engagement and independence in learning, is increasing and more persuasive. The literature, especially in England, is very positive and rarely negative (Higgins *et.al,* 1999) about aspects of technology use. Many researchers have shown that in schools, the use of technology by teachers is very effective in raising learners' motivation and extending their communication skills (BECTa, 2007a; DfES, 2003; OFSTED, 2005). This motivating power can be particularly effective for pupils with special educational needs (SEN). Technology can help them to overcome some of their barriers, for example their ability to produce legible and tidy work, and hence can raise their achievement (BECTa, 2007c).

The benefits gained from the use of ICT apply to all students, especially to students that have special educational needs (Franklin, 2001; OFSTED, 2004). Students who are reluctant learners for whom the classroom language is their second language or learners with learning difficulties or disabilities, can work in private at their own pace without feeling that they are holding back. There is a substantial body of research into the ways in which technology can support pupils with additional or special educational needs; Technology is a powerful tool in supporting inclusive practice (BECTa, 2007c). With technology, students who have special educational needs have the right to access the whole curriculum; Technology facilitates both mixed abilities classrooms and inclusion education (Smith, 1999). The DES (1990) argues that '*information technology is making a unique and valuable contribution to the learning of learners with special educational needs, enriching their learning experiences and enhancing their access to a broad curriculum*' (pg 43). Technology is able to provide all children with access to communication, expression and information and thus a broader curriculum and experience (Loveless, 1995). Wenglinsky (1998) refers to the debate on technology's effectiveness. On one hand, advocates for technology assert that most uses of technology are valuable and can lead to improvements; technology can support higher-order skills and increases students' motivation. On the other hand, those who are opposed to technology assert that computers limit opportunities for social interaction and that the gains to academic achievement are not balanced to the costs of buying and maintaining technology. The use of technology in the classrooms has caused the fear of social isolation or reduction of students' social skills (Hennessy *et al.*, 1989). Thompson (2003) argues that technology promotes discussion and helps students to develop their thinking and understanding, particularly their mathematics thinking and their individual reasoning.

If educators accept that there are social, economic, intellectual and pedagogical reasons for using technology in education, they need to consider not only how to use a range of ICT resources but also why and when to use them. If teachers do not understand the purpose for using such applications and the right time to use them then they may not get the innovations and changes they hoped for. In England, the National Numeracy Strategy (NNS) states that the teachers should use technology in their daily mathematics lesson only if it is the most efficient and effective way to meet their lesson's objectives (DFEE, 1999).

The fact that a particular technology is available in a classroom does not automatically mean that it will be used at all or that it will be used in a particular way or that it will have positive outcomes. Agalianos *et al.* (2001) argue that technologies and their use in the classroom are '*socially contextualized and socially shaped*' (pgs 479-480). Technology does matter to academic achievement but is dependent on how it is used. When used properly technology can lead to positive outcomes. It is important that technology is used in those areas where it provides benefits and reduced in areas where it does not (Wenglinsky, 1998).

With respect to the study, it is imperative that the curriculum implementers identify topics that require use of technology and allow the students to explore the world of knowledge themselves. Geometry and Algebra are branches of mathematics that require technology use and should be explored extensively.

2.6 Computer Instruction and Achievement

Sulak (2002) studied effects of computer based instruction on student's achievement and attitude in mathematics courses. In the study, the computer based teaching was found to be better when compared to the traditional methods in terms of both achievement and attitudes. Similarly, Aktümen & Kaçar (2008) have investigated possible effects of computer algebra system (Mapple) on students' attitudes toward mathematics. They reported that the students who use Mapple in learning environments have more positive attitudes towards mathematics. Güven & Karatas (2003) aimed to determine students' views about computer-based learning environment created by dynamic geometry software Cabri. At the end of the study, the students' views had changed positively for mathematics in general and geometry in particular. The students also found dynamic geometry environment very useful. Furthermore, it is reported that the students gain more confidence by exploratory mathematical activities. Karakus (2008) intended to determine possible effects of computer-based teaching on students' achievement for transformation geometry subjects. In the experimental study, there was significant difference in favor of experiment group. All students of the experiment group had achieved high attainment level with computer-based instruction in teaching of transformation geometry. Moreover, this difference becomes more significant and gets higher for successful students in the subjects of reflection and rotation. However, there is not any significant difference between experiment and control groups for low successful students; it has been observed that computer based instruction increased the experimental group success. This study through its null hypothesis $\mathbf{H_{01}}$ sought to test whether there is any significance difference in the achievement of students taught Transformations using Geogebra and those taught using conventional teaching methods.

2.7 Computer Instruction and Attitude

Today's learner is called a digital student. Information and communication technology (ICT) permeates our whole life including work, learning, leisure and relationships. Digital literacy will, if it does not already, undoubtedly play a significant role in our future lives (Allen, 2007). Students nowadays live in a world where ICT plays a central role in their daily lives. They enter the classroom not only having encountered rich digital experiences but also being part of a society influenced by new technologies. In order for them to succeed in our digital culture, they need to be equipped not only with basic but also higher-order skills. Papert

(1994) states that ‘not very long ago, young people would learn skills they could use in their work throughout life. Today, in industrial countries, most people are doing jobs that did not exist when they were born. The most important skill determining a person’s life pattern has already become the ability to learn new skills, to deal with the unexpected’.

Education needs to prepare students for their adult lives in today’s and tomorrow’s world, so that they can contribute in activities not as passive but as active and empowered participants (Pachler, 2001). Undoubtedly we are empowered by technology and the challenge for education is to develop those human talents that technological tools cannot provide. With emerging information and communication technologies, the pressure has made everyone involved in the teaching process shift their views on effective teaching and learning even further, this greatly and positively affects the learner’s attitude. ICT and especially computers are considered to be necessary tools in classrooms and their use is mentioned in several of the goals of many National Curricula. Davis (2001) argues that ICT can play many roles in education that will continue to develop: ICT aspects of core skills, ICT as a theme of knowledge and ICT as a means of enriching learning.

New applications of technology have the potential to support learning across the curriculum and allow effective communication between teachers and learners in ways that have not been possible before. ICT has ‘the potential not only to support the current curriculum but also to enhance the experience and understanding of that curriculum and even extend thinking and learning in new ways’ (Loveless, 1995). Students are provided with a sense of mastery over their environment; they are thinking about their thinking, checking their work and reflecting. The use of ICT promotes initiative and independent learning, with pupils being able to make informed judgments and develop the ability to be critical in their choices (DfEE, 1999). Loveless (1995) states that, ‘ICT has the potential to organize and process information, freeing the children to ask questions, look for answers, take risks in exploration and use a wide range of resources for information. They can develop a positive attitude to their work by using real and relevant data and presenting work in a polished and accessible form. A positive experience of ICT in the classroom, developing children's confidence and confidence in working as individuals and with others, should contribute to the general quality of their learning'. Teaching with ICT in the classroom is seen as qualitatively different from explicit, traditional teaching. While the need for effective use of ICT in teaching subjects across the curriculum is increasing, good practice remains uncommon especially in Kenya (Ofsted, 2001). The rapid growth of technology for learning which include the introduction of Geogebra software has reports that provide evidence on the effectiveness of the software. Results show that students have positive perception towards learning and have better learning achievement using Geogebra. Available free online, Geogebra can benefit students Mathematics learning and diversifying learning in classrooms. The overflown of resources triggered students' interest to learn Mathematics however, the selection of software has to be properly planned.

According to Majid et.al (2010) who carries out research on Computer Aided Instruction (CAI) and student attitude towards learning Mathematics, the research revealed that CAI increases the learning level of students and improves their attitudes towards mathematics compared with traditional instruction.

This study through its null hypothesis $\mathbf{H_{02}}$ sought to test whether there is any significance difference in attitude towards transformations in mathematics between students taught using Geogebra (GIS) and those taught using conventional teaching methods.

2.8 Creativity

There is no one agreed-upon definition for creativity. Oxford Dictionary defines creativity as "*thinking about problems in new ways or thinking of new ideas*". According to Webster Dictionary "*Creativity is the ability to think up and design new inventions, produce works of art, solve problems in new ways, or develop an idea based on an original, novel, or unconventional approach".*

Research findings have shown that creativity is an inborn talent and is inherent in every human being. Maslow (1970) believes that creativity is a part of intelligence and "all people are creative" in a sense that it exists in all humans and like other abilities needs to be improved. According to Amabil (1998) the sources of creativity are: knowledge, creative thinking, and motivation. The knowledge provides required information for creative plans, creative thinking helps people handle problems and social relationship, and motivation is the key to creative production and is the most important internal feeling and desire to achieve goals.

According to Sternberg and Lubart's theory (cited in Adam 2006), creativity requires the combination of six factors including sufficient knowledge in the field of interest and research, social support, and facilitating and encouraging environment. Gogne (1977) considers creation as a kind of problem solving that takes shape on the basis of background knowledge. In a similar way, Woolflek (2004) asserts that the ability to be creative such as solving a problem is dependent on individual's knowledge and information related to the field in which the person is creating.

Guilford (1987) considers creativity as divergent thinking in solving problems, that is, the type of thinking that moves in various directions. He considers the divergent thinking composed of several elements such as fluency, that is, generating several thoughts at the same time; flexibility, that is, producing different and unconventional ideas and solutions for one problem; originality, that is, using new and unique solutions; and elaboration, that is, creation of details and determination of interpretations and users. Seif (2009) has listed the factors that have been suggested by educationists to improve creativity such as letting students experience without limiting them to specific situations, providing them with opportunities for self-improvement and discovery learning, respecting learners' individual differences, and providing them with models of creative behavioural patterns.

2.8.1. Computers Instruction and creativity

With the widespread integration of computer in education, many researchers investigated its effect and application in academic centres on key end-users. Proctor (1999) believes that creative thinking and problem solving with the help of computer started in late 70s and its theoretical basis was on Maslow's, Rogers's, and Kelly's propositions. The development of different types of educational software that work on the basis of complex cognitive modes of thinking rather than just repetition is the result of these kinds of studies. In line with this, there has been a surge of interest in the literature to investigate the influence of Computer based programmes on students' creativity, attitudes to subject matters, and increasing the outcome of learning

Yashau *et al.* (2003), for instance, have reviewed many studies with regard to the influence of computer based programmes on mathematics and found that the programmes can improve teaching mathematics. Jeffries (1989) reviewed studies done in this regard and came into conclusion that computer based programmes has at least the same effect that traditional teaching can have on all students' learning in different grades and many different school subjects, CAI can be more helpful for weaker students, it can create positive attitudes in students towards school subjects, and it decreases the time and duration of learning in comparison to traditional teaching.

Educationists believe that computer can create opportunities for students to improve their creativity. Kozielska (2004) for instance has proposed that the level of creativity of students could be improved if didactic computer programs were applied along with other known methods and resources of education. Dodge (1991) believes that the usefulness and application of computers in developing creativity is related to in the following features:

(i) Flexibility: with ability to change points of view and redefinition of the problem more widely and decreasing abstract ideas

(ii) Fluency: to be able to generate many different ideas knowing that just a few of them are valuable

(iii) Elaboration: the ability to synthesize separate elements to make new combinations

(iv) Assessing: the ability to test ideas, and elimination of those which are useless

In the era of technology, modern educational centres are different from traditional schools that were made on the basis of face to face relationship between students and teachers. Schools are now supported by computer-aided instructional environments. As modern society needs members who are creative, investigating the function of educational centres that integrate computers into their curriculum seems inevitably necessary. This study thus tries to shed light on students' creativity in mathematics classes by comparing them in two learning instructions, the traditional teaching and computer-aided instruction.

2.9 Critique to the Literature review

The review of related literature on effectiveness of using computer in the teaching and learning of mathematics reveals the following;

(i) The students who use computers score significantly higher than those taught using conventional methods (Singh *et al.,* 1991). Karakus (2008) was able to show that there is significant difference in achievement of students who are high achievers, however, there was no significant difference for low achievers.

(ii) The students who used the computers showed significantly highly favourable attitude towards mathematics than those who did not use the computer. Although Majid et.al (2010), says that Computer Aided Instruction increases the learning level of students and improves their attitudes towards mathematics compared with traditional instruction. Little study is known in Kenya on whether the attitude is enhanced on whole mathematics topics or sections.

(iii) Achievement in mathematics and change in attitude towards mathematics were found to be independent of the sex factor.

(iv) Students' exhibit higher creativity when using computers than the conventional class environment. The fact that computers can impact students' development of creativity can be related to the unique capability of computers to create highly interactive learning environments, to provide a variety of learning activities, to offer independence to users in the process of learning, to improve learners' self- confidence as a result of security in learning, and to encourage learners and motivate them to learn in a better way with technology-based tools (Mahnaz *et al*, 2005). This can be helpful particularly in mathematics classes where teachers are worried about class time and ways of teaching mathematics concepts to maximize students' understanding. Computers have the ability to teach concepts in various modes and forms, portraying abstract ideas, and making math classes interesting and motivating. Consequently, students' positive attitudes and knowledge are increased which in turn can affect the development of their creativity. However, this creativity is in learning, little information is available in Kenya on manipulation of tools.

There is equally a lot of literature on Geogebra and its functions, however little information is obtained on its effectiveness in achievement, attitude change and creativity in Mathematics in Secondary Schools particularly in Kenya. The study aims at bridging this gap.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter gives a detailed account of the description of the study area, population, sample and sampling techniques, data collection procedures, research design, research instrumentation, variables and analysis procedures.

3.2 The Study Location

The study was conducted in eight randomly selected secondary schools in Kakamega Central Sub-County of the Kakamega County in the Republic of Kenya. The latitude for Kakamega, Kenya is 0.2827^{o}N and the longitude is 34.7519^{o}E. There are 24 schools in Kakamega Central, with one being a National School, seven county schools, four private schools while the rest are subcounty schools mainly mixed day schools. Kakamega County is the second most densely populated county in the republic of Kenya, with its highest density being in Kakamega Central Subcounty (Republic of Kenya report, 2002). Yet Kakamega Central is amongst the Sub-county's with poor results in Mathematics at Kenya Certificate of Secondary Education (KCSE) examinations (Kakamega County Education report, 2014). It was a pilot Sub-county during SMASSE piloting, but that seems not to have impacted positively, despite the sub-county eargerness to improve on the students' performance in mathematics. Having benefitted from government funding aimed at improving the ICT infrastructure, there is need to explore a computer based tutorial software which has the potential of enhancing learners creativity and consequently achievement in mathematics. It is on this basis that the Sub-county was choosen. Figure 5 in Appendix G (Pg 117) shows a map of Kakamega County where Kakamega Central is located.

3.3 Research Design

The study incorporated a quasi-experimental nonequivalent Solomon four as the main research design. However, for the information that could not be obtained quantitatively, the researcher employed qualitative research design.

3.3.1 Quasi-Experimental design

The Solomon (1949) Four –Fold design was employed for this study. The reason for this choice is two-fold. First, its nature, computer based Instruction as an innovation is justifying its inclusion in the school curriculum. Secondly, the potential benefits of computer based instruction are yet to be determined and explored fully. The application of this design to educational studies can be challenging to a researcher, because of the daunting task the researcher has to undertake in manipulating the independent variable while holding all other variables constant in the required educational context (Ary *et al*, 1982). The researcher is therefore held responsible for:

(i) Selecting the sample of subjects;

(ii) Determining the treatment;

(iii) Deciding which groups to receive the treatment;

(iv) Controlling other variables besides the treatment ;

(v) Observing and assessing the effect of the treatment on the group after the treatment is terminated (Kiboss, 1997).

The design was rigorous and robust enough in eliminating variations that might arise because of experiences and consequently contaminate the validity of the study. Threats such as history, maturation, testing, instrumentation, statistical regression, selection-maturation interaction effects, mortality and diffusion are eliminated by randomization. "Randomization cancels out the effects of any systematic error due to extrinsic variables that may be associated with either the dependent or independent variables" (Nanchmias *et al*, 1987, pg. 491)

The design of the study demands that the subjects be exposed to pre-test and post-test treatments to counter limitations that are associated with it. A sample of the experimental design is illustrated in table 3.1:

Table 3.1: A paradigm of the study design

Solomon Four-Fold design

Group	Pretest	Treatment	Post-test
E_1	O_1	X	O_2
C_1	O_3		O_4
E_2		X	O_5
C_2			O_6

Source: http://www.experiment-resources.com/solomon-four-group design.html#ixzz0zXDIC7Ky

Where;

E_1- Experimental group 1; E_2- experimental group 2; C_1- Control group 1; C_2- Control group 2;

O_1 and O_3 – Pre-test (E_1 and C_1)

O_2, O_4, O_5 and O_6 are Post-test (All the four groups)

X- Treatment (E_1 and E_2)

From the four groups randomly selected out of the 240 subjects, two groups were assigned to them (preferably treated together) but only one of these groups and one from the remaining groups (both selected at random) were pre-tested. It was preferable that the pre-testing of the two gropus and post-testing of the four groups was done at the same time.

When setting the experiments, the outcome of the pre-test offers valuable information concerning time sequence as a basis of comparison, since severe reactive effects are anticipated. Through sensitization of the sampled population, the pre-test might in and out of itself affect the post-test outcomes. However, the choice of Solomon Four fold design offers an additional set of experimental and control groups that are not pre-tested. Thus, the additional set of groups enables the reactive effects of testing not to be directly measured by comparing the two experimental and control groups. The indication on whether the treatment has an independent effect on the groups that were not sensitised by the pre-test can then be compared. The ability to show the effect of the independent variable even in the absence of the pre-test can be generalized to the populations that were not measured prior to the treatment as alluded by Campbell and Stanley (1966) in their statement; "Not only is generalizability increased, but also in addition, the effects of treatments are replicated in four different fashions: $O_2 > O_1$, $O_2 > O_4$, $O_5 > O_6$ and $O_5 > O_3$. The actual instabilities of experimentation are such that if these comparisons are in agreement, the strength of the inference is greatly increased" (Campbell *et.al*, 1966 pg. 32).

3.3.2 The qualitative research design

Literature reviews revealed that not all the information about the effects of new technology on learning can be obtained from quantitative data. Direct observations and/or interviews of the learners are required to supplement the data obtained quantitatively so as to understand the classroom dynamics. Gardiner *et al.* (2000) alledges that there has been lack of sensitivity when it comes to changes that affect the instructional settings resulting from new technology. Presently, stronger voices are echoed for inquiries into the computer based Instruction research leading to the discovery of instructionally significant tasks for future research (Clark & Salomon, 1986). Thus, empirical data needs to be complemented with qualitative data. The reason for opting for qualitative research methodology was to carry-out group and individual interviews to unravel meanings that students attach to classroom dynamics and their experiences with instructional materials especially computer based instruction software - Geogebra (Milles & Hubberman, 1984).

Based on the tenets of the qualitative research design, the researcher probed the group of selected subjects to gain insights on how instructional software fit into their learning and instructional needs. The researcher also noted responses and remarks, queried a selected group to delve into their experiences with computer in contrast to conventional methods used by the teachers. During and after the field sessions, the researcher recorded summary sections and compared them with the research questions. The researcher made deliberate attempts to collect complete and accurate data by reviewing relevant copies of the information from the interviews prior to being accessed and verified by the concerned subjects. The interview responses collected were analysed and presented as descriptive data. The interview guide for the teachers and studenta was designed and used to collect the qualitative data (Appendix A, pg.95).

3.4 Target Population

At the time of the study, Kakamega Central Sub-county had a total of 24 secondary schools. Out of these, one is single sex boys National boarding school, five are single sex girls boarding schools, four are private schools (one single sex girls boarding and three co-educational day) and the rest 15 are coeducational-day secondary schools. The total population of students at the time of the study was about 8700 while teachers were about 300. Eight of these schools have computers and use them not only for management but also for instructional purposes.

3.5 The Sample and Sampling technique

A total of 240 form two secondary school students from eight secondary schools in Kakamega Central Sub-county of Kakamega County in Kenya served as the subjects of the study. The sample size determination for this study was based on Nassiuma (2000) formula for calculating the minimum sample size for each category. Nassiuma (2000) asserts that in most surveys or experiments a coefficient of variation in the range of 21% to 30% and a standard error in the range of 2% to 5% is usually acceptable.

$$S = \frac{N(Cv)^2}{(Cv)^2 + (N-1)e^2}$$

Where;

S = the sample size

N = the population size

Cv = the coefficient of variation

e = standard error

Using the above formula therefore, the selected sample size from a study population of 8700 form two students was:

$$\frac{8700 \times (0.3)^2}{(0.3^2) + (8700 - 1)(0.02^2)} = 219$$

Stratified random sampling was used to select the 8 schools because the research involved the use of computers and only schools satisfying the following three criteria were involved: (1)

Schools that had computers. (2) Schools that offered computer studies. (3) Schools that were trained in ICT integration in teaching and learning.

The subjects of the study for experimental and control purposes were drawn from the 240 Form two students class. The Experimental Groups (E_1, E_2) were selected from four schools and comprised of 120 students randomly selected. The students picked yes and no papers to be included in the group. The remaining 120 who also picked yes and no papers, were selected from the other four schools which formed the Control Groups (C_1, C_2). The Mathematics teachers who handled the selected students were definitely included in the study. The experiment took one month (4 weeks) to be completed. Form two students were deemed most suitable because the topic of transformation I is taught at this level. The computer studies class added some advantage to the research since the students had acquired basic computing ideas and skills. The Mathematics teachers involved in the study either had basic computing knowledge or were given orientation on the basics by the computer teachers available in school under the supevision of the researcher.

In the study, simple random sampling was used to select groups, herein referred to as Experimental Groups 1 and 2 (E_1, E_2) and Control Groups 1 and 2 (C_1, C_2). The random assignment of subjects to groups was to ensure that the subjects of the study had an equal and known chance of being included in the sample and that this probability is equal throughout the experimental treatment. The experimental groups were exposed to the Geogebra instruction software while the control groups were taught using conventional methods such as demonstration and lecture methods by their teachers.

3.6 Instrumentation

Data collection was done using the following instruments:

(i) Instructional software: The programme was used by the experimental groups only.

(ii) Mathematics Achievement test: The test items based on the topic of transformation was administered to the students before and after the study. The pre-test was based on the topic of Gradients and equations of a stright line as this is a prerequisite to Transformation I. The post-test was on Transformation I. The questions were obtained from the previous years KNEC papers.

(iii) Questionnaires, which were administered before and after the study.

(iv) Face to face Interviews: The process was scheduled during and after the study.

3.6.1 Mathematics Classroom Environment Questionnaire (MCEQ)

The MCEQ instruments (Appendices C and D) had a scaling tool that comprised of a number of positive and negative items reflecting on the students classroom dynamics (learning process) during a mathematics lesson. After review of literature on attitude and motivation, the researcher constructed items of individual responses. In appendix C, questions 1-7 targetted attitude, while 8-14 targetted creativity. In appendix D, questions 1-6 were on attitude while 7-16 were on creativity. Several bipolar individual response statements that depicts the mathematics lessons as understandable/difficult to understand, interesting/dull, useful/meaningless, easy/difficult were prefered by the researcher to assess the classroom environment in terms of course, subject and ICT use in the school. The data obtained from the experimental and control groups on classroom environment before and after treatment were analyzed using analysis of variance (ANOVA). The experimental groups were non-equivalent.

3.6.2 Interview Schedule

The groups E_1 and E_2 were the students in the study interviewed by the researcher in order to establish qualitative data about the effectiveness of Computer based Instruction (Geogebra) as contrasted with conventional methods. The students randomly selected (by allowing them to pick yes or no) were interviewed for 25 minutes during and after mathematics lesson.

The interviewees were handled individually in order to perceive their own perceptions of the two methods of instruction in the teaching and learning of mathematics in the topic of transformation.

In order to reduce on any biases, the information from the interviewees were reviewed by the researcher and copies given back to subjects concerned to confirm the data earlier given. Through this action, the researcher's confidence in the reliability and validity of results was increased. Overally, the interview guide (Appendices A & B) contained multi-structured questions meant to provide a means of collecting data from the participating subjects in a more relaxed way. The interview guide was designed with the research questions in mind. The students were interviewed on site, during and after the lesson. The teachers were interviewed by the researcher alone while the teachers used in the study assisted the researcher to interview students. The researcher and his assistants were able to collect sufficient descriptive information about the teachers and students feelings towards the lessons taught using Geogebra and those handled conventionally.

3.6.3 Instructional Skill (Creative) Activities

The students used in the study were exposed to instructional creative activities developed by the researcher on the topic of transformations. The activities were designed such that they were menu-driven. The topic was preceded by statement of specific objectives. The primary input device was the mouse, but occassionally the students could use the keyboard when there was need. The activities were developed for instruction and practice.

Two pedagogical methods were used, the Geogebra instructional software and the conventional methods of instruction. On Geogebra software, the teacher's role was to facilitate learning, that is, organize and supervise the students learning process during the computer based lessons. The subjects received all their instructions from the computer software. The content to be covered and the lesson assignments were conducted within the normal mathematics laboratory setting. Thus, the students creativity was envisioned in the way they manipulated the tasks and navigated through the Geogebra tools. On the other hand, during conventional methods, the teachers gave instructions using the usual teaching methods (as is suggested in the Teacher's Guide available) such as discussion, problem solving, lecture and any other, while the students listened and responded to instructions. Thus, the teacher was in control of the instructional process.

3.6.4 The Mathematics Achievement Test

The Mathematics Achievement Test (MAT) Pre-test (Appendix E) consisted of 5 question items while Post-test (Appendix F) consisted of 3 question items. The content of the items were derived from the topic selected and specific objectives taken from Kenya Institute of Curriculum Development (KICD) approved syllabus for Mathematics education, and Kenya National Examination Council (KNEC) syllabus. In the study, the question items used have equal weighting of the course content covered during the experimental treatment. The researcher obtained the questions from the previous KNEC past papers to ensure standardization.

3.7 Piloting

The instruments were piloted on a group of 80 students and 4 Mathematics teachers in two schools in the sub-county that did not take part in the actual study. Both gender were considered (since this was not a variable) in piloting as test-retest method was used. The pilot study helped the researcher to identify any field problems that was likely to be encountered or any problem associated with the instruments and enabled their review before their actual use in the study. The pilot study also enabled the researcher to check on whether the instructions in the questionnaires were clearly understood by the repondents. The results were analysed and a post test undertaken to test the validity and reliability of the research tools. The class of 40 was divided into two with one group being exposed to Geogebra under supervision of a teacher while the other to conventional methods under the supervision of the other teacher. A reliability of 0.75 was obtained using Pearson's product moment correlation coefficient formula when the responses were scored and treated. This was observed to be a reasonable index since it was above the recommended minimum r-value of 0.5, according to Koul (1992).

3.8 Validity of the instruments

Validity refers to the extend to which a tool measures what it purports to measure. The researcher constructed the research instruments and validated them for the study with guidance from the supervisors. During the test construction, the researcher narrated the purpose of each instrument before developing a matrix of test specification on the content areas covered by the instruments and entered them in ways which would make the contest be manifested. The items were corroborated so as to correspond to each cell in the test specification hence ensuring adequate coverage and purpose of the instrument.

By seeking opinion, the most appropriate design was sought. The tools in this study were prefered because they enabled the researcher to collate views from a large number of respondents in the shortest time possible. The instruments were validated before they were used to collect data on the subjects knowledge, mastery of skills, creativity and for the interviews. Likewise, the Geogebra instructional software was reviewed and piloted before it was used in the actual study. The purpose of doing this was to confirm the relevance of computer based instruction software to the present syllabi, level of the student learning in terms of instructional quality, technical quality, interactivity and support of materials. The implementation of the Geogebra was considered as the crux of the computer based instruction evaluation process in which the effectiveness of the software was to be determined by subjecting the programme to a large number of students in a normal classroom setting. In view of these, a valid and reliable measuring tool to gather data necessary to answer the questions and testing the hypotheses was mandatory.

The Mathematics Classroom Environment Questionnaire (MCEQ) instruments were subjected to a team of experts from the department of Mathematics and Science Education (SME) at Masinde Muliro University of Science and Technology (MMUST) to review the contents and improve its quality. The researcher piloted the instruments to avoid ambiquity and changed or removed unclear items.

Mathematics Achievement Test (MAT) was given to a team of experts from dapartment of Science and Mathematics Education at MMUST knowledgeable in mathematics education at secondary level to sieve the language use and any difficulties that may arise from the items. MAT was used in both pre-test and post-test activities. A table of specifications of all objectives included in the achievement test was prepared in order to ensure content validity was observed. The items were then piloted in two separate schools in the same sub-county.

More experts were involved in developing research items because analysis heavily hinge on the type of items the respondents are exposed to. Mbuthia (1996) stresses that "validity however should not depend on the subjective judgement of one specialist. It should be based upon careful analysis by several specialists, of instructional objectives and of actual subject matter studied".

3.9 Reliability of the instruments

Reliability refers to the consistency of a measure. A measure is said to have a high reliability if it produces consistent results under consistent conditions. The researcher used test-retest method to assess the degree to which the test scores were consistent from one test administration to the next. This involved:

- Administering a test to a group of individuals
- Re-administering the same test to the same group at some later time
- Correlating the first set of scores with the second.

The correlation between scores on the first test and the scores on the retest was used to estimate the reliability of the test using the Pearson product-moment correlation coefficient (r);

$$r^2 = \frac{\text{Total variation-Unexplained variation}}{\text{Total variation}}$$

Conventionally,

$$r = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{\left[N\sum x^2 - \left(\sum x\right)^2\right]\left[N\sum y^2 - \left(\sum y\right)^2\right]}}$$

Where;

r = Reliability Coefficient

N= Total number of subjects in the pilot study

$\sum X$ = Sum of scores of the pilot experimental group

$\sum y$ = Sum of scores of the pilot control group

$(\sum X)^2$= Sum of squares of scores of the pilot experimental group

$(\sum y)^2$ = sum of squares of scores of the pilot group

This coefficient (r) is a correlation, which measures the intensity and direction of a relationship between two or more variables. In this context, it is an internal measure of relationship that reflects the proportional reduction of error when one shifts from the mean as the prediction rule to the linear regression equation.

3.9.1 Reliability of the MCEQ

The MCEQ were administered to a group of 40 students selected from the four schools used for piloting in the same sub-county of study. A reliability of 0.75 was obtained using Pearson's product moment correlation formula when the responses were scored and treated. This was observed to be a reasonable index since it was above the recommended minimum r-value of 0.5, according to Koul (1992). During the actual study, a reliability coefficient of 0.85 was obtained using the same formula. This was done to rule out any doubts that may arise there after.

3.9.2 Reliability of the test scores on the MAT

The researcher collated and scored the student's responses in the pilot study. This was meant to determine the internal consistency of the test items used in the instrument. The analysis using Pearson's product- moment correlation coefficient (r) showed a value of 0.75, which was a reasonable index for research instruments, given that the value was above the minimum r-value of 0.5 according to Koul (1992). A high reliability value (0.7 or higher) shows that the characteristic measured what it was designed to measure (James & Kintz). The validity and reliability of these items were reviewed by the education experts and Secondary school mathematics teachers as well, whose comments were incorporated in the item contents.

3.10 Research Variables

In this study, the independent variable comprised of the instructional method based on two levels:

(i) Geogebra instructional software (ii) Conventional methods of instruction.

The dependent variables in the study were the student's Attitude, Creativity (classroom dynamics) and student's achievement in mathematics tests.

3.11 The setting of the study

The subjects drawn from form two class, were randomly assigned to experimental and control groups. The two groups were further subdivided into four (two each) and handled separately with fixed tasks assigned to them. One experimental and one control groups were pre-tested so as to measure the dependent variables. This enabled the research to evaluate their feeling, thinking and performance in order to obtain what the design herein reflects as XE_1 and XC_1 mean scores. The teacher(s) and students were assembled in the mathematics laboratory with computers where they received orientation on the basic computer-operation skills . The experimental group was later exposed to transformation concepts through the Geogebra software after pre-testing. The control groups were taught the same content through the conventional methods of instruction. As the students navigated the Geogebra tools, they were presented with tasks in the form of activities from each sub-topic, which required them to manipulate, make observations and then draw conclusions.

3.12 Data Collection Procedures

The researcher sought permission from the Ministry of Education through the Faculty of Education and Social Sciences, Masinde Muliro University of Science and Technology and National Commission of Science, Technology and Innovation (NACOSTI, Appendix G). Notification letters to do research in the selected schools were forwarded to the Principals of the schools and the teachers concerned. The researcher visited the schools and informed the Principals of the purpose of the study. The classes concerned were then handed over to the researcher who made arrangements with the teachers about the induction course and the conduct of the study. The induction exercise lasted for one week. All the students involved in two (Groups E_1 & C_1) of the four groups of the sample took a pre-test after the induction.

The researcher collected the scripts immediately after the administration of the pre-test and coded them manually. The similarity of experimental and control groups were determined using the raw scores. The interviews were conducted for the two groups separately. The treatment was administered two weeks after the pre-test date. Finally, the post-test was administered to all the groups of the sampled students, scripts collected and marks obtained by the researcher together with the teachers who were acting as research assistants. The mean scores were calculated for every group and these provided the scores for the experimental and control groups respectively. The collection of data was done at several stages during the implementation process. A total of 240 randomly selected students participated in the study, from which 120 students were selected for the experiment and constituted experimental groups (E_1 & E_2) comprising of 60 members each. Similarly, the remaining 120 students constituted the control groups (C_1 & C_2) each having 60 members. The data obtained from the study was subjected to qualitative and quantitative analyses.

3.13 Data Analysis

The analysis was facilitated using raw data obtained from the creativity and achievement tests summarized in tables and coded before being fed into the computer for analysis. The Statistical Package for Social Sciences (SPSS version 17.0) was used . In the analysis, both descriptive and inferential statistics were used to describe the results and test the hypotheses respectively. In the descriptive statistics, arithmetic means and standard deviations were used to show not only the proportional amount creativity and achievement towards the subject within the four groups, but also the differences between the four groups under comparison. In inferential statistics, analysis of variance (ANOVA) was employed to determine the significance of the difference in student's creativity and achievement in mathematics between the experimental and control groups.

The analyses of data were focused on the testing of the three null hypotheses in the study. Anova which is a more versatile statistical technique compared to t-test was prefered (Ary et.al 1978). The qualitative descriptions were used to supplement the quantitative analysis and offer a wider and varied picture of the findings particularly in areas that were not easily brought out by quantification.

As Miles and Huberman (1984) points out; the analysis of qualitative data involves three levels namely:

(i) Initial impressions on reflection such as interviews, questionnaires, teaching and testing, diary/teacher's journals.

(ii) Secondary impressions when reflecting on and reviewing the processing of data sources e.g. transcribing interviews, summarizing the processing of data sources, summarizing lesson observation schedules, reflecting on documents, making and summarizing achievement tests and transcribing lesson process.

(iii) Formal thematic analysis such as study of raw data, coding of raw data, listing categories, noting relationships between categories, building logical chain of evidence and linking understanding to research.

The analysis process involved the use of instruments that were developed, validated and piloted before being used in the actual classroom setting. The purpose was to obtain data on the subjects creativity and achievement before and after the mathematics course and also to interview the subjects during and after the Geogebra tutorial classes. The learner's questionnaire involved a five point Likert-type questions testing on their creativity and attitude and designed to measure their opinion towards Geogebra as a tutorial software viz-a viz conventional methods of instruction. The questionnaire addressed the second and third objectives of the study. An achievement test consisting of 5 questions tested on the learners' acquisition of knowledge and skills in the mathematics course, thus addressed the first objective of the study.

3.14 Ethical Considerations

The number of students who live in homes which have access to ICT tools, such as computers, CD-ROMs and the Internet regularly are few. Majority of the students come from less affluent or less endowed backgrounds thus their entry level to digital literacy are quite varied. In order to limit this disparity, all students who participated in the research had training lessons (orientation) in Geogebra. As stated before, GeoGebra is freely-available, open-source software, thus, there isn't any license issue in its use. However, the most important ethical issue in the research concerned the confidentiality of the responses and anonymity of the respondents. The researcher assured the participants of confidentiality of the data and protection of identities. Direct observations technique made some of the respondents apprehensive as some of their classroom practices were recorded. To overcome this, a familiarity meeting was organised to diffuse any anxiety, fears and suspicions, thus making the parties more relaxed and inclusive in the study. Ethical considerations were made by assuring the respondents about the confidentiality of the their responses given some hinged on their classroom practices.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 Introduction

This study explored the effectiveness of Geogebra Instructional Software on students' creativity, attitude and achievement in secondary school mathematics. The findings presented in this chapter are given meaning in the light of the available evidence on the effectiveness of Geogebra Instruction software on students' attitude, creativity and achievement in mathematics. The need to investigate the effect of Geogebra on students' creativity, achievement and attitudes arose from the concern over performance in the subject over the years. Specifically the study sought to: (i) Investigate whether there was any significant differences in the achievement of students taught transformations using Geogebra software (GIS) and those taught using conventional teaching methods. (ii) Assess whether there was any significant difference in creativity between students taught transformations using Geogebra software and those taught using conventional teaching methods. (iii) Assess whether there was any significant difference in attitude development between students taught transformations using Geogebra software (GIS) compared to those taught using conventional teaching methods.

Using Solomon four-fold design, 240 form two students from secondary schools in Kakamega Central Sub-county and with the aid of questionnaires, interview schedule, and an achievement test, the researcher collected data. The research data collected was duly subjected to both descriptive and inferential statistics. In descriptive analysis, means and standard deviations were used to show not only the level of creativity and achievement towards the subject within the four groups, but also the differences between the four groups under comparison. By computing the means and standard deviations and carrying out assessment the researcher was able to highlight important aspects of the trends of data observed. In inferential statistics, the statistical method employed was the t-test and one way analysis of variance (ANOVA). The t-score gives the direction of the difference while ANOVA shows whether there is a difference. ANOVA was employed to determine the significance of the difference in student's creativity and achievement in mathematics between the experimental and control groups. The hypotheses were tested at the 0.05 level of significance. This chapter focuses on the presentation, discussion and interpretations of the findings. It also looks at the implications of the same.

4.2 The Respondent's Demographic Profile

Twenty mathematics teachers from eight secondary schools and 240 form two students in Kakamega Central Sub-county of Kakamega County in Kenya participated in the study. The subjects were exposed to the Mathematics Teacher's Questionnaire (MTQ), the Mathematics Student's Questionnaire (MSQ), the Mathematics Achievement Test (MAT) and interview Schedule (IS) as the research instruments for data collection. A summary of schools and respondent's demographical data were as in Table 4.1.

Table 4.1: The Respondent's demographic Profile

VARIABLES	FREQUENCIES	PERCENTAGES
CATEGORY OF SCHOOL		
Sub-County	5	62.50%
County	2	25%
National	1	12.50%
GENDER (TEACHERS)		
Male	16	80%
Female	4	20%
Girls	60	50%
Boys	60	50%
PROFESSIONAL QUALIFICATION		
Diploma	2	10%
B.Ed & B.A (PGDE)	14	70%
Med/MSc/MA	4	20%
TEACHING EXPERIENCE		
Less than a year	2	10%
1-4 years	4	20%
5-10 years	6	30%
11-15 years	6	30%
Over 15 years	1	10%
PROFIECIENCY IN ICT SKILLS		
Very comfortable	4	20%
Comfortable	7	35%
Uncomfortable	6	30%
Not familiar	3	15%
Proficiency (Students)		
Very comfortable	60	50%
Comfortable	30	25%
Uncomfortable	20	17%
Not familiar	10	8%

From the results shown in table 4.1, it can be seen that 62.5% of the schools chosen were sub-county schools, County schools constituted 25% while 12.5% was a national school. This is a representation of what is on the ground, currently there are more sub-county schools than county schools. The number of county schools surpasses the national schools. Whereas the percentages may not be the same, there is a strong correlation in terms of choice of schools under study. On gender; 80% were male teachers while their female counterparts constituted 20%. This is another replica of gender representation as far as science and mathematics courses are concerned. In a number of schools in the county the teachers of science are handling biology and chemistry, very few teach mathematics and physics, as these two are considered male oriented (Ministry of Education report, 2005). However, equal number of boys and girls were interviewed. It was also interesting to note that 70% of the teachers were graduates, 20% were post-graduate teachers while 10% were holders of diploma. Kenya being a fast developing country has a number of teachers doing their second or third degrees. Infact majority of the diploma holders especially in art-oriented subjects were deployed in primary schools as there was influx of graduates in those subjects in 1988. The science subjects however still have few diploma holders, although a bigger population are in their sunset years.

On teaching experience; 30% of the teachers had taught for between 5-10 years and 10-15 years each, 20% had taught for between 1-4 years while 10% had taught for less than a year and another 10% for over 15 years each. This fact is correct given that many experienced teachers left teaching for other jobs like Quality Assurance and various positions in their counties (MoEST report, 2005). Secondly, the Kenyan Government rarely employs new teachers due to financial constraints. The small number is as a result of replacement due to natural attrition or those who left for greener pastures. The table shows clearly that 20% were very comfortable with ICT skills, 35% of the subjects were comfortable, 30% were however uncomfortable while 15% were not familiar with digital literacy skills. It is worth noting that a number of teachers have taught for between 5 to 15 years. This group of teachers are also digitally literate, hence comfortable with ICT skills. Interestingly enough 50% of the students were very comfortable with ICT skills, 25% comfortable, 17% were uncomfotable while a meagre 8% were not familiar with the skills.

4.3 Geogebra Instruction Software and its effect on student's achievement in transformations

One of the objectives of the study was to investigate on whether there were any significant difference in the achievement of students taught transformations using Geogebra Instruction Software and those taught using conventional teaching methods. This was done by calculating the arithmetic means and standard deviations of the Mathematics Achievement Tests (MAT) of the pre-test and post-test results. A t-test for independent samples was applied to check whether the difference between the groups was meaningful. The comparisons of the means and standard deviations of the various groups were done.

Each of the four groups had post-test result to reflect the overall ability and eliminate any bias arising from the test. The post-test result showed the level of retention of the concept learnt over the period of time for both control and experimental groups. Each group comprised of 60 students each giving a total of 240 students. Table 4.2 shows the mean and standard deviations of the pre-tests and post-tests of both control and experimental groups of the sampled schools analysed within the 0.05 level of significance.

Table 4. 2: Comparison of Mean scores, Standard Deviations and t-test on the MAT for the control and experimental groups in pre-test.

Analysis	No	Group E_1	Group C_1	Critical t-value	Calculated t-value	Result
Mean (Pre-test)	60	50.63	52.34			
Std.Dev.		*10.301	*10.816	1.89	0.0246	*0.0246
Highest Score		45%	59%			

$n_1 = 60$, $n_2 = 60$, $\alpha = 0.05$, df = 118, critical t-value = 1.89

*No Significance

The pre-test scores of the control group and the experimental group did not show any significant difference. The assumption made is that the two groups started out with equivalent means, which implies they had same ability and capacity from the beginning thus equal mathematical performance.

In Table 4.3, the achievement scores of the control and experimental group in post-test is shown.

Table 4. 3: Comparison of Mean scores, standard deviations and t-test on the MAT for the control and experimental groups in post-test.

Analysis	No	Group E_1	Group C_1	Critical t-value	Calculated t-value	Result
Mean (Post-test)	60	71.98	54.45			
Std.Dev.		*8.34	*9.88	1.89	9.633	*9.633
Highest Score		55%	79%			

$n_1 = 60$, $n_2 = 60$, $\alpha = 0.05$, critical t-value = 1.89

*Significant

The post-test results showed that the experimental group had higher mean scores than the control group. The t-test for the independent samples carried out for the two groups showed significant difference on the post-test. From Table 4.3, experimental group attained 71.98% while control group realized 54.45%. The calculated t-test value was 9.633 at degree of freedom of 118 ($n_1+n_2-2 = 118$) and was greater than the critical value of 1.89.

When means, standard deviations (SD) for E_1, C_1, E_2 and C_2 and Improvement Index of Mathematics test was compared between the pre-test and post-test, the results are as shown in Table 4.4.

Table 4. 4: Comparison of the Means, Standard Deviations (SD) and Improvement Index on Mathematics Achievement Test (MAT)

Scale	E_1	C_1	E_2	C_2	Average
Mean (Pre-test)	52.63	52.45	-	-	52.54
SD	10.3	10.82	-	-	10.56
Mean (Post-test)	71.98	54.45	69.34	62.75	62.75
SD	8.34	9.88	8.97	8.06	8.81
Improvement	***19.35**	**0.94**	**-**	**-**	**10.21**

*Significant Mean Improvement

Table 4.4 showed that the degrees of significance of the four sample groups. The results showed that the scores of the experimental group were consistently higher than those of the control group while the standard deviation of the control group was lower than that of the experimental group, thus the significance level above the critical t-value of 1.89. There is also significant mean improvement by experimental group on MAT compared to that of the control group. The range of the highest and lowest scores also reduced significantly as shown by the value of the Standard Deviation. When the independent sample t-test for post-test scores on MAT were calculated, the results were as shown in Table 4.5.

Table 4. 5: Independent sample t-test for post-test mean scores on MAT

Groups	t-values
E_1 Vs E_2	1.444
E_1 Vs C_1	*9.633
E_1 Vs C_2	*9.643
C_1 Vs C_2	0.372
C_1 Vs E_2	*6.891
E_2 Vs C_2	*6.994

*Significance at $\alpha = 0.05$, critical t-value = 1.89

It was observed from Table 4.5 that there was a significant difference between the achievement of students taught using Geogebra and those taught using conventional methods. The null hypothesis, **H_{O1}** **"**There is no significant difference in the achievement of students taught transformations using Geogebra (ICT) and those taught using conventional teaching methods" was therefore rejected. It was then concluded that students taught transformations using Geogebra had better achievement than those taught using conventional methods. When a comparison was made between the independent t-test means on MAT of the different study groups the results were as shown on figure 5.

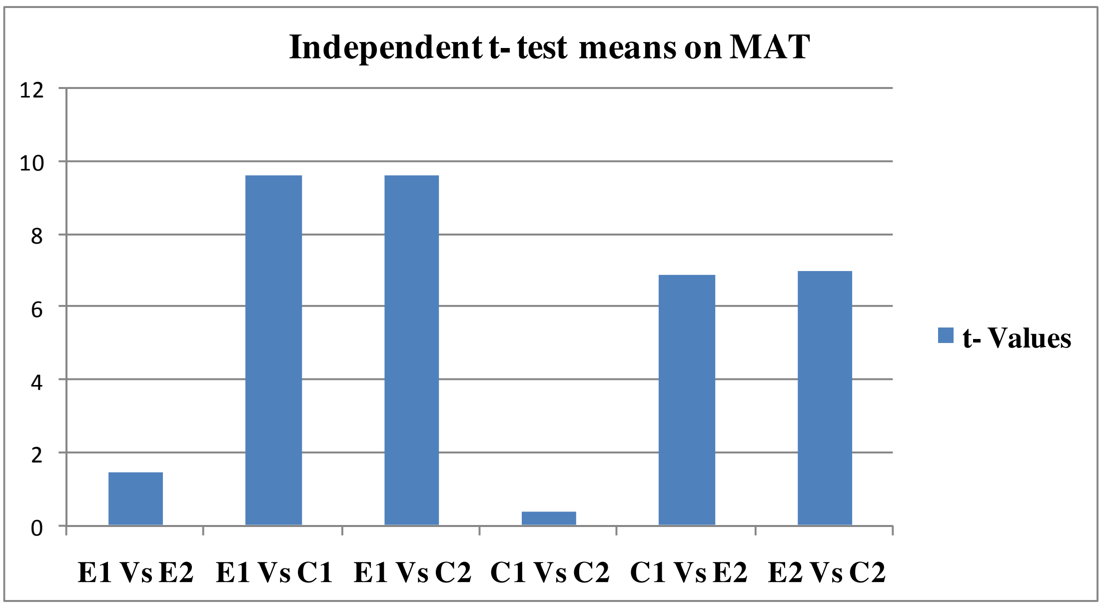

Figure 5: Independent sample t-test mean scores on MAT

The level of retention of the learnt concepts between the experimental and control groups were calculated, it was realized that the experimental group exhibited a positive deviation of +2.64 while the control group showed +0.4. It was then concluded that students taught using Geogebra had higher retention than those taught using the conventional methods.

4.4 Interpretation of the findings

The findings presented about H_{01} on pages (65-68) in the schools under review, show existence of significant differences in achievement between the control and the experimental groups. Although the available data from this case did not show any significant difference in the pre-test scores, significant difference was however observed in post-test scores. This made the hypothesis to be rejected. Unlike the mean scores of the two treatment groups (E_1 and E_2), the mean scores of the control groups (C_1 and C_2) were significantly different from those of the former with respect to the mathematics achievement test (MAT) as shown on page (67). The experimental groups exhibited a higher rate of general learning (achievement) than the control groups. Since the observed results deviated from the expectation, then it is reasoned that the superior achievement displayed in general learning in respect to the experimental groups was due to the fact that the transformation content information was presented in form of a computer based instructional programme text.

On the basis of these findings, it is advanced that the use of GIS programme in mathematics was probably the factor influencing the student's level of achievement. These findings provide empirical evidence and basis for concluding that the use of a computer programmed instructional medium such as Geogebra Instruction Software facilitates higher level of achievement in the topic of transformation in mathematics.

The implication of the findings is that the level of achievement in learning of mathematical concepts of transformation, is higher when the students are taught using the computer based instructional medium (GIS) than when the conventional method is employed. Among the studies in support of the findings are those by Dalton et.al. 1989; Kulik and Kulik, 1987; Mevarech et.al.1987; Yeuh and Allessi, 1988) who maintain that, effective learning is more assured through a computer programmed instruction approach like GIS than with the conventional instructional approach. Further, it can be concluded from the findings that, the addition of media such as computer programmed texts to lectures, discussions, and demonstrations in the teaching and learning of mathematics is likely to enhance students' achievement. In general, the findings of this study are in accord with the views expressed in the aforementioned studies.

4.5 Students' attitudes towards transformations when taught using Geogebra and when taught using conventional approaches

Literature review revealed that most students usually express passive or active involvement in the various learning experiences depending on the activities they engage in. The motivation derived from such activities arouses their interests and such involvement dictates the extent of their attitude towards learning of mathematics (Kulik & Kulik, 1987). The outcomes of the various variables that were set to measure attitude are illustrated in the subsections below. The effect of Geogebra and conventional methods of instruction on the subjects' attitudes and creativity towards mathematics lessons on the concepts of transformation was determined by performing an ANOVA on the pre-test and post-test scores obtained by the subjects on the Mathematics Students' Questionnaire. Interviews were further used to give more information on the students' attitude and creativity towards Mathematics lessons on the concepts of transformation.

The effect of Geogebra and Conventional methods of instruction on the subjects attitude towards Mathematics course was measured using the Mathematics student's questionnaire. Responses to the interview are presented in Table 4.6 as percentages. The means and standard deviation arising thereof are subjected further to ANOVA as in Tables 4.7 and 4.8. The descriptive data obtained during the interview were triangulated in terms of three attitudinal variables and converted into percentages.

Table 4. 6: Percentages of the interviewee's agreeing with responses on the questionnaire

Variable	E_1	E_2
Understood content covered by the software	72	79
Satisfied with the information from the software	81	86
Software was meaningful, fun and challenging	76	83

Results from Table 4.6 shows that 72% of the subjects in the E_1 and 79% of the subjects in the E_2 group felt that they understood the content covered by the software and applied the knowledge acquired. The percentage of the subjects rose in both E_1 and E_2 (81% & 86%) as they expressed satisfaction with the information taught. Further to these, the results showed that 76% and 83% in the E_1 & E_2 respectively were of the opinion that the software was meaningful, fun and quite challenging. The figures were well above 50% which is the average score.

Table 4.7 shows the pre-test and post-test mean scores, standard deviations and the overall improvement index obtained by the subjects on the MSQ.

Table 4.7: Mean scores, standard deviations and Improvement Index on the pre-test and post-test on the MSQ

SCALE	NUMBER (N=240)	E_1	E_2	C_1	C_2
MEAN (Pre-test)	54.26	54.68	-	54.84	-
S.D	15.98	16.2	-	15.76	-
MEAN (Post- test)	59.38	61.98	60.33	59.98	55.23
S.D	12.71	11.76	13.12	12.98	12.99
Improvement Index	5.12	7.3		5.14	

The results in Table 4.7 reveals that:

(i) The overall improvement index of the entire sample is 5.12;

(ii) The mean gain in the E_1 group stands at 7.3;

(iii) The improvement index of the control group C_1 is 5.14. These figures clearly indicated that the improvement index when using Geogebra was 2.18 higher than the overall mean gain and 2.16 higher than the improvement index of the control group C_1.

Generally the mean scores of the subjects in the experimental groups (E_1 & E_2) are higher than the overall improvement index of the entire sample and higher than the mean scores of the control groups. This implies that the subjects in the experimental groups scored higher on the students' attitude questionnaire than those in the control groups. This is further corroborated by the ANOVA as shown in Table 4.8

Table 4.8: Analysis of variance of the post-test scores on the MSQ

SOURCE	D.F	S.S	M.S	F-Ratio	Significance
Between groups	(4-3) = 1	96.23	96.23		
Within groups	240-4 = 236	4234.7	18.19	5.78	0.43
TOTAL	239	4377.67	115.21		

Critical value is 2.62<5.78, significant at 0.05 level of significance

The results in Table 4.8 shows that the f-ratio is statistically significant because the f-value (5.78) exceeds the critical value of 2.62 needed to reject the hypothesis in question. This implies the post-test scores obtained by the students taught by conventional methods had lower mean scores and hence were out performed by the two treatment groups. Overally, the null hypothesis (HO_2) in respect of the students attitude towards mathetics lessons was rejected.

4.6 Interpretation of the findings

The findings presented about $H_{\mathbf{02}}$, show existence of a significant difference between the experimental groups (E_1 and E_2) as shown on pages (71-72). The experimental groups (E_1 and E_2) registered significantly higher scores on MSQ questionnaire as shown on page 71.

The inference made from these findings is that the GIS programme had a marked positive influence on students' attitude towards the mathematics course than when the conventional instruction method was used.

The findings of this study showed that the experimental groups obtained significantly higher scores than the control groups in the post-test. More so the similarity in the mean scores of the treatment groups (E_1 and E_2) is not coincidental but was influenced by the GIS programme. Therefore, the (H_{O2}) suggesting that there is no significant difference in the students' attitude towards transformations when subjected to the two methods of instruction was rejected. On the basis of these findings it was concluded that the GIS programme had significant effect on the subjects' attitude towards the mathematics course. The implication from the above interpretation suggests that the GIS exerted a more positive influence on the subjects' attitude towards the mathematics course than the conventional instructional method approach. In support of these findings are earlier discussions by Kulik and Kulik (1987), Voogt (1993) Kulik and Bangert-Drowns (1985) and Teh *et.al* (1993). These studies confirm that students demonstrate a more favorable attitude towards learning transformations and are highly inspired through GIS than when taught using the conventional instructional methods. In general, the findings of this study are in agreement with the views expressed in the aforementioned studies.

4.7 Student's creativity when taught transformations using Geogebra Instruction software as compared to those taught using conventional methods of Instruction

According to Diković (2009), teaching of mathematics at the school level can be done on an interactive and creative way. Statistical analysis confirmed the fact that the use of the applets created with the help of Geogebra and used in the teaching of Mathematics had a positive effect on the understanding and knowledge of the students. This is because the software enabled the students to simultaneously use a computer algebra system and an interactive geometric system; by doing this, they can increase their cognitive abilities in the best way. Geogebra is created in such a way that students grasp experimental, problem-oriented and research-oriented learning of mathematics, both in the classroom and at home. Research results suggest that these software packages can be used to encourage discovery, experimentation and visualization in the teaching of mathematics. However, researchers suggest that, for the majority of teachers, the main problem is how to provide the technology necessary for the successful integration of ICT into teaching (Ruthven & Hennessy, 2004).

The effect of the subject's creativity when using Geogebra and Conventional methods of instruction towards Mathematics course was measured using the MCEQ student's questionnaire. Responses to the interview are presented in table 4.9 as percentages. The means and standard deviation obtained were further subjected to ANOVA as in Tables 4.10 and 4.11. The descriptive data obtained during the interview were triangulated in terms of three creativity variables and converted into percentages.

Table 4. 9: Percentages of the interviewee's agreeing with statements on the questionnaire

Variable	E_1	E_2
Teacher gave clear instruction	78	81
Software tools easily navigated	86	89
Students were engaged in more activities using the software	88	90

There is an indication from Table 4.9 that 78% of the subjects in the E_1 and 81% of the subjects in the E_2 group felt that the teacher(s) gave clear instruction. Increased percentage of subjects in both E_1 and E_2 (86% & 89%) expressed satisfaction with the way they navigated the software tools particularly the geometry view. In addition, the results showed that 88%

and 90% in the E_1 & E_2 respectively were of the opinion that the software enabled many students to go through a number of activities. Again these figures were way above the 50% average percentage mark. From the interview, the researcher noted that 70% of the subjects were comfortable handling the software and tackled the activities on transformations. Table 4.10 shows the pre-test and post-test mean scores, standard deviations and the overall improvement index obtained by the subjects on the MSQ.

Table 4. 10: Mean scores, standard deviations and Improvement Index on the pre-test and post-test on the MSQ

SCALE	NUMBER (N=240)	E_1	E_2	C_1	C_2
MEAN (Pretest)	44.54	44.24	-	44.84	-
S.D	14.48	14.2	-	14.76	-
MEAN (Post test)	49.88	51.33	51.33	50.97	45.23
S.D	16.96	17.76	16.12	16.98	16.99
Improvement Index	5.34	7.74	-	6.13	-

The results in Table 4.10 reveals that:

(i) The overall improvement index of the entire sample was 5.34;

(ii) The improvement index of the E_1 group stands at 7.74.

(iii)The improvement index of the control group C_1 was 6.13. The statistics above reveal that the improvement index when using Geogebra was 2.40 higher than the overall improvement gain and 1.61 higher than the improvement index of the control group. The experimental groups (E_1 & E_2) had higher mean scores than the overall improvement index of the entire sample and also higher than the mean scores of the control groups. This indicates that the subjects in the experimental groups scored higher on the students' creativity questionnaire than those in the control groups. The analysis from the ANOVA on the results shown in Table 4.11 further highlights this outcome.

Table 4. 11: Analysis of variance of the post-test scores on the MSQ

SOURCE	D.F	S.S	M.S	F-Ratio	Significance
Between groups	(4-3) = 1	84.99	84.99		
Within groups	240-4 = 236	5234.7	22.18	5.98	0.43
TOTAL	239	5377.67	115.21		

Critical value is 2.62<5.98, significant at 0.05 level of significance

The table results show that the f-ratio is statistically significant because the f-value (5.98) exceeds the critical value of 2.62 needed to reject the hypothesis in question. This implies the post-test scores obtained by the students taught by conventional methods had lower mean scores and hence were out performed in creativity by the two treatment groups. In an attempt to investigate on the difference in creativity when students were taught using Geogebra as opposed to conventional methods of instruction the students were subjected to key questions during the interview such as; (i) were the slow learners able to integrate ICT skills comfortably during and after the lessons and (ii) were the ICT skills meaningful, relevant and important. Generally, both qualitative and quantitative data about the students' creativity during mathematics lessons resulted in similar trends for the experimental groups. The qualitative results have been factored in these findings.

From the foregoing results, there is a significant difference in performance on creativity between the experimental groups (E_1 & E_2) and the control groups (C_1& C_2) in favour of the former. This evidence confirms that the students taught the topic of transformation using Geogebra Instructional software exhibit higher creativity than those taught using conventional method of instruction.

Thus, the null hypothesis (H_{O3}) in respect of students creativity when taught using Geogebra as compared to those thaught using conventional methods was rejected.

4.8 Interpretation of the findings

The findings presented about H_{03}, show existence of a significant difference between the experimental groups (E_1 and E_2) as shown on pages (74-76). The experimental groups (E_1 and E_2) registered significantly higher scores on MSQ questionnaire as shown on page 74. The inference made from these findings is that the GIS programme had a marked positive influence on students' creativity towards the mathematics course than when the conventional instruction method was used.

The findings of this study showed that the experimental groups obtained significantly higher scores than the control groups. More so the similarity in the mean scores of the treatment groups (E1 and E2) is not coincidental but was probably influenced by the GIS programme. Therefore, the (H_{O3}) suggesting that there is no significant difference in the students' creativity towards mathematics when subjected to the two methods of instruction was rejected. On the basis of these findings it can be safely concluded that the GIS programme had marked effect on the subjects' creativity towards the mathematics course. The implication from the above interpretation suggests that the GIS exerted a more positive influence on the subjects' creativity towards the mathematics course than the conventional instructional method approach. In support of these findings are earlier discussions by Dikovic (2009), Dubinsky & Schwingendorf (2004). These studies confirm that by students manipulating the objects easily, they create opportunities to solve problems by dynamically investigating the mathematical relations. Creation of situation that foster making of mathematical constructions enable student's to be highly inspired through GIS than when taught using the conventional instructional method. In general, the findings of this study are in agreement with the views expressed in the aforementioned studies. Thus, the null hypothesis (H_{O3}) in respect of students' creativity when taught using Geogebra as compared to those taught using conventional methods was rejected.

4.9 Implications of the findings

The initial findings revealed that there was no significant difference in general performance on the MAT, and MSQ between the two groups (E_1 & C_1) when pre-tested. The research finding shows that after treatment there was significant difference on the achievement test in favour of the experimental groups. This evidence further corroborates the idea that students taught using Geogebra Instructional Software have a better grasp and retention of the concepts of transformation and consequently perform better, than those taught using conventional methods of instruction. Thus, all the null hpotheses (H_{O1}, H_{O2} and H_{O3}) were rejected.

4.10 Generalisability of the study

When interpreting the results of this study, several factors should be considered. For instance:

1) The study investigated only students in Kakamega Central Sub-county of Kakamega County in the Republic of Kenya;
2) The study involved only concepts from a topic in form two;
3) The time slot for each topic had already been determined by the Kenya Institute of Curriculum Development for schools to comply with and;
4) The study involved only schools with computers, those that offer studies and make use of computers in instruction.

The generalization of the findings of this study is therefore limited by selection treatment interaction (Campbell & Stanley 1966). This refers to the limitations placed on the generalization of the results of a study on populations other than those actually included in the investigation. Although certain implications of the findings are relevant to other form two student populations in Kenya; it would be naïve to generalize the results to populations outside the form two students in Kakamega Central Sub-county of Kakamega County, Kenya from which the sample of the study was randomly selected.

It must be emphasized that the GIS mode of instruction is not yet a classroom method of teaching in the education system in Kenya. Thus, one can question whether the results of this study can be generalized to situations in which the presentations of instructional conditions were not similar. The specific content area of this study namely transformation was selected because it was pointed out by 45 mathematics teachers in Kakamega Central Sub-county, Kakamega County, Kenya as an area that was in need of a different method of teaching other than the conventional method (SMASSE report 2005). Furthermore, in accordance with the scheme of work prepared by schools, this topic would be taught at the time this study was implemented. Because of the purposive and specific content area selected and its limited scope, the results of this study should be generalized with caution to other mathematics topics in Form Two and other Classes at the Secondary School level of education.

Also, the implementation of this study was limited to the time made available, students' accessibility to the computer instructional programme and the computers made available in the mathematics/computer laboratories. Therefore due to resource and time allocation limitation, it would be inappropriate to equate or compare the results of this study to other programmes that have sufficient time and adequate resources for all students' use. As was discussed earlier in the methodology chapter the internal and external validity of the present study was considered robust enough for the study. As such the generalisability of the findings of this study to the whole sub-county represented by the samples appears reasonable. However, several factors should be borne in mind when generalizing these findings namely:

1. The size of the sample;

2. The duration of the study;

3. The scope of the content;

4. The possible influence of Hawthorne effects.

5. Length of contact (exposure) of the students with the computer

The generalisability issue is not as crucial as the replicability and emerging scenario of teacher-student- material interactions resulting from the implementation of the GIS in an essentially teacher-dominated classroom environment. The implementation of the GIS has brought about in some measure, a shift in instructional practice of a mathematics teacher. The teacher comes from the background of the talk-and-chalk approach. However, with his exposure to the GIS approach they seemed ready to exchange their authoritative role for that of a facilitative role. The potential for creative development as the teacher admits seems to augur well for their future instructional practice. The software used in the study was designed internationally but can be selected to fit the existing curriculum and the instructional needs of the teacher. From the foregoing, it seems that the findings of this study are quite relevant to the teaching and learning of the mathematics course in Kakamega Central Sub-county, the whole country and possibly the whole world.

4.11 The Distinctiveness of the Study

The previous chapter indicates that the results of this study have consistently shown that the GIS (unlike other methods of instruction in Kenyan secondary schools) can indeed endear positive effect on the student's achievement, attitude, and creativity. In all instances, the data showed significant mean gain in favor of the GIS programme. The f-ratios of both the dependent variables (MAT and MSQ) post-test results were statistically significant in favor of the GIS treatment groups. Critically speaking, several factors contributed to the distinctiveness of this study. For instance:

1. The GIS programme employed was curriculum based and specifically tailored to meet instructional and learning needs of the target group. In other words, the GIS programme adopted was content specific and curriculum specific in that during its developmental process, it conformed very closely to the requisite curriculum materials stipulated by the KICD mathematics education syllabus.
2. The study showed that the GIS programme used in this study was a more effective instructional method in the classroom than the Conventional Method of Instruction. In addition, it has shown that the use of the GIS as a group learning strategy in management education is efficacious. The programme increased the learner-learning time.
3. The GIS programme in this study was programmed in the visual basic language, which is easy to learn and use. Similarly, the navigation tools were easy to learn.
4. In contrast to previous studies, which focused on gathering data on the availability and use of computers in schools, this study has shown that the GIS can be used to augment conventional mathematics instruction. It is hoped that teachers could integrate the GIS in mathematics instruction and find this approach useful for enhancing their mathematics instruction at the secondary school level where the learner's performance has been wanting.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives an overview of the study findings, draws conclusions from the findings as interpreted in the light of the available evidence and offers recommendations and suggestions for further research.

5.2 Summary of the Study

The purpose of the study was to explore the effectiveness of using Geogebra Instruction Software as a pedagogical tool on the student's creativity, attitude and achievement in secondary school mathematics. The three measurement instruments used in this study were; Mathematical Achievement Test, Mathematical Student Questionnaire and an interview schedule. The variables of interest were the effects of Geogebra Instruction Software (GIS) alongside the conventional methods of instruction in the teaching and learning process in transformations. The Solomon Four-Fold experimental and qualitative research designs were adopted. It involved a pre-test, treatment, and a post-test. The target populations for the study were students at secondary school level. The sample of the study was Form II students of the selected schools in Kakamega Central Sub-county of the Kakamega County. The data derived from the tests and the interview schedules were computed and analyzed by the use of both descriptive and inferential statistics. Descriptive statistics included the means and standard deviations while inferential statistics involved the use of (ANOVA) an analysis of variance. The hypotheses tested in the study were rejected at an alpha = 0.05 level of significance.

5.3 Summary of the Findings

Geogebra was created to help students gain a better understanding of mathematics. Students can manipulate variables easily by simply dragging "free" objects around the plane of drawing, or by using sliders (Diković 2009). Students can generate changes using a technique of manipulating free objects, and then they can learn how the dependent objects will be affected. In this way, students have the opportunity to solve problems by investigating mathematical relations dynamically. According to Dubinsky & Schwingendorf (2004), cooperative learning is the right context for a mathematics course. Lecturing should be replaced by a task oriented interactive classroom. The primary role of teaching is not to lecture, explain, or otherwise attempt to "transfer" mathematical knowledge, but to create situations for students that will foster their making the necessary mental constructions. In that sense, Geogebra provides a good opportunity for cooperative learning, i.e. cooperative problem solving in small groups, or whole class interactive teaching, or individual/group student presentations.

There has been deliberate attempt to use the results from the field data to answer the research questions as well as negate the hypotheses posited for testing as concerns the concepts in the mathematics course. The results obtained affirms that there is significant difference between students taught using Geogebra Instruction Software and those taught using the conventional methods of instruction. By rejecting the null hypothesis (H_{O1}), the research findings indicated that using Geogebra Instruction Software leads to higher achievement in test scores of the students. The null hypotheses (H_{O2} & H_{O3}) were equally rejected, indicating that the students attitude and level of creativity was raised when they were subjected to Geogebra Instruction Software as opposed to conventional methods of instruction. An attempt to give meaning to the findings of the study has been made in chapter 4. The findings of this study have demonstrated that the use of GIS can be more effective than the Conventional Method of Instruction in improving students' achievement in mathematics and enhancing positive students' attitudes and creativity towards mathematics. In respect to research objectives about whether there would be any significant differences between achievement, attitudes and creativity towards the mathematics course of the students' exposed to the GIS and those taught by Conventional Method of Instruction, the findings of this study on all the three dependent measures are in the affirmative. Specifically, the inferential statistics revealed that the difference between the mean scores obtained by the subjects in the GIS treatment groups (E_1 & E_2) and those of the control groups (C_1 & C_2) on all the dependent measures were statistically significant. The results of the study seem to have demonstrated the effectiveness of GIS over Conventional Method of Instruction in enhancing gains in cognitive, psychomotor and affective domains.

Another contribution of the study is the demonstration that the use of GIS can provide a point of departure to move away from the predominant expository teaching that gives the students very few opportunities to develop practical skills that are necessary for them to negotiate meanings, be creative and effectively participate in learning. It also provides a point that the use of GIS can improve the impoverished situation of mathematics instruction in secondary schools in Kenya.

5.4 Conclusions

On the basis of the findings in this study, the following conclusions were drawn:

(a) There exists a significant difference in the achievement of students when taught transformations through Geogebra Instruction Software than conventional method. Students taught through GIS achieved better scores than those taught by conventional method.

(b) The GIS programme had marked effect on the subjects' attitude towards the mathematics course. The implication of this finding suggests that the GIS exerted a more positive influence on the subjects' attitude towards the mathematics course than the conventional instructional method approach.

(c) The GIS programme had significant effect on the subjects' creativity towards the mathematics course. This implies that the GIS exerted a more positive influence on the subjects' creativity towards the mathematics course than the conventional instructional method approach.

(d) The Conventional method is inferior when compared to Geogebra Instructional Software in the amount of learning achieved and on students' attitudes and creativity towards mathematics course. The findings of this study suggest that the teaching of the mathematics course require the use of a computer programmed text.

(e) The use of GIS method in this study has demonstrated a great potential to promote cognitive, affective and psychomotor skills of Secondary school students in the mathematics topic of transformation.

(f) The effect of the GIS in promoting collaborative learning may form part of the solution to the emergence of large classes in the context of inadequate human and material resources. This finding indicates that the GIS method has a potential for encouraging student participation in mathematics lessons, enhancing creativity and problem solving abilities.

5.5 Recommendations

1. The use of Geogebra Instruction Software seems to enhance positive student's attitude and creativity towards the mathematics course. The researcher therefore recommends that, the teacher(s) should embrace and integrate the use of computer based instructional software in their lessons whenever the matter at hand requires

positive students attitude towards the subject (mathematics) and a high level of creativity for effective learning.

2. The researcher recommends that, since the use of Geogebra Instructional Software seems to enhance higher ability in learning achievement, then mathematics teachers should make every effort to produce or obtain appropriate and well integrated instructional materials and use them in their lessons especially when abstract concepts are to be taught.
3. The researcher recommends that the Government of Kenya through the Ministry of Education and Kenya Institute of Curriculum Development should embark on a serious campaign to enable teachers understand and appreciate that the teaching of mathematics would be greatly enhanced in the event that they use GIS. Any teacher with the desire to improve student's attitude, creativity and achievement in mathematics should be sensitized and capacity built on the use of GIS in mathematics.
4. The researcher recommends the incorporation of mandatory computer studies in teacher training to equip teachers with the relevant skills required in information driven society. However, capacity building for practicing teachers of mathematics should be encouraged to enable them cope up with the current computing demands.

5.6 Suggestions for Further Research

Based on the findings, the researcher made the following suggestions for further research.

1) Replication of the study on a large sample. This may include other topics, more schools and teachers to confirm whether or not the findings of this study hold.

2) Replication of study to determine whether there would be any significant difference of the GIS and CMI on students' perceptions of the classroom environment.

3) A study of the use of the GIS in different secondary schools in order to understand whether or not there is a strong novelty effect in the use of the GIS. Such an implementation should be extensive enough to help ascertain the duration of the effectiveness of the GIS.

4) A systematic study to determine the attitudes of teachers towards the integration of GIS in the mathematics instruction.

5) A study into the effect of GIS on students' performance in other topics of mathematics.

6) A study into the effects of gender parity on GIS.

7) A study on the effectiveness of Quality and Standards Officers in evaluating integration of GIS programmes.

This study has explored the effectiveness of GIS versus conventional methods in the teaching of mathematics course. The suggestions for further researches presented above are intended to widen the database and to enable educators and policy makers make more generalizations that are valid to different students' population, instructional settings and effective evaluation of teaching and learning methods.

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APPENDICES

APPENDIX A: The Mathematics Teacher's Interview schedule

Name of School:…………………………………………………………..

The following questions were used by the researcher through the process of interview with the teachers.

1. What is the category of your school?

   (i) (a) National ☐ (b) Provincial ☐ (c) District ☐

   (ii) (a) single sex girls ☐ (b) single sex boys ☐ (c) mixed school ☐

   (iii) (a) Urban ☐ (b) Rural ☐

2. Gender. (a) Male ☐ (b) Female ☐

3. What is your responsibility in school?

(a) Principal ☐ (b) Deputy Principal ☐

(c) H.O.D ☐ (d) Class Teacher ☐

If (d), do you have any administrative duties other than teaching in the classroom?

(i) Yes ☐ (ii) No ☐

If yes, specify...

....

…………………………………………………………………………………….

4. What is your highest academic achievement:

   (a) Post graduate: M.A./ M.Ed / MSc/ PhD ☐
   (b) University degree ☐
   (c) E.A.A.C.E./K.A.C.E. ☐
   (d) E.A.C.E./ K.C.E ☐
   (e) K.C.S.E. ☐

(f) Others (specify)..

....

5. How many lessons do you teach per week?..

6. What is your comment about the teaching load?

....

....

7. Have you attended any INSET workshop(s) or seminars for your professional development?

(a) Yes ☐ (b) No ☐

If yes specify...

....

....

8. How has your school featured in the K.C.S.E. in mathematics within the sub-county?

(a) Below average ☐

(b) Average ☐

(c) Above average.

9. What was the school's mathematics mean score in last year's K.C.S.E.?

....

10. Are you happy with Mathematics K.C.S.E. results?

(a) Yes ☐ (b) No ☐

If no, what in your own opinion are the reasons responsible for this kind of performance?...

....

11. What is the school policy on teaching in the mathematics department?

(a) Team teaching ☐ (b) vertical teaching ☐

(c) Horizontal teaching ☐ (d) all the above ☐

(e) None of the above. ☐

12. For how long have you taught Transformations?

(a) Less than a year ☐

(b) 1 - 4 years ☐

(c) 5 - 10 years ☐

(d) 11- 15 years ☐

(e) Over 15 years. ☐

13. How do your students answer questions on transformations involving drawing skills?

(a) Very well ☐ (b) well ☐ (c) poorly. ☐

If your response is poorly, give a brief explanation why that is so...

....

....

14. Which teaching method do you find convenient teaching Transformations?

(i)...

Comment on the above method's suitability..

....

15. How long on average do you take to complete teaching Transformations in Form 2?

(a) 1 week ☐ (b) two weeks ☐ (c) over 2 weeks ☐

Comment on this duration...

....

16. Name two most popular teaching methods employed by mathematics teachers in the order of their popularity in your school.

(i)..

(ii)..

17. Why do you think most teachers prefer the above methods? ....

....

18. Has your school embraced ICT in the Teaching/Learning process?

(a) Yes ☐ (b) No ☐

If No, what challenges does your school face?

....

....

19. Have you ever used ICT to teach Mathematics?

(a) Yes ☐ (b) No ☐

If yes, specify the ICT tools used.

....

....

20. How proficient are you in ICT Skills?

☐ Very comfortable
☐ Comfortable
☐ Uncomfortable
☐ Not familiar

21. Have you ever used Geogebra Instruction software as a mathematics teaching tool?

(a) Yes ☐ (b) No ☐

If yes, what activities did you engage your students in?.

....

....

22. Do your students have basic computer literacy skills?

(a) Yes ☐ (b) No ☐

If yes, what percentage is comfortable in handling computers?

....

....

23. How often are your students engaged in activity-oriented tasks in mathematics?

- ☐ Frequently
- ☐ Moderately
- ☐ Occassionally
- ☐ Rarely

24. In your absence in the classroom;

(a) Students make noise ☐

(b) Students do assignments in other subjects ☐

(c) Students do your previous day's assignments ☐

(d) Students revise the previous day's work in groups/or using one leader on the chalkboard. ☐

(e) Students engage in new tasks ☐

(f) Students celebrate your absence and just chat over issues outside mathematics ☐

Thank you for your kind co-operation.

APPENDIX B: The Student's Interview schedule

Name of School:…………………………………………………………..

The following questions were used by the researcher through the process of interview with the students.

1. What is the category of the school?

   (i) (a) National ☐ (b) Provincial ☐ (c) District ☐

   (ii) (a) single sex girls ☐ (b) single sex boys ☐ (c) mixed school ☐

   (iii) (a) Urban ☐ (b) Rural ☐

2. Gender. (a) Male ☐ (b) Female ☐

3. What is your responsibility in school?

(a) Senior Prefect ☐ (b) Class prefect ☐

(c) Ordinary student ☐

4. What is your highest achievement in Mathematics at Secondary level:

   (g) Above 70% ☐

   (h) Between 50-70% ☐

   (i) Between 30-50% ☐

   (j) Below 30% ☐

5. How has your school featured in the K.C.S.E. in mathematics within the sub-county?

   (d) Below average ☐

   (e) Average ☐

   (f) Above average.

6. What was the school's mathematics mean score in last year's K.C.S.E.?

……………………………………………………………………………………………

7. Are you happy with Mathematics K.C.S.E. results?

(a) Yes ☐ (b) No ☐

If no, what in your own opinion are the reasons responsible for this kind of performance?..

....

8. How simple are questions on transformations involving drawing skills?

(b) Very simple ☐ (b) simple ☐ (c) difficult ☐

If your response is difficult, give a brief explanation why that is so...

....

9. Has your school embraced ICT in the Teaching/Learning process?

(b) Yes ☐ (b) No ☐

If No, what challenges does your school face?

....

....

10. Have you ever used ICT to learn Mathematics?

(b) Yes ☐ (b) No ☐

If yes, specify the ICT tools used.

....

....

11. How proficient are you in ICT Skills?

☐ Very comfortable

☐ Comfortable

☐ Uncomfortable

☐ Not familiar

12. Have you ever used Geogebra Instruction software as a mathematics teaching tool?

(b) Yes ☐ (b) No ☐

If yes, what activities did you engage in?.

....

....

Thank you for your kind co-operation.

APPENDIX C: The Mathematics Student's Questionnaire (MSQ).

Instructions

i). We are interested to know how you feel about the mathematics lesson taught using Geogebra. ICT tools include computers, cameras (web, video & digital), TVs, projectors, printers, scanners, mobile phones and internet amongst others. Meanwhile in Geogebra, the tools include Geometry view, Algebra view and Spread sheet view.

ii). This is NOT a test and there are no WRONG and RIGHT answers

iii). Your HONEST opinion is highly appreciated.

iv). For each of the following statements below, read and understand then tick the letter that corresponds to your response. Use the key below:

1. Strongly Agree. 2. Agree. 3. Undecided. 4. Disagree. 5. Strongly Disagree.

   Example: A student can easily score 100% in a mathematics examination. If you strongly agree, tick 1; however if you strongly disagree tick 5.

1	2	3	4	5
✓				

		1	2	3	4	5
1. The mathematics lessons taught using Geogebra are understandable						
2. The mathematics lessons taught using Geogebra are dull						
3. The mathematics lessons taught using Geogebra are useful						
4. The mathematics lessons taught using						

Geogebra are meaningless						
5. The mathematics lessons taught using Geogebra are difficult						
6. The teacher gave direction to the students and guided us accordingly during ICT lessons						
7. The teacher gave more activities and facilitated the learning processes						
8. The teacher did not involve all the students in the class activities during ICT lessons						
9. The teacher did not work with slow learners during ICT integrated lessons						
10. You were competent in handling Geogebra tools and shared your experiences with the rest						
11. You were competent in handling computers and had advantage during ICT integrated lessons						
12. You navigated the Geogebra tools quite easily						
13. You went through ICT integrated lessons quite happily and were eager to learn more.						
14. You went through ICT integrated lessons and were unhappy and frustrated.						

Thank you for your kind co-operation

APPENDIX D: The Mathematics Teacher's Questionnaire (MTQ).
Instructions

i) We are interested to know how you feel about the mathematics lesson taught using Geogebra. ICT tools include computers, cameras (web, video & digital), TVs, projectors, printers, scanners, mobile phones and internet amongst others. Meanwhile in Geogebra, the tools include Geometry view, Algebra view and Spread sheet view.

ii). This is NOT a test and there are no WRONG and RIGHT answers

iii). Your HONEST opinion is highly appreciated.

iv). For each of the following statements below, read and understand then tick the letter that corresponds to your response. Use the key below:

2. Strongly Agree. 2. Agree. 3. Undecided. 4. Disagree. 5. Strongly Disagree.

   Example: A student can easily score 100% in a mathematics examination. If you strongly agree, tick 1; however if you strongly disagree tick 5.

1	2	3	4	5
✓				

	1	2	3	4	5
1. Teaching mathematics using Geogebra is boring, dull and frustrating.					
2.Teaching mathematics using Geogebra is fun, stimulating and satisfying.					
3.Teaching mathematics using Geogebra is informative and useful.					
4.Teaching mathematics using Geogebra is hard, involving and challenging.					
5.The learners' understanding of mathematics concepts highly depends on the computer literacy skills acquired.					
6. The learners' retention is enhanced by their physical manipulation of Geogebra tools.					
7.Teaching mathematics using Geogebra makes me curious about the lesson development					
8.Teaching mathematics using Geogebra makes me feel confident about the lessons I presented					
9.Preparing for a mathematics lesson using Geogebra is too stressful and demanding.					
10. The students' activities make concepts flow easily thus making the lesson interesting.					

11. The students' group activities are stimulating and enriching.					
12. The students' activities are useful, interesting and well organized.					
13. The Geogebra tools are navigated quite easily by the students					
14. The ICT skills are meaningful, relevant and important					
15. The ICT skills are unfriendly, useless and difficult					
16. The slow learners are able to integrate ICT skills comfortably during and after the lessons					

Thank you very much for your kind co-operation.

APPENDIX E: Mathematics Achievement Test (Pre-test)

Topic: Equations of a straight line **Class:** Form Two **Time:** 1 Hr

Instructions

(i) Attempt all the questions

(ii) Do not spend too much time on a particular question

1. The co-ordinates of points P and Q are (1 -2) and (4, 10) respectively. A point T divides the line PQ in the ratio 2:1.

(a) Determine the coordinates of T (3mks)

(b)(i) Find the gradient of a line perpendicular to PQ. (2mks)

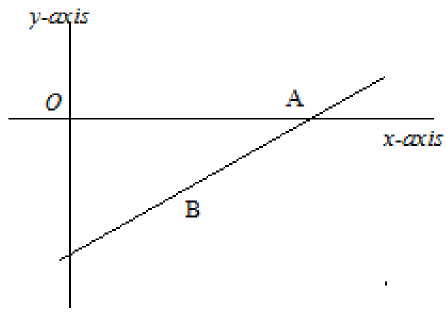
(ii) Hence determine the equation of the line perpendicular to PQ and passing through T. (2mks)

(iii) If the line meets the y-axis at R, calculate the distance TR, to 3 significant figures. (3mks)

2. (a) A line L_1 passes through point (1, 2) and has a gradient of 5. Another line L_2 is perpendicular to L_1 and meets it at a point where x = 4. Find the equation for L_2 in the form of $y = mx + c$ (3mks)

(b) P (5, -4) and Q (-1, 2) are points on a straight line. Find the equation of the perpendicular bisector of PQ; giving the answer in the form of $y + mx = c$. (2mks)

3(a) On the diagram below, the line whose equation is $7y - 3x + 30 = 0$ passes through the points A and B. Point A is on the x-axis while point B is equidistant from x and y axes.



Calculate the co-ordinates of the points A and B. (3mks)

(b) A line with gradient of -3 passes through points (3, *k*) and (*k*, 8). Find the value of *k* and hence express the equation of the line in the form of $ax + by = c$, where *a*, *b* and *c* are constants. (3mks)

4. The equation of a line is $\frac{3}{5}x + 3y = 6$. Find the:

(a) Gradient of the line. (2mk)

(b) Equation of a line passing through point (1, 2) and perpendicular to the given line. (3mks)

5.(a) Find the equation of the line which passes through the points P (3, 7) and Q (6, 1). (2mks)

(b) Find the equation of the line whose *x*-intercepts is -2 and *y*-intercepts is 5. (2mks)

APPENDIX F: Mathematics Achievement Test (Post-test)

Topic: Transformations **Class**: Form Two **Time**: 1Hr

Instructions

(i) Attempt **all** the questions

(ii) Do not spend too much time on a particular question

1.(a). Triangle ABC with coordinates A (1, 1), B (4, 3) and C (2,4) is transformed by an enlargement centre (-1,-1) and scale factor 2. **Draw** triangle ABC and its image $A^1B^1C^1$ under this transformation on the grid provided.

(2mks)

(b) ΔABC is transformed by a translation T = $\begin{pmatrix} -3 \\ 3 \end{pmatrix}$ to $A^2B^2C^2$. **Draw** the image $A^2B^2C^2$ on the grid and state the co-ordinates of $A^{2,}$ B^2 and C^2. (2mks)

(c) Triangle $A^2B^2C^2$ is transformed to $A^3B^3C^3$ by reflection in the line $x + y = 2$. **Construct** triangle $A^3B^3C^3$ and state the co-ordinates of A^3, B^3, and C^3 (2mks)

(d) Triangle $A^4B^4C^4$ is the image of triangle $A^3B^3C^3$ under a rotation with centre Q. **Find** the angle of rotation and the coordinates of Q by construction if A^4(2,-3), B^4(4,0), C^4(5,-2) are the image points. (4mks)

2. A rectangle OABC has vertices O (0, 0), A(2,0), B(2,3) and C(0,3). Transformation T_1 maps OABC onto O'A'B'C' whose coordinates are O'(0,4), A'(2,4), B'(2,7) and C'(0,7). Transformation T_2 maps O'A'B'C'onto O"A"B"C", with coordinates O"(-4,0), A"(-4,2), B"(-7,2) and C"(-7,0).

(a) **Draw** on the grid provided, rectangles OABC, O'A'B'C'and O"A"B"C". (3mks)

(b) **Describe** fully transformation T_1 (2mks)

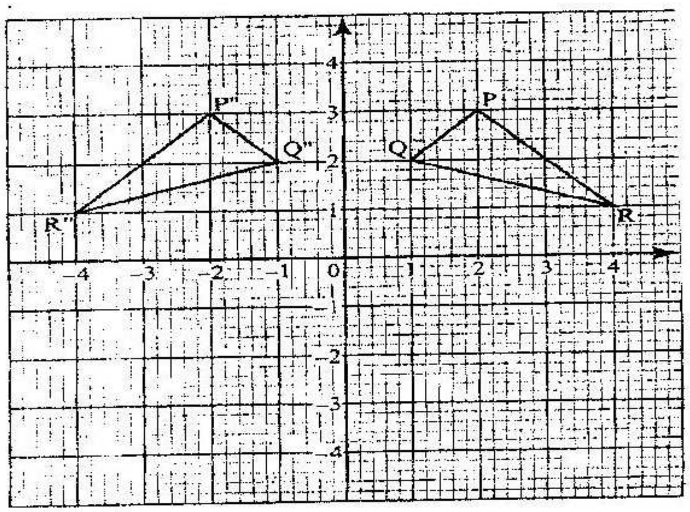
(c) **Describe** fully transformation T_2 (2mks)

(d) Using the figures, **find** the centre and angle of rotation which maps OABC onto

O”A”B”C” (3mks)

3. On the Cartesian plane below, triangle PQR has vertices P(2, 3), Q (1,2) and R (4,1)

while triangles P” Q” R” has vertices P” (-2, 3), Q” (-1,2) and R” (-4, 1)



(a) **Describe** fully a single transformation which maps triangle PQR onto triangle P”Q”R” (2mks)

(b) On the same plane, **draw** triangle P’Q’R’, the image of triangle PQR, under reflection in line $y = -x$ (2mks)

(c) **Describe** fully a single transformation which maps triangle P’Q’R’ onto triangle P”Q”R. (2mks)

(d) **Draw** triangle P”Q”R” such that it can be mapped onto triangle PQR by a positive quarter turn about (0, 0). (2mks)

(e) **State** all pairs of triangle that are oppositely congruent. (2mks)

APPENDIX G: Map of Study Location

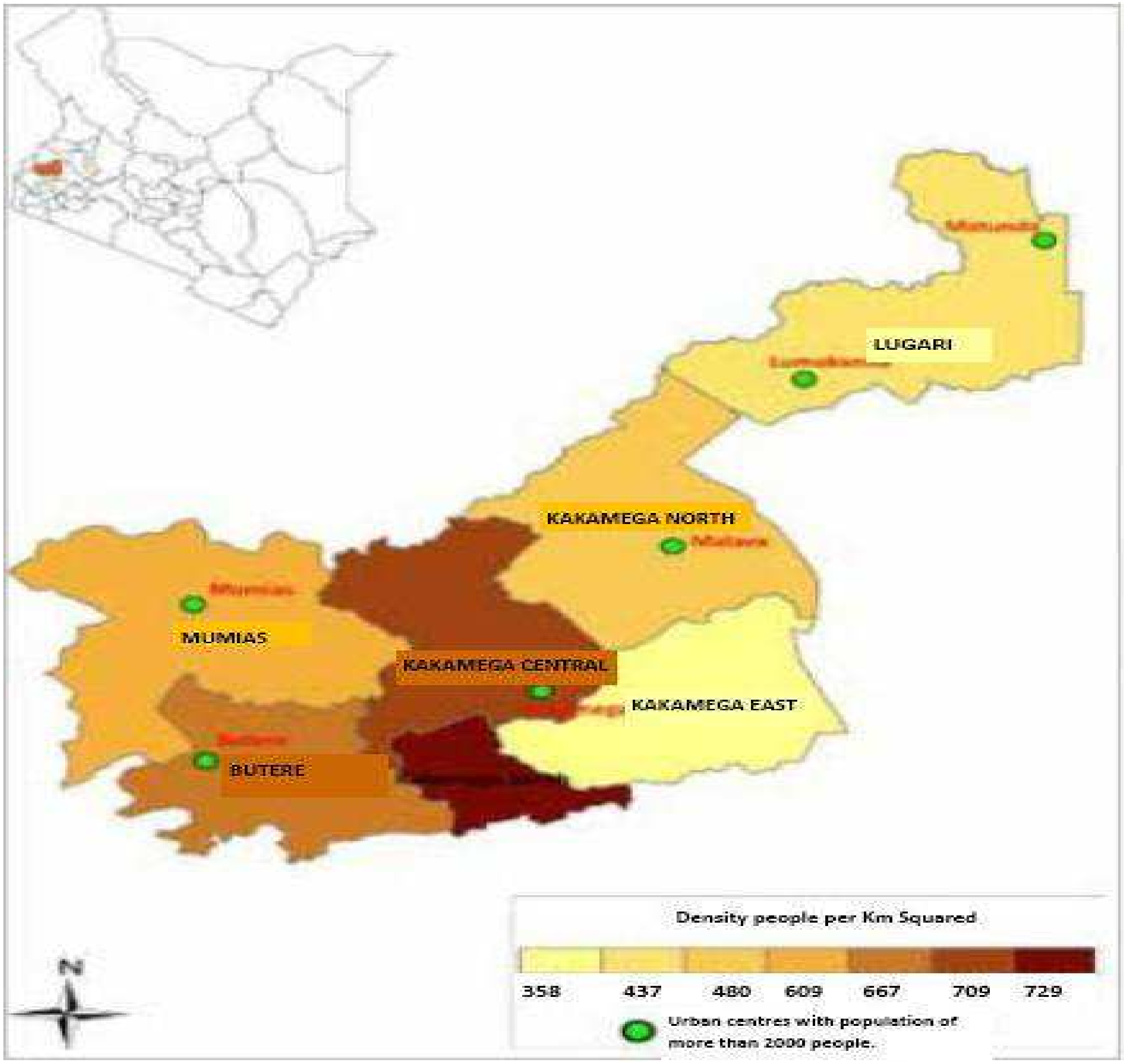


Figure 6: Map of Kakamega County

Source: http://devolutionhub.or.ke/files/large/1a97e2b5affb561d61fc8e707a876caf.jpg

APPENDIX H: Research Permit

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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9th Floor, Utalii House
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NAIROBI-KENYA

Ref: No.

Date:

NACOSTI/P/16/6237/13564

31st October, 2016

Hesborne Otieno Omolo
Masinde Muliro University of
Science and Technology
P.O. Box 190-50100
KAKAMEGA.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Geogebra instruction software and its effect on students' performance in mathematics in secondary schools of Kakamega County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Kakamega County** for the period ending **28th October, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Kakamega 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.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kakamega County.