

**COMPUTER SIMULATION EFFECT ON LEARNER ACHIEVEMENT
IN PROBABILITY IN MATHEMATICS IN SECONDARY SCHOOLS IN
KISII COUNTY, KENYA**

BY

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DECLARATION

I confirm that this thesis is my original work and has not been presented for a degree in any other university/institution for consideration. This research has been complemented by works duly acknowledged. Where text, data, graphics, pictures, or tables have been borrowed from other works including the internet, the sources are specifically accredited and references are cited in accordance and line with anti-plagiarism regulations.

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DEDICATION

This study is dedicated to my Wife, Damaris Nyabate Mogire, and our five children, Diana Nyanchera, Bolton Monyoro, Gloria Moraa, Bradley Omari, and Ben Ayora for their lovely care and support.

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ABBREVIATIONS AND ACRONYMS

ACER	Australian Council for Educational Research
ATMI	Attitudes towards Mathematics Inventory
CAL	Computer Assisted Learning
CBS	Computer Based Simulation
DET	Department of Education and Training
HA	High Achievers
ITBS	Iowa Test of Basic Skills
KNEC	Kenya National Examinations Council
KUGS	Kenyatta University Graduate School
LA	Low Achievers
MoEST	Ministry of Education Science and Technology
MTIS	Mathematics Teachers Interview Schedule
NACOSTI	National Commission for Science, Technology & Innovation
NCTM	National Council Teachers of Mathematics
PRESMT	Pre-test Students' Mathematics Test
POSMT	Post-test Students' Mathematics Test
PP1	Paper one
PP2	Paper two
ROK	Republic of Kenya
SHST	Selective High Schools Test
SQ	Students' Questionnaire

ABSTRACT

From 2012 to 2018, pupils taking the Kenya Certificate of Secondary Education (KCSE) routinely performed poorly in mathematics on a national level. In KCSE Test data from 2012 to 2018, it was noted that probability was one of the mathematical concepts that the majority of pupils found challenging. A novel approach that advocates for the incorporation of computer assisted learning methods like simulation has been put out to address the issue. In this study, learner achievement in probability in mathematics was compared to computer-based simulation (CBS) effect in public secondary schools in Kisii County. The study was guided by five objectives: (1) determine the difference in achievement in Probability between students using computer simulation and those taught using conventional methods (2) establish the effect of computer simulation on achievement of high-ability (HA) and low-ability (LA) students in Probability; (3) determine the effect of computer simulation on students' achievement in Probability by sex; (4) determine the effect of computer simulation on students' achievement in Probability based on their attitude towards mathematics; and (5) establish the challenges of implementation of computer simulation in the teaching and learning of Probability in Kenya. To collect data, Solomon's four-group type quasi-experimental research design was devised. In Kisii County, data were collected from 198 Form 3 students and eight (8) Mathematics class teachers from four (4) public secondary schools who were purposefully chosen to participate in the study. To obtain qualitative and quantitative data, the researcher used students' questionnaires, pre-tests, and post-tests, as well as students' Mathematics achievement tests and instructors' interview schedules. Mean, standard deviation, and ANOVA were used to examine the results for the first objective. It was discovered that, on average, the experimental group outperformed the control group. The experimental group outperformed the control group specifically in probability achievement. Nonetheless, the pre-test outcomes for the experimental group and the control group were comparable. In order to test objective two, a two-way analysis of variance was used. The results showed that, in the control group, students with low ability (LA) had a greater influence on achievement than students with high ability (HA), while in the experimental group, high ability (HA) students had a significantly larger effect on probability achievement than in the control group. When goal 3 was tested using a two-way analysis of variance (ANOVA) test, the findings showed that boys and girls had relatively different mean probabilistic accomplishment levels. Objective 4 was tested using the Post Hoc Tukey's (HSD) test and an ANOVA, and the results showed that the strategy's use had a greater impact on the experimental groups than the control groups. In order to evaluate goal 5, a schedule of interviews was employed. The results showed that there was a lack of physical infrastructure, computer labs, computer hardware, and software, as well as stable internet connectivity and a dependable power supply. Statistical Package for Social Sciences (SPSS) software was typically used to quantitatively examine the data that was obtained. Depending on the research hypothesis, either a one-way ANOVA or a two-way ANOVA was used to test the hypothesis at a 95% level of significance. Additional tests were based on factor analysis, post hoc analysis, and t-tests. The main finding is that CBS's teaching approach is better than traditional approaches to teaching probability.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter provides a background to the problem, a statement of the problem, the purpose of the study, the significance of the study, delimitation and limitation of the study, and the theoretical and conceptual framework of the study. The context of the study is public secondary schools in Kisii County, Kenya.

1.2 Background to the Study

Mathematics is a significant component of the educational curriculum in the majority of the world's countries. This is as a result of the subject's perceived significance in educating pupils for employment options in the future. It has been discovered that this subject in particular strengthens reasoning and spatial abilities in learners as well as the human intellect (Nur, 2010; Wanjiru, Miheso & Ndethiu, 2015). Mathematics is frequently regarded as crucial in science and technical fields (Ajewole, Oginni, & Okedeyi, 2006; Ogembo, 2012; Salau, 2000; Tella, 2007). Mathematics is also beneficial for personal growth and everyday application. As a result, educational policymakers and curriculum specialists in all countries, including Kenya, are enthusiastic about the subject. Mathematics has been declared compulsory for all students at the fundamental levels of education in these countries, which in Kenya comprise the Pre-primary, Primary, and Secondary levels.

Mathematics is an important subject in preparing learners for problem-solving and future career-related challenges. Student performance in the subject has been low both in Kisii County and nationally, according to evidence. According to KNEC reports from 2014 to 2018, probability as a topic is inadequately covered in the mandatory section A of the KCSE Mathematics examinations for both paper one (PP1) and paper two, and is typically missed if it is set in the optional section B. (PP2). Tables 1.1 and 1.2, respectively, show this.

Table 1.1: Mean scores in KCSE Mathematics in Kisii County, 2014-2018

Sub-county	2014	2015	2016	2017	2018
1. Marani	2.151	2.016	2.215	3.432	2.631
2. Sameta	1.782	1.601	1.512	2.114	2.151
3. Kisii Central	2.152	2.201	3.014	3.156	2.871
4. Kisii South	2.415	2.103	2.012	3.012	2.602
5. Nyamache	2.321	2.002	2.211	2.934	2.023
6. Gucha	1.872	1.612	2.042	2.678	2.321
7. Gucha South	2.015	2.123	1.478	2.842	1.827
8. Kenyenyia	1.791	2.017	1.787	2.785	2.783
9. Masaba South	1.982	2.111	2.124	3.012	2.033
Mean	2.053	1.976	2.044	2.885	2.360

Source; Ministry of education, Kisii County (2018)

According to data in Table 1.1, between 2014 and 2018, the mean mathematics score for applicants transferring into secondary education in Kisii County was 2.264 out of 12. This indicates that for five years in a row, the average score was D-, much below the C+ average that is advised for minimal university admittance (KUCCPS, 2014). At the national level, the subject, PP1, and PP2 showed a similar achievement trend to that shown in Table 1.2. (a).

Table 1.2 (a): KCSE National Mathematics performance 2011 – 2018 (%)

Year	2011	2012	2013	2014	2015	2016	2017	2018
PP1	22.71	19.55	22.76	22.37	26.21	21.36	29.46	28.12
PP2	15.36	19.91	19.82	19.87	19.92	28.22	27.86	27.03
Mean	19.04	19.73	21.29	21.12	23.07	24.79	28.66	27.58

Source: KNEC Reports 2011 - 2018

The findings in Table 1.2 show that learners' national average mathematics achievement was 23.16%, substantially below the anticipated 55% C+ approved aggregate. This observation backs up the conclusions of other academics who have looked at students' subpar math ability in Africa and Kenya. In Kenya, there are Benson and Jones (1999) and Miheso, whereas for Nigeria, there are Umoinyang (1999), Tella (2007), and Nur (2010). (2002). Students' poor performance in mathematics has been linked to a variety of factors, including the vocabulary and symbolism used in instruction, the format and arrangement of the curriculum, instructional strategies, and the accessibility of teaching materials (Akala, 2000). Many students, according to Yadavalli and Swarna (2014), struggle with discrimination, memory, and comprehension, which can affect their Mathematics and another academic achievement. Inadequate foundational skills at the basic level have been found to anticipate these obstacles, including those linked to students' computational skills (NCTM, 2000), with the implications leading to academic difficulties in a variety of subject areas as well as other academic disciplines. Simultaneously, Andriani, Widada, Herawaty, D., Ardy, Nugroho, Ma'rifah, & Anggoro, (2020) claimed that Mathematics is an abstract subject with the reasoning that has a range of characteristics, such as precision,

verification, certainty, similarity to ordinary reasoning, and uniqueness. Simultaneously, they say that the subject has its language, in which symbols play a significant role that students struggle to comprehend leading to poor performance in the subject.

Probability was identified as a topic in Mathematics that posed a challenge to the majority of students during national examinations (KNEC reports, 2011-2018) illustrated in table 1.2 (b)

Table 1.2 (b): KCSE National probability marks & Performance report (2011-2018)

Year	2011	2012	2013	2014	2015	2016	2017	2018
SEC A	2	0	0	0	2	0	4	0
SEC B	0	10	0	10	10	0	0	10
Weakness	No score	No score	Not set	No score	No score	Not set	No score	No score
Popularity	Unpopular	Unpopular		Unpopular	Unpopular		Unpopular	Unpopular
Advise To Teachers	Practice	Practice		Practice	Practice		Practice	Practice
Mean	declined	declined	improved	declined	declined	improved	declined	declined

Source: KNEC Reports 2011 - 2018

Table 1.2(b) indicates the marks awarded to the probability question in compulsory section A with a maximum score of 4 marks and sec B with a maximum score of 10 marks and how it was reported with weakness, popularity to students attempting the question, and advice to teachers on how to improve. Weakness on the part of learners indicated no score, unpopular with students, meaning it was not attempted by students and the report went ahead to advise teachers to do more practice with students to attempt probability questions in

subsequent examinations. In the years 2013 and 2016 for instance, the mean for Mathematics improved, because Probability was not examined in the compulsory section, and section B posed a challenge to the learners. The overall report showed that Probability was very unpopular with students, because most students could not identify an occurrence of two independent events and lack of knowledge of the laws of probability (KCSE, 2014). Students were unable to obtain the required Probabilities without replacement and the majority never attempted Probability at all examined in both sections of A and B (KCSE, 2014).

Probability is part of the Mathematics content that students are exposed to at the secondary school level (ROK, 2002). However, Chiesi and Primi (2010) found that many students struggled with Probability, with the problem persisting even among graduate students. It is on this basis that the researcher identified the performance gap at the secondary level of learning Probability and the poor performance of Probability at the secondary level. Probability contributes significantly to students' ability to develop the skills and capacities they need to face life's problems (Chiesi & Primi, 2010). Students that have a positive attitude toward Probability perform better in school, according to several studies (Kazima, 2006; Watson, 2006). The importance of Probability in everyday life and business entrepreneurship, according to empirical study, necessitates a greater focus on it (NCTM, 2000; Shaughnessy, 2007; Watson, 2006). Yadavalli and Swarna (2014) ascribed learners' low performance in Probability to the use of traditional Mathematical procedural learning methods, which were completely unfriendly to

learners' ability to create their concepts and schema. The most significant psychological obstacle to understanding Probability principles was the difficulty of using deductive reasoning to comprehend chance situations. Traditional methods of instruction, which emphasize Mathematics teachers' communication of facts, principles, laws, and theories to students who are passive recipients of the concepts (Ben- Zvi & Garfield, (2008), are said to be insufficient in providing learners with the necessary skills in the subject. Students were relegated to becoming passive consumers of knowledge for the goal of storing and occasionally maintaining thoughts, rather than being equipped with critical thinking and problem-solving skills. Such traditional Mathematical procedural learning approaches were proven to be unfavorable for learners to create their thoughts and schema because no creative learning circumstances were supplied to them (Yadavalli & Swarna, 2014). It was suggested that higher performance could only be achieved if learners developed critical and analytical skills in phenomena. Moore (1997), NCTM (2000), Shaughnessy (2007), and Watson (2006) are some of the other proponents of this school of thinking. As a result, the adoption of CBS helped to close the gap in memorization of Probability chances such as tossing a die and how many times six appear in two tosses to practical computer simulation of chance and outcomes of tosses.

Several treatments were presented in an attempt to minimize the educational approach to the teaching and learning of Probability. The idea of including introductory themes linked to Probability in elementary school to create a firmer

basis for later study in high school was one of the recommendations (MSEB, 1990; NCTM, 2000). Probability was not always apparent, it was thought that if it was not included in the curriculum early on, young children would not develop an understanding of Probability (NCTM, 2000). This implies that many middle and high school students struggled with Probability, according to Garfield and Ahlgren (1988), which they attributed to deficiencies in prerequisite Probability abilities at early stages of education. The key reason for this, according to the researchers, is that elementary school students receive little or no Probability of teaching. It was pointed out that because Probability literacy takes a long time to develop, it was vital to start teaching it in the early years of schooling (Franklin & Garfield, 2006; Shaughnessy, 2007).

Researchers advocated that Computer Based Instruction (CBI) should be used in the teaching and learning of Mathematics in general, and Probability in particular. This would require incorporating Computer Based Simulation (CBS) tools into Probability teaching and learning. Studies show that CAL techniques, such as computer-based simulation, necessitate a contemporaneous and integrated practical approach to Probability training. A contemporaneous and integrated practical approach to the teaching of probability is necessary for CBS, or computer-based simulation. Unlike to conventional methods, which largely concentrate on the mathematical presentation of the underlying theory and are accompanied by separate theoretical and numerical problems for each topic (Manuguerra & Petocz, 2014). In terms of pedagogy, it means infusing

knowledge of students' concepts of essential ideas like chance and variability into the course of instruction, which is best accomplished through the use of a practical-based approach augmented by the use of CBS tools. The justification for the technique was founded on the assumption that because the concepts learned in Probability were not only abstract but also connected, the best way to grasp them was to use more practically focused teaching approaches (Batanero, Burrill, & Reading, 2011).

The arrival of microcomputers, according to Nievergelt (1986) in Hung and Khine (2006), promoted the adoption of graphic animation and a larger range of instructional strategies, like simulation and modeling, whose acceptance would have a considerable influence on classroom teaching. The Programmed Logic for Automatic Teaching operations was one of the major CAL projects that emerged from these efforts in the early 1970s (Guzdial, & du Boulay, 2019). In recent years, with rising interest in statistical approaches and the use of information technology, (Biehler, 1991) has been able to simulate models from the study of Probability as a limit of stable frequency thanks to the introduction of efficient computers in secondary education in Italy.

Alessi & Trollip, (2001) observed that visual presentation strategies with computer-assisted learning, techniques like simulations, animation, tutorials, drills and practice, educational games, and hypermedia are very effective at teaching facts, concepts, and procedures. Students built their mental models from

observations, which were later retained in long-term memory as schemas. By helping pupils to visualize concepts and facts, simulation as a teaching tool improved students' understanding of them (Ali & Zamzuri, 2007). For a longer time, the recorded information was kept in the memory structure.

According to Lindgren and Schwartz (2009), the use of visual teaching methods increased accomplishment by promoting students' conceptual understanding and supporting their memory recall. Data showed that computer-based simulation (CBS), with its animated color visual images, could exhibit the dynamic nature of abstract concepts that were difficult to communicate using conventional teaching methods (Smetana & Bell, 2012). It created process skills, facilitated conceptual transformation, and promoted the learning of probability and science topic knowledge more effectively than conventional teaching techniques.

Attempts were made by Kiboss, Wekesa, and Ndiragu (2006), to assess the efficacy of computer-based simulation in yielding positive learning outcomes in subjects such as Biology and Physics. They both evaluated the benefits of a Computer-Based Instruction Simulation (CBIS) Programme built for teaching cell theory in school biology; the CBIS software resulted in considerable learning gains as well as increased motivation to learn. In a study to ascertain the impact of computer-based simulation (CBS) module on students' achievement in the magnetic effect of an electric current in physics, Chumba, Omwenga, and Atemi (2020) found that the CBS module produced a statistically significant difference

in academic achievement in the subject between students taught using the strategy and those taught using traditional methods. They came to the conclusion that implementing this teaching technique will assist students in improving their persistently subpar performance in Physics, Mathematics, and science courses. In chemistry, the effectiveness of computer-based simulation methods was also evaluated (Mihindo, Wachanga, & Anditi, 2017), with statistically significant results.

When teaching probability, NCTM (2000) favored technology-based simulations are recommended because they "provide students with access to relatively large samples that can be generated rapidly and adjusted simply" (pg. 254). According to Pratt (2000), computer simulation tools helped researchers better comprehend the relationship between sample size and data distribution. When utilized in whole-class education using one computer display, Burgess, Greaves, & Vignoles, (2019) demonstrated that computer simulation software improved elementary students' knowledge of probability derived from empirical data. According to Lee, Rider, and Tarr (2005), students' use of large sample sizes and attention to variability when working with computer simulation tools facilitated deeper linkages between actual data observations and reasoning about an unknown theoretical distribution.

According to these investigations, simulation tools aided students in developing a grasp of the link between theoretical Probability and empirical evidence. Koparan

and Yilmaz (2015) in a study designed to assess the effect of simulation-based Probability teaching on prospective teachers' inference skills, it was discovered that simulation-based Probability teaching enhanced the prospective teachers' prediction and related inference skills and positively impacted the students' success.

Most industrialized countries have used CBS in the teaching and learning of Probability (Chiesi & Primi, 2010). For example, New Zealand's schools have an innovative and world-leading Probability curriculum that emphasized the use of digital resources (MOE, 2007; Watson as cited in Burgess, 2014). The French were believed to have adopted the new program in 2000, leading to a qualitative shift in the likelihood of instruction (Bihan-Poudec & Dutarte, 2014). In 2001, Italian schools started utilizing CBS in the teaching of Probability at all levels of education under the topic "Data and predictions" (Mignani, Ottaviani & Ricci, 2014).

For instance, teaching probability in secondary schools in Italy has been delegated to a secondary and frequently marginal level, resulting in misunderstandings, especially with the rise of gambling, and posing a barrier to classroom teaching and learning of the subject in Italy as well as other nations (Batanero, et al., 2005). Evidence also demonstrated that encouraged by the global push to reform Probability teaching and learning, China modernized Probability teaching and

learning at the elementary and junior high school levels in the country (MOE, 2001).

With the inclusion of Probability in their curricula, several European countries have contributed to the debate over the meaning and interpretation of Probability as it relates to Mathematical theory development (Shaughnessy, 1992). However, efforts in this area have not shown significant results, with the topic receiving little attention for a variety of reasons, including the lack of expertise and training among instructors (Stohl, 2005).

However, in the twenty-first century, a growing interest in statistical methods and the use of computer-based simulation have contributed to a massive study of Probability as a stabilized frequency limit (Biehler, 1991). Computer-based simulation allows for the replication of a model of a real or imagined system, allowing for discovery and programmed learning. Furthermore, when teaching Probability, a teacher must use effective and efficient representations that serve to clarify and minimize any Probabilistic misunderstandings (Pfannkuch & Ziedins, 2014). Shaughnessy (2007) and Jones, Langrall, and Mooney (2007) both voiced concern about the dearth of research on probability teaching outside of Western nations. Developing countries, particularly in Sub-Saharan Africa, like Kenya, have not embraced fully the use of computer-based simulation in teaching and learning Probability and Mathematics in general (Kiboss et al, 2006).

1.3 Statement of the Problem

Mathematics is a significant component of the educational curriculum in the majority of the world's countries. This is because the subject is known to be crucial for educating pupils for problem-solving and potential future employment. Considering the significance of the topic, research revealed that students' math achievement from 2011 to 2018 in Kisii County and nationally was low (KNEC Reports, 2011 - 2018). Analysis of the various exams from 2011 to 2018 has indicated that Probability is among the topics poorly performed. The data on the analysis of performance per question is available in table 1.2 (b).

According to the KCSE report for each question in table 1.2(b), low performance in probability is a weakness that contributes to poor performance in mathematics as a whole. Due to the persistently poor performance of students in probability, policy makers and math educators must work together to establish teaching and learning methodologies that will specifically raise students' performance in probability as well as mathematics in general. Mathematical probability is a vital subject that tries to prepare students for future employment. A new approach was developed and primarily applied in Western nations to address the issue, which pushed for the inclusion of computer-based simulation (CBS) in probability teaching and learning.

Kirby (2004b) analyzed data from grade eight students, finding that 91 of them utilized computer software to learn Mathematics while the rest used traditional

classroom teaching techniques. The results showed that students who received computer-based simulation (CBS) instruction improved their arithmetic scores significantly. The findings necessitated more research on the impact of computer-based simulation (CBS) in Probability teaching and learning on student achievement.

Study comparing existing tactics to best practices, such as the integration of computer-based simulation, is urgently needed because there is a dearth of empirical evidence on the effectiveness of the current pedagogical approach, which is mostly oriented on traditional teaching methods. In order to close the knowledge gap on the proposed outcome, the study sought to assess the effects of incorporating computer-based simulation (CBS) in classroom instruction of probability in Kenya and its impact on learner achievement in probability in particular and Mathematics in general in public secondary schools in Kisii County, Kenya.

1.4 Purpose of the Study

The purpose of the study was to examine whether integrating Computer Based Simulation (CBS) into Probability teaching and learning improves learner achievement in Probability.

1.5 Objective of the Study

Specifically, the study sought to:

- i. Determine the difference in achievement in Probability between students using computer simulation and those taught using conventional methods.
- ii. Establish the effect of computer simulation on the achievement of high-ability (HA) and low-ability (LA) students in Probability.
- iii. Determine the effect of computer simulation on students' achievement in Probability by sex.
- iv. Determine the effect of computer simulation on students' achievement in Probability based on their attitude toward Mathematics.
- v. Establish the challenges of implementation of computer simulation in the teaching and learning of Probability in the Kenyan education system.

1.6 Hypotheses

Based on the objectives, the study sought to test the following null hypotheses:

H01: There is no significant difference in achievement in Probability between students taught through computer simulation and those taught through conventional methods

H02: There is no significant difference in achievement in Probability between high-ability (HA) and low-ability (LA) students when taught through computer simulation.

H03: There is no significant difference in achievement in Probability by sex when taught through computer simulation.

H04: There is no significant difference in achievement in Probability between students with a positive and negative attitudes towards Mathematics when taught through computer simulation.

1.7 Significance of the Study

The results of this study add to our understanding of the body of research on mathematics education as well as how computer-based simulation (CBS) technologies can be used to teach and learn probability. Students and teachers who were important participants in Probability classroom instruction are expected to benefit directly from the study. The research is valuable to Mathematics teachers since it provided them with information on innovative techniques for teaching Probability. They can use the findings to better develop and implement classes in a way that best met learners' future employment prospects, exposed them to the expected problems of topic education, and prepared them in advance for how to overcome those challenges. In their study of computer-based instruction, Kulik and Kulik (1991) concluded that the typical student in an average CBI class would perform at the 62nd percentile on an achievement examination, implying that the average CBI student would outperform 62% of the students in the traditional class (CBI). The outcomes of this study were advantageous to students since they gave a new technique for learning the topic and, by extension, Mathematics.

Students recognized where they fit in the relatively new model of learning Probability because they knew what was expected of them. In particular, the information they gathered advised them on how people may best participate in the building of knowledge, as opposed to the old approach, which called for them to remain passive users of knowledge. Students were also introduced to the inherent challenges of learning the topic, as well as the expected challenges, so they may plan ahead of time how to overcome them. The findings of the study are useful to policymakers at the Ministry of Education, such as curriculum planners and teacher trainers. Policymakers discovered information on best practices in Probability management and implementation to conduct an educated review of the subject's curriculum. On the other hand, the results provided teacher trainers with best practices for instructing teacher candidates on how to manage and implement lessons in probability for a greater level of learner comprehension and success in the topic and, consequently, the subject.

1.8 Delimitations and Limitations of the study

The study in this section will look into the topic of study, Probability, and the location of the study

1.8.1 Delimitations of the Study

The research is limited to secondary school Probability teaching and learning. First and foremost, while secondary school curriculum instruction included a variety of courses, the study focused solely on the Mathematics curriculum. Second, whereas the high school Mathematics curriculum covers a wide range of

topics, only Probability was evaluated. Finally, while the County had both public and private schools, the study focused solely on public secondary schools with ICT infrastructure.

1.8.2 Limitations of the Study

The study's principal weakness was that the sample respondents were taken from a small number of Kisii County schools. As a result, the sample may not be a representative sample of all secondary schools in Kenya where Mathematics, and Probability education was provided. However, sampling was done in such a way that it represented a majority of learners in the county and throughout the republic, specifically in county and sub-county schools. In Kenya, teaching and learning of concepts are done in all subjects provided and tested in the KCSE, whereas the study solely looked at Mathematics. However, because most courses, particularly the pure and applied sciences, adopt the same educational method, constructivism, the findings from this study applied to other topics.

1.9 Assumptions

Throughout the research, it was assumed that:

All schools under investigation were on the same level in terms of syllabus coverage and all students in these schools learned in similar ways using conventional teaching methods. The teachers and learners in both the control and experimental groups have not been exposed to the use of CBS tools in teaching and learning Probability and Mathematics in general. There will be no sharing of

teaching and learning by students and teachers in the experimental group and their teachers in the control group. The study anticipated that Mathematics teachers were easily accessible, upbeat, and willing to help with the implementation of CBS sessions. After the study, it was considered that teachers were ready to execute CBS teachings, and they discussed their experiences.

1.10 Theoretical and Conceptual Framework

1.10.1 Theoretical Framework

Constructivism, which has two distinct belief systems, radical constructivism and social constructivism, served as the theoretical foundation for this investigation. Jean Piaget (1896-1980) is typically credited with formalizing the theory of radical constructivism, according to Von Glasersfeld (1991).

Piaget proposed that people build new knowledge from their experiences through processes of accommodation and assimilation, in accordance with Von Glasersfeld (1991). According to radical constructivists, learning is a process in which the student actively creates new ideas or concepts based on prior knowledge and experience. This research was founded on Glasersfeld's (1995) radical constructivism theory, which indicates that knowledge is actively produced upon previously constructed knowledge by identifying the subject, rather than being passively absorbed. The adaptive purpose of cognition in this process was to organize the experiencing environment rather than to find ontological reality. Learners utilized the framework to construct a workable

understanding of situations they saw and experimented with in the real world by applying their knowledge structures (Derry, 1996). It was determined to be relevant in this study because it advocated for the contemporaneous acquisition of Mathematical information through the active engagement of learners, which is something that CAL technologies like simulation encourage (Glaserfeld, 1987).

The constructivism component is when an individual creates information and understanding and connects it to their own experiences and thoughts (Von Glaserfeld, 1989). Assimilation involves applying new experiences to pre-existing schema, knowledge, and experiences, whereas understanding involves actively acquiring knowledge (Von Glaserfeld, 2013). The radical constructive learning theory holds that the only conscious reality we can exist in is the one we create from our own experiences and interpretations (Von Glaserfeld, 2013).

According to radical constructivism theory, a learner can make sense of new information by drawing on prior knowledge, relevant experiences, and social interaction with other group members. As opposed to a blank slate that needs to be filled with information, a learner's mind. Vygotsky (1978) asserted that students may perform at greater intellectual levels when required to work in teams, and that by sharing computers, students will be able to learn more.

A radical constructivist classroom focuses on student-centered CBS technologies that encourage critical thinking and active engagement from the students.

Students use computers to research topics, ask questions, and find solutions using a range of computer simulations. In a radical constructivist classroom, the teacher's duty is to probe students' thinking, present a computer-solvable problem, provide problems that may interest the entire class, and create scenarios that will test students' ways of thinking.

While in a radical constructivist learning environment, students play more active roles in manipulating the computer software to learn more and accept greater responsibility for their learning at their own pace, students in a social constructivist learning environment are expected to cooperate and contribute to discussions with other peers in social groups. The aforementioned descriptions of CBS, which are detailed on pages 4, 5, and 6 of this chapter, are mostly constructs and features of the radical constructivism theory of learning, which justifies the adoption of this theory as the study's theoretical framework.

1.10.2 Conceptual Framework

The study's conceptual framework represented dependent and independent variables as well as the connections between the elements assumed to influence secondary school students' proficiency in probability and mathematics in general, as indicated by the arrows in Figure 1.1.

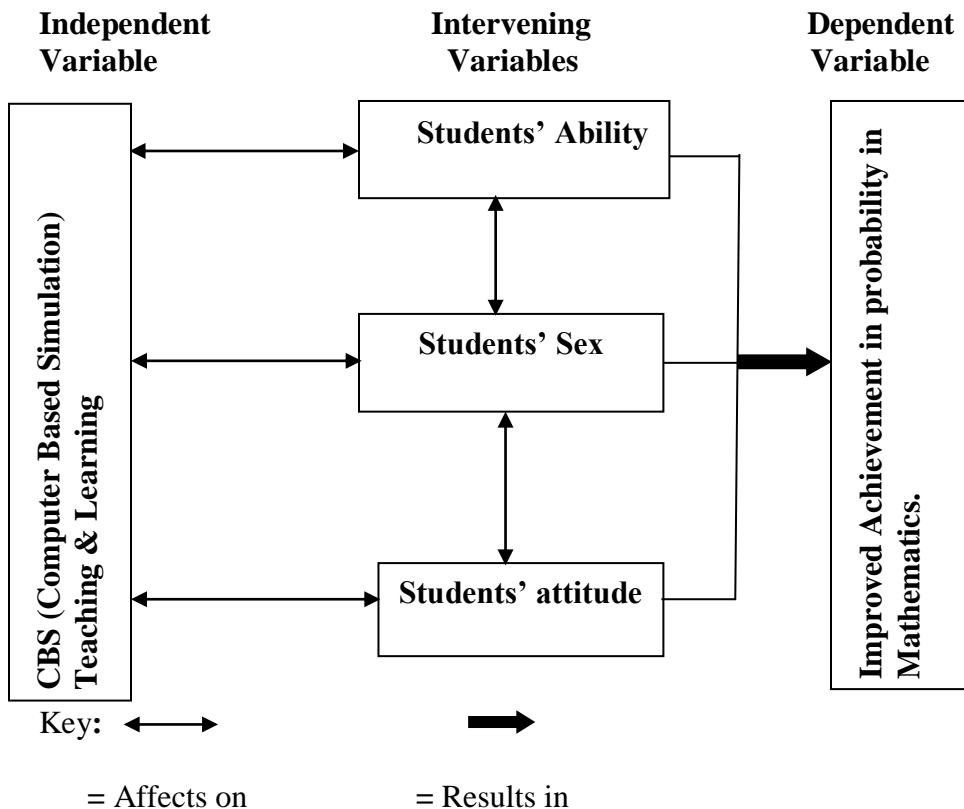


Figure 1.1: Conceptual Framework model of the study

Source: Benjamin E. Arthur (2014)

The study's main thought was that, depending on the teaching strategy used conventional or computer-based simulation learners will either perform well or poorly in probability and mathematics as a whole. Methods of instruction, such as computer-based simulation and conventional classroom teaching, were crucial indicators in the framework.

It was hypothesized that the model of instruction used in the teaching and learning of Probability had a significant impact on achievement. Several student-related characteristics, such as sex, ability, and attitudes toward Mathematics, influenced the association in the direction shown by the arrow.

1.11 Organization of the Thesis

This thesis is organized into five chapters. Chapter one presents background knowledge of the problem. It also displays the purpose of the study, objectives, and significance of the study. Theoretical and conceptual frameworks and operational definitions of terms have been contextually defined in this chapter. The second chapter examines a survey of relevant literature. In chapter three, the methodology is explored in depth.

These methods include the research design, study variables, location of the study, target population, sampling techniques, construction of research instruments, validity and reliability of data, and data collection techniques. The fourth chapter is devoted to the study's outcomes and findings. The research, including all findings, conclusions, consequences, and recommendations for future research, are summarized in Chapter 5.

1.12 Operational Definition of Terms.

Computer-Assisted Learning: Incorporation of computers and computer-assisted learning applications into instruction.

Computer-based Simulation: Computer-based simulation of the consequences of a Mathematical model connected with a system to reproduce its behavior.

Conventional instruction methods: Teaching methods that emphasize classroom instruction supplemented by other resources rather than computer-based simulation.

ICT integration: Classroom learning is aided by the use of ICT tools.

High Achievement: A good level of mathematics achievement is equivalent to more than 40% on a standardized test.

Higher Order Skills: Critical, logical, introspective, metacognitive, and creative thinking skills are all linked.

Low achievement: An arithmetic achievement level that is less than 30% on a standardized test is considered unsatisfactory.

Public Schools: A government-funded and operated tuition-free school.

Probability: A mathematical topic that deals with the probability of an event occurring, as assessed by the ratio of favorable cases to the total number of possible cases.

Chance experiment: An activity with several conceivable outcomes for which we have no way of knowing which one will occur.

Trial: Within an experiment, there is only one performance.

Outcome: The result of a trial.

Event: A subset of all conceivable outcomes that have been chosen.

Technology: The theory and practice of learning process and resource design, development, utilization, management, and evaluation.

1.13 Chapter Summary

This chapter has covered how secondary school students perform below average in probability and mathematics as a whole. Also, it has been noted that the kind of education used by math teachers makes students passive rather than active learners. The problem has been identified, and goals for the study have been defined. The study's importance has been demonstrated, and its goal has been described. The study's purpose and methodology have also been covered in this chapter. The proposed conceptual model has been produced via discussion of the study's theoretical models.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter presents a review of the literature associated with methods of instruction Computer-Based Simulation in probability and their influence on learners' achievement in Mathematics. The review considered several issues which included; theoretical foundations for computer use in education, CBS and Instruction of Probability in Secondary Schools, students' ability and integration of CBS, students' attitude and integration of CBS in mathematics instruction, challenges of integration of CBS in the instruction of Probability and the summary of the existing literature and the research gap.

2.2 Theoretical foundations for computer use in education

B.F.Skinner (1954) created a teaching machine to reinforce student behavior instead of punishing them. When an inaccurate answer was followed by a weaker reinforcement, Skinner's principle was seen (Skinner, 1960). Skinner's idea is built upon CBS education systems, which provide instant positive reinforcement to improve student performance. Skinner's computer teaching machine was built on Pavlov's classical conditioning theory, which states that a stimulus causes a specific reaction (Ormrod, 1999). According to Thorndike, responses to a circumstance that results in satisfaction are strengthened, whereas those that result in discomfort are diminished. When this response stimulus is good, it helps to reinforce learning. Students are given positive reinforcement and measurable

goals as a result of the stimulus-response relationship in Computer-based simulation programs. The concept of educational scaffolding is based on Vygotsky's social development theory, as stated in Chang, Chen & Sung, (2000).

CBS is a lesson delivery approach based on scaffolding that involves skill mastery by breaking down lectures into little activities. During the learning process of a new skill, teachers gave direction and aid to the learner. Once tasks are mastered, the computer's built-in learning mechanism gives immediate positive reinforcement to the student. When CBS is employed, students become more engaged. It promotes student engagement and, most likely, learning, which has a direct impact on their dedication to the learning process and sense of belonging (Christenson, Sinclair, Lahr & Godber, 2001).

Piaget, Dewey, and Vygotsky are frequently mentioned as the founders of constructivist theory (Hein, 1991). The learner develops meaning through interacting with problems, scenarios, puzzles, and other situations while using computer-assisted learning, therefore generating knowledge through interaction with the computer. Constructivism is significantly influenced by developmental psychology and theories of social learning. For this constructive process to occur and transfer to situations outside the training classroom, constructivists believe that learning must be placed in a rich context, representative of real-world contexts (Bednar et al, 1995).

According to research by Brown, Collins, and Duguid (1989; Resnick, 1987), when analyzing dependencies to divide knowledge areas, the constructivist approach to taking into account what real individuals in a particular knowledge domain and real-life setting normally do, and the constructivist view towards a consideration of what real people actually do are all effective methods. With this method, the learner is encouraged to approach the subject matter in the same way an expert user would. This study will look into a concept called CBS, which splits knowledge into little chunks for quick feedback.

While an external reality may exist, the core of that reality, according to radical constructivism, is that knowledge becomes a subjective construction of the individual based on the individual's cumulative experiences (Piaget 1972; Von Glasersfeld, 1995). This subjective construction reflects the radical constructivist view that knowledge is the result of a person's active cognizing for learning, rather than being passively transferred from the environment to the person. The ultimate purpose of knowledge is to develop internal mental structures that correspond to an external reality, as well as internally coherent mental structures that are adaptable and lead to efficient and successful thinking and conduct (Von Glasersfeld, 1998). Social constructivism theory, on the other hand, is a version of constructivism that stresses the social aspect of knowledge and embraces social interactions as a source of information rather than individual cognition (Garrison, 1998, Gergen, 1995; Prawat & Floden, 1994). With the community acting as the main source of meaning for things and events in the world, personal meaning-

making involves socially accepted ways of dividing up reality (Prawat, 1996). Language, culture, and context are crucial when using social activity as a source of knowledge (Dewey, 1896, Gergen 1995; Vygotsky, 1986). According to social constructivism, truth is an adaptive and socially determined meaning that develops among people seeking the truth together through their dialogic interaction, as opposed to being found inside a person's head (Bakhtin, 1984).

In addition to radical and social constructivism, cognitive constructivism emphasizes the external nature of knowledge. It is a conservative form of constructivism. Nonetheless, cognitive constructivism holds that one can learn to know reality or truth as it exists outside of oneself, in contrast to radical and social constructivism (Mayer, 1996; Prawat, 1996).

According to Moshman (1982):

"Knowledge construction is primarily a reconstruction of structures that have already occurred in the external world." Though an active organism is supposed to be involved in the abstraction of knowledge from that environment, empirical guiding of this constructive activity remains the most important aspect in controlling the course of learning... "Structures that they would like to depict"

As a result, cognitive constructivists believe that the search for knowledge is a search for how the world truly works and that the worth of information is decided by its consistency with reality (Pepper, 1942; Prawat & Floden, 1994). Today's world has grown in technology, with people using computers to connect online

and learn. Based on the constructivism philosophy of learning, CBS will envision and realize the teaching and learning of Probability using computers.

Constructivist philosophers contend that students assess knowledge and the world in light of their own realities, learning through observation, processing, and interpretation before personalizing the knowledge gained (Cooper, 1993; Wilson, 1997). When the material is contextualized for immediate application and personal significance, learners are more likely to remember it. Siemens (2004) presented the connectivism hypothesis, which combines the principles investigated by chaos, network, complexity, and self-organization theories. Learning is no longer within the control of the learner due to technological advancements; rather, it is heavily influenced by changing settings, innovations, and changes in the discipline to change all that has been learned to learn how to evaluate new knowledge. Downes (2006) agrees with Siemens on connectivism and proposes that what needs to be taught is determined by others and changes over time.

Considering that machines, and computers are becoming smarter as a result of the employment of intelligent students, Siemens wonders if learning may be stored in machines, and computers so that they can communicate with students as needed. However, educators will face a challenge in designing instruction for both machines and humans, as well as how the two can interact. For example, if a procedure for using a computer changes, the machine's wireless capability will

allow the updated procedure to be downloaded for the user to access and guide them through the procedure (Siemens, 2004). The instructor serves as a guide and facilitator in the learning process, with the student at the center. Rather than being taught, students should be allowed to develop their knowledge (Duffy & Cunningham, 1996). Knowledge is created through physical and mental learning processes (Phillips, 2005). Constructivists emphasize situated learning, which views learning to be contextualized (Hung, Looi, & Koh, 2004).

Learning is moving away from one-way instruction and toward knowledge generation and exploration, according to Tapscott (1998). Mezirow (1991) mixes constructivism with cognitivism in his transformation theory of learning to explain how people learn as a process of using prior interpretation to construct a new or revised interpretation of the meaning of one's experience in order to effect future action. According to Mezirow (1991), the learner's frame of reference or meaning viewpoint; communication conditions; the line of action (process) in which the learning occurs (environment); the learner's self-image; and the situation experienced during the learning process (Experience with learning). To support constructivist learning, collaborative and cooperative learning should be encouraged (Hooper & Hannafin, 1991; Johnson & Johnson, 1996; Palloff & Pratt, 1999). Working in groups with other students gives them real-world experience with others and allows them to practice their metacognitive skills while also learning more from them.

Learning, according to Heinich, Molenda, Russell, and Smaldino (2002), is the process of acquiring new knowledge, abilities, and attitudes as a result of the learner's interactions with information and the environment. Interaction is essential for cultivating a sense of present and encouraging transformational learning (Murphy & Cifuentes, 2001). According to Garrison (1998), the transactional character of the relationship between the teacher, learners, and the content that is important to the learning experience is included in the design of an educational experience. Rather than partitioning knowledge domains based on logical examination of dependencies, the constructivist viewpoint considers what real individuals in a given knowledge area and context normally do (Brown, Collins & Duguid, 1989; Resnick, 1987). In learning, the process of developing a viewpoint or understanding is critical; no meaningful construction can take place until all necessary knowledge is pre-specified (Bednar et al. 1995).

Gagne (1977) defines learning in terms of skill and capability categories and the conditions under which they are acquired. Intellectual skills, linguistic knowledge, cognitive methods, physical skills, and attitudes are the five categories that Gagne divides learning outcomes into. Learning is influenced by internal and external factors in each individual and their environment, with each outcome occurring under its own set of internal and external conditions. According to Gagne's theory, both learner characteristics and environmental events contribute to learning, with each type of learning outcome having its own set of internal and external variables.

Regardless of the theoretical standpoint, Steinberg's (1984) synthesis of Gagne's and Brandford's theories found that four components are critical to learning: target population, learning goals, the task involved, and instruction approach. According to Steinberg, there are many individual variances among learners in a target audience, which influences their ability to learn new things. Goals are the computer-determined intended outcomes of training, such as demonstrating knowledge or expertise, participating in simulated experiences such as decision-making, or changing attitudes. Computers are good instruments for adopting well-established educational paradigms; when used correctly, a computer can be an excellent teaching tool if the lesson it provides is effective, efficient, and acceptable to the intended learners (Steinberg, 1984).

Gestalt insight-learning theory disputed the notion that all learning consists of basic connection responses to stimuli, insisting that experience is constantly ordered and that we react to a complex pattern of stimuli (Moore & Fitz, 1993). The learner experiences stimuli in structured wholes rather than disconnected bits, arranging his or her perceptual field according to four laws: (i) proximity, (ii) resemblance and familiarity, (iii) closure, and (iv) continuation. Gestalt learning theorists' contributions to cognitivism include perception, meaning, and insight (Merriam & Caffarella, 1999). As a feature of cognitivist-oriented learning, Gestaltists' theory focuses on the individual learner's mental processes.

According to Hooper & Rieber, (1995), a systematic design of training, behavioral objectives, programmed instruction, computer-assisted instruction, and competency-based education are all strongly anchored in behavioural learning theory. Objectives have been shown to have a favorable influence on learning at the individual level by Merriam & Caffarella, (1999). Learning theorists were becoming increasingly interested in the study of internal knowledge structures and cognitive processes that underpin task performance, as opposed to behavioral theories of learning and memory (Bosco & Morrison, 2000). Contemporary methods of computer-based learning are more frequently based on cognitive learning theory, and they focus not just on the computer's product technology, but also on the computer's concept technologies (Hooper & Rieber, 1995). Constructivist learning approaches are often emphasized by idea technology (Papert, 1993; Schwartz, Yerushalmy & Wilson, 1993).

The impacts on learning are best understood by categorizing them as "effects of" versus "effects with" computers on cognition (Patel, 2013). Mathematics is taught in Moroccan middle schools with a variety of issues, including instructional approach, which places Morocco among the last countries in terms of student aptitude in math and science (Bosco & Morrison, 2000). In research conducted in Morocco employing computerized programs for teaching and learning mathematics, the experimental group showed considerable progress in both rural and urban students (Bosco & Morrison, 2000). There was no significant difference in the experimental group's outcomes between boys and girls, implying

that computer simulations do not discriminate between sexes and that rural students' scores are slightly lower than those of urban students (Bosco & Morrison, 2000).

The relevance of basic science in Nigerian elementary school curriculum from primary to junior secondary level correctly reflects the role of mathematics in modern society (Hooper & Rieber, (1995). However, there are issues with its methodology, with kids at the primary school level in Nigeria achieving frustrating results in mathematics and science (Hooper & Rieber, (1995). According to Yerushalmy & Wilson, (1993), children perform badly in science and mathematics in secondary school due to a lack of basic scientific and mathematics knowledge. Poor math and science achievement is ascribed to ineffective teaching techniques, teachers who are not doing their jobs correctly, and a lack of utilization of ICT resources (Moore & Fitz, 1993). Innovative teaching approaches and technology-driven strategies can be used to teach basic science and mathematics at both the primary and secondary levels, with some findings indicating that they help increase students' science and mathematics learning outcomes (Bosco & Morrison, 2000).

According to Murphy & Cifuentes, (2001), the goals of ICT in education include, among other things, increased individual acquisition of knowledge and skills required for better living and sustainable development; promotion of the human-environment relationship while implementing the principles of long-term

education through distance education; and promotion of the human-environment relationship. By providing teachers with tools to explain particular points or processes while promoting long-term learning, the appropriate use of ICT can revolutionize the entire teaching-learning process, leading to a paradigm shift in both content and teaching methods (Murphy & Cifuentes, 2001). A computer is a technology that may be used to provide instructional events that have been specifically created, developed, and generated for individualized learning settings to improve teaching and learning (Merriam & Caffarella, 1999).

2.3 CBS and Instruction of Probability in Secondary Schools

According to reports, secondary school Mathematics and Science instruction has continued to encounter several obstacles, particularly in poor countries like Kenya. The difficulties were attributed, among other things, to a lack of access to or usage of instructional materials, institutional issues, teacher-related factors, and student-related factors (Kunene & Bansilal, 2011; Lamb & Fullarton, 2001; Ogembo, 2012).

The findings revealed that such difficulties were the primary cause of a majority of student's poor performance in the course (Kiwauka, Van Damme, Van Den Noortgate, Anumendem & Namusisi, 2015; Wanyonyi, 2013). To reverse the trend, among other things, a shift in the pedagogical approach to teaching and studying the topic was increasingly pushed for and implemented. The adoption of

CBS in classroom instruction was one of the alternatives pushed for (Nduati, 2015; Ogembo, 2017).

In general, empirical studies showed that incorporating CBS into classroom education had a beneficial outcome. According to Siddiqui and Khatoon (2013), this was due to the potential of CAL's tools, which included computer-based simulations (CBS) and games, to promote new, inquiry-based methods of Mathematics and Science instruction. Learners were able to perceive, examine, and construct scientific explanations for events that would otherwise be impossible to observe and modify using traditional methods. According to Earle (2002), CBS tools assisted the development of metacognitive skills and self-regulation among learners, resulting in a more successful learning method among students.

Linn, Chang, Chiu, Zhang, and McElhaney (2010) discovered that CBS helped students relate abstract scientific conceptions (e.g. equations) to the invisible processes that underpin phenomena and their observations. A study by Serin (2011) discovered a statistically significant increase in the achievement and problem-solving abilities of students in the experimental group. Similar observations were made by Yusuf and Afolabi (2010), Kiboss and Tanui (2013), Orora, Keraro, and Wachanga (2014), and Wekesa, Wekesa and Amadalo (2014).

In the case of mathematics, data indicated that using technology aided students in significantly improving their Mathematics learning by enhancing their excitement and drive for the subject (Ursini & Sanchez, 2008). Dhamija (2016) found significant differences between the experimental and control groups in an experimental study evaluating the influence of Computer simulation Linn, Chang, Chiu, Zhang, and McElhaney (2010) discovered that CBS tools helped students relate abstract scientific conceptions, e.g., equations to the invisible processes that underpin phenomena and their observations. Serin (2011) in a study on the effects of computer-based instruction on the accomplishment and problem-solving skills of science and technology students, it was found that there was a statistically significant improvement in the achievement and problem-solving skills of students in the experimental group. Similar observations were made by Yusuf and Afolabi (2010), Kiboss and Tanui (2013), Orora, Keraro, and Wachanga (2014), and Wekesa, D., Wekesa, E., and Amadalo (2014). (2013).

Gal (2005) came to the conclusion that citizens need probability knowledge and reasoning in everyday life and professional settings in order to make decisions in contexts like the stock market, political voting, medical diagnosis, such as vaccine trials, and understanding sampling and inference even in informal approaches. Furthermore, Gal (2005) contends that a more nuanced understanding of Probability is essential when training scientists or professionals (e.g., engineers, and doctors) at the university level. As a result, developing educational programs that can assist students to build Probability knowledge and reasoning necessitates

an explanation of the many components at the basic, secondary, and college or university levels.

Modeling & the meaning of Probability were emphasized in the curriculum while using conventional methods to benefit and preserve the current emphasis on coins, dice, and balls chosen from a bag. Children used to play board games, but now they play games in real-time on screens, making Probability a more helpful tool for modeling computer-based activity and simulating real-world events and phenomena (Pratt, 2011). Pratt and Ainley (2014) discovered that involving students in a model using technology is the most effective way to teach them how to use Probability to model real-world phenomena and that technology can help students learn and teach Probability by sampling, storing, organizing, and analyzing data generated by a Probabilistic model (CBS).

The majority of research linking CBS integration in teaching and learning Mathematics was foreign-based, according to a critical examination. The majority of extant material in Kenya focuses on ICT integration in Mathematics teaching and learning (Kiboss and Tanui (2013). There were few experimental or quasi-experimental research in Kenya that specifically demonstrated the efficiency of CBS in teaching and learning Mathematics. More crucially, there were no studies that showed how the method was used in the teaching and learning of Probability.

CBS is the most recent and most innovative instructional innovation for the learning environment that may be employed in the teaching of Mathematics by both the instructor and the student (Hicks & Hunka, 1972). CBS is a common technology in today's educational environment, and it may be used to assist students in learning across the curriculum (Patel, 2013). With or without the help of the teacher, CBS enables 39 instructional contacts between the learner and the computer in content (Encyclopedia Britannica, 2017). Learners become actively involved in the learning process with CBS, and they end up developing their knowledge (Kiboss and Tanui (2013).

A typical CBS, according to Morrison, Ross, Morrison, & Kalman, (2019), contains numerous aspects such as text, multimedia, or both, multiple choice questions, problems, rapid feedback, practice exercises, worksheets, and tests. One of the oldest types of CBS was drill and practice learning (Johnson, Smith, Willis, Levine, & Haywood, 2010). It is consistent with the behaviourist approach since it enables systematic reinforcement of previously learned ideas as well as routine practice of lower-level cognitive abilities. According to Kauchak and Eggen (1993), using computers to review previously taught content is one of the most effective and cost-effective methods. Tutorial mode is used to teach new concepts by presenting material, guiding learners through the system, allowing them to practice, and assessing them (Johnson, et al., 2010).

Computer simulations are programs that create a computer model of an experiment or a hypothetical situation (Trowbridge, WBybee, & Powell, 2004). In Probability, simulation is frequently built on interactive graphics that allow the learner to visualize a process and the impact of altering parameters on the system's operation. Computer simulation is a potent educational delivery system that gives learners a contextualized, authentic form of practice, feedback on their performance, and a desire to learn while avoiding physical risk and limits (Johnson, et al., 2010).

Students' performance is improved and their interest in the learning process is piqued when they receive computer multimedia training (Gambari, 2010). The role of multimodal senses in the learning process is used in multimedia presentations. To make learning more entertaining and effective, text, voice, pictures, music, animation, graphics, and video are all included. It fits the behaviourist model because it allows for regular practice of lower-level cognitive skills as well as systematic reinforcement of previously learned notions. The CBS technique can be a strong assistance in the teaching and learning process since it integrates sound, sight, and graphics or images.

2.3.1 Computer simulation, teaching, and Achievement

There is evidence that Computer-based simulation (CBS) can help students improve their academic performance. Serin (2011) discovered a statistically significant boost in achievement and problem-solving skills in the experimental

group of fourth-year students who were taught computer-based science and technology. Olga (2008) investigated the impact of CBS on fourth-grade Mathematics students' achievement, attitudes, and retention, and found that there was a substantial difference between the groups on post-assessment tests and attitude scores in favour of the experimental group.

In a small sample of Kenyan secondary schools, Jesse, Twoli, and Maundu (2014) assessed the effect of computer-assisted instruction on scientific achievement. The results showed that pupils who were taught using CBS performed significantly better in science than those who were taught using conventional methods. Charagu (2015) found that the experimental group outperformed the control group in a study to examine the effects of computer-based learning on secondary school students' achievement in chemistry.

Ahiatrogah, Madjoub, and Bervell (2013) discovered that the CBS group outperformed the traditional method of instruction group in a study on the effects of computer-based simulation on the achievement of junior high school students in pre-technical skills. In a study comparing the effects of CBS and the traditional technique on senior secondary school students' accomplishment, Kareem (2015) discovered that CBS enhanced students' academic achievement in Biology. In a study to ascertain the effects of computer-based simulation in promoting intrinsic and extrinsic motivation among senior secondary students, Olakanmi, Gambari, Gdodi, and Abalaka (2016) found that students taught chemistry using computer-

based simulation had higher extrinsic and intrinsic motivation as well as an achievement than students taught using traditional teaching methods.

According to Ardac and Sezen (2002), the effectiveness of CBS increases when learning is accompanied by teacher-directed advice, while students demonstrate greater control over content knowledge when learning is not accompanied by teacher-directed guidance. The use of computer-based simulation (CBS) enhances student performance scores, according to the literature evaluated. The studies mentioned above, however, did not look at computer based simulation (CBS) and learner achievement in probability in secondary schools.

In their study of the impact of computer use in teaching and learning chemistry, (Jules-Van-Belle & Soetaert, 2001) discovered that students who were taught using computers had higher grades than those who were taught using traditional methods. According to (Johnson, et al., 2010), using CBS boosted student engagement, cooperation, and achievement in science. Serin (2011) discovered that fourth-year science and technology students in Turkey who received CBS performed better than those who were exposed to traditional techniques. According to Kareem (2015), the use of CBS led to an increase in academic achievement in Biology. CBS has been shown to have a positive impact on student's academic achievement in several studies (Jesse, Twoli & Maundu, 2014, Ahiatrogah, Madjoub & Bervell, 2013). According to Bhagwan (2005), CBS has several advantages over traditional teaching/learning methods, making learning

more student-centered, changing the focus of teaching and learning from being teacher-centered to being student-centered, supporting collaborative learning and fostering teacher-student contact, and providing evaluative learning are just a few ways to improve student attitudes. According to Mauro (1994), CBS enables students to engage in self-directed learning by giving them the freedom to select, manage, and evaluate the learning activities that the computer can handle at any time and anywhere. These advantages of CBS make learning mathematics more successful than with conventional methods.

2.3.2 Limitations of CBS

There are a few restrictions on the usage of CBS in the classroom that have limited its effectiveness. When students are left to their own devices, they may become overwhelmed by the amount of knowledge and resources accessible, causing them to lose focus on the core learning aim. Not only would the malfunctioning equipment waste time, but it may also fail, producing dissatisfaction among the students (Ross, & Broh (2000)). According to Ross, & Broh (2000), CBS may not be appropriate for all learning approaches. One of the most pressing concerns with CBS adoption is how to fund it, as most CBS software components are too expensive for poor school districts. For developing countries, fully implementing CBS in educational settings may be a significant difficulty. The unfavorable attitude of teachers and their inability to use CBS resources is a major concern in its implementation, but successful ICT integration teachers create significant changes in their teaching techniques and students'

achievement (Demirci, A. (2009). Curriculum integration, or the use of computers to help and enhance learning and teaching in Mathematical sessions, is another major hurdle to the efficient use of CBS. As a result, for optimal integration and application of CBS, it should be included in the curriculum (Shaw, 2004).

In a study conducted in Nigeria, three experimental groups were used to examine how well students performed in practical physics based on their level of mathematical reasoning proficiency. In the first group, only hands-on experiments were employed; in the second, only computer-simulated experiments; and in the third, both simulated and hands-on studies were used. The student's performance was assessed using the outcomes of both the physics achievement test and the manipulative skills practical. Of the three groups of students, those who used both computer-simulated and hands-on experiments scored the highest, while those who just used hands-on experiments got the lowest. Computer simulations can help a student with average mathematical competence enhance their performance, as evidenced by the fact that students with little mathematical reasoning skills did best in all groups (Huntley, Rasmussen, Villarubi, Sangtong & Fey, 2004). (2000).

In Egypt, Ahmad (2010) investigated the impact of using an e-lab on students' attainment of physics concepts, development of higher-order thinking skills, and motivation to learn science. He used a control group of 90 female students and an experimental group of 90 female students. The experimental group received

instruction in sound and light via e-lab software, while the control group received instruction via traditional techniques. The experimental group had a significant advantage in the achievement and learning of higher-order thinking skills, indicating that the e-lab program had a favorable impact. According to the findings, students in the experimental group are more motivated to learn physics than their classmates in the control group. Computers can be used as a supplement to attain educational objectives. The usage of computers is said to have a good impact on student talents and capabilities (Nurhikmah Febriati, & Ervianti, 2021). According to Jonassen, Carr, & Hsiu-Ping (1998), computers contain the majority of knowledge connected to natural phenomena, allowing students to visualize the phenomena.

2.4 Students' Ability and Integration of CBS

In most subjects, including Mathematics, cognitive aptitude has been found to predict the educational accomplishment of a majority of students. As a result, several researchers has focused on techniques to improve learners' cognitive abilities. They were primarily designed to provide learners with the knowledge and abilities they needed to think critically, solve difficult problems, and flourish in 21st-century society and economy, which was the primary purpose of practically all educational systems across the world (Scardamalia, & Bereiter, 1994). This was even more obvious in disciplines like Mathematics, where the majority of students consistently performed poorly. Jencks (1979) found relationships between cognitive test scores and educational outcomes ranging

from 0.40 to 0.63 in an analysis of eight samples from six longitudinal studies. Recently, several studies summaries revealed similar outcomes (Sternberg, Grigorenko, & Bundy, 2001). Deary, Strand, Smith, & Fernandes, (2007) discovered that general mental capacity has a significant impact on school attainment.

Research have shown that students' cognitive ability determines their level of mathematics achievement. For instance, Lipnevich, MacCann, Krumm, Burrus, and Roberts (2011) showed that exposure to mathematics materials and cognitive ability were two essential prerequisites for mathematical achievement. Taub, Benson, and Szente (2014) found that general intelligence had an indirect impact on students' ability in mathematics when comparing the effects of general intelligence and seven other cognitive capabilities. Scardamalia, & Bereiter (1994), on the other hand, found that students' cognitive abilities predicted their academic achievement, particularly in disciplines like mathematics. Taub, Floyd, Keith, and McGrew (2008) found a statistically significant direct link between students' general cognitive aptitude and their Mathematics achievement.

As a result, initiatives to increase children's arithmetic performance have tended to focus on learner-enhancing strategies. One of these projects was the adoption of modern classroom instruction methods, which included the use of CBS tools such as computer-based simulation. Previous research had demonstrated that integrating CBS technologies into teaching and learning improved students'

mathematical and spatial reasoning skills as well as overall accomplishment, particularly in the subjects of science and mathematics. Morgil et al. (2005) found a statistically significant difference in favor of computer-based simulation on measures of computational attitudes, three-dimensional spatial visualization skills, and learning styles in their study on the impact of computer-based simulation on these variables.

Talanquer (2014) argued for the use of instruction methods like CBS tools that helped students visualize three-dimensional structures from their two-dimensional representations after realizing that one of the main obstacles to developing spatial abilities was a lack of understanding of the depth cues provided in two-dimensional representations. This study sought to advance the discussion by examining the effects of computer-based simulation on learners' proficiency and success in probability.

Krishnamachari (1988) investigated how the use of computer simulations enhanced students' comprehension of basic Probability concepts by using workbooks with questions based on computer simulations. The test demonstrated that students had a good grasp of probability concepts. Konold (1989), on the other hand, used a computer modeling intervention to try to improve students' misconceptions and found mixed results, with some students revising their beliefs and interpretations while others stuck with their wrong concepts. Garfield and DelMas (1989) employed the computer software Coin Toss with mixed results,

with some students changing their minds on variability for the better after utilizing the computer lesson and others sticking to their old attitudes. Computer simulations, according to Snee (1993), may not be effective in changing students' preconceptions about probability, but they can aid conceptual understanding by allowing students to explore and depict stochastic models, modify parameters, varying assumptions, and examine data (Jones et al, 2007).

In Pennsylvania, Soeder (2001) looked at two groups to see how computer-assisted instruction affected student achievement. For the first three years of the study, one group received computer-assisted training, while the other received traditional instruction without the use of computers. The study found that using technology has a stronger impact on student accomplishment because it makes learning more student-centered, facilitates cooperative learning, and drives enhanced teacher-student interactions.

Sivin-kachala (1998), asserts that the benefits of the USA integrated learning system technology, fundamental skills, and computer instruction were positive, and student achievement grew as time spent in the program increased. Furthermore, the study found that students gained favorable attitudes about mathematics learning and that teachers became passionate about using computer technology in Mathematics teaching and learning (Mann et al, 1999). The United States produces the world's most advanced technology and software for teaching and learning Mathematics. According to the Program for International Student

Assessment (PISA), US students came in 24th out of 29 countries studied. It was also stated that American students were lagging behind their Asian and European peers, with Poland, Hungary, and Spain leading the way (Dobbs, 2004).

Students who got instruction using computer technology, and united streaming videos, exhibited a significant boost in student achievement in Mathematics, according to Boster et al. (2002) findings. Mwei, Too, and Wando (2011) studied the impact of computer-based simulation (CBS) on students' attitudes and achievement in matrices and transformations in Mathematics, finding that CBS treatment groups had superior achievement.

According to Wanjala (2005), students who learned in cooperative groups with computer-assisted education did better than those who learned separately. By analyzing research studies carried out in Taiwan, Liao (2007) found in his meta-analysis study that computer-based training had a positive impact on people. The results of this study are in line with other studies' conclusions about the application of computer simulations in learning. When Hykle (2011) looked at the relationship between gender and science subject achievement, she found that teachers who used computer-assisted instruction had better levels of success. According to Feyzioglu (2009), computer-based simulation programs that engage students more actively in the learning process often led to higher academic accomplishment than those that do not.

2.5 Students' sex and Integration of CBS in Mathematics Instruction

Sex was thought to be a social regulating system that controlled a specific cognitive organization based on biological distinctions and ruled feminine and masculine concepts (Ojeda & Flores, 2008). Sex refers to the biological distinctions between females and males. Through interactions with peers, teachers, and the local environment, children begin to construct sex schemas or ordered networks of knowledge about what it means to be a boy or a girl.

This socio-cultural construct categorized men's and women's social relationships, social practices, and how individuals interact with physical and cognitive objects. This concept had been one of the foundations for the study of human behavior and predispositions for a long time (Ogembo, 2017). Assuming that the goal of adding technology into Mathematics classrooms was to promote all students' learning, it was critical to determine whether it benefited all students or the vast majority, or if it benefited only select groups, particularly those based on sex. It was particularly vital to track students' participation in Mathematics instruction and learning, as well as their attitudes regarding computer-based Mathematics and, most significantly, the outcomes of both situations.

The purpose of this study was to see how technology affected these dimensions: did it promote sex equality or did it worsen the gap between boys and girls? The findings on the relationship between sex and the use of CBS tools in the classroom were mixed. Two key tendencies arose. On the one hand, a number of

research claimed that CBS tools had a considerable impact on learner achievement dependent on sex. Oginni and Popoola (2013) found a significant difference in performance based on sex favoring male students in a quasi-experimental study analyzing the impact of mathematical innovation and technology on students' academic performance in open and remote learning. Similar conclusions were reached by Eccles and Wigfield (2001), Bandura, Barbaranelli, Caprana, and Pastorelli (2001), and others.

On the other hand, other studies have identified no significant differences in achievement between male and female students who have been exposed to CBS. For example, Ursini, Sanchez, Orendai, and Butto (2004) observed that incorporating technology into Mathematics classrooms appeared to increase gender parity in student conduct. Yusuf and Afolabi (2010) showed that students exposed to computer-based simulation (CBS) performed better individually or jointly than their peers exposed to a traditional classroom education in a study of the effects of CBS on secondary school student's performance in biology.

In both individual and cooperative tasks, there was no significant difference in performance between boys and girls students exposed to CBS. Mcdowall and Jackling (2010), Mihindo et al. (2017), and Ogembo et al. (2017) were among the other investigations. Early research revealed that teachers regarded girls and boys differently, with males' arithmetic ability often being rated higher than girls'

(Upadyaya & Eccles, 2014), and boys receiving higher demands and more specific feedback (Sadker & Sadker, 1986).

According to research on arithmetic achievement, there is a traditional gender disparity in favor of boys (Aunola, Leskinen, Lerkkanen & Nurmi, 2008, Martin & Cheng, 2008). However, other researchers have concluded that gender differences in mathematics achievement are negligible (Lindberg, Hyde, Peterson, & Linn, 2010), supporting the findings of Robinson and Lubienski (2011) who discovered that girls over the past 40 years have received slightly higher grades in mathematics than boys. These findings were also supported by Brown and Kanyongo (2010). Studies showing a connection between teacher and peer support and academic attitudes, achievement, emotions, learning, motivation, and self-efficacy provide evidence for this claim (Danielsen, Wiium, Wilhelmsen & Wold, 2010).

Boys and girls learn together in one classroom in Israel's primary school Mathematics classes, although there is a disparity between their achievements (Bachar, 2012). Ayalon and Livnah (2013) addressed the gender gap in Mathematics and science achievement in the Meyzav test, a national examination of students' achievement in elementary school that revealed an apparent difference between boys and girls, with girls' scores being 12 points lower than boys' scores and the gap existing throughout Israel. In the likelihood that CBS, computer-assisted learning, will cause girls and boys to attain success in the topic, I chose it.

I can build meaningful relationships with the children through computerized communication that is private and non-threatening, especially with the girls who are more comfortable utilizing CBS in the classroom where they are less comfortable expressing questions in front of other students.

Professor Hazan (2010) claims that females' achievement improves when they learn in classrooms with other girls, rather than in classes with boys, because of an outdated perception that girls have poorer talents in the subject of probability and mathematics in general. Girls who learn in courses without boys, on the other hand, are more likely to achieve better levels of accomplishment, according to Gray (2009). Separate courses in school with diverse teaching approaches, such as CBS, is one possibility, according to Dr. Miller (2009), an educational psychologist. Teachers have different attitudes toward boys and girls, according to Bachar (2012), with boys being given more time than girls and girls being handled with compassion and forgiving emotions. Boys credit their success to personal abilities and capabilities, but girls credit it to investment, an easy test, a competent instructor who clearly explains the content, luck, group work, and social learning (Bachar, 2012).

This research aimed to add to the ongoing discussion by examining the impact of computer-based simulation on student learning and accomplishment in probability based on sex. Girls underachieve in science and Mathematics, according to Eshiwani (1982), and this underperformance is largely due to teachers' bias in the

teaching and learning process. Teachers tend to focus on boys more than girls, placing them behind. FAWE (1999) found that girls' achievement in science and Mathematics is poorer, in part due to their negative attitude. According to Erwin (1993), boys are more interested in Mathematics than girls in secondary school. According to research, there is a gender imbalance in school sciences, with more boys taking science and Mathematics topics than girls (Rostvik, & Fyfe, 2018).

However, while there are no sex differences in overall (IQ), there are significant variances in cognitive ability between boys and girls on tests. According to Trowbridge, Bybee, and Powel (2004), sex differences in physics are significant, while in Mathematics they are minor or non-existent. Kans, & Claesson, (2022) claims that sex inequalities in science interest are primarily related to boys' interest in physical sciences against girls' interest in biological sciences. EACEA (2010), the European Commission's executive agency for education, audiovisual, and culture, found that sex inequalities in science were significant within schools or programmes in European countries.

Girls have six points higher Mathematical achievement than boys in grade 8 science students throughout the trends in international Mathematics and science the survey, TIMSS 2007 countries, according to Martin, Mullis, and Foy (2008). Professor Hazan (2010) claims that when girls learn in classes with other girls rather than boys, their performance improves. Girls are aware of the notion that they have poor Mathematical aptitude. According to Banks (2013), girls who attend classes without boys obtain more success. Separate classes for girls and

boys in schools with various teaching approaches for each sex, according to Dr. Miller (2009), a trained psychologist, is one of the options to ensure that girls compete favorably with boys in Mathematics and other subjects. Competitiveness and achievement-oriented learning are less effective for girls than cooperation and personal communication (Kiran, 2009).

Sex was supposed to be a social regulating system that dominated feminine and masculine conceptions and controlled a specific cognitive organization based on biological distinctions (Ojeda & Flores, 2008). Gender, according to Wangid & Widyastuti, (2021), refers to the traits and behaviours that society considers proper for men and women, whereas sex refers to biological distinctions between females and males. Through interactions with peers, instructors, and the environment, children begin to form sex schemas or ordered networks of knowledge about what it means to be a boy or a girl.

This socio-cultural construct categorized men's and women's social relationships, social practices, and how individuals interact with physical and cognitive objects. This concept had been one of the foundations for the study of human behaviour and predispositions for a long time (Ogembo, 2017). Assuming that the goal of adding technology into Mathematics classrooms is to promote all students' learning, it was critical to determine whether it benefited all students or the vast majority, or if it benefited only select groups, particularly those based on sex. It was particularly vital to track students' participation in Mathematics instruction

and learning, as well as their attitudes regarding computer-based Mathematics and, most significantly, the outcomes of both situations. The purpose of this study is to see how technology affected these dimensions: did it promote gender equality or did it worsen the gap between boys and girls?

The findings on the relationship between sex and the use of CBS tools in the classroom were mixed. Two key tendencies arose. On the one hand, several research claimed that CBS tools had a considerable impact on learner achievement dependent on sex. In a quasi-experimental study aimed at evaluating the effect of Mathematical innovation and technology on students' academic performance in open and remote learning, Oginni and Popoola (2013) discovered a significant difference in performance depending on sex in favor of boys. Bandura, Barbaranelli, Caprana, and Pastorelli (2001), as well as Eccles and Wigfield (2001), came to similar results.

On the other hand, other studies have identified no significant differences in learner achievement between boys and girls who have been exposed to CBS. For example, Ursini, Sanchez, Orendai, and Butto (2004) observed that incorporating technology into Mathematics classrooms appeared to increase gender parity in student conduct. Yusuf and Afolabi (2010) showed that students exposed to computer-based simulation (CBS) performed better individually or jointly than their peers exposed to a traditional classroom education in a study of the effects of CBS on secondary school student's performance in biology. In either individual or

cooperative tasks, there was no significant difference in performance between male and female students exposed to CBS. Mcdowall and Jackling (2010), Mihindo et al. (2017), and Ogembo et al. (2017) were among the other investigations.

Early research revealed that teachers regarded girls and boys differently, with males' arithmetic ability often being rated higher than girls' (Upadaya & Eccles, 2014), and boys receiving higher demands and more specific feedback (Sadker & Sadker, 1986). There is a conventional gender imbalance in favour of boys, according to research on arithmetic achievement (Aunola, Leskinen, Lerkkanen & Nurmi, 2008, Martin & Cheng, 2008).

Other researchers, on the other hand, have concluded that gender differences in Mathematics achievement are insignificant (Lindberg, Hyde, Peterson, & Linn, 2010), corroborating Robinson and Lubienski (2011)'s findings that girls have received slightly better grades in Mathematics over the last four decades than boys, findings that Brown and Kanyongo also supported.

Teacher and peer support are favorably associated with academic attitudes, achievement, emotions, learning, motivation, and self-efficacy, according to a study (Danielsen, Wiium, Wilhelmsen & Wold, 2010). In Israel's elementary school mathematics classes, boys and girls study together in one classroom, even though their achievement levels differ (Bachar, 2012).

In the Meyzav test, a national examination of students' achievement in elementary school that revealed an apparent difference between boys and girls, with girls' scores being 12 points lower than boys' scores and the gap existing throughout Israel, Ayalon and Livnah (2013) addressed the gender gap in Mathematics and science achievement. I chose it because I believe CBS (computer-based simulation) will help girls and boys succeed in the subject. I can form meaningful relationships with the children through private and non-threatening digital communication, particularly with the girls who are more comfortable using CBS in the classroom whereas they are less comfortable asking questions in front of their peers.

CBS will help girls learn better by empowering them and allowing them to compete. However, Bachar (2012) attributes boys' success in Mathematics to their abilities and talents, whereas girls' success in Mathematics is attributed to investment, an easy test, a good teacher who explains Mathematics well, and good luck. Bacher (2012) goes on to say that girls prefer group learning and social learning, whereas Mathematics is seen as a competitive and achievement-oriented subject. Any change in strategy will have a significant impact on the attitudes of female students and teachers.

Fear of Mathematics and anxiety about completing arithmetic are low among students who are terrified of Mathematics, according to Beilock, Gunderson,

Ramire, and Levine (2010). This is because the majority of teachers in lower early childhood education are women who have a negative attitude toward Mathematics and hence discourage young children from learning Mathematics at an early age (Beilock, et al., 2010).

According to a meta-analysis, boys outperform girls in problem-solving Mathematics assessments (Li, Zhang, Liu, & Hao, 2018) while comparatively in another research project girls are stronger in computation, but there is no substantial difference in understanding Mathematics topics between the sexes. According to another study, girls in Mathematics tend to do better than boys (Downey & Vogt Yuan, 2005).

Mazana, Suero Montero, & Olifage, (2019), highlighted attitudes about the usefulness and confidence in learning Mathematics as crucial, with boys demonstrating that they were more confident and believed that Mathematics would be more beneficial to them than females. Another study, which looked into the factors that influence arithmetic achievement in Mathematics classes with a gender disparity, found that boys outperformed girls (Van Mier, Schleepen, & Van den Berg, 2019). Hall et al (1999) looked at gender disparities in Mathematics achievement among American children in grades 5 through 8 and found no significant differences.

2.5.1 Students' Attitude and Integration of CBS in Mathematics Instruction

Allport (1935) defines attitude as "a mental and neurological state of readiness that is organized through experience and has a direct or dynamic influence on an individual's response to all things and situations." Attitudes are strong and long-lasting, influencing our actions by helping us to analyze and make decisions about our surroundings (Sternberg, 2004).

Douglas and McLeod (1992) focused on positive and negative responses to an entity, suggesting that attitudes are affective responses involving pleasant or negative sentiments that are stable. According to Eagly and Chaiken (1993), attitude is a psychological inclination expressed as a degree of favor or disfavor in evaluating a certain thing or person. Students' attitudes have been demonstrated to be a significant predictor of their Mathematical achievement. In reality, empirical evidence links students' attitudes to their academic success (Zan & Di Martino, 2007).

Learner aptitude and motivation to learn Mathematics, execute a range of prescribed tasks, and their persistence in the tasks were claimed to be determined in part by their attitude. Simultaneously, learners' ideas of mathematics were linked to how they approached Mathematical challenges, which in turn determined their productive or non-productive approaches to the subject. In general, the attitude was a key notion in social judgements and conduct, as well as

one of the most crucial concepts in decision-making (Venkatesh, Morris, Davis, G. & Davis, F., 2003).

As a result, several studies have been conducted to emphasize the importance of students' attitudes toward Mathematics training, with either positive or negative results. There is a link between students' attitudes toward Mathematics and their academic aptitude in the subject, according to a review of the research (Nicolaidou & Philippou, 2003).

According to Singh, Granville, and Dika (2002), students' ideas and expectations about the difficulty of Mathematics, their levels of involvement, and their likelihood or perceived worth of success all have a significant impact on their Mathematical achievement. Students with favorable attitudes toward Mathematics performed better than those with negative views, according to Nicolaidou and Philippou (2003), suggesting that attitudes and performance in the subject are linked. Mata, Monteiro, and Peixoto (2010), as well as Carmona, Martnez, and Sanchez (2010), backed up this claim (2010). (2004). According to Lipnevich et al. (2011), learner attitude explained 25% to 32% of the variance in Mathematics achievement, with the variance being independent of mathematical skill. High achievement in the subject indicates a positive attitude toward Mathematics, according to Georgiou, Stavrinides, and Kalavana (2007), however, Mata et al. (2012) discovered that the more positive the attitude, the higher the degree of student achievement in the subject.

Researchers recommended for adoption of tactics that would assist alter students' attitudes toward Mathematics in response to recommendations to improve learning results in Mathematics, particularly among low-achieving students. Integration of CBS in Mathematics teaching and learning was one of these ways. For example, Slouti and Barton (2007) found that including CBS in lessons can engage students to learn by adding variation to the lessons while also maintaining teachers' enthusiasm for teaching.

Including CBS into teaching and learning has an effect on both students' and teachers' attitudes toward formal education, claim Mathew and Halpin (2002). The National Council of Teachers of Mathematics (NCTM) praised the application of educational technology in the study of mathematics, claiming that it was essential for teaching and learning the subject and that it enhanced students' learning (National Council of Teachers of Mathematics, 2000). The majority of these studies were conducted in other countries, leaving a research void on the impact of CBS integration on students' attitude-based achievement, which this study sought to fill.

Pytel (2007) investigated student attitudes toward Mathematics when technology is used in a lesson and found that student's passion and interest in learning are higher when computers are used than when traditional methods are employed. Stratham and Torell (1996) conducted a meta-analysis of the use of computers in teaching and learning and found that incorporating technology into schools leads

to fewer discipline concerns and higher-class attendance. Collaboration, simulation, student queries, and problem-solving became anticipated behaviors in the mathematics classroom when CBS was used as intended, according to the study. Learning is reinforced by CBS's instant feedback, which offers the student self-confidence and a sense of self-worthiness (Marzano, 1998).

More advanced topic instruction could increase girls' early Mathematics achievement because Mathematics exams are significantly connected with school-taught curricula (Downey & Vogt Yuan, 2005). Females' achievement in Mathematics was aided by teacher and peer assistance (Riegle-Crumb, Farkas & Muller, 2006). These Mathematical findings are supported up by broader statistics that reveal a positive association between academic attitudes, achievement, emotions, learning, motivation, and self-efficacy, as well as teacher and peer support (Danielsen, Wiium, Wilhelmsen & Wold, 2010). Gherasim, Butnaru, and Mairean (2013) found gender disparities in performance goals, classroom environment, and Mathematics achievement among young adolescents, finding that girls outperformed boys in math. Jones, et al., (2007) found that men have more positive attitudes toward math and science than women.

Girls reported lower levels of fun and pride in Mathematics than boys, according to Frenzel, Pekrun, and Goetz (2007). Girls felt slightly more guilt than boys during a Mathematics lecture, according to Frenzel et al, (2007). Too much

individual practice (Tobias, 1987) and teachers who focus on students' shortcomings might lead to a negative attitude toward Probability.

2.5.2 Attitudes and Confidence in Mathematics

A student's attitude toward mathematics can be influenced by a variety of factors. The classroom teacher has a significant impact on student attitudes. Teacher quality, enthusiasm, respect, dedication, and good attitudes toward mathematics are linked, according to Shaughnessy (1992). Midgley & Urdan (1995) discovered that when a teacher used more supporting comments during contact with students, children reported less negative affect and self-handicapping attitudes than when the instructor made more critical comments during interactions. They concluded that teachers needed to be aware of how they interact with students because teachers constantly transmit messages to students, both vocally and non-verbally, and these messages influenced student confidence and attitudes toward mathematics. The level of success a student has in mathematics has also been demonstrated to influence their attitudes.

Ross, & Broh (2000) studied factors that influence Mathematics achievement in a sample of college-aged men and women. They focused on self-esteem and personal control, in particular, attributes of success and failure. "By far the biggest predictor of academic achievement in the 12th grade is earlier academic achievement" or success in Mathematics, according to one of their studies. The more success a student had in math, the more enthusiastic they were about it

(Hootstein, 1994). While this looked logical on the surface, it also meant that teachers of Attitudes, Performance, and Achievement 8 needed to develop strategies for students to feel successful. This was especially true for students who had previously experienced only a limited level of success. It may be tough to improve a student's attitude and confidence. This may be beneficial if a student has a positive mindset, but it could be detrimental if the student's attitude and confidence are negative.

In a three-year study of students' attitudes and beliefs about mathematics, Turner and Meyer (2009) found that, depending on the manner of approach, roughly 66% of students' attitudes and confidence changed from year to year. Hence, computer-assisted learning will significantly alter how they view probability and mathematics in general. Pupils who said their confidence levels had changed merely went from one level to the next; for instance, as a student's math skills improved, they went from having low confidence to having high confidence.

Schau, Stevens, Dauphine, & del Vecchio, (1995) developed attitude as a multidimensional term after a cyclical research process with attitudes divided into three components. Gómez-Chacón (2000) defined Probability feelings as "pleasure or dissatisfaction with probability," "interest or indifference in Mathematics," and "likely rejection or worry toward Probability." Behavioral component toward Probability (BP): The teacher's proclivity to act in a certain way toward the attitude object, to make decisions that benefit other colleagues

(staff mates), and to apply Probability. The teacher's self-perception of self-competence, knowledge, and intellectual skills, when applied to Probability, is called cognitive competence towards Probability (CCP) (Gal, 2005).

In their experiments, the three components resulted in three different attitudes regarding Probability. The emotive component of teaching Probability resulted in personal feelings about teaching Probability that varied depending on the affective component of the issue in terms of joy or dissatisfaction, fear – lack of confidence, interest or lack of interest in teaching Probability (Gal, 2005). The teaching Probability competence component (CT) evaluates the teacher's perception of his or her abilities to teach Probability, answer students' issues, propose acceptable work, and locate appropriate resources for the topic (Batanero, & Lancaster, 2011). The behavioural component of teaching Probability (BT) was used to rate the didactic action trend. If the teacher has or has not taught Probability, or if he or she is willing to teach it, if he or she prioritizes it over other courses if he or she believes it should be delayed or reinforced (Batanero, & Lancaster, 2011)

Finally, they incorporated a Value component toward Probability and its teaching (VPT): an understanding of the utility, relevance, and significance of Probability and its teaching in personal and professional life. Although Schau et al. (1995) discovered components of value, none of the scales evaluated included the value offered for teaching; this is the gap that this study aimed to fill by including

computers in teaching and learning Probabilities (CBS). According to Middleton and Spanias (1999), a lack of teacher support and a bad classroom climate can explain students' negative attitudes toward Mathematics.

When children achieve success in Mathematics, their confidence grows, and their whole attitude toward Mathematics, especially Probability, improves (Martin, Mullis, and Foy 2008). Students, on the other hand, become demotivated when they are unable to complete a Mathematics task (Ursini, Sanchez, Orendain, M, & Butto, 2004).

Students feel they can do Mathematics if they try, according to Middleton, & Spanias (1999). They believe they can do Mathematics if they try because they know their triumphs are important and stem from their abilities and a high level of effort. Tasks should provide an appropriate amount of challenge for each student to enhance student attitudes (Brophy, 1999).

Classical conditioning, operant conditioning, and observational learning are examples of learning theories that can be used to influence learners' attitudes (Tabrani, & Masbur, (2016). By linking pleasant sentiments with the learning process, classical conditioning is utilized to promote positive emotional reactions in learners. Learners can employ operant conditioning to strengthen positive attitudes toward learning and to diminish negative attitudes toward Mathematics.

Learners can also improve their bad habits by seeing people who have a positive approach toward Mathematics.

Learners can change their attitudes in two ways, according to the Elaboration Likelihood Theory of Attitude Change: they can be motivated to listen to and think about Mathematical messages, resulting in attitude change, or they can be influenced by teacher characteristics, resulting in a temporary change of attitude (Kundu, and Ghose, 2016). When learners have conflicting ideas about a topic or issue, the dissonance theory of attitude modification claims that they can adjust their attitudes to alleviate the tension generated by incompatible beliefs and shift their attitudes (Kundu, and Ghose, 2016).

Mathematics achievement, anxiety, self-efficacy, self-concept, motivation, and school experiences are three groupings of characteristics that influence learner attitudes, according to (Fakomogbon, Omiola, Awoyemi, & Mohammed, 2014). Fakomogbon, et. al., (2014) discovered that student views were influenced by their learning settings at home, school, and with peers. All school factors include teacher and instructional resources, classroom order, teachers' expertise and attitude toward Mathematics, and both teacher and student beliefs and motivation. Home and societal variables include things like background, parental expectations, and parental occupation (Otieno, 2010).

Wilkins, & Ma, (2003) discovered that social factors like parental influence, instructor influence, and peer influence children's attitudes toward Mathematics. Wilkins concluded that positive reinforcement from teachers, parents, and peers might assist kids to acquire positive views about the importance of Mathematics, which could help students build negative beliefs and attitudes toward learning.

According to (Kundu, and Ghose, 2016), attitude change has a significant impact on behavior, and the same factors that cause attitude creation can also cause attitude change. According to (Kundu, and Ghose, 2016), certain ideas provide insight into how attitudes might be modified. Three forms of learning theories for changing one's attitude are classical conditioning, operant conditioning, and observational learning.

When the learner, item, person, or event is associated with pleasurable experiences, classical conditioning can be used to generate favorable reactions to the learner, item, person, or event. Positive attitudes can be reinforced while bad attitudes are weakened through operant training. What people observe in others may also impact their attitudes.

According to Kupari and Nissinen, cross-factors related to students, teachers, and schools are the cause of poor mathematics performance (2013). Several academics believe that students' attitudes play a significant role in determining whether they do mathematically well or poorly (Mata, Monteiro & Peixoto,

2012). A cheerful outlook can aid youngsters in learning more effectively because attitudes can change and evolve (Syyeda, 2016). (Akinsola & Olowojaiye, 2008).

Negative attitudes impede effective learning and, as a result, impact learning outcomes and, as a result, performance (Joseph, 2013). Effect, cognition, and behavior are the three basic components of attitude (Syyeda, 2016). These three elements are intertwined and encompass a variety of factors that influence one's overall attitude toward Mathematics.

2.6 Challenges of Integration of CBS in Instruction of Probability

Based on existing empirical evidence, incorporating CBS in schools is a challenging procedure. Limited ICT resources, expensive Internet access, limited information sharing, limited skills for CBS integration, and a labor shortage as a result of training institutions failing to produce the ICT technicians and professionals required for the labor market, as reported in Mwalongo, were among these, according to Swarts and Wachira (2010). (2011). According to Smarkola (2007), other obstacles included a lack of energy, smartphone access, and an insufficient quantity of computers.

Hare (2007) identified a lack of regulatory framework, insufficient infrastructure, excessive bandwidth costs, and insufficient in-service teacher training on CBS in education as some of the barriers to CBS integration. While some studies have documented the difficulties associated with CBS in the Kenyan educational

system, they were not particular to ICT integration in Mathematics teaching and learning or CBS in Probability. The goal of this study was to get insight into the issues associated with this particular focal area.

Chapman and Tunmer, (1997) affirmed that Students who did well in Mathematics displayed appropriate task-focused conduct and positive learning techniques, but students who were cautious in learning circumstances and avoided problems in Probability did badly (Midgley and Urdan, 1995, Zuckerman, Kieffer & Knee,1998). According to Stohl (2005), teachers' Probability reasoning and knowledge, as well as teachers' deeper understanding of students' misconceptions, have a significant impact on students' Probability reasoning and comprehension. However, research studies on secondary school teachers' knowledge revealed that they lacked the necessary knowledge to teach Probability (e.g., Batanero, Godino, & Roa, 2004; Begg & Edward, 1999; Jacobbe & Horton, 2010), leading to the conclusion that many teachers had little exposure to Probability before the adoption of new mathematics standards and curricula, and that they are now expected to teach probability (Onatsu-Arvillomi and Nurmi, 2002).

Challenges to CBS implementation in schools, according to Mwalongo (2011), include a lack of CBS facilities, expensive internet access, limited information sharing, limited skills for ICT integration, and a loss of labor force due to training institutions' failure to produce ICT technicians and professionals required by the labour market. As cited in Mwangolo, Mendes, Tuijnman, and Young (2003), as

well as Swarts and Wachira (2010), repeated the same views. Hesselmark (2003), also supports a lack of electricity in schools, lack of smartphone service, and a lack of computers.

Lack of a regulatory framework, insufficient infrastructure, excessive bandwidth costs, and a lack of in-service training on ICT integration in education were all cited by Hare (2007) as barriers to ICT integration in education. In a study of the extent of use of ICT resources in Tanzania, Mendes et al. (2003) found that there is less emphasis on ICT training in schools due to limited facilities, while Adomi and Kpangban (2010) found that the low rate of ICT adoption in secondary schools in Nigeria is due to poor infrastructure, a lack of ICT facilities in schools, frequent electricity interruptions, a lack of ICT policy implementation strategy, and a lack of manpower.

Some studies identify issues in the Kenyan education system's use of ICT in teaching and learning, but they aren't particular to CBS integration in Probability teaching and learning. This research tried to shed light on the difficulties associated with teaching and learning in this particular field. According to Shaughnessy (1992), there were relatively few studies that looked at the impact of formal education on students' Probability misunderstandings, and even fewer studies that looked at secondary school students on the use of CBS in teaching and learning Probability.

However, most studies focused on students' Probabilistic thinking before teaching, and classroom research that examines the impact of instruction on secondary school students' Probability ideas and learning utilizing CBS is still needed (Jones, Langrall & Mooney, 2007).

2.6.1 Probability misconceptions as one of the challenges for integrating CBS

Students face some misconceptions in their study of Probability. The following are some of the examples of the existing misconceptions about Probability.

2.6.1.1 Simple and compound events

This occurs when a pupil fails to consider the order of events when comparing a simple event to a compound event (Fischbein & Schnarch, 1997). When tossing two dice at the same time, a student might believe that the likelihood of each die showing 6 is the same as the Probability of one die showing 5 and the other die showing 6. Fischbein and Schnarch (1997) discovered that this misunderstanding was common and consistent across generations.

2.6.1.2 Equiprobability misconception

This is a situation in which students believe that all possible outcomes of a Probability experiment have the same chance of occurring (Shaughnessy, 2003). Anything can happen, and students frequently make assertions like "50-50 chance." However, the fact that the answer is equally likely to occur is another form of misunderstanding.

2.6.1.3 Representativeness misconception

When a student evaluates the chance of an event based on how well it represents the parent population, this is what happens (Kargiban, Kahneman & Tversky 1972; Shaughnessy, 2003). For example, in the lottery, a person may believe that random numbers such as 39, 1,17,33,8,27 are more likely to win than pattern numbers such as 1,2,3,4,5,6 (Fischbein & Schnarch, 1997), or in coin tossing, a student may believe that a sequence of five coin tosses is more likely to be THHHTH than HTHTH (Fischbein & Schnarch, 1997). These findings suggested that when confronted with a stochastic circumstance, such as the coin situation described above, participants are more likely to perceive the situation as a random event and to expect "random" consequences. As a result, THHHTH is more probable than HTHTH to occur. In research of 277 secondary school students' perceptions of randomness, Batanero and Serrana (1999) discovered that students overemphasized unpredictability and luck to support their attribution of randomness.

2.6.1.4 Negative and positive recency effect misconception

This occurs when a person feels that a particular outcome of a series of independent occurrences is more or less likely to occur as a result of the absence of that outcome in preceding findings (Fischbein & Schnarch, 1997) For example, if a student tosses a coin five times and the first four times it lands on heads, he or she may believe the coin is more likely or less likely to land on heads the fifth

time. Pawlak, (2022) on the other hand, argued that this idea looked to be more in line with computer-assisted coin tossing experiments.

2.6.1.5 Effect of the time axis misconception

A student believes that an event cannot affect its cause in the future (Fischbein & Schnarch, 1997). Taking one marble at a time from an urn with three yellow and three green marbles, for example. A student with a time axis misperception who never learned the color of the first marble but knew the color of the second would believe that knowing the color of the second marble had no bearing on the Probability of the first marble's color.

This study will use CBS, which will provide real-time replies on an experimental method to learning Probability, to assist students in overcoming some or all of their misconceptions. Cognitive conflict was utilized by Fischbein & Schnarch, (1997) to rectify misconceptions and inconsistencies. Focusing on a single concept may lead to another misunderstanding.

2.6.1.6 Elimination of Probability misconceptions

The use of various techniques to learning and teaching Probability leads to misconceptions on the side of the students. Using CBS, teachers can still address and try to eliminate any misconceptions during class. Cognitive conflict was employed by Pawlak, (2022) to rectify the learner's misconceptions and inconsistencies. He observed that some of the misunderstandings become more

prevalent as people become older, while others become less prevalent. Students will be able to minimize or remove misconceptions and have a good understanding of Probability at all stages of learning if they apply CBS.

2.6.2 Teacher knowledge on Probability as a challenge for integrating CBS

Teachers' Probability reasoning and knowledge, as well as the teacher's deeper grasp of misunderstandings affecting students, have a significant impact on students' Probability reasoning and comprehension (Stohl, 2005). In teacher education and professional development, Probability has received less attention than other issues in mathematics, and there have been calls for further research in this area (Shaughnessy, 1992; Stohl, 2005). Because Probability is becoming a more essential aspect of the Mathematics curriculum (National Council of Teachers of Mathematics, 2000), many teachers who have never taught Probability are now expected to do so. There isn't much empirical study on teachers' content knowledge of Probability; nonetheless, studies have looked into a variety of topics, including Probability misconceptions and variance (Begg & Edward 1999). Teachers, according to Liu & Thompson (2007) and Watson (2001), lack the understanding to teach Probability and require additional training.

Primary instructors, according to Pereira-Mendoza (2002), lack sufficient Probabilistic understanding to teach Probability. He claims that the issue stems from the professors' likely poor knowledge. Teachers may be familiar with Probability theories and how to apply them, but they may not completely

appreciate the contexts in which a theory is applicable. According to Liu and Thompson (2007), there was a complicated mix of Probability beliefs and understandings among and among the teachers. Batanero et al. (2004) discovered similar outcomes with the introduction of teacher education. They discovered that the participants lacked sufficient understanding of randomness and stochastic processes.

According to Pelgrum (2001), school administrators see teachers' lack of CBS related knowledge as one of the barriers to achieving CBS integration goals. Hennessy, Harrison, & Wamakote (2010), highlighted teacher attitudes, training, and competencies in the use of ICT. Learning resources and other learning materials that involve ICT use are in general insufficient (JISC, 2004). National ICT policies, according to Jones (2004), provide a rationale, a set of goals, and advice for how education systems work to benefit both students and instructors once CBS is implemented in schools.

Tella (2007) discovered that computer use is highly linked to learning intentions, which will encourage teachers to use them whether or not they are available. In 2009, the UNESCO Institute of Statistics focused on ICT infrastructure, the availability of various types, and teacher readiness to integrate ICT in classrooms. The study discovered that Caribbean countries have a higher level of ICT infrastructure integration than Latin American ones. They also evaluated the 1:1 computer-to-student ratio, and schools developed strong ICT policies in

education. In Kenya, the national council for science and technology (2010) conducted a survey and discovered that computer studies was an optional topic and that only one class with a student ratio of 1:40 was registered. They also discovered that Kenyan instructors used ICT in teaching and learning to a lesser extent.

Veen (1993) noticed that a major barrier to CBS deployment was a lack of initial teacher training in computer use. According to Ringgold (2001), the lack of time required for proper integration of CBS into the curriculum is a barrier to CBS integration in Probability teaching and learning. Inaccessibility of CBS resources, according to Becta (2004), is not solely due to a lack of hardware and software or a lack of digital infrastructure within the school, but also to poor resource organization, poor quality hardware - computers, inappropriate software, or a lack of personal access for teachers.

Pelgrum (2001) investigated teachers' concerns about CBS implementation in 26 countries and found that four of the ten hurdles were connected to a lack of computers, peripherals or accessories, and software for teaching and learning. Toprakci (2006) discovered that a lack of computers, analogue, and slow computers, and a lack of software in Turkish schools were all barriers to successful CBS deployment. According to Beggs (2000), the implementation of CBS in Turkish schools was hampered by a lack of teacher training in the use of ICT.

Gomes (2005) stated that in the Ghanaian context, difficulties in adopting CBS in classroom practice included a lack of digital literacy training, as well as pedagogical and didactic training on how to use ICT in the classroom in certain subject areas. He concluded that strong teacher professional development gives teachers the ability to create their instructions, be innovative with technology, and use facilitation tactics.

In summary, the findings showed that teachers had poor knowledge of Probability, frequently held multiple misconceptions, and used nonstandard vocabulary while discussing Probability concepts. However, current research is insufficient to contrast secondary instructors, thus researchers and teacher educators are needed to assist secondary teachers in being better prepared to teach Probability. Teachers' technical skills and experience, as well as their ideas and perceptions regarding CBS, are some of the barriers to CBS adoption in the classroom, according to Harrison (2010). Low levels of CBS knowledge and abilities among instructors, according to Toprakci (2006), are a major barrier to effectively introducing technology into African classrooms.

2.6.3 Teacher's Gender and CBS integration

According to Russell and Bradley (1997), there is a link between gender and computer anxiety, with female teachers reporting higher levels of anxiety than male teachers. This is because male teachers have a more positive attitude toward CBS than female teachers. Teachers who are female have a negative attitude

toward the usage of CBS Ogembo (2017). This is due to female Mathematics teachers' ineffective use of CBS, which is caused by an excessive workload and a lack of self-confidence in using CBS Salau (2000). Male secondary school instructors have more confidence in computers than female teachers, according to Bovée, Voogt, , & Meelissen, (2007).

Male instructors are more efficient and have better CBS skills than female teachers, according to Vekiri, & Chronaki, (2008). Female instructors' usage of technology in the classroom has been reported to be low, owing to a variety of causes including limited access to tools, inadequate abilities, and a lack of enthusiasm, according to reports (Christensen, & Knezek, 2009). Early research on female teachers' usage of CBS found that they do not appreciate technology and would support the status quo for fear of being made obsolete, according to Ogembo (2017). Female teachers' use of CBS in the classroom was less than male teachers, according to Sanders, (2005). However, Steele (2006, March) found that female instructors' self-perceptions of technology competence improved while their male counterparts' stayed unchanged. Females were more likely than males to use CBS tools in the classroom, according to Sanders, J. (2005). Furthermore, Gordon (2003) found that gender is not a predictor of CBS integration in the classroom.

2.6.4 Teachers' educational background and use of CBS

Various researchers have differing opinions on the impact of teachers' educational backgrounds on their usage of ICT tools like CBS. Verhoeven, Heerwegh, & De

Wit, 2010), discovered a link between teachers' educational backgrounds and their willingness to adopt CBS into their classrooms. According to Salau (2000), the level of academic qualification of instructors has an impact on CBS adoption. According to Tezci (2009), a teacher's degree of training has a substantial impact on their CBS skills, resulting in the successful use of CBS in the classroom. This study aimed to provide a Kenyan perspective on the impact of teachers' backgrounds on technology integration in Mathematics teaching and learning, with a particular focus on the use of CBS in Probability education. Some Kenyan colleges have made ICT teacher training a core unit in their undergraduate programs, while others continue to use traditional approaches, according to KEMI (2019). This finding is in line with that of Mahmud and Ismail (2010), who found that ICT training improved teachers' ICT literacy.

2.6.5 Teachers' teaching load and use of CBS

Despite efforts to alleviate the demands, current trends in education reveal that instructors face numerous problems. In a paper titled "The Illusion of Free Primary Education," Sifuna (2004), offers a bleak image of the country's education system, citing concerns with teaching and learning facilities.

Teachers in Kenya are anxious, according to Naylor (2001), because of unmet student needs, large class numbers, special needs in regular schools, and a bloated workload of up to 27 lessons per week. Classrooms are overcrowded as a result of the flood of new students at secondary schools with 100% transition, and existing

facilities make it impossible to implement the free secondary education program, according to Otach (2012). Researchers such as Samarawickrema and Stacy (2007) and Neyland (2011), as quoted in Buabeng-Andoh (2012), concur that the classroom teacher has been strained to the limit in terms of workload and class management. According to van Veen (2008), to implement CBS and deliver quality education, teachers' teaching load should be fewer than 27 lessons per week in public secondary schools. The impact of a teacher's teaching load on the extent to which computers are used in the classroom was investigated in this study.

2.6.6. Professional Development for teachers

Teachers' professional development enables the efficient incorporation of CBS in probability teaching and learning. According to studies, even while ICT resources such as CBS were available in schools, teachers continued to use traditional classroom teaching methods and did not make an effort to incorporate CBS to create new learning experiences for students (Jules-Van-Belle & Soetaert, 2001). According to the researchers, teachers need ICT expertise in teacher development to integrate CBS into their teaching and learning (Pedretti, Mayer-Smith & Woodrow, 1999). As a result, as a solution to the teacher problem of using ICT, teacher development must focus on both ICT skills training and suitable ICT integration techniques in the curriculum (Divaharan & Koh, 2010). Because ICT education is a relatively recent idea, teacher professional development is critical to its successful integration into classroom teaching. ICT training programs improve teachers' computer skills, affect teachers' attitudes toward computers, and

help teachers rearrange the task of technology and how new CBS tools are important in student teaching and learning, according to Bauer & Kenton, 2005; Franklin, (2006).

Technology training, according to Riegle-Crumb, (2006), is linked to successful technology integration in the classroom. According to both research, professional development and continued support for outstanding practice are the most important determinants of effective CBS integration. Other research has indicated that the efficacy of ICT integration is influenced by instructors' ICT competencies as well as their motivations for using it (Vanderlinde, Van Braak & Hermans, 2009; Venezky, 2004). Teachers' ICT abilities, according to Sandholtz and Reilly (2004), as cited in Buabeng-Anduh (2012), determine the quantity of ICT used in classroom teaching and learning.

As mentioned by Buabeng-Anduh, teachers should be exposed to ICT programs that strengthen their mastery of pedagogical ICT abilities, as well as access to technology specialists for guidance on how to incorporate ICT tools such as CBS to help students learn (Chen, 2010), Lawless and Pellegrino (2007), and Plair (2012). This study looked into the impact of Mathematics teachers' professional development in terms of ICT on their use of CBS to further this area of inquiry.

2.6.7 Teachers' Attitude and Use of CBS

When it comes to measuring the usefulness of technology in the classroom, teacher attitudes and beliefs are critical (Ertmer, 2005). Teachers' attitudes and ideas about educational technology and pedagogy, in general, will have an impact on how they use technology in the classroom. Attitude is a complicated mental state that includes a variety of beliefs (Hussain, Ali, Khan, Ramzan & Qadeer, 2011). It is a person's natural predisposition to react positively or negatively to a certain object, person, or group of people, institutions, or events. Anxiety, lack of confidence, competence, and fear, according to Russell and Bradley (1997), often means CBS takes a back place to traditional teaching and learning methods.

According to Huang and Liaw (2005), as stated in Buabeng-Anduh (2012), teachers' acceptance of technology's utility and incorporation into education is largely determined by their attitude toward technology. Schoolnet (2010), as referenced in Buabeng-Anduh (2012), reported in a study on variables influencing technology adoption in Europe that teachers' use of netbooks favourably influenced their learning by fostering personalized learning to extend study beyond the school day, resulting in a positive attitude. In Buabeng-Andoh (2012), Korte and Husind (2007) and Becta (2008) published contradictory findings, demonstrating that attitude has little effect on specific advantages of ICT tools. However, Hew and Brush (2007) argue that teachers are unlikely to incorporate technology that does not assist them, their students, or the educational process.

According to Buabeng-Andoh (2012), experts believe that instructors' attitudes and beliefs are crucial variables in the successful integration of CBS. According to their findings, teachers who have a positive attitude toward technology integration are more likely to seek out relevant information on its acceptance and use. Demirci (2009) and Drent and Meelissen (2008) all found that the teacher educator's favourable attitude toward computers, computer experience, and personal interest have a direct influence on the innovative use of ICT tools, which is mirrored by Buabeng-Andoh (2012). According to Rozell and Gardner (1999), the more experience instructors have with computers, the more likely they are to have positive attitudes toward them.

Positive computer attitudes, according to Van Braak, Tondeur, and Valcke (2004), as mentioned in Buabeng-Andoh (2012), support computer integration in teaching and learning. In a comparative study of secondary school teachers' usage of computers Ayere Odera & Agak (2011) discovered that 60% of the interviewees had a good opinion, 30% were very positive, and only 10% were negative. He did notice, however, that the teachers had moderate to high degrees of computer fear. Even in circumstances where teachers had a favorable attitude, phobia was assumed to be the main reason for their unwillingness to embrace ICT technologies.

More research is needed to understand how these tendencies affect the adoption of CBS in teaching and learning, an area to which this study aims to contribute. If

teachers feel less in control of their classes while utilizing technology, they are less willing to use it and are less likely to experiment with new ways to include technology in their lesson plans (Demirci (2009).

One of the predictors of teachers' technology use, according to Demirci (2009), is confidence in using technology to achieve instructional goals. Teachers who believe they need ICT training might choose to work with technology at their current level of skill or postpone using the technology until they feel they have sufficient knowledge (Ertmer, 2005). Building teachers' ICT abilities would increase their confidence in using ICT tools such as CBS.

2.6.8 Computer Anxiety and use of CBS

Ahiatrogah, et al., (2013) linked anxiety with technology integration in classroom teaching and learning. He says that anxiety is a chronic physiological condition. Teachers' levels of computer fear were linked to their judgments of the tool's utility, according to Russell and Bradley (1997). Tsai and Tsai (2003) discovered a strong link between metacognitive skills, computer achievement, and computer anxiety in students. Other studies have discovered a strong link between computer anxiety and age (Namlu & Ceyhan, 2002), computer experience (Yaghi & Ghaith, 2002), frequency of computer use (Necessary & Parish, 1996), neuroticism (Anthony, Clarke & Anderson, 2000), and a person's assessment of a computing scenario (Anthony, Clarke & Anderson, 2000). (Crale, Brodzinski, Scherer & Johes, 1994).

According to Ahiatrogah, et al., (2013), computer anxiety is a significant predictor of teachers' attitudes toward interactive computer technology, and one might be prompted to conclude from the study's findings that, because the majority of secondary school teachers appear to be technophobic, their uptake of computer technology skills for onward transfer to the education system is slow, low, and insignificant. Russell and Bradley (1997) cited Pelgrum and Plomp (1991), while Papanastasiou, & Angeli (2008) made similar observations. The ability of CBC to teach difficult or complex concepts has been acknowledged (Namlu & Ceyhan, 2002). Computer-based simulations (CBS) can help students understand dynamic and complex topics that are difficult to explain using words, equations, or class activities.

The goal of the study was to see how computer anxiety affected Mathematics teachers' incorporation of CBC in probability teaching and learning. In today's Mathematics education and learning, CBC is extremely significant (Cheng, 2009). Computers can be used as a complement to help students attain their educational goals. It is said that using computers boosts student confidence and aids in the discovery of interconnections between the components of a complicated system (Namlu & Ceyhan, 2002).

2.6.9 School factors and use of CBS

School characteristics, according to Buabeng-Andoh (2012), boost instructors' current qualities to a greater extent. According to Norris, Sullivan, Poirot, &

Soloway, (2003), the amount of time instructors devote to teaching and the amount of technology training they receive determine their use of technology in the classroom. For effective CBC integration, several scholars have advocated improving professional development (Bauer & Kenton, 2005; Franklin, 2006), computer tool accessibility (Usluel, Askar & Bas, 2008) and technical assistance (Becta, 2004; Jones, 2004). To understand the influence of Kenyan secondary school elements on the process of CBC integration in teaching and learning, this study hypothesized that a better understanding of school characteristics that influence teachers' adoption and integration of CBC is necessary.

Previous research has shown that having access to ICT resources and infrastructure in schools is a prerequisite for effective CBC integration (Plomp, Anderson, Law & Quale, 2009). Because instructors can only use what they have access to in the classroom setting (Buabeng-Andoh, 2012), the availability and accessibility of ICT resources such as software and hardware are critical for the efficient adoption and integration of CBC technologies. This is in line with the findings of Usluel et al (2008). Inadequate access to ICT resources has been found to have hurt CBC integration.

According to Afshari, Bakar, Luan, Samah, and Fooi (2009), more than half of the teachers in their study said they used computers for lesson preparation; 78% of the respondents said they had little access to computers in the classroom, while 38% said that inadequate computers were not a major barrier to ICT use in their

classroom; and improved availability and access to resources by teachers, students, and school administrators.

According to Friedhoff (2008), as stated in Chen (2010), access to tools is vital, but so is the quality of the tools and software packages accessible to support teaching and learning. Dexter and Reidel (2003) found that 37.4% of preservice instructors had access to computers, while 14.4% of students had access to computers in a study of preservice teachers. Because computers are more readily available to teachers than to students, students must have access to high-quality technology tools in CBC to foster student-centered digital learning.

Installation, operation, maintenance, networking, and security of computer tools are all part of technical support in schools for ICT integration (Sife, Lwoga & Sanga, 2007). Appropriate initiatives, such as recruiting, training, retraining, and retention of experienced computer employees, should be implemented. Jones (2004), Becta (2004), and Yilmaz (2011), as cited in Buabeng-Andoh (2012), agree with these findings, with Jones (2004) reporting that lack of technical assistance during a computer's breakdown causes interruptions, discouraging teachers from using computers, and Becta (2004) asserting that a school's lack of technical support impedes maintenance, resulting in a higher risk of technical breakdown.

Yilmaz (2011) advises stakeholders that in addition to supplying schools with ICT hardware and internet access, technical help for repair and maintenance is also necessary to ensure the continuing use of CBC tools in schools. Teachers are frustrated with technology and refuse to use it, according to empirical data on technical support for school technology needs (Korte & Husing, 2007 and Tong & Triniada, 2005 as cited by Buabeng-Andoh, 2012).

2.7 Examples of Using Computers in Teaching and Learning

A benefit of computers in the Mathematics classroom is customized instruction, which is based on educational theory foundations (Stratham and Torell, 1996). Computer-based simulation is relevant and establishes direct links between newly acquired skills and the student's prior knowledge and understanding (Fengfeng, 2008). Early studies (Mann, et al., (1999) investigated the use of CBC in education and discovered that it improves student achievement.

One of the advantages of technology, according to Cohen Chapman & Tunmer, (1997), is that it allows for the education of all students at all levels and employs a range of different learning styles. Stratham and Torell (1996) looked at the usage of computers in teaching and learning, analyzing 10 research on the usefulness of computer technology in education and found that bringing computer technology into schools leads to fewer discipline issues and higher school attendance rates.

The study also found that computer technology and computer-based teaching and learning are particularly beneficial among at-risk student populations. The findings also demonstrated that when computer technology is used correctly, excitement, collaboration, student inquiry, and problem-solving strategies become commonplace in the classroom. The use of computers to complement textbooks in education has resulted in increased student achievement in Mathematics, as well as a favourable attitude toward Mathematics learning and computer Mathematics games in Probability (Fengfeng, 2008).

According to Short (2002), middle school Mathematics explorer, a computer-based simulation software for teaching Mathematics, resulted in a significant rise in student Mathematics scores between pre-test and post-test results, and children profited with exposure to the application. When computers were employed in teaching and learning for one hour a week in middle school mathematics, Ash (2005) observed significant increases in student test results. This is because computers provide students power and autonomy over classes and assessments, allowing them to learn at their own pace, one-on-one, and with a better level of expertise.

Fengfeng, (2008) promoted mastery learning techniques as a way to cut down on the time it takes to master a skill. He claims that mastery learning improves students' positive attitudes and interests. A warm-up session, lesson presentation using videos with step-by-step problem solving and tailored training, guided

practice, and ultimately a quiz is provided to students who need to learn a lesson using computer-based simulation (CBS).

Once a student falls below the 70% mark, he or she may seek teacher assistance and use CBS as needed to locate examples of problems that will help the student learn the material. According to Pelgrum & Plomp (1991), many educational systems in 1989, at the level of British Columbia and the United States, had student-to-computer ratios of 15:25 in British Columbia, Israel, Japan, France, and the United States, and twice to thrice as much in countries like the Netherlands and New Zealand. In the same countries, the student-to-computer ratio in elementary classrooms changed dramatically.

However, as seen in Switzerland and the United States, the student-to-computer ratio is better in secondary schools than in elementary schools (Pelgrum, 1991). Access to computers in elementary education was low in Japan and Portugal (25% and 29%, respectively), moderate in Belgium-French (54%), Israel (62%), and the Netherlands (53%), and high in British Columbia (99%), France (92%), New Zealand (78%), and the United States (100%) (Williem J, Pelgrum & Tjeerd Plomp, 1991). In Greece (4%), China (61%), and India (7%), most upper secondary schools have limited or moderate computer access, and when computers are accessible, they are mostly used for teaching purposes (Plomp, 1991).

Since 1992, Chile's ministry of education has promoted educational technology development to increase the quality and equity of public education (Plomp, et al., (2009). With internet connectivity in over 7,000 schools, the student-to-computer ratio dropped from 80:1 to around 10:1 between 2000 and 2010. In comparison to Chile, Spain, and Portugal had a lower rate of ICT adoption, with a variety of traditional teaching techniques being replaced by modern educational technology, resulting in improved reading skills (Zan, & Di Martino, (2007).

World Bank, (2007), Computers are more commonly available for secondary education based on enrolment, reflecting the trend throughout Sub-Saharan Africa including Djibouti to promote ICT in the secondary curriculum. In Madagascar's upper secondary schools, the student-to-computer ratio is 500:1, whereas, in Rwanda, the ratio is 40:1 in secondary and primary schools, a remnant of Rwanda's one laptop per child effort (World Bank, 2008). In addition to Rwanda, Mauritius (23:1 in primary and 19:1 in secondary) and Botswana (55:1 in primary and 17:1 in upper secondary) have student-to-computer ratios of 23:1 in primary and 19:1 in secondary (World Bank 2008).

In South Africa, 93% of respondents said they use computers for teaching and learning, while just 7% said they don't, indicating that most schools are at least at the applying stage, if not the infusing stage, of the UNESCO model (2002). A total of 79.1% of respondents said their school had a computer lab, while 20.9% said they didn't. In research on ICT use in South Africa, Cohen (2004) discovered

that computers were mostly utilized for administrative purposes, with minimal use in teaching and learning due to a lack of time for preparation and administrative and technical assistance.

2.8 Summary of Existing gaps in the Literature reviewed

Evidence presented demonstrated that efforts were made to improve students' learning results by implementing current teaching and learning approaches, particularly in disciplines like Mathematics, where the topic was thought to be abstract. Computer-based simulations, for example, have the potential to enable the effective teaching of facts, concepts, and procedures due to their built-in visual display (Fong, Por & Tang, 2012). The anticipated benefits of using such technologies had progressively influenced empirical investigations aiming at proving the methods' efficacy, primarily in Western countries. The generalized conclusions of such research in teaching and learning Probability, an essential area of Mathematics education in secondary school, were applied to Kenya in teaching and learning Probability. There is no specific research that demonstrates the degree and impact of CBS integration in Probability teaching and learning. The researcher used this as the foundation for evaluating the benefits of computer-based simulation, CBS in the teaching and learning of Probability in Mathematics in public secondary schools in Kisii County, Kenya.

Previous research has shown that CBS has a good impact on classroom pedagogy, and it is commonly recognized that different ICT tools are better suited for

teaching distinct curricular subjects. Although a lot of resources have been expended to develop ICT tools like those used in CBS integration, the availability of resources does not guarantee that they will be utilized. However, some of the resources available are said to be inappropriate for classroom instruction. More effort has been put into making ICT resources available, with little regard for the users who may be unprepared to use them. The research gap is to discover the best degrees of use of CBS tools to guarantee an enriched classroom environment about probability in mathematics a subject in which a majority of students have persistently reported poor achievement in past years both at the county level in Kisii and nationally in Kenya.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter explains the research methodology that was used. According to Kohari (2004), research methodology is a method for systematically solving the research problem. This chapter provided an overview of the research design, research variables, study location, target population, sampling technique, and sample size. The chapter also covers the instruments used to collect data, the pilot phase for pretesting the instruments, reliability and validity, the method used to gather the data, methods of data processing, and ethical considerations.

3.2 Research Design

A research project's methodology is its official plan of action. This study used a mixed method approach that included both quantitative and qualitative research designs. The challenges that social and health science researchers attempt to solve are complicated, and Creswell (2009) contends that using either quantitative or only qualitative methodologies is insufficient to deal with this complexity. According to Cohen, Manion, and Morrison (2011), researchers can simultaneously draw generalizations about a population from the findings of a sample and get a deeper understanding of the phenomena of interest by using both quantitative and qualitative data and data analysis.

The goal of the study was to evaluate how computer simulation (CBS) affected secondary school students' proficiency in probability and mathematics as a whole.

To do this, the researcher used Solomon's four-group type quasi-experimental design. Participants in this study were divided into two experimental groups and two control groups, totaling four groups. Those that were open to new experiences made up the first group. In contrast to the control group, which was evaluated both before and after receiving no therapy, it was evaluated both before and after treatment. A test group also included the third group. Only one examination of this cohort was performed after therapy. The fourth group, a distinct control group, underwent a single examination without any pre-testing or therapy. Visual representation of Solomon's four-group model is as follows:

Group	Pre-test	Treatment	Post-test
E₁	O ₁	X	O ₂
C₁	O ₃		O ₄
E₂		X	O ₅
C₂			O ₆

KEY: E₁: Experimental group 1, C₁: Control group 1, X: Treatment,

O: Testing

According to Johnson and Onwuegbuzie (2004), this strategy offered substantial evidence in support of intervention while also enabling the assessment of both testing effects and confounding variables.

The two-group pre-test-treatment-post-test and two-group treatment-post-test models were unable to do this. The four-group model proposed by Solomon eliminates the drawbacks of the two-group treatment-post-test and two-group pre-

test-treatment-post-test models while combining their benefits. The two techniques were integrated in Solomon's four-group model. To provide a greater grasp of the various realities of the phenomenon to be examined, quantitative and qualitative designs were applied (Strauss & Corbin, 1992). To collect various viewpoints as they evolved, learner questionnaires and teacher interview schedules were used (John (2002).

3.2.1 Treatment and control procedures

Pre-test and post-test comparisons offer a thorough evaluation of a pedagogical intervention, in accordance with Denzin and Lincoln (Eds.). (2000), by identifying potential alterations before to or following treatment. For this investigation, control and treatment groups were used. Four (4) of the county's 55 public schools (details discussed under sampling). The control group received two of the chosen schools, and the experimental group received the other two. The experimental group was taught by the trained teachers using the computer simulation (CBS) approach, whereas the control group was taught by their teachers using the traditional teacher-centered approach.

Prior to therapy, a pretest was given to each group. The two groups were retested following their two months of instruction, 12 lessons in probability utilizing a face-to-face CBS computer simulation. Pre- and post-test data were compared to offer a thorough evaluation of a pedagogical intervention by identifying potential improvements. According to Kothari (2004), the randomization principle protects

against the impact of unrelated elements when conducting an experiment. We can obtain a better approximation of the experimental error by using this technique (Kothari, 2004).

3.2.2 Briefing for teachers

When research findings are produced outside of the setting of the classroom, teachers are frequently positioned as consumers of those findings. Math teachers who were considered members of the research and development team worked together to perform this study. By using this method, the researcher and the math teachers were jointly held accountable for the caliber of the students' math instruction. Eight (8) Mathematics teachers who handle learners in Form 3 were involved and they taught the experimental groups after they were taken through an orientation training for one day with follow-ups for two more days. They were made aware of the study's objective and given instructions on how to carry it out. They were also given the CBS, computer-based simulation software to install on their computer desktops for teaching Probability.

3.3 Study Variables

According to Creswell (2009), there are only three basic ways to use variables in research or hypotheses: comparing independent variables to determine how they affect dependent variables, relating independent variables to dependent variables, and describing responses as independent, mediating, or dependent variables. In this study, all three categories were used. The CBS computer-based simulation

approach was the study's independent variable, or the factor that determines or influences outcomes. The variable that depends on the independent variable was known as the dependent variable or outcome variable. The achievement of secondary school pupils and their increased performance in probability were the dependent variables in this study.

The purpose of the study was that student performance in Probability was influenced by the mode of instruction. The integration of CBS in Probability teaching and learning was the method to be examined. As a result, the experimental groups received the CBS for Probability instruction and learning, while the control groups received no treatment. Instead, the control group was allowed to continue with their current method of teaching and studying Probability. Conventional strategies were used in this case. Thus, teaching methodologies, CBS or conventional, were the study's independent variables, while student accomplishment in Probability was the study's dependent variable.

Apart from the established independent variable, instructional technique, numerous additional factors influenced student achievement in Probability, the dependent variable. This was a set of control variables, intervening variables. Students' attitudes toward Mathematics, students' sex, accomplishment levels, and students aptitude score in Probability were among the control variables studied by the researcher. Students' attitudes were classified as positive or negative, and their Probability competence was graded as high or low. The samples were chosen in such a way that students with these characteristics were

found in both the experimental and control groups. This statistical approach was designed to ensure that the study's conclusions had a high level of internal validity. When control variables are included in a study, their effects on the dependent variables are taken into account, according to Mugenda and Mugenda (2003), making the study findings more reliable.

3.4 Location of the Study

The study was carried out in Kisii County, one of Kenya's forty-seven counties. This was necessitated because of the existing problem of poor performance in Probability in Mathematics in Kisii County. The county borders Nyamira, Homa Bay, and Migori counties, and is located in the former Nyanza province. The County was divided into seven (7) Sub-Counties. In the County, there were one hundred and seventy (170) public secondary schools, including four (4) national schools, twenty-four (24) extra-County, thirty-four (34) County, and one hundred and twelve (112) Sub-County schools.

3.5 Target Population

Every study involves two different sorts of population: the target population and the accessible, accessed population. According to Creswell (2009), the target population of a study is the collection of cases about which the researcher would like to draw generalizations. It is also the group of subjects from which data is needed and examined. According to Creswell (2009), the available, accessed population is the chosen group of people who are accessible and available to the

researcher as a pool of study subjects. Typically, researchers take a representative sample from a community that is easily accessible and then attempt to generalize to a target population.

Because Probability is taught in the Form three Mathematics Syllabus, the study's target group was Form three students and teachers of Mathematics in Kisii County's public secondary schools with computer infrastructure for CBS integration. According to data obtained from Kisii County's Director of Education office, the target population consisted of 6,038 Form three students and 136 Mathematics teachers in 67 public secondary schools having ICT infrastructure for CBS integration. The Form four students were excluded because they were likely to be preoccupied with KCSE examinations, while the Form one and two students were excluded because they had not yet been taught Probability and had not yet received appropriate academic exposure to secondary school Mathematics. The study was carried out in public schools because they all had a common Mathematics curriculum and most of them had Teachers Service Commission-employed Mathematics teachers who were well-trained (TSC). It was expected that trained teachers, as opposed to their untrained peers, had a thorough understanding of the philosophical and psychological foundations of various teaching tactics and would so implement CBS lessons with ease. The lessons necessitated the ability to make critical assessments about whether students were learning and when and to what extent to remove or intervene with various groups.

3.6 Sampling Techniques and Sample Size

Sampling is the process of drawing inferences about a population from a small sample of its components or members. The researcher can estimate population characteristics that are unknown by sampling and draw generalizations (Devine (2002). Both non-probability sampling, which is arbitrary (non-random) and subjective (Read & Marsh, 2002) purposive sampling of schools with computer infrastructure, and probability sampling, which is based on a random selection where each population element is given a known non-zero chance of selection, were used to ensure that the sample would be representative of the population (McNabb, 2004). In form three, there was a fair possibility of selection for every student. The statistical regularity law, which asserts that "if on average the sample chosen is a random one, the sample will have the same composition and features as the target population," is ensured by probability sampling (Kothari, 2004).

3.6.1 Sampling Techniques

Four layers of sampling were carried out: the County was the first, then schools, teachers, and students.

On purpose, Kisii County was selected as the study's location. Poor performance in math was the main cause of this. The county was one of the newly established 47 devolved divisions of government in Kenya, which were promulgated in 2010. No studies on the application of CBS in the secondary school teaching and

learning of probability had been conducted in the area. Also, the County has kids who are relevant to the study in both high- and low-performing schools.

Purposive sampling was used to select the sample based on school type. The researcher only used students from County and Sub-County schools because their entrance examinations were comparable. Furthermore, nearly all of the county's schools fall into one of these two categories, so using them as the only categories allowed the findings to be more broadly applied across the county. Only 12 schools, representing 17.9% of the 67 public secondary schools in the county with ICT infrastructure were classified as national or extra-county schools. Because these schools, National and Extra-County only accepted students who scored minimum of 340 marks out of the possible 500 marks in the Kenya Certificate of Primary Examinations (KCPE), there were no, or very few low-achieving students in Mathematics.

County and Sub-County schools, on the other hand, chose students with an average KCPE score of 280 marks out of the possible 500 marks and were thus more likely to have students who fit both the High Achievers (HA) and Low Achievers (LA) categories in Mathematics. The researcher was interested in both of these types of students. The researcher intended to use stratified random sampling on a school-by-school basis. This method was chosen because it ensured the desired representation of relevant subgroups Banks (2013), in this case mixed county and mixed Sub-County schools. The study enlisted the participation of

four schools. Two of the schools were county-run, while the other two were Sub-County-run. One County school and one Sub-County school will be in each of the experimental and control groups.

The sampling grid for schools is shown in Table 3.1:

Table 3.1: Sampling grid for schools

	School Type	Number of schools	Sample
Schools	County	17	2
	Sub-county	38	2
Total		55	4

In Kisii County, most schools had two to four streams for each class. In County schools, there were three to four streams for each class, whereas, in Sub-County schools, there were one to two streams per class. As a result, if the school had numerous streams per class, the researcher sampled one stream at random for each of the sampled schools. Without being randomly assigned to either the control or experimental groups, these students were engaged in their already existing groups/streams. Rather, the schools were assigned to either the experiment or control groups at random, so that no single sampled school included students in both groups. Because the members of the control group were unaware of the existence of an experimental group, the John Henry effect, which is associated with experimental studies, was reduced. Because the study's design required that two groups be pretested and post-tested, and two others be post-

tested only, there were two schools in the experimental group and two in the control group.

Table 3.2: Sampling grid for students

	School type	Streams sampled	Students sampled
Schools	County	2	100
	Sub-County	2	100
Total		4	200

The teachers who took part in this study were purposively chosen from the sampled schools. This was done to guarantee that the teachers chosen were those who worked with the sampling streams and had Mathematics education training. As a result, the study included four Mathematics teachers who taught the four streams. Those schools that utilized team teaching, on the other hand, included all of the teachers in charge of Form three classrooms in the study. Teachers were then given brief instructions on how to implement the CBS lessons before being requested to do so over the term. Mathematics teachers were inducted about their new roles in CBS teaching and learning and how they would evaluate the learning outcomes, when and how to intervene when students became stuck during the learning process. The researcher assumed that putting trained teachers through such training would be easier than putting inexperienced teachers through it.

3.6.2 Sample Size

According to Kothari (2004), the sample size should technically be sufficient to provide a confidence interval. The study employed Solomon's four-group model of quasi-experimental designs, which produced four streams with an average student population of 50 (Hansen and Kloppfer, 2006). As a result, 198 individuals were chosen as the sample size for the student body. Because most schools in the County had adopted a team-teaching format, the study required at least eight Mathematics teachers including the four Mathematics teachers handling the four test groups. As mentioned in the sampling methodology section, 198 students and 4 Mathematics teachers were recruited from the 4 purposively sampled schools in the County. Thus the total study sample was 202.

3.7 Research Instruments

The study used four instruments to achieve the stated goals and objectives.

- (a) The researcher made Pre-test Students' Mathematics Test (PRESMT);
- (b) Post-test Students' Mathematics Test (POSMT);
- (c) Students' Questionnaire (SQ); and
- (d) Teachers Interview Schedule (TIS).

The instruments utilized in this study were created with the goals in mind. The study's major goal was to determine the impact of the CBS teaching style on student Probability performance. The study also set out to determine the effects of CBS on the performance of students with varying levels of Mathematics achievement as well as their attitudes toward Mathematics.

3.7.1 Students Questionnaire (SQ)

The purpose of the students' questionnaire was to measure their attitudes toward Mathematics. The questionnaire was adapted from Tapia and Mash (2004) Attitudes towards Mathematics Inventory (ATMI), which has been utilized in several other research. The measure included 40 statements on a Likert scale that assessed learners' self-confidence, value, enjoyment, and motivation to learn mathematics. Appendix 2 of the thesis included a copy of this instrument.

3.7.2 Pre-test Students' Mathematics Test (PRESMT)

The Pre-test Student Mathematics Test (PRESMT) instrument included items, and questions from a variety of areas in Probability that had previously been studied by all of the study's participants. The primary goal of the pre-test instrument was to assess the students' Mathematical abilities in Probability. The test consisted of ten sums: eight in section A, which were brief structured questions worth a total of 30 points, and two in section B, which were each worth 10 points. All of the questions were taken from prior KCSE Mathematics paper I and II exams from 2010 to 2018 to ensure content and construct validity. Three senior KNEC Mathematics examiners validated the instrument before it was given out. Furthermore, using the Kuder-Richardson formula 20 and the findings from the pilot, dependability was determined (KR-20) and found to be 0.70 signifying that it was reasonably reliable (Kothari, 2004). This document's appendix 3 contains a copy of this instrument.

3.7.3 Post-test Students' Mathematics Test (POSMT)

A Post-test evaluation at the end of the treatment phase was used to assess the impact of the intervention on students' Mathematical abilities. The Post-test Student Mathematics Test (POSMT) instrument included items, and questions from a variety of areas in Probability that had previously been studied by all of the study's participants. The primary goal of the Post-test instrument was to assess the students' Mathematical abilities in Probability. The test consisted of ten sums based on the theme of Probability, eight in section A, which were brief structured questions worth a total of 30 points, and two in section B, which were each worth 10 points. All of the questions were taken from prior KCSE Mathematics paper I and II exams from 2010 to 2018 to ensure content and construct validity. Three senior KNEC Mathematics examiners validated the instrument before it was given out. Furthermore, using the Kuder-Richardson formula 20 and the findings from the pilot, dependability was determined (KR-20). This document's appendix 4 contains a copy of this instrument.

3.7.4 Mathematics Teachers' Interview Schedule (MTIS)

This study employed an interview schedule for Mathematics teachers to gain their perspectives on the issues they face when teaching Probability through CBS. It also sought information on teachers' perceptions of students' beliefs and experiences with Mathematics education in general, as well as CBS-enabled classes and the problems they face in Mathematics lessons in which CBS is used. Appendix 5 of this thesis contains a copy of this instrument.

3.8 Pilot Study

The data-gathering instruments were tested in a non-participating school in Kisii County with 50 students and two Mathematics teachers. On the first day, the students were requested to complete the questionnaires, followed by the PRESMT and POSMT on the second and third days, respectively. Piloting allowed the researcher to make adjustments to the instruments as needed. As detailed in the following section, the pilot data was utilized to assess the validity and reliability of the study instruments.

3.8.1 Validity

According to Silverman (2000), threats to internal validity impede researchers from determining the true causal relationship of a study. Banks (2013) suggests that effective methods for addressing internal threats to internal validity include random participant selection and random assignment to treatment and control groups. In order to lessen risks to internal validity, Form 3 pupils were chosen at random from the treatment and control groups.

The items for the various examinations in the PRESMT and POSMT were gathered from a variety of trustworthy sources and researchers in the field of mathematics education. For example, the items in the Mathematics ability section of the SMT were developed using the Selective High Schools Test (SHST) published jointly by the Department of Education and Training (DET) and the Australian Council for Educational Research (ACER) and the Alberta grade 9 test

of Mathematics achievement (2010). The items were created using a variety of Mathematical strands of varying degrees of intricacy. The test was designed to assess students' mathematical skills and reasoning rather than their computational competence. Some of the items on students' problem-solving ability were derived with adjustments from the Iowa Test of Basic Skills (ITBS) and the Kenya National Examinations Council (KNEC) material, which is a reputable organization in Kenya that offered various examinations.

The students' questionnaire, which was based on ATMI and given by Tapia and Mash (2004), was used to measure students' attitudes toward Mathematics. Many studies on students' attitudes toward Mathematics had employed the ATMI with effectiveness. To compare Mathematics achievement for students with varied attitudes toward Mathematics when taught using the CBS approach, the researcher needed to include attitude in the study. In addition, the experimental and control groups were matched in terms of attitude, which was recognized as an extraneous variable in this study. According to Hansen and Kloppfer (2006), one of the greatest techniques for boosting the internal validity of study findings was to match individuals in a quasi-experimental design. The researcher evaluated all participants on the indicated control variables before giving the intervention (CBS) and then matched them. This was done to guarantee that people in both the control and experimental groups had an equivalent amount of control variables. Items that were deemed to be unclear and/or unambiguous after the pilot study

were rewritten or removed from the tools. The dependability of the instruments was also determined using the pilot data.

3.8.2 Reliability

The consistency of the test results, or how well the test measures what you want it to assess, is referred to as reliability White, (2001, May). Internal consistency techniques were used to assess the instruments' reliability in this study. These methods were chosen because they enabled the administration of the instruments to be done only once, saving time and resources. The achievement examinations were divided into three sections, each with a set of dichotomous items. The purpose of this instrument was to assess students' mathematical competence, problem-solving skills, and mathematics success. Since the items were of varying degrees of difficulty, the Kuder-Richardson formula 20 or (KR-20) was used to estimate the instrument's reliability:

$$KR-20 = \frac{n}{n-1} \left[1 - \frac{\sum p \cdot q}{s^2_x} \right]$$

Where KR20 = Kuder Richardson reliability coefficient

n = Number of items used to measure the concept

p = proportion of people passing the item

q = proportion of people failing the item.

S² = Variance of all scores

s²_x = Variance of individual scores.

Source: Mugenda and Mugenda (1999: 99)

A minimum coefficient of 0.5 was allowed for this instrument. A Kuder Richardson coefficient of 0.5 to 0.7 was rated acceptable by Bonnet (2003), while one greater than 0.7 was considered excellent. The Students Questionnaire was the other tool employed in this study (SQ). The purpose of the survey was to gauge students' attitudes toward Probability in Mathematics. Non-dichotomous items with a wide range of score weights were included in this instrument. As a result, Cronbach's Alpha coefficient was used to test the instrument's reliability. To determine whether there was a significant correlation between the short answer essay test item scores and the overall scores at the 0.01 or 0.05 levels, each item's score was measured.

Cronbach's coefficient Alpha (α) formula is presented as follows:

$$\alpha = \frac{k}{k-1} \left[\frac{1 - \sum \sigma^2 k}{\sigma^2} \right]$$

where $\sum \sigma^2 k$ is the sum of variances of the k parts (items of the test) and σ^2 is the standard deviation of the test. The study tested research instrument using the Cronbach's Alpha coefficient, which is an internal consistency technique. By comparing the scores acquired with scores obtained from other items in the study instrument, the internal consistency of the data was evaluated. Cronbach's coefficient Alpha is a commonly used reliability coefficient to assess the internal consistency of a sample of test takers' psychometric test results (students). Cronbach's coefficient Alpha, which measures the correlation, ranges from 0 to +1. Mugenda and Mugenda (2003) state that the coefficient is considered to be high when its absolute value is greater than or equal to 0.7 and low when it is not.

A high coefficient denotes a high correlation between the variables, which suggests a high level of consistency between the variables under test.

3.9 Data Collection Procedures

First, the researcher applied to Kenyatta University, for permission to undertake the study. After receiving approval from Kenyatta University, the researcher applied to the National Commission for Science, Technology, and Innovation (NACOSTI) for authorization to perform the study. The County Commissioner and the County Director of Education in Kisii were contacted for approval, which was granted. The officers were made aware of the researcher's plans to travel through their jurisdiction. The study was carried out in stages after these field offices gave their assent.

The researcher visited participating schools in the first phase to be introduced, and familiarized, obtain permission and cooperation from respondents, and schedule relevant appointments. Because CBS lessons were provided by Mathematics class teachers, the researcher visited the teachers and held discussions with them about CBS and how such lessons would be prepared and conducted throughout the initial phase. The CBS lessons were then produced by the researcher and the teachers. At the same time, the researcher installed the CBS-supported lesson programs on the desktops and laptops with the help of each school's ICT technician for later usage in the schools sampled for CBS classes. The students were given the pre-test instrument in the second phase.

The students were to be pre-tested on Probability as well as measured on the control variables that had been selected. Students' attitudes toward mathematics and their degree of mathematics achievement were among the variables studied. The SMT Pre-test and the SQ were both given on the same day. The students were given CBS and traditional treatment approaches in the third phase. Drills, tutorials, and simulations were used to teach probability to the experimental class utilizing CAL tools. The researcher instructed the teachers on how to deliver the CBS -supported lectures, and tutorials to the experimental group. The control group was instructed to use traditional, conventional methods. By supplying the teachers with a consistent time plan, the researcher guaranteed that both the control and experimental groups covered the lesson within the allotted time of two months. To assess the problems of adopting CBS-assisted Mathematics classes, the researcher interviewed teachers as part of the treatment implementation process. Finally, toward the end of the treatment period, the researcher administered the Post-test SMT instrument and SQ to the students in the final phase with the assistance of the Mathematics teachers who took part in the study.

3.10 Data Analysis

Pre- and post-intervention tests, questionnaires, and interview schedules from the field were used to collect data from secondary students and Mathematics teachers. This data was then organized and summarized to reflect its overall meaning. To achieve objectives was the aim of this study. The first objective was to assess if there was a difference in Probability achievement between students who were

taught using the CBS strategy and those who were taught using Conventional methods. The ratio scale was used to assess student Probability achievement, while the teaching technique, and treatment variable were assessed at the nominal level as either CBS or Conventional. The data collected for this objective was analyzed using a one-way Analysis of Variance (ANOVA) to compare the means of all research groups. However, for the post-test mean scores of the experimental group and the control group that was not pretested, an independent samples t-test was used to examine the effects of the therapy on the post-test scores.

The second objective was to compare student achievement in Probability when CBS was used against when Conventional methods were used, using Mathematical aptitude as a component. The categorical variables were teaching strategy and student ability. The teaching style was classified as either CBS or Conventional, while the student's ability was classified as either High Ability (HA) or Low Ability (LA). The data were analyzed using a two-way analysis of variance (ANOVA) because the aim had two factors: teaching strategy and ability level.

The third objective was to assess if there was a difference in Mathematics achievement between students who were taught using CBS and those who were taught using Conventional methods, with sex as a factor. A two-way analysis of variance was used to analyze the data for this goal as well. The fourth objective was to determine the effects of the CBS teaching style on student achievement in

Probability in Mathematics, but it also included attitude toward Mathematics as a component. A two-way analysis of variance was used to examine this goal.

Finally, the fifth objective was to determine the difficulties in implementing computer simulation in the teaching and learning of probability in Kenyan schools. Factor Analysis was used to assess the data collected for this goal. Other evaluations of internal and external validity were conducted because there were four groups, two experimental and two control. To assess if the pre-test affected the post-test scores, an independent samples t-test was performed on the post-test means of the two experimental groups, one of which was exposed to a pre-test. A t-test was performed on the combined means of the pre-tests and the post-test mean score of the group that was not pre-tested nor treated to see if subject maturation influenced post-test mean scores.

3.11 Logistical and Ethical Considerations

The study's background research was completed without compromising quality with the time and money that were available. Confidentiality of information, names, and sources were ethical considerations. The researcher promoted informed consent that results from willing engagement (Mugenda & Mugenda, 2003). Permission from relevant organizations, such as the ministry of education and secondary schools where research was conducted, was first acquired in order to access the necessary data. In cases involving sensitive or public information, confidentiality or anonymity of surveys and interviews was stressed. The subjects

(Form 3 students employed in the study) and the Mathematics teachers were both asked for permission to use their data in the study.

3.11.1 Logistical considerations

By receiving authorization from all necessary authorities, the study followed all current laws governing data collecting in Kenyan schools. The Ministry of Education, Science and Technology (MoEST), the National Commission for Science, Technology, and Innovation (NACOSTI), Kenyatta University, and individual schools were among the authorities involved.

3.11.2 Ethical considerations

The study's participants were informed that the data they provided would be kept confidential and used only to further the study's goals. Confidentiality of information, names, and sources were ethical considerations. The researcher promoted informed consent that results from willing engagement (Mugenda & Mugenda, 2003).

3.12 Chapter Summary

The research design was introduced in this chapter, together with information on the study population and location. The utilization of research tools, sample procedures, and the size of the pilot study have all been covered. To acquire a general sense of information and overall significance, it was necessary to compile and summarize the data collected from students and mathematics teachers via questionnaires and field interviews. The procedures followed to guarantee the

accuracy and dependability of the data have been presented. This chapter took ethical issues into account and covered the methods used for collecting data, presenting data, and analyzing data.

CHAPTER FOUR
PRESENTATION OF FINDINGS, INTERPRETATION, AND
DISCUSSION

4.1 Introduction

This chapter presents the analysis, interpretation, and discussion of the findings under the objectives of the study. Both quantitative and qualitative research findings are presented.

4.2 General and Demographic Information

The study mainly sought to determine the effect of CBS on learner achievement in Probability in Mathematics. The study sought to provide insight into the following five objectives.

- i. Determine the difference in achievement in Probability between students using computer simulation and those taught using conventional methods.
- ii. Establish the effect of computer simulation on the achievement of high-ability (HA) and low-ability (LA) students in Probability.
- iii. Determine the effect of computer simulation on students' achievement in Probability by sex.
- iv. Determine the effect of computer simulation on students' achievement in Probability based on their attitude toward Mathematics.
- v. Establish the challenges of implementation of computer-based simulation (CBS) in the teaching and learning of Probability in the Kenyan education system.

The study employed null hypotheses. The following four hypotheses were formulated:

H01: There is no significant difference in achievement in Probability between students taught through computer simulation and those taught through conventional methods

H02: There is no significant difference in achievement in Probability between high-ability (HA) and low-ability (LA) students when taught through computer simulation.

H03: There is no significant difference in achievement in Probability by sex when taught through computer simulation.

H04: There is no significant difference in achievement in Probability between students with a positive and negative attitudes toward Mathematics when taught through computer simulation.

4.2.1 General Information

Solomon's four quasi-experimental research design was used to attain the study's goal. A total of 198 Form three students from Kisii County's 4 public, 2 County, 2 Sub-County coeducational secondary schools within the County with ICT infrastructure for integration or use of CBS participated in the study. In comparison to girls, there were slightly more boys, 102 boys, and 96 girls. Students' composition almost attained gender parity. The students were divided into four groups, with a study unit consisting of a group of students from each

school who were randomly allocated to either the experimental or control groups, two experimental and two control groups.

The research design was introduced in this chapter, together with information on the study population and location. The utilization of research tools, sample procedures, and the size of the pilot study have all been covered. To acquire a general sense of information and overall significance, it was necessary to compile and summarize the data collected from students and mathematics teachers via questionnaires and field interviews. The procedures followed to guarantee the accuracy and dependability of the data have been presented. This chapter took ethical issues into account and covered the methods used for collecting data, presenting data, and analyzing data.

4.2.2 Demographic Information

Respondents' demographic information considered for review included sex and school category for students while teachers' professional training was considered.

4.2.2.1 Students' Demographics

Data on students' ages shows that more boys 102 (51%) and 96 (48%) girls participated in the study. E1 and E2 had 49 (24.7%) students while C1 and C2 had 50 (25.3%) students.

4.2.2.2 Teachers' Demographics

For the sake of confidentiality, four Mathematics teachers—A, B, C, and D—were given fictitious names in order to participate in the interview and contribute qualitative data for the study.

The study sample was found to be fairly distributed across the experimental and control groups in terms of these variables, such as sex, ability, and attitude, which are discussed later in the chapter. In conclusion, the findings on respondents demonstrated that the study sample was adequately representative of the targeted respondents, specifically students.

4.3 Presentation of Findings and Interpretations

This part covers the findings of the study in the order in which they were assessed, starting with descriptive statistics, hypotheses testing, qualitative data, and finally, discussions.

4.3.1 CBS and Students' Achievement in Probability

Solomon's Four matrices was used for this study and it was subdivided into two main groups; the experimental group and the control group.

The experimental group was further subdivided into two; experimental group one (E1) and experimental group two (E2). Similarly, the control group was subdivided into two; control group one (C1) and control group two (C2). The E1 group was subjected to a pre-test then they were subjected to the treatment with CBS, computer simulation on teaching and learning Probability, then finally

subjected to a post-test. The C1 group was given a pre-test and they continued learning Probability without using CBS, computer simulation, then finally subjected to a post-test. The E2 group was subjected to the teaching and learning of Probability using CBS, and computer simulation, and then later subjected to a post-test while the C2 group was not subjected to the use of CBS, or computer simulation in teaching and learning Probability but was tested with a post-test.

The initial goal was to assess if there was a difference in Probability achievement between students who were taught using CBS, computer-based simulation, and those who were not. To do this, a control (C1) and experimental (E1) set of students were pre-tested with a designed pre-test, the intervention was provided, and the students were then post-tested to measure the effect of the intervention. The pre-test test administered to two test groups C₁ and E₁ yielded results as presented in Table 4.1.

Table 4.1: Students' Achievement in Probability – Pre-test

	Test groups composition				Total	
	E1		C1			
	f	%	f	%	f	%
Less than 20	35	35.4	29	29.3	64	64.6
20 – 40	11	11.1	17	17.2	28	28.3
Above 40	3	3.0	4	4.0	7	7.1
Total	49	49.5	50	50.5	99	100
Mean	14.63		17.58		16.12	
SD	11.39		11.07		11.27	

The results suggest that students in the control group C1 with a mean of (M=17.58, SD=11.07) had higher achievement than those in the experimental group E1 with a mean of (M=14.63, SD=11.39). More than half of the students (64.6%) scored below 20% on the test, with E1 students (35.4%) outnumbering C1 students (29.3%), showing that the experimental group failed in the pre-test more than the control group. Students from C1 scored somewhat higher (17.2%) than those from E1 in the 20–40% range (11.1%). A similar pattern was observed in individuals with a score of 40 or above, with 4.0% coming from C1 and 3.0% from E1. In general, the results show that students in the control group C1 fared better in the pre-test examination than their experimental group E1 peers. This could be attributed to the instructional methodology of the conventional approach, not using CBS, in teaching and learning Probability for both the experimental group and the control group before treatment.

On the pre-test results, an independent sample t-test was used to determine homogeneity in the makeup of the test groups based on students' Probability achievement.

The results are summarized in Table 4.2.

Table 4.2: Independent Sample Test for Pre-test Results

Test Groups	N	Mean	Std. Dev	df	t – value	p – value
E ₁	49	14.63	11.39	97	1.305	.195
C ₁	50	17.58	11.07			

The variances of the experimental and control groups were not significantly different, according to Levene's test for equality of variance (F=0.017, p = 0.898).

This indicates that the data produced is consistent with the homogeneity of variance assumptions for the combined experimental and control groups. An analysis of test data under the assumption of equal variance revealed no significant mean difference between the experimental (M=14.63, SD=11.392) and control (M=17.58, SD=11.071) groups, $t(97) = 1.305$, $p = .195$. This suggests that these groups had similar mean values with a marginal differences, indicating that they had learners with similar qualities who were suitable for the study.

Then, an assessment of the effect of computer-based simulation in the teaching and learning of Probability and conventional methods administered to students in their respective groups for three weeks was undertaken through, a post-test. The observation of students in the E1 and C1 groups is compared in Table 4.3.

Table 4.3: Students' Achievement in Probability – Post-test Results for E₁ & C₁

	Test groups composition				Total	
	E1		C1		F	%
	f	%	f	%		
Less than 20	3	3.1	23	23.2	26	26.3
20 – 40	21	21.2	21	21.2	42	42.4
Above 40	25	25.3	6	6.1	31	31.3
Total	49	49.5	50	50.5	99	100.0
Mean	43.59		24.24		33.82	
SD	16.73		14.04		15.36	

The results suggest that students from E1 (M=43.59, SD=16.73) scored higher on the post-test than those from C1 (M=24.24, SD=14.04). In particular, nearly a

quarter of the students (26.3%) scored less than 20% on the post-test. The majority (23.2%) of these students were from C1 as opposed to E1 (3.1%), implying that more students from C1 scored below average in the post-test assessment, contrary to what was observed in the pre-test examination. There were four times as many students from E1 (25.3%) as those from C1 among those who scored above 40%. (6.1%). Overall, the findings suggest that, even though the majority of students scored between 20-40% on the post-test examination, students from E1 had higher accomplishment levels than their counterparts from C1 after the treatment.

As shown in Table 4.4, a similar pattern was observed in the accomplishment levels of students in E2 and C2 who were not pretested.

Table 4.4: Students' Achievement in Probability – Post-test Results for E₂ & C₂

	Test groups composition				Total	
	E2		C2		F	%
	f	%	f	%		
Less than 20	0	0.0	12	12.1	12	12.1
20 – 40	14	14.1	29	29.3	43	43.4
Above 40	35	35.4	9	9.1	44	44.5
Total	49	49.5	50	50.5	99	100.0
Mean	51.27		32.18		41.63	
SD	14.87		13.79		14.28	

Table 4.4 shows that students in experimental group E2 (M=51.27, SD=14.87) outperformed students in control group C2 (M=32.18, SD=13.79) in terms of achievement. Results showed that all of the students who got less than 20% were

from C2. There were twice as many students in C2 (29.3%) as in E2 among the 43.4% who scored 20–40%. However, there were four times as many students from E2 (35.4%) as those from C2 (9.1%) among those who scored above 40% in the post-test, corroborating the allegation that more students from the experimental group fared better than their counterparts from the control group.

An independent sample t-test for the post-test findings of the two groups that were not pre-tested was used to determine the existence or absence of a possible effect of pre-test sensitization on the process outcome.

The final results are reported in Table 4.5.

Table 4.5: Independent Sample Test for Post-test Results for E₂ & C₂

Test Groups	N	Mean	Std. Dev	df	t – value	p – value
E ₂	49	51.27	14.87	97	6.62	.000
C ₂	45	32.18	13.79		0.286	.594

The variances in achievement for students in the experimental group E2 and the control group C2 were not statistically different, according to Levene's test for equality of variance (F=0.286, p=0.594). This indicates that the post-test results for both the experimental and control groups are compatible with the premise of homogeneity of variance. As a result, a mean analysis was performed for the two groups, with the results indicating that there is a significant mean difference between the scores of the two non-pre-tested groups, experimental and control, with the experimental group's mean score being significantly higher than the control group's (t (97) = 6.62, P 0.001). This conclusion is in line with the observed mean achievement difference between students in the experimental and

control groups who were pre-tested, implying that pre-test sensitization is implausible, results agree that the experimental group performed better than the control group in the post-test scores.

The results in table 4.5 on the post-test, enabled the researcher to examine the first hypothesis. The first hypothesis, H_{01} , intended to assess if there was a statistically significant difference in Probability performance between students who were taught using CBS, Computer simulation and those who were taught using non-CBS, Computer simulation approach. A one-way analysis of variance was used to find an inferential interpretation of the existing association, and the results are shown in Tables 4.6 and 4.7.

Table 4.6: Effect of CBS on Student's Achievement (ANOVA- Descriptive)

	N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
E1	49	43.59	16.726	2.389	38.79	48.40	13	76
E2	49	51.27	14.874	2.125	46.99	55.54	23	76
C1	50	24.24	14.043	1.986	20.25	28.23	3	57
C2	50	32.18	13.788	1.950	28.26	36.10	7	59
Total	198	37.72	18.070	1.284	35.19	40.25	3	76

Students in the experimental groups (E1) and (E2) had a higher mean (M=43.59, SD=16.73 and M=51.27, SD=14.87 respectively) in the post-test examination than their counterparts in the control groups (C1 and C2) (M=24.24, SD=14.04

and $M=32.18$, $SD=13.79$ respectively) as shown in Table 4.6 from the ANOVA descriptive.

The existing relationship is interpreted using ANOVA in Table 4.7.

Table 4.7: Effect of CBS on Students Achievement (ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21299.834	3	7099.945	32.013	.000
Within Groups	43025.888	194	221.783		
Total	64325.722	197			

Table 4.7 demonstrates that the observed mean difference was significant at the 0.05 level of significance, with $F(3, 194) = 32.01$, $p.001$. Similarly, the results of a Post Hoc test (Tukey) are presented in Table 4.8.

Table 4.8: Post Hoc Test Results in % (Tukey)

(I) Group	(J) Group	Mean Difference(I - J)	Std. Error	Sig. p	95% Confidence Interval	
					Lower Bound	Upper Bound
E1	E2	-7.673	3.009	.056	-15.47	.12
	C1	19.352*	2.994	.000	11.59	27.11
	C2	11.412*	2.994	.001	3.65	19.17
E2	E1	7.673	3.009	.056	-.12	15.47
	C1	27.025*	2.994	.000	19.27	34.78
	C2	19.085*	2.994	.000	11.33	26.84
C1	E1	-19.352*	2.994	.000	-27.11	-11.59
	E2	-27.025*	2.994	.000	-34.78	-19.27
	C2	-7.940	2.978	.041	-15.66	-.22
C2	E1	-11.412*	2.994	.001	-19.17	-3.65
	E2	-19.085*	2.994	.000	-26.84	-11.33
	C1	7.940	2.978	.041	.22	15.66

*The mean difference is significant at the 0.05 level.

The post test results for E1 ($M=43.59$, $SD=16.73$) are substantially different from C1 ($M=24.24$, $SD=14.04$) and C2 ($M=32.18$, $SD=13.79$) according to post hoc Tukey's test. The results for E2 ($M=51.27$, $SD=14.87$) are significantly different from C1 ($M=24.24$, $SD=14.04$) and C2 ($M=32.18$, $SD=13.79$), which is consistent with the data. The finding simply stated that students in the experimental groups who were exposed to the CBS teaching technique fared significantly better than students in the control group who were exposed to the conventional teaching strategy. As a result, it may be stated that CBS is a superior teaching strategy to non-CBS teaching strategy, as evidenced by the improved performance of CBS students. As a result, the null hypothesis H_{01} was rejected, which indicated that there is no significant difference in probability achievement between students taught using CBS and those taught using conventional techniques.

In summary, the main aim of the objective was to compare the effect of CBS and conventional teaching methods on students' achievement in Probability. Descriptive results from the pre-test showed that there was a poor achievement in probability tests. This observation is consistent with existing empirical data that attest to students' poor achievement in Probability. For instance, KNEC (2013) and Ogembo (2012) among others lament persistent poor achievement in Probability.

Descriptive data of the post-test results showed that the mean achievement of students from the experimental group was higher than that of students from the control groups. Specifically, students from E1 (25.3%) scored above 40% more than those from the control group C1 (6.1%), hence students from E1 had higher accomplishment levels than their counterparts from C1 in the post-test although they had passed the pre-test slightly more than post-test. This observation agrees with Henriques (2000) who maintains that CBS enhances the learning of Probability resulting in improved achievement in Probability. This finding corroborates Ahiatrogah, et al., (2013) who discovered that the CBS group outperformed the conventional method of instruction group in a study comparing the effects of CBS and traditional techniques on senior secondary school students pre-technical skills.

This finding also agrees with Kareem (2015) in a study comparing the effects of CBS and traditional techniques on senior secondary school students' accomplishment, discovered that CBS enhanced students' academic achievement in mathematics. Mauro (1994) is categorical that CBS can transform how students engage in self-directed learning by empowering them to choose, control, and assess their learning activities which can be handled by a computer anytime and in any location. The researchers insist that CBS has a variety of visual presentation through computers in contrast to the one-dimensional conventional methods which opens horizons for learners of all abilities, from low achievers to high achievers.

4.3.2 CBS and Students' achievement in Probability based on their ability

The study sought to determine the impact of CBS on students' ability-based achievement. The study's second hypothesis, H_{02} , intended to observe if there was a statistically significant difference in accomplishment between LA and HA exposed to CBS. Based on the results of the Pre-test Student Mathematics Test (PRESMT) given to the two groups at the start of the procedure, students were classified as low ability (LA) or high ability (HA) students in Probability achievement. Those who performed below average on the test were labeled LA, while those who performed above average were labeled HA in Probability achievement. Students were classified as LA or HA based on their performance on the PRESMT test, resulting in the group makeup shown in Table 4.9.

Table 4.9: Students' Ability in Mathematics

Ability level	E1		C1		Total	
	f	%	f	%	f	%
Low ability(LA)	41	41.4	40	40.4	81	81.8
High ability(HA)	8	8.1	10	10.1	18	18.2
Total	49	49.5	50	50.5	99	100.0

According to the data, the bulk of the students (81.8%) were classified as LA. There were somewhat more E1 students (41.4%) than C1 students among these (40.4%). When it came to those classified as HA (18.2%), significantly more students (10.1%) came from C1 than from E1 (8.1%), showing that there were more LA students in E1 than C1 and more HA students in C1 than E1.

To determine homogeneity or otherwise in the makeup of the groups by students based on ability, an independent sample t-test was used. Table 4.10 summarizes the findings.

Table 4.10: Independent Sample Test Group Composition based on Ability

Test Groups	N	Mean	Std. Dev	df	t- value	p – value
E ₁	49	1.16	.373	97	0.470	.640
C ₁	50	1.20	.404		0.888	.348

Insignificant differences in variances in the composition of E1 and C1 with students classified as LA and HA were found using Levene's test for equality of variance, $F=0.888$, $p=0.348$. This signifies that the data acquired conforms to the homogeneity of variance assumptions for the combination of groups in terms of student aptitude in the experimental and control groups. An equal variance analysis of test results revealed no significant mean difference between the experimental ($M=1.16$) and control ($M=1.20$) groups, $t(97)=0.470$, $p=0.640$. This suggests that the groups had similar mean values and had learners with similar critical study characteristics.

The study's second hypothesis, H_{o2} , was to observe if there was a statistically significant difference in achievement between low-ability (LA) and high-ability (HA) students exposed to CBS. The results of the Post-test Students' Mathematics Test (POSMT) were subjected to a two-way analysis of variance to examine the effects of the CBS teaching strategy on students' achievement in the subject. As seen in Table 4.11, the findings were as follows.

Table 4.11: Effect of CBS on Low and High-Ability students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11469.602 ^a	3	3823.201	17.387	.000	.354
Intercept	82629.202	1	82629.202	375.783	.000	.798
Gp	4915.192	1	4915.192	22.353	.000	.190
Ability	2042.837	1	2042.837	9.290	.003	.089
Gp * Ability	72.962	1	72.962	.332	.566	.003
Error	20889.126	95	219.886			
Total	145582.000	99				
Corrected Total	32358.727	98				

a. R Squared = .354 (Adjusted R Squared = .334)

According to table 4.11, ability accounts for 35.4% of the overall variance in achievement. As a result, ability accounts for around a third of the entire variation in achievement. Ability and groups are important, according to the research. The interaction effect, however, is not significant ($F(1,99) = 0.332, p = .566, p^2 = 0.003$). $F(1,99) = 9.29, p = .003, p^2 = 0.089$, $F(1,99) = 9.29, p = .003, p^2 = 0.089$, $F(1,99) = 9.29, p = .003, p^2 = 0.089$, $F(1,99) = 9.29, p = .003, p^2 = 0.089$, $F(1,99) = 22.35, p = .001, p^2 = 0.190$, $F(1,99) = 22.35, p = .001, p^2 = 0.190$, $F(1,99) = 22.35, p = .001, p^2 = 0.190$, $F(1,99) = 22.35, p = .001, p^2 = 0.190$, $F(1,99) = 22.35, p = .001, p^2 = 0.190$

It was also discovered that HA students' achievement levels ($M=43.56, SE=3.52$) were significantly different from LA students' achievement levels ($M=31.73, SE=1.65$) and that students in the experimental group E1's achievement levels ($M=46.83, SE=2.87$) were significantly different from students in the control group C1's ($M=28.46, SE=2.62$). The effect was substantially bigger for LA in the experimental group E1 ($M=42.02, SE=2.32$) than in the control group ($M=21.43, SE=2.33$), according to a pairwise comparison. $F(1,99) = 9.29, p = .003, p^2 = 0.089$

=0.089, and test groups, $F(1,99) = 22.35$, $p = 0.001$, $\eta^2 = 0.19$. Univariate test results were likewise significant for ability, $F(1,99) = 22.35$, $p = 0.001$, $\eta^2 = 0.19$. This might be construed to mean that using CBS in Probability teaching has a greater influence on low-ability students than on high-ability students. As a result, hypothesis H0₂, which indicated that when teaching Probability using CBS there is no significant difference in accomplishment between low and high-ability students, was rejected.

In summary, descriptive data explained the similarity of distribution of students with LA and HA across control and experimental groups of the study important for consideration. Findings from ANOVA showed a significant effect of CBS on the ability of students, with 35.4% of the total variance being attributed to the effect of teaching strategy consistent with (Scardamalia, & Bereiter, 1994) who found out that students' cognitive abilities predicted their academic achievement, particularly in disciplines like Mathematics. Similarly, Bartels, Rietveld, Van Vaal, & Boomsma, (2002) found relationships between cognitive test scores and educational outcomes ranging from 0.40 to 0.63 in IQ scores and school performance grades in an analysis of eight samples from six longitudinal studies. Specifically for Mathematics, Taub, Floyd, Keith, and McGrew (2008) found a statistically significant direct link between students' general cognitive aptitude and their Mathematics achievement.

Results specifically indicated the greater effect of CBS for LA as compared to HA students as was seen from the mean posted by this category of learners. This implies that the use of CBS in teaching and learning Probability significantly improves the achievement of LA students compared to HA students. These findings partly agree with that of Garfield and Delmas (1989) who found out that when CBS is employed to toss a coin with mixed results, some students change their minds on variability for better performance after utilizing the CBS software and others stick to their old attitudes.

The significant effect of CBS on achievement levels of both HA and LA students is demonstrated by the significantly higher achievement levels in the experimental groups compared to those from the control groups, with each learner in the experimental groups posting significantly higher mean scores than their counterparts in the control groups. This result is congruent with those of Wanjala (2005) and Liao (2007), who discovered that students performed better when they learnt in cooperative groups with CBS than when they learned independently without using CBS. This aids in bridging the gap between traditional approaches and the more sophisticated CBS visualization methods employed by scientists.

In general, the study found that the CBS teaching style is a more effective way to teach probability because it improves education for low-ability students by giving them more hands-on experiences that engage their thinking, increasing their retention and raising their performance levels. This finding supports that made by

Feyzioglu (2009), who discovered that computer-based instructional methods that encourage active student participation in the learning process frequently result in greater academic achievement than those that do not.

4.3.3 CBS and students' achievement in Probability based on their sex

The study sought to determine the impact of CBS on student achievement based on their sex. The study's third hypothesis, H_{03} , was to observe if there was a statistically significant difference in achievement between boys and girls CBS subjects. Data on students' sex were presented in figure 4.12.

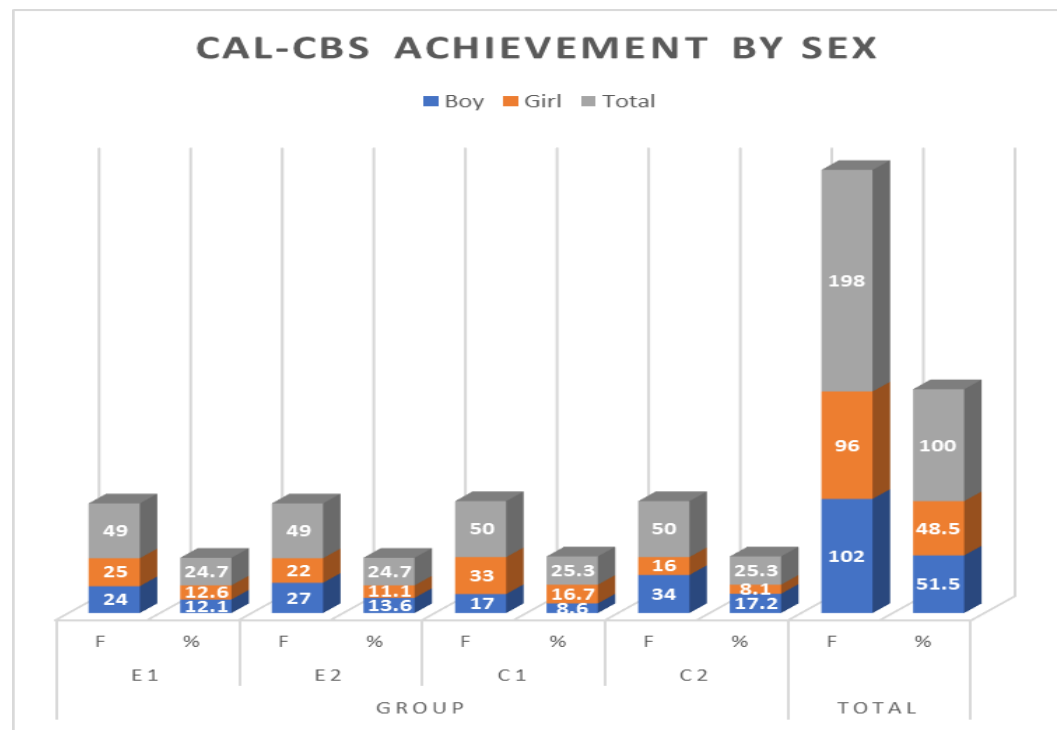


Figure: 4.12 Students' sex

According to the data in Fig 4.12, each of the four test groups contained 102 boys and 96 girls. For the test of homogeneity of the composition of the test groups in terms of gender, ANOVA statistics, $F(3,194) = 1.67$, $p = 0.235$, indicated

insignificant mean differences at the 0.05 level of significance, allowing continued analysis. The results of the pre-test are provided in Figure 4.13.

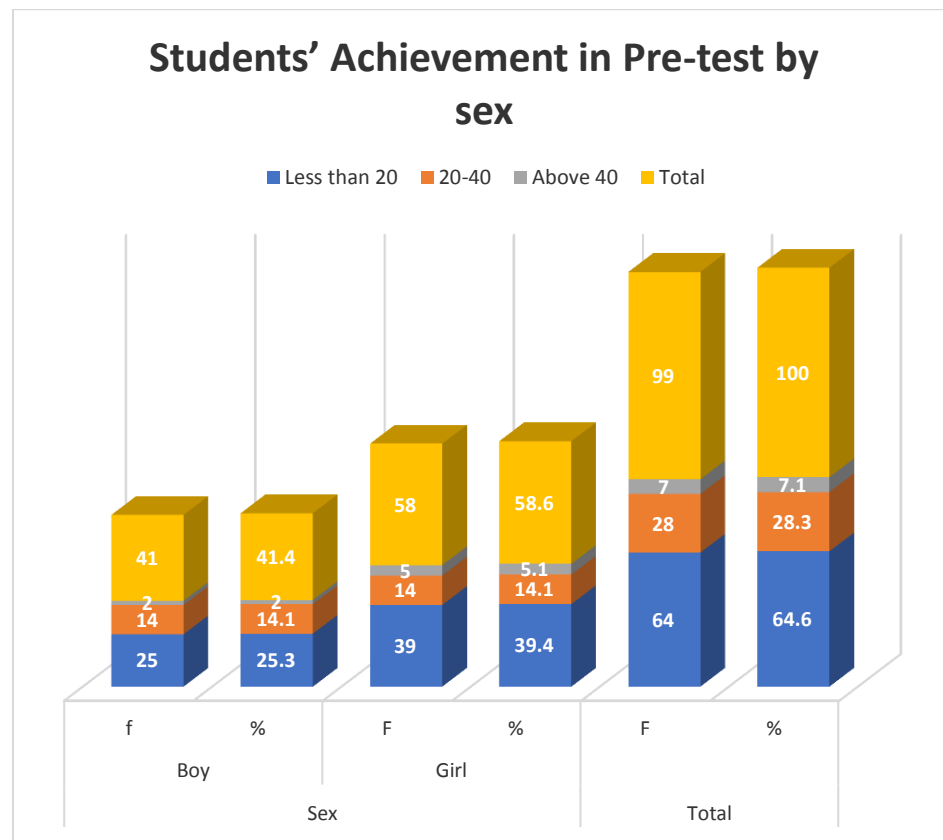


Figure 4.13: Students' Achievement in Pre-test by Sex

The data revealed that the majority of the students scored less than 20% on the pre-test. Females made up 39.4% of the population, while males made up 25.3%. In the pre-test, an equal proportion of male and female students scored between 20 and 40%, but twice as many female students 5.1% than male students 2.0% scored above 40%. In the pre-test, an independent sample t-test was utilized to evaluate male and female students' success levels. Female students' mean achievement (M=16.38) was somewhat higher than male students' (M=15.76). This suggests that female students outperformed male students by a small margin.

The results of these students' exposure to CBS and subsequent post-testing are shown in Figure 4.14

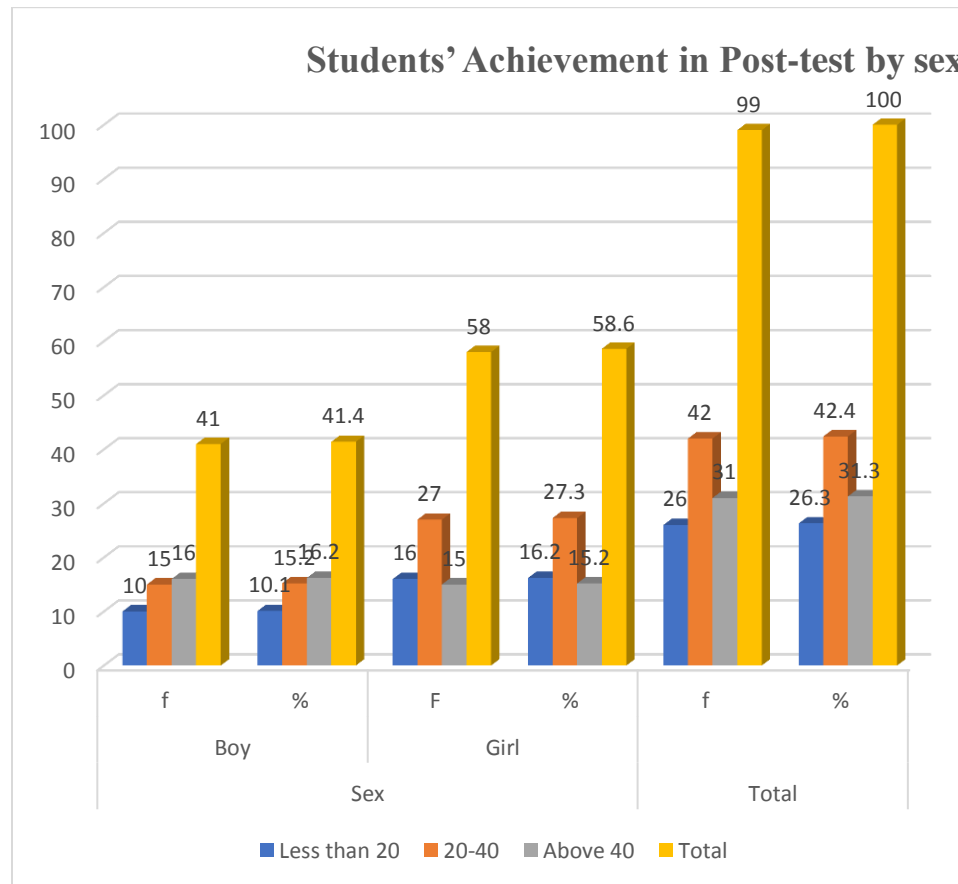


Figure 4.14: Students' achievement in Post-test by sex

Figure 4.14 shows that a quarter of students 26.3% scored less than 20% on the post-test, with somewhat more females scoring less than 20% than males. When it came to individuals with scores between 20% and 40%, a similar trend was seen, with more females than males scoring between 20 % and 40%. However, there were more male students (16.2%) than female students (15.2 %) among those who scored above 40%.

The study also aimed to look into the impact of CBS on student achievement based on sex. The study's third hypothesis, Ho₃, intended to determine whether there is a statistically significant difference in achievement in Probability between male and female students when they are exposed to CBS. To examine the impacts of CBS on students' achievement based on sex, a two-way analysis of variance (ANOVA) test was used, and the results are shown in Table 4.15.

Table 4.15: Effect of CBS on Students' Achievement based on sex

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10852.647 ^a	3	3617.549	15.980	.000	.335
Intercept	105703.031	1	105703.031	466.928	.000	.831
Gender	190.619	1	190.619	.842	.361	.009
Gp	9570.802	1	9570.802	42.278	.000	.308
Gender * Gp	1346.969	1	1346.969	5.950	.017	.059
Error	21506.080	95	226.380			
Total	145582.000	99				
Corrected Total	32358.727	98				

a. R Squared = .335 (Adjusted R Squared = .314)

Significant disparities in achievement levels were detected between students in the experimental groups E1 (M=43.70, SE=2.11) and C1 (M=23.48, SE=2.20), which were similar to those observed between E2 (M=51.45, SE=2.12) and C2 (M=31.75, SE=2.23). Students in E1 had substantially different exam scores from those in C1 and C2, while students in E2 had significantly different test scores from those in C1 and C2. $F(3,198) = 33.05, p.001, p^2 = 0.343$, $F(3,198) = 33.05, p.001, p^2 = 0.343$, $F(3,198) = 33.05, p.001, p^2 = 0.343$, $F(3,198) = 33.05, p.001, p^2 = 0.343$.

A post hoc (Tukey HSD) test revealed that there is a substantial mean difference between E1 and C1 and C2 students' achievement levels. The achievement levels of E2 students, as well as those in C1 and C2, followed a similar pattern.

Male students had a comparatively greater mean achievement in Probability ($M=37.39$) than female students ($M=31.29$) based on gender. $F(1,198) = .273$, $p = .602$, $p^2 = 0.001$, although the differences were not significant, male students in E1 had a higher mean ($M=48.91$) than female students in the same group ($M=38.48$) within the groups. In C1, the mean achievement of female students ($M=25.85$) was higher than that of male students in the same group ($M=21.12$).

Though the use of CBS in instruction comparably influenced students of different sex, resulting in a negligible effect across sex, the difference in achievement levels between the experimental and control groups demonstrated its superiority as a method of instruction for Probability and Mathematics in general. As a result, the data gained failed to refute the third hypothesis, H_{03} , which suggested that when Probability is taught by CBS, computer simulation, there is no significant difference in achievement by sex and either sex would use CBS, Computer simulation in learning probability.

In summary, therefore, findings showed the insignificant effect of the use of CBS on the achievement of students based on gender implying that the use of CBS affects the achievement of boys and girls equally. It is consistent with that of

Ursini, Sanchez, Orendai, and Butto (2004) who observed that incorporating technology into Mathematics classrooms appeared to increase gender parity in student conduct. However, it contradicts that of Oginni and Popoola (2013) who discovered that there is a significant difference in performance depending on gender in favor of boys than girls. Similar results were arrived at by Bandura, Barbaranelli, Caprana, and Pastorelli (2001) as well as Eccles and Wigfield (2001).

From descriptive findings, Male students had a comparatively greater mean achievement in Probability ($M=37.39$) than female students ($M=31.29$) based on gender. However, it contradicts the findings of Robinson and Lubienski (2011), who found out that girls received slightly better grades in Mathematics over the last four decades than boys, findings that Brown and Kanyongo (2010) also supported. In a mixed research, Ayalon and Livnah (2013) addressed the gender gap in Mathematics achievement in the Meyzav test, a national examination of students' achievement in elementary school that revealed an apparent difference between boys and girls, with girls' scores being 12 points lower than boys' scores and the gap existing throughout Israel.

Hudig, Scheepers, Schippers, & Smeets, (2021) affirms that girls prefer group learning and social learning using CBS and do well than boys. However, their investment in Mathematics and an easy test, a good teacher who explains Mathematics well, and good luck are all attributes of good performance in Mathematics. It is inconsistent with that of Hall *et al* (1999) who looked at gender

disparities in Mathematics achievement among American children in grades 5 through 8 and found no significant differences.

4.3.4 CBS and Students' achievement in Probability based on their attitude

The study's fourth objective was to determine the effect of CBS on student achievement in Probability based on their attitude. The study's fourth hypothesis, H_{o4} , aimed to observe if there is a statistically significant difference in Probability success between students who have a positive and negative attitude toward Probability and Mathematics in general when taught by CBS. Students' attitudes toward Probability were categorized as positive attitude (PA) or negative attitude (NA) based on the findings of a student's questionnaire (SQ) administered to the students at the start of the study to examine their attitudes toward Probability.

The information gathered was edited, coded, and entered into computer software, yielding the results shown in appendix 6. Respondents showed a good attitude toward Probability, in Mathematics ($M=3.30$, $SD=0.387$), indicating that most students in the study had a positive attitude toward probability in Mathematics. In particular, a higher percentage of students said they want to improve their Mathematical skills (79.3%), a higher percentage said they get a lot of satisfaction from solving a Mathematics problem (94.9%), a higher percentage said Mathematics helps develop the mind and teaches people to think (78.3%), and a significant proportion (88.9%) believe Mathematics is important in everyday life. In comparison to those who believed the opposite, fewer students, 12.6% admitted

that they learn Mathematics easily, while (29.3%) admitted that they enjoy solving new problems in Mathematics, and (39.4%) admitted that they genuinely enjoy Mathematics.

The study then proceeded to rate the students' attitudes based on a comparison of the average attitude score and the actual score on the attitude scale. When calculating students' scores on the attitude scale, it was discovered that the least score was 71 and the greatest score was 176. As a result, those with a score of less than 123.5 on the scale were classified as having a negative attitude (NA), while those with a score of more than 123.5 were classified as having a positive attitude (PA), resulting in the data shown in Table 4.16.

Table 4.16: Students' Attitude (Categorized)

Gender	Group								Total	
	E1		E2		C1		C2		f	%
	f	%	f	%	F	%	f	%	f	%
NA	1	0.5	8	4.0	9	4.5	23	11.6	41	20.7
PA	48	24.2	41	20.7	41	20.7	27	13.6	157	79.3
Total	49	24.7	49	24.7	50	25.3	50	25.3	198	100.0

Table 4.16 shows that the majority of students (79.3%) scored well on the attitude measure and were thus classified as PA students rather than NA students (20.7%). The study's four test groups also revealed that the different categories of students' attitudes were fairly distributed across the four test groups.

In addition, at the end of the intervention stage, the researcher sought and collected students' scores on the elements of attitude to analyze the impact of CBS on students' attitudes. According to the data, students had a positive attitude, $M=3.44$ out of 5 which is consistent with earlier observations. This indicates a positive shift of 0.14 on the attitude scale compared to the $M=3.30$ recorded during the pre-test.

The study's fourth hypothesis, H_{04} , was to assess if there was a statistically significant difference in achievement between children with a negative and positive attitude who were exposed to CBS. It was also meant to see if CBS had any impact on the students' attitudes toward Probability. A two-way analysis of variance test of their pre-test attitude score on their post-test SQ score was used to see if CBS integration had a significant influence on students' accomplishment differently depending on their attitude, whether NA or PA. Table 4.17 summarizes the research findings.

Table 4.17: Effect of CBS on Students' Attitude

Source	Type Sum Squares	III of	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6011.638 ^a		7	858.805	12.248	.000	.330
Intercept	444490.384		1	444490.384	6339.311	.000	.973
Attitude	19.293		1	19.293	.275	.601	.002
Group	5863.590		3	1954.530	27.875	.000	.325
Attitude * Group	214.000		3	71.333	1.017	.386	.017
Error	12200.274		174	70.117			
Total	473612.000		182				
Corrected Total	18211.912		181				

a. R Squared = .330 (Adjusted R Squared = .303)

The effect of CBS on accomplishment was substantial as a model, accounting for 33% of the total variance in Probability in Mathematics achievement. The differences in achievement between students with a positive attitudes and students with negative attitudes were minor, according to the results, $F(1,182) = .275$, $p = .601$, and $p^2 = 0.002$. Significant differences between groups CBS and conventional methods were identified, $F(3,182) = 27.88$, $p = 0.001$, $p^2 = 0.33$, while there was no significant interaction effect between attitude and groups, $F(3,182) = 1.02$, $p = .017$, $p^2 = 0.017$.

There was also no discernible difference in accomplishment levels between students with a good attitude ($M=43.76$, $SE=4.46$) and those with a negative attitude ($M=38.44$, $SE=1.22$). However, there was a significant difference in the accomplishment levels of students in the experimental group E1 ($M=45.18$,

SE=4.44) and those of students in the control group C1 (M=24.02, SE=2.19). Students in E1 had substantially different exam scores from those in C1 and C2, while students in E2 had significantly different test scores from those in C1 and C2. $F(3,188) = 13.06$, $p = .001$, $\eta^2 = 0.17$, but $F(1,188) = 1.32$, $p = .252$, $\eta^2 = 0.007$. Univariate test results were also significant for the test group, $F(3,188) = 13.06$, $p = .001$, $\eta^2 = 0.17$, but insignificant for attitude, $F(1,188) = 1.32$, $p = .252$, $\eta^2 = 0.007$. This might be read to mean that using CBS in class impacted students with both positive and negative attitudes in the same way, resulting in a negligible effect across attitudes but a substantial effect across groups. As a result, the data failed to reject null hypothesis four, H_{04} , which said that when students are taught using CBS, there is no significant difference in Probability achievement between students who have a good and negative attitude toward Mathematics.

A one-way analysis of variance test of the fluctuation of students' scores on the aspects of attitude in post-test and pre-test versus test groups, experimental or control was operationalized to examine the effect of CBS teaching strategy on students' attitude towards probability in Mathematics.

Tables 4.18 and 4.19 summarize the results collected.

Table 4.18: Effect of CBS on Students' Attitude (Descriptive)

	N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
E1	48	9.9000	34.23940	4.84218	.1693	19.6307	-105.00	71.00
E2	48	11.2917	17.94549	2.59021	6.0808	16.5025	-36.00	47.00
C1	50	2.7400	19.76268	2.79487	-8.3565	2.8765	-54.00	45.00
C2	50	5.6875	12.00028	1.73209	2.2030	9.1720	-13.00	51.00
Total	196	5.9847	23.14004	1.65286	2.7249	9.2445	-105.00	71.00

The results show that on the scale of change of attitude, the change in students' scores on elements of attitude from E2 was highest (M=11.29), followed by those from E1 (M=9.90), C2 (M=5.69), and C1 (M=2.74) in decreasing order. The actual ANOVA interpretation of the effect is shown in Table 4.19.

Table 4.19: Effect of CBS on Students' Attitude (ANOVA)

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5928.605	3	1976.202	3.853	.010
Within Groups	98486.349	192	512.950		
Total	104414.954	195			

Table 4.19 reveals that the observed mean difference was significant, with $F(3, 192) = 3.85, p = 0.010$.

The findings of the Post Hoc (Tukey) test are summarized in Table 4.20.

Table 4.20: Multiple Comparisons of Attitude Change (Tukey HSD)

(I) Group	(J) Group	Mean Difference (I - J)	SE	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
E1	E2	-5.60417	4.62308	.620	-17.5857	6.3774
	C1	8.42750*	4.57662	.257	-3.4336	20.2886
	C2	-4.21250	4.57662	.794	-16.0736	7.6486
E2	E1	5.60417	4.62308	.620	-6.3774	17.5857
	C1	14.03167*	4.57662	.013	2.1706	25.8928
	C2	1.39167	4.57662	.990	-10.4694	13.2528
C1	E1	-8.42750	4.57662	.257	-20.2886	3.4336
	E2	-14.03167*	4.57662	.013	-25.8928	-2.1706
	C2	-12.64000*	4.52968	.029	-24.3794	-.9006
C2	E1	4.21250	4.57662	.794	-7.6486	16.0736
	E2	-1.39167	4.57662	.990	-13.2528	10.4694
	C1	12.64000*	4.52968	.029	.9006	24.3794

*. The mean difference is significant at the 0.05 level.

The post-test findings for E1 (M=9.90) were substantially different from C1 (M=2.74), with the change in the attitude of students in the experimental group being significantly higher than that of the control group, according to a post Hoc Tukey's (HSD) test. Similarly, substantial mean differences were found between E2 (M=11.29) and C1 (M=2.74) post-test findings, with the mean change in students' attitudes in the experimental group being much higher than that of the control group. According to the findings, the influence of CBS on students' attitudes was largest in the experimental group compared to the control group, which might be attributed to the experimental group's use of strategy. As a result, the supplementary hypothesis H0₄, which indicated that the influence of CBS on students' attitudes is not significantly different, was rejected.

In summary, the main aim of this objective was to assess the effect of the CBS teaching strategy on the achievement of students with positive and negative attitudes. Descriptive pre-test scores on attitude illustrated students' scores of above-average levels of a majority of elements. According to the data, students had a positive attitude, $M=3.44$ out of 5 which is consistent with earlier observations by Lipnevich *et al.* (2011) who explained that learner attitude explained 25% of the variance in Mathematics achievement with the variance being independent of Mathematical skill but a positive attitude of the learner. This is in tandem with Mata *et al.*, (2012) who discovered that the more positive the attitude, the higher the degree of student achievement in Mathematics.

Descriptive results show that on the scale of change of attitude, the change in students' score on elements of attitude from E2 was highest ($M=11.29$), followed by those from E1 ($M=9.90$), C2 ($M=5.69$), and C1 ($M=2.74$) in decreasing order. This corroborates studies by Pytel (2007) who investigated student attitudes toward Mathematics when technology is used and found that students' passion and interest in learning are higher when CBS is used than when conventional methods are employed.

The differences in achievement between students with a positive attitudes and students with negative attitudes were minor, according to the results, $F(1,182) = .275$, $p = .601$, and $p_2 = 0.002$. Significant differences between groups CBS and conventional methods were identified, $F(3,182) = 27.88$, $p.001$, $p_2 = 0.33$, while

there was no significant interaction effect between attitude and groups, $F(3,182) = 1.02$, $p = .017$, $\eta^2 = 0.017$. This might be read to mean that using CBS in class impacted students with both positive and negative attitudes in the same way, resulting in a negligible effect across attitudes but a substantial effect across groups. These results conform to those of Ross, & Broh (2000) who studied factors that influence Mathematics achievement in a sample of men and women, focused on attitude and self-esteem and attributes of success and failure as the main causes of low achievement in Mathematics and not attitude. However, Martin, Mullis and Foy (2008) apportion children's achievement in Mathematics to their confidence and whole attitude towards Mathematics.

According to the findings, the influence of CBS on students' attitudes was largest in the experimental group compared to the control group, which might be attributed to the experimental group's use of strategy. In an investigation into the effect of computer-based simulation on students' understanding of Mathematics, Ozman (2007) found that there is a statistically significant difference between groups in favor of the experimental group, but insignificant for attitude. This observation is consistent with his findings.

4.3.5 Challenges in Integrating CBS in Instruction of Probability

The final objective was to determine the difficulties in implementing CBS in Probability teaching and learning. Mathematics teachers who assisted in the implementation of the intervention were interviewed utilizing the Mathematics

Teachers Interview Schedule to achieve this (MTIS). Table 4.21 summarizes the characteristics of the teachers who took part in the interview and so supplied qualitative data.

Table 4.21: Interviewee Identity

Participant Code	Type of School
P	E ₁
Q	E ₂
R	C ₁
S	C ₂

Table 4.21 demonstrates that for anonymity, four Mathematics teachers called P, Q, R, and S participated in the interview and thereby provided qualitative data for the study. P and Q came from the experimental research groups, while R and S came from the control groups.

The MITS instrument evaluated several topics, including the extent to which CBS tools are used, the obstacles that prevent CBS from being integrated into teaching and learning, and recommended ways for resolving the challenges. The respondents were unanimous in their comments when it came to the extent to which CBS tools, are used in teaching and learning Probability in Mathematics. Due to a "lack of sufficient CBS hardware and software," interviewee P claimed that "below average" use of CBS tools in the teaching and learning process. Interviewees Q, R, and S all expressed similar opinions. Due to a lack of suitable computer hardware and software, respondent Q mentioned that he had to resort to alternate teaching tactics such as the "question and answer approach." Teacher 'R' claimed that his school's "poor conditions," had forced him to revert to "old

modes of teaching Mathematics, such as the lecture style. When CBS tools become “available,” interviewee S stated that she prefers to use them since they are “learner-friendly and that they promote optimum learner involvement” in the teaching and learning process. Figure 4.15 summarizes how teachers responded to the challenges of the CBS approach to teaching probability.

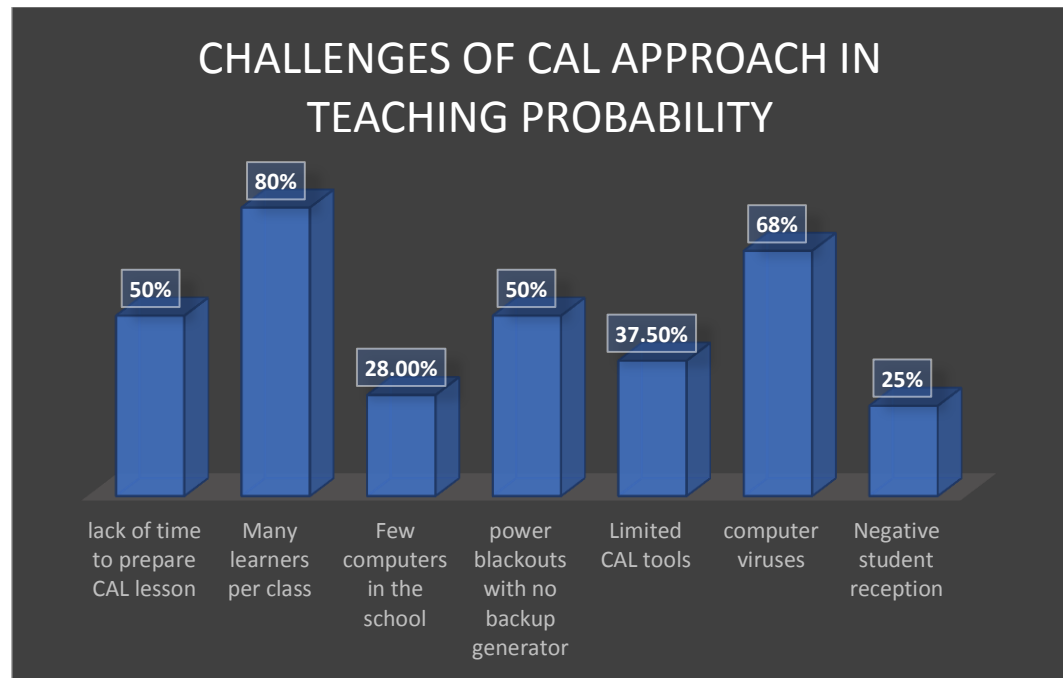


Figure 4.15: Challenges of the CBS approach in teaching Probability

About time, 50% of the respondents said they did not have enough time to prepare for the lesson, citing the complexity involved in preparing CBS tools, to use for different concepts in Mathematics.

They also mentioned that classes are overcrowded with learners with 80% of the respondents affirming this challenge making it difficult to use the few CBS tools available for all learners. On the issue of the availability of computer hardware,

28% of the respondents confirmed that they are few in schools while the majority agreed that they are available, but not being utilized to teach Probability and Mathematics in general. Power blackouts in most schools were the predominant challenge with 50% of the respondents corroborating the same. About CBS tools, 37.5% of respondents said "Limited CBS tools" did not enable them to fully utilize the CBS approach to teaching Probability posing a challenge in its implementation. Computer viruses posed a great challenge by 'eating up'-destroying the already developed CBS software with 68% of the respondents confirming it which discourages teachers from developing and using CBS software more often. On student perceptions of the use of CBS tools in learning Probability, 25% of the respondents acknowledged that learners exhibited signs of negative attitude towards CBS tools posing a challenge to its implementation.

In general, interviewees felt that while CBS technologies are appropriate for classroom instruction, several factors prevent them from being used in their schools and "over the enrollment of students" resulting in huge class sizes, according to interviewee P. Interviewees Q and R both expressed similar opinions. In addition to the stated impediments, interviewee S regretted the detrimental effects of "restricted physical infrastructure" and "lack of regular power supply" on the usage of CBS tools. As a result, they urge that schools be fully equipped with physical infrastructure including "computer laboratories," "computer hardware and software," "stable internet access," and "reliable power supply including backup generators."

In summary, lack of time to prepare by teachers was found to have a negative effect on teachers' use of CBS implying that teachers' workload could be inhibiting the use of the strategy. Itunga (2011) Otach (2008), Sifuni and Sawamura (2009), and the public school system is beset by a huge intake of students, crowded classrooms, and outdated facilities that make a mockery of the government's commitment to provide free education, laments UNESCO (2004). The classroom instructor has been overworked and under pressure to manage the class, which may be harming their ability to prepare for using CBS. Teachers indicated a lack of enough CBS tools for teaching and learning Probability in Mathematics. This observation is in accordance with Usluel et al. (2008) who suggested improving accessibility to ICT tools for effective CBS use and Norris et al. (2003) who highlighted the significance of access to technology. On power blackouts, it agrees with Mendes et al (2003) as reported in Mwangolo (2011) that there is less emphasis on ICT training in basic and secondary schools in Tanzania because of poor facilities and power outages in a study on the level of use of ICT resources.

4.4 Chapter Summary

This chapter has considered results, interpretation, and discussions. The study established that the CBS approach used in teaching and learning Probability to secondary school students has the potential of positively affecting their levels of cognitive and psychomotor domains and thereby improving their achievement in probability and mathematics in general. A CBS approach in teaching and learning

Probability, if fully implemented has the potential of changing the conventional way of teaching Probability and Mathematics in general to a CBS view of teaching Probability by Mathematics teachers.

The views of Mathematics teachers who teach Probability had a negative view of using CBS than a conventional way of teaching Probability. However, their views changed after teaching Probability using the CBS approach and their views became more oriented towards using CBS driven view than the conventional, traditional approach to teaching and learning Probability. The Mathematics teachers during the implementation stage could not fully put into practice their newly formed perceptions about Probability teaching and learning as a result of several impending challenges.

CHAPTER FIVE
SUMMARY OF FINDINGS, CONCLUSIONS, AND
RECOMMENDATIONS

5.1 Introduction

The purpose of the study was to examine whether integrating Computer Based Simulation (CBS) into Probability teaching and learning improves learner achievement in Probability.

The study was guided by five objectives (1) to determine the difference in achievement in Probability between students using computer simulation and those taught using conventional methods, (2) to establish the effect of computer simulation on achievement of high-ability (HA) and low-ability (LA) students in Probability, (3) to determine the effect of computer simulation on students' achievement in Probability by sex, (4) to determine the effect of computer simulation on students' achievement in Probability based on their attitude towards Mathematics and (5) to establish the challenges of implementation of computer-based simulation (CBS) in the teaching and learning of Probability in the Kenyan education system. The data collected were analyzed, presented, and discussed based on the above objectives using the statistical package for social sciences (SPSS) package.

To satisfactorily achieve this purpose, four research hypotheses were developed and data sought to provide answers. This chapter thus seeks to discuss the

findings based on the hypothesis tested in the preceding chapter. The discussion is presented sequentially beginning with the first hypothesis. Therefore, this chapter summarizes the findings of the study, draws conclusions, makes recommendations, and suggests areas for further research.

5.2 Summary of Main Findings

The first objective sought to compare the effect of CBS teaching strategy and conventional methods on students' achievement in Probability. Descriptive findings specifically, data obtained showed that students in the control group C_1 performed better in the pre-test examination as compared to their counterparts in the experimental group E_1 thus a comparatively higher mean for the control group, $M=17.58$, $SD=11.07$ and $M=14.63$, $SD=11.39$ for the experimental group. This is because both groups were subjected to conventional methods before any treatment with CBS was done. However, on exposure to the intervention, CBS for the experimental group and conventional methods for the control group resulted in students in the experimental group posting achievement levels greater than their counterparts in the control group, $M=43.59$, $SD=16.73$ for the experimental and $M=24.24$, $SD=14.04$ for control respectively, implying that CBS teaching strategy is a better teaching strategy compared to conventional methods. ANOVA results showed that the observed mean difference was significant at 0.05 level of significance, the mean difference being significantly greater in favor of the experimental group. On the whole, data obtained showed that the CBS teaching strategy is a better teaching strategy as compared to conventional methods.

The second objective sought to compare the effect of CBS teaching strategy and conventional methods on students' achievement in Probability based on learner ability. Students were classified as LA and HA based on results obtained from the Pre-test PRESMT administered to the two groups at the beginning of the process. Descriptive data explained the similarity of distribution of the two categories of students, LA and HA students across experimental and control groups in the study. The model used illustrated that ability accounts for 35.4% of the total variance in achievement implying that ability explains about a third of the total variance in achievement. Two-way ANOVA illustrated a significant difference in achievement between high and low-ability students. Specifically, findings illustrated that the achievement levels of HA students were significantly different from those of LA students. Pairwise comparison showed that the effect of CBS was significantly greater for the low achievers in the experimental group compared to those in the control group. In general, therefore, findings illustrated that integration of CBS in the instruction of Probability impacts more low ability than high-ability students.

The third objective set out to examine the effect of CBS on the achievement of students based on their sex. Hypothesis three, H_{03} of the study sought to determine whether there exists a statistically significant difference between the achievements of boys and girls exposed to CBS. Descriptive findings illustrated a fair distribution of students by sex in control and experimental groups. Data obtained showed that the achievement level of girls ($M=16.38$) was slightly

higher than that of boys students ($M=15.76$). This means that girls performed better than boys in the pre-test. Results from the post-test showed that boys in the experimental group posted a higher mean achievement compared to girls in the same group, the mean difference though insignificant. This implies that the use of CBS in instruction in Probability impacts students of different sex similarly thus the insignificant effect across sex.

The fourth objective of the study sought to establish the effect of CBS on the achievement of students based on their attitude. The study's fourth hypothesis was to assess if there was a statistically significant difference in Probability accomplishment between students who had a positive and negative attitude toward Mathematics when they were taught using computer simulation. Students' attitudes toward Mathematics were categorized as positive attitude (PA) or negative attitude (NA) based on the findings of a students' questionnaire (SQ) presented to the students at the start of the study to examine their attitudes toward Mathematics. Data obtained showed that a majority of the students (79.3%) scored highly on the scale of attitude and were thus categorized as PA students compared to those categorized as NA students (20.7%). This finding could be interpreted to imply that a significant proportion of the students have a positive attitude toward Mathematics. The model used illustrated that the effect of CBS in the relationship between CBS and achievement was significant and accounted for 33% of the total variance in achievement in Mathematics. This could be interpreted to mean that attitude is a significant predictor of students' achievement

in Mathematics and the study, it accounted for approximately a third of the total variance in achievement in Mathematics. Descriptive statistics showed a positive change in mean rating for attitude between the pre-test and post-test scores, a shift from $M=3.30$ at the pre-test to $M=3.44$ implying a positive change of 0.14 in the scale of attitude. This could be interpreted to mean that integration of CBS affects positively students' attitudes toward Mathematics. The differences in achievement between students with positive and negative attitudes toward Mathematics were small 0.14 on the scale of attitude, according to the findings. This might be read to mean that using CBS in class affects students with both positive and negative attitudes in the same way, resulting in a negligible effect across attitudes.

The fifth and last objective sought to highlight challenges that could be inhibiting the integration of CBS in teaching and learning of topics in Mathematics with a specific focus on Probability. Results from an interview with teachers showed the extent of integration of CBS tools in teaching and learning Probability to range from below average to an average extent. A participant in the interview lamented the "current deplorable conditions" at his school, which had compelled him to use "ancient methods of teaching Mathematics, such as the lecture technique. Limited CBS resources and high class sizes as a result of student enrollment were two specific implementation problems. Additional problems that affect the usage of CBS tools include "restricted physical infrastructure" and "lack of steady power supply."

5.3 Implications of the Findings

The study's findings imply that because the CBS approach intervention had a positive impact on the Form 3 students' achievement in probability, it can be inferred that, if the CBS approach is fully implemented, students will be more likely to tackle all probabilistic problems and thus achieve better results in probability and mathematics as a whole.

Secondly, the study found out that the Form three students used a conventional approach, using Black wall chalk and talking to the teacher to learn Probability than the CBS approach view, using computer simulation about the teaching and learning of Probability. Yet, after being taught via the CBS intervention, their perspectives became more orientated towards the CBS approach view than the traditional approach view. This suggests that positive improvement in perceptions and attitudes toward probability and mathematics in general will be observed in the classroom if a CBS approach is reinforced in the teaching of probability to students. Initial learner education, according to Barkatsas and Malone (2005), has the potential to change students' prior attitudes about teaching and learning.

The change in divided views and attitudes between Mathematics teachers over the conventional approach and the CBS approach view of Probability teaching and learning implies that a CBS approach has great potential of transforming the Mathematics teacher's views about Probability teaching and learning and Mathematics in general.

Last but not least, rather than being structural, the lack of CBS activities in modules was the biggest hindrance to the implementation of the CBS strategy, along with large class sizes and teachers who were resistant to it. The assumption is that the difficulties will be overcome if the CBS technique is implemented and receives compliance. This advises that fresh instructional materials be created so that math teachers can use CBS exercises with their students.

5.4 Conclusions

From the findings presented and discussed, the study draws five major conclusions. The first objective sought to compare the effect of CBS teaching strategy and conventional methods on students' achievement in Probability. According to descriptive findings, students in the experimental group performed better academically than those in the control group. The experimental group benefitted significantly from the observed mean difference. So, it can be said that, if properly applied, CBS has the potential to improve students' performance in probability and mathematics in general.

The second objective sought to compare the effect of CBS teaching strategy and conventional methods on students' achievement in Probability based on learner ability. Students were classified as low achievers and high achievers.

Two-way ANOVA illustrated a significant difference in achievement between high and low-ability students. Pairwise comparison showed that the effect of CBS

was significantly greater for the low achievers in the experimental group compared to those in the control group implying that CBS impacts more low ability than high-ability students. It can therefore be concluded that if CBS is effectively implemented it would enable low-ability students to do well in probability and Mathematics in general.

The third objective set out to examine the effect of CBS on the achievement of students based on their sex. Results from the post-test showed that boys in the experimental group posted a higher mean achievement compared to girls, the mean difference though insignificant implying that the use of CBS in instruction in Probability impacts students of different sex similarly. It can therefore be concluded that CBS's teaching strategy in school is an effective teaching strategy for both boys and girls.

The fourth objective of the study sought to establish the effect of CBS on the achievement of students based on their attitude. Students' attitudes were classified as positive attitudes (PA) and negative attitudes (NA). Descriptive statistics showed a positive change in mean rating for attitude between pre-test and post-test scores implying that integration of CBS affects positively students' attitudes in Mathematics. However, results from the inferential analysis showed that the differences in achievement between students with a positive and negative attitudes towards Mathematics were insignificant implying that the use of CBS in instruction in Probability impacted students with a positive and negative attitudes.

It can therefore be concluded that the CBS teaching strategy is an effective teaching strategy for learners both with a positive and negative attitudes towards Mathematics.

The last objective sought to highlight challenges that could be inhibiting the integration of CBS in teaching and learning of topics in Mathematics with a specific focus on Probability. The respondents reported that there is a range of below average to average integration of CBS in teaching and studying mathematics. Results showed that factors preventing the use of CBS tools included a lack of adequate physical infrastructure, a lack of reliable power supply, a lack of sufficient physical student enrollment, and big class sizes. According to the study's findings, there are a number of obstacles that must be overcome in order for mathematics teachers to embrace and successfully use the CBS approach as a method of instruction for teaching probability in secondary schools in the Kenyan educational system.

Lastly, a teaching strategy, such as a CBS method or a conventional approach, was incorporated into the conceptual theory of this study as a critical element for raising learners' achievement in probability. Also, it was supposed to have an impact on math teachers' understanding of how probability is taught and learned. Accordingly, based on the study's findings, it can be said that the conceptual framework effectively guided the study, and the desired results an improvement in probability performance and math achievement overall, as well as a shift in

students' perceptions and attitudes toward math learning from the traditional approach to computer-based simulation (CBS) approach were all realized.

5.5 Recommendations

Based on the findings of this study, recommendations are made in two areas namely policy and suggestions for further research.

5.5.1 Policy Recommendations

The study determined that the incorporation of CBS increases students' learning and achievement in probability. Some policy recommendations derived from this study include:

- i. So, in order to profit from the teaching strategy's inherent advantages, it is advised that teachers be encouraged to implement it in their classroom instruction. Teachers in Sub-County and County schools with a preponderance of low-ability children should be given priority during this process as they have been shown by the study to benefit most from CBS.
- ii. The study also showed that the integration of CBS tools in the study's participating schools' teaching and learning of probability and mathematics ranged from below average to average. It is advised that a deliberate effort be made to improve the integration of CBS tools in classroom education since it is essential to achieving the benefits of CBS that the study found to be of enormous benefit.
- iii. The study also showed that there are a number of barriers to the integration of CBS. These factors include the absence of adequate CBS

tools, the huge class sizes caused by student enrolment, the inadequate physical infrastructure, and the irregular power supply. Therefore, it is advised that a diverse strategy be used to lessen the difficulties and assure best practices for minimizing such problems.

5.5.2 Recommendations for Further Research

It is recommended that more investigation be done in the following areas:

- i. A longitudinal study of CBS's effectiveness in secondary schools in Kisii County, Kenya, for teaching and learning other topics in mathematics.
- ii. At public and private schools in Kisii County, Kenya, a comparison of primary school students' mathematics achievement using a CBS-driven curriculum, a traditional-driven curriculum, and a blend of the two.
- iii. Research on how the CBS approach can be utilized to alter mathematics teachers' opinions about how to teach and study probability.

5.6 Chapter Summary

A summary of the study's findings, conclusions, recommendations, and ideas for additional research have all been included in this chapter. Additionally, it has contributed to the international literature in this field of study and created a new field of probability study utilizing the CBS approach in Kenya.

REFERENCES

- Adomi E. E. and Anie S. O. (2006). An Assessment of Computer Literacy Skills of Professionals in Nigerian University Libraries. *Library Hi TechNews*,(23)2:10-14 Available:[http:// www.emeraldinsight.com/Insight/ View Content Servlet? Filename= Published/ Emerald Full Text Article/ Articles/ 2390230203. html](http://www.emeraldinsight.com/Insight/ViewContentServlet?Filename=Published/EmeraldFullTextArticle/Articles/2390230203.html) [18 October 2006]
- Afshari, M., Bakar, K. A., Luan, W. S., Samah, B. A., & Fooi, F. S. (2009). Factors affecting teachers' use of ICT. *Online Submission*, 2(1), 77-104. 201
- Ahiatrogah, P. D., Madjoub, M. B. & Bervell, B. (2013). Effect of Computer Assisted Instruction on the Achievement of Basic School Students in Pre- Technical Skills. *Academic Journal of Interdisciplinary*
- Ahiatrogah, P. D., Madjoub, M. B. & Bervell, B. (2013). Effects of computer assisted instruction on the achievement of basic school students in pre-technical skills. *Academic Journal of Interdisciplinary Studies*, 2 (1),77-86.
- Ahmad, A. (2010). The effect of using a e-lab on the physics concepts achievement, acquisition of higher-order thinking skills and motivation toward science learning among students of the third preparatory class, *Scientific Journal of Education*, 13(6), 1-46, Egypt.
- Ajewole, G. A., Oginni, A. M., & Okedeyi, A. S. (2006). Management of resources for science, technology, and mathematics education:

- Problems and way forward. In *Science Teachers Association of Nigeria Annual Conference Proceedings* (p. 67). Science Teachers Association of Nigeria.
- Akala, J. (2000). The agony of teaching mathematics. *Kenya Times*, 16(1).
- Akinsola, M. K., & Olowojaiye, F. B. (2008). Teacher Instructional Methods and Student Attitudes towards Mathematics. *International Electronic Journal of Mathematics Education*, 3(1), 60-73. <http://www.iejme.com/download/teacher-instructional-methods-and-student-attitudes-towards-mathematics.pdf>
- Alessi, S. M., & Trollip, S. R. (2001). Simulations. *Multimedia for Learning (Methods and Development)*, 213-269.
- Ali, M., & Zamzuri, A. (2007). Kesan koswer strategi animasi pelbagai kawalan penggunaan terhadap prestasi kognitif dan ketekalan pelajar. Tesis ijazah Doktor Falsafah, Universiti Sains Malaysia, Pulau Pinang.
- Allport, G. W. (1935). *Handbook of Social Psychology*. Worcester, MA: Clark
- Andriani, D., Widada, W., Herawaty, D., Ardy, H., Nugroho, K. U. Z., Ma'rifah, N., & Anggoro, A. F. D. (2020). Understanding the number concepts through learning Connected Mathematics (CM): A local cultural approach. *Universal Journal of Educational Research*, 8(3), 1055-1061.
- Anthony, L. M., Clarke, M. C., & Anderson, S. J. (2000). Technophobia and personality subtypes in a sample of South African university students. *Computers in Human Behavior*, 16(1), 31-44.

- Ardac, D. & Sezen, A. H. (2002). Effectiveness of computer-based chemistry instruction in enhancing the learning of content and variable control under Guided versus Unguided conditions. *Journal of Science and Technology*, 11(1), 39-48.
- Ash, J. E. (2005). *The effects of computer-assisted instruction on middle school mathematics achievement* (Unpublished doctoral dissertation). Tennessee State University. Nashville, TN.
- Aunola, K. E., Leskinen, E., Lerkkanen, M.-K., & Nurmi, J.-E. (2008). Developmental dynamics of math performance from preschool to grade 2. *Journal of Educational Psychology*, 84, 261–271.
- Ayalon H., Livnah I. (2013). Educational Standardization and Gender Differences
- Ayere M. A, Odera F. Y., & Agak J. O. (2010). E-learning in secondary schools in Kenya: A case of the NEPAD E-schools. *Educational Research and Reviews*, 5(5), 218-223.
- Babbie, E. and Mouton, J. (2003). *The practice of Social Research*. Cape Town: Oxford University Press. p. 261.
- Bachar S. (2012). Gender and Gender Equality in Education, To Study Scientific and Technological Subjects in Gender Segregation. <http://cms.education.gov.il/EducationCMS/Units/Shivion/MaagareyMeidaMadaVetechnologyaBehafradaMigdarit.htm> (Hebrew)
- Bakhtin, M. M. (1984). *Problem of Dostoevsky's poetics*. Minneapolis, MN:University of Minnesota Press.

- Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child development*, 72(1), 187-206.
- Banks, J. A. (2013). The nature of multicultural education. *Multicultural education: Issues and perspectives*, 3-24.
- Barkatsas, A., & Malone, J. (2005). A typology of mathematics teachers' beliefs about teaching and learning mathematics and instructional practices. *Mathematics Education Research Journal*, 17(2), 69-90.
- Bartels, M., Rietveld, M. J. H., Van Baal, G. C. M., & Boomsma, D. I. (2002b). Heritability of educational achievement in 12-year-olds and the overlap with cognitive ability. *Twin Research*, 5, 544–553.
- Batanero, C., Burrill, G., & Reading, C. (2011). Overview: challenges for teaching statistics in school mathematics and preparing mathematics teachers. *Teaching Statistics in School Mathematics- Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study*. London: Springer, 407-418.
- Batanero, C., Godino, J. D., & Roa, R. (2004). Training teachers to teach
- Batanero, C., Henry, M., & Parzysz, B. (2005). The nature of chance and probability. In G.A. Jones (Ed.), *Exploring probability in school: Challenges for teaching and learning* (pp.15–37). New York: Kluwer/ Springer Academic Publishers.

- Bauer, J., & Kenton, J. (2005). Toward technology integration in the schools: Why it isn't happening. *Journal of Technology and Teacher Education*, 13(4), 519–546
- Becta. (2004). A Review of the Research Literature on Barriers to the Uptake of ICT by Teachers. *British Educational Communication and Technology Agency*.
- Bednar, A. K., Cunningham, D., Duffy, R. M., & Perry, J. D. (1995). *Theory into practice: How do we link?* In G. J. Anglin (Ed.), *Instructional Technology: Past, present, and future* (2nd ed., pp. 100-112). Englewood, CO: Libraries Unlimited, Inc
- Begg, A., & Edwards, R. (1999, December). Teachers' idea about teaching statistics. *Paper presented at the combined annual meeting of the Australian Association for Research in Education and the New Zealand Association for Research in Education*. Melbourne, Australia.
- Beggs, (2000). *What the Research says about using ICT in Geography*. Coventry: Becta.
- Beilock S.L., Gunderson E.A., Ramire G., Levine, S.C. (2010). *Female Teachers Math Anxiety Acts Girls Math Achievement*. „PNAS” February, Vol. 107, No. 5, s. 1860–186
- Benson, C. T., & Jones, G. A. (1999). Assessing students' thinking in modelling probability contexts. *The Mathematics Educator*, 4(2), 1-21.
- Ben- Zvi, D., & Garfield, J. (2008). Introducing the emerging discipline of statistics education. *School Science and Mathematics*, 108(8), 355-361.

- Bhagwan, D. (2005). *Educational uses of Information and Communication. Encyclopaedia of educational techniques and methodology*. New Delhi: Anmol Publication.
- Biehler, R., (1991). Computers in probability education. In R. Kapadia, & M. Borovcnik (Eds.), *Chance encounters - Probability in education* (pp. 169–211). Dordrecht: Kluwer.
- Bihan-Poudec, A., & Dutarte, P. (2014, July). What did they learn? Statistics skills: From French secondary school to university. In *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics (ICOTS9)*.
- Bosco, J., & Morrison, J. E. (2000). *Contexts for training*. In S. Tobias, & J. D. Fletcher (Eds.), *Training & retraining: A handbook for business, industry, government, and the military* (pp.25-50). New York: Macmillian Reference USA.
- Boster, F. J., Meyer, G. S., Roberto, A. J., & Inge, C. C. (2002). A report on the effect of the united streaming application on educational performance. *Technical Report*. Retrieved from http://www.unitedstreaming.com/home/pdf/1a_summary.pdf.
- Bovée, C., Voogt, J., & Meelissen, M. (2007). Computer attitudes of primary and secondary students in South Africa. *Computers in Human Behavior*, 23(4), 1762-1776.

- Brophy, J. (1999). Toward a model of the value aspects of motivation in education: Developing appreciation for.. *Educational psychologist*, 34(2), 75-85.
- Brown, J. S., Collins, A., & Duguid, P. (1989). *Situated cognition and the culture of learning*. *Educational Researcher*, 18, 32-42.
- Brown, L. I., & Kanyongo, G. Y. (2010). Gender differences in performance in mathematics in Trinidad and Tobago: Examining affective factors. *International Electronic Journal of Mathematics Education*, 5, 113–130.
- Brussels: EACEA/Eurydice. *Encyclopedia Britannica*. (2017). *Computer Assisted Instruction (CAI)*. Retrieved January 3, 2017 at <https://www.britannica.com>.
- Buabeng-Andoh, C. (2012). An exploration of teachers' skills, perceptions and practices of ICT in teaching and learning in the Ghanaian second-cycle schools. *Contemporary Educational Technology*, 3(1), 36-49.
- Burgess, J. P. (2014). Quine's Philosophy of Logic and Mathematics. *A Companion to WVO Quine*, 279-295.
- Burgess, S., Greaves, E., & Vignoles, A. (2019). School choice in England: evidence from national administrative data. *Oxford Review of Education*, 45(5), 690-710.
- Carmona, J., Martínez, R. J., & Sánchez, M. (2005). Mathematical background and attitudes toward statistics in a sample of Spanish college students. *Psychological reports*, 97(1), 53-62.

- Chang, K., Chen, I., & Sung, Y. (2002). The effect of concept mapping to enhance text comprehension and summarization. *The Journal of Experimental Education* 71(1), 5-23.
- Charagu, S. N. (2015). *Effects of computer assisted learning on secondary school students' achievement in Chemistry in Murang'a South Sub-county, Murang'a County, Kenya*. Unpublished MED thesis, Kenyatta University, Nairobi.
- Chen, R. J. (2010). Investigating models for preservice teachers' use of technology to support student-centered learning. *Computers & Education* in Press.
- Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. *Statistics Education Research Journal*, 9(1), 6-26.
- Christensen, R. W., & Knezek, G. A. (2009). Construct validity for the teachers' attitudes toward computers questionnaire. *Journal of computing in Teacher Education*, 25(4), 143-155.
- Christenson, Sinclair, Lahr, and Godber, McGraw-Hill. (2007). *Missouri Assessment Program Technical Report 2007* (Rep.). Retrieved dese.mo.gov/div/improve/.../Final%20MAP%20Tech%20Report.pdf
- Chumba, A. K., Omwenga, E. N., & Atemi, G. (2020). Effects of using computer simulations on learners' academic achievement in physics in secondary schools in Ainamoi Sub-County, Kericho County. *Journal of Research Innovation and Implications in Education*, 4(1), 126-138.

- Cohen Chapman, J. W., & Tunmer, W. E. (1997). A longitudinal study of beginning reading achievement and reading self-concept. *British Journal of Educational Psychology*, 67, 279–291. Clark, D. M. (1997).
- Cohen, J. (1992). A power primer. *Psychological bulletin*, 112(1), 155.
- Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. Milton Park. Abingdon, Oxon,[England]: Routledge.
- Cohen, S. (2003). *Report on the Use of ICTs in Schools Research Project*. Johannesburg: South African Institute for Distance Education (SAIDE).
- Cooper, P. A. (1993). *Paradigm shifts in designing instruction: From behaviorism to cognitivism to constructivism*. *Educational Technology*, 33(5), 12–1
- Creswell, J. W. (2009). *Research design: Qualitative, quantitative and mixed methods approaches* (3rd ed.). London: Sage.
- Danielsen, A. G., Wium, N., Wilhelmsen, B., & Wold, B. (2010). Perceived support provided by teachers and classmates and students' self-reported academic initiative. *Journal of School Psychology*, 48,247–267.
- Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2007). Intelligence and educational achievement. *Intelligence*, 35(1), 13-21.
- Demirci, A. (2009). How do teachers approach new technologies: Geography teachers' attitudes towards Geographic Information Systems (GIS). *European Journal of Educational Studies*, 1(1), 43-53.
- Denzin, N. K., & Lincoln, Y. S. (Eds.). (2000). *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.
- Derry, S. J. (1996). Cognitive schema theory in the constructivist debate. *Educational Psychologist*, 31(3-4), 163-174.

- Devine, F. (2002). Qualitative methods. In D. Marsh & G. Stoker (Eds.), *Theory and methods in political science* (2nd ed., pp. 197-215). New York, NY: Palgrave Macmillan.
- Dexter, S., & Riedel, E. (2003). Why improving preservice teacher educational technology preparation must go beyond the college's walls. *Journal of teacher education*, 54(4), 334-346.
- Dhamija, N. (2016). Development and Efficacy of Computer-Assisted Instructional Modules for IX Class Students. *Remarking*. 2(10), 100-03.
- Divaharan, S., & Koh, J. H. L. (2010). Learning as students to become better teachers: Pre-service teachers' IWB learning experience. *Australasian Journal of Educational Technology*, 26(4).
- Dobbs, M. (2004, December 7). In a global test of math skills, U.S. students behind the curve. *Washington Post*. Retrieved from <http://www.washingtonpost.com/wpdyn/articles/A41278-2004Dec6.html>
- Downes, S. (2006). *An introduction to connective knowledge*. Retrieved March 6, 2007, from <http://www.downes.ca/post/33034>
- Downey, D. B., & Vogt Yuan, A. S. (2005). Sex differences in school performance during high school: puzzling patterns and possible explanations. *Sociological Quarterly*, 46(2), 299–321.
- Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education*, 51(1), 187-199. 210

- Duffy, T. M., & Cunningham, D. J. (1996). *Constructivism: Implications for the design and delivery of instruction*. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 170–198). New York: Simon & Schuster Macmillan.
- EACEA (2011). *Science Education in Europe: National Policies, Practices and Research*.
- Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Fort Worth, TX: Harcourt, Brace, Jovanovich.
- Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *Educational technology-Saddle Brook then Englewood Cliffs NJ-*, 42(1), 5-13.
- Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual review of psychology*, 53(1), 109-132.
- Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration?. *Educational technology research and development*, 53(4), 25-39.
- Erwin, J. (1993). *Friendship and peer relationship in children*. England: John Wiley & Sons Ltd.
- Eshiwani, G. S. (1982). *A study of Women's Access to higher Education in Kenya with a special reference to Mathematics and Science Education*. Bureau of Education research, Nairobi.
- Fakomogbon, M. A., Omiola, M. A., Awoyemi, S. O., & Mohammed, R. E. (2014). Effect of computer assisted instructional package on the

- performance of students in mathematics in Ilorin metropolis. *European Scientific Journal, ESJ*, 10(25), 196-206.
- FAWE (1999). *Improving Performance of Girls in Schools*. A Report. Nairobi, Kenya.
- Fengfeng, K. (2008). *A case study of computer gaming for math: Engaged learning from gameplay?* (Doctoral dissertation, University of New Mexico) (pp. 1609-1620). *Computers & Education*. doi: doi: 10.1016/j.physletb.2003.10.071
- Feyzioglu, B. (2009). An investigation of the relationship between science process skills with efficient laboratory use and science achievement in chemistry education. *Journal of Turkish Science Education*, 6 (3).
- Fischbein, E. & Schnarch, D. (1997). The evolution with age of probabilistic, intuitively based misconceptions. *Journal for Research in Mathematics Education*, 28, 96-105
- Fong, S. F., Por, F. P., & Tang, A. L. (2012). Effects of multiple simulation presentation among students of different anxiety levels in the learning of probability. *TOJET: The Turkish Online Journal of Educational Technology*, 11(3), 103-115.
- Franklin, C. A., & Garfield, J. (2006). The GAISE project: Developing statistics education guidelines for grades pre-K-12 and college courses. *Thinking and reasoning with data and chance*, 345-376.
- Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics – A “hopeless” issue? A control value approach to gender differences in

- emotions towards mathematics. *European Journal of Psychology of Education*, 22, 497–514.
- Gagne, R. M. (1977). *The conditions of learning (3rd ed.)*. New York: Holt, Rinehart, and Winston. Gagne, R. M. (1985). *The conditions of learning (4th ed.)*. New York: Holt, Rinehart, and Winston.
- Gal, I. (2005). Towards “probability literacy” for all citizens: Building blocks and instructional dilemmas. In G. A. Jones (Ed.), *Exploring probability in school. Challenges for teaching and learning* (pp. 39–63). Dordrecht, The Netherlands: Kluwer.
- Gambari, A. I. (2010). *Effects of computer supported cooperative learning strategy on the performance of senior secondary students in physics in Minna, Nigeria* Doctoral dissertation. University of Ilorin, Ilorin.
- Garfield, J., & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for research in Mathematics Education*, 44-63.
- Garfield, J., & delMas, R. (1989). Reasoning about chance events: assessing and changing students’ conception of probability. In C. Maher, G. Goldin, and B. Davis (Eds.), *The Proceedings of the Eleventh Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Volume II*, 189-196, Rutgers University Press.

- Garrison, J. (1998). *Toward a pragmatic social constructivism*. In M. Larochelle, N. Bednarz, & J. Garrison (Eds.), *Constructivism and education* (pp. 3-60). Cambridge, UK: Cambridge.
- Gergen, K. J. (1995). Social construction and the educational process. In L. P. Georgiou, S. N., Stavriniades, P., & Kalavana, T. (2007). Is Victor better than Victoria at maths? *Educational Psychology in Practice*, 23(4), 329-342.
- Gherasim, L. R., Butnaru, S., & Mairean, C. (2013). Classroom environment, achievement goals and maths performance: gender differences. *Educational Studies*, 39, 1–12.
- Gomes, C. (2005). *Integration of ICT in science teaching: A study performed in Azores, Portugal. Recent Research Developments in Learning Technologies*. Government of Ghana. (2003).
- Gómez-Chacón, I. M. (2000). Affective influences in the knowledge of mathematics. *Educational Studies in Mathematics*, 43, 149–168.
- Gordon, J. (2003). E-learning tagged as best corporate. IT investment. *e- learning*, 4(1), 8.
- Gray M. (2009). Only Girls in the Class – Higher Achievements. <http://www.mako.co.il/homefamily-kids/education/Article-5a90efde95e2021006.htm> March 22. (Hebrew)
- Guzdial, M., & du Boulay, B. (2019). The History of Computing. *The Cambridge handbook of computing education research* (2019), 11.

- Hansen, B. B., & Klopfer, S. O. (2006). Optimal full matching and related designs via network flows. *Journal of computational and Graphical Statistics*, (3), 609-627.
- Hare, H. 2007, 'ICT in education in Tanzania', in G. Farrell, S. Isaacs & M. Trucano (ed.), *Survey of ICT and Education in Africa: 53 Country Reports*, DC: info Dev / World Bank, Washington.
- Harrison, D. (2010). *Developing use of ICT to enhance teaching and learning in East African schools: a review of the literature*. Centre for Commonwealth Education & Aga Khan University Institute for Educational Development – Eastern Africa Research Report No. 1
- Hazan O. (2010). Gender Segregation: For and against. On the Agenda: The Female Angle. <http://www.asimon.co.il/ArticlePage.aspx? AID=8185> (Hebrew)
- Hein, George E. (1991). Constructivist Learning Theory. Paper presented to the international Committee of Museum Educators. Jerusalem Israel.
 etrieved from <http://www.exploratorium.edu/IFI/resources/constructivistlearning.html>
- Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (2002). *Instructional media and technologies for learning*. NJ: Pearson Education.
- Hennessy, S., Harrison, D., & Wamakote, L. (2010). Teacher factors influencing classroom use of ICT in Sub-Saharan Africa. *Itupale online journal of African studies*, 2(1), 39-54.

- Henriques, L. (2002). Children's ideas about weather: A review of the literature. *School Science and Mathematics, 102*(5), 202-215.
- Hesselmark, O. 2003. ICT in Five African countries. [Online] Available: http://www.com.washington.edu/ict4d/upload/2004041522570097_00140794.pdf [17 August 2006].
- Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223-252.
- Hicks, B. L. & Hunka, S. (1972). *The Teacher and the Computer*. London, W.B. Saunders Company.
- Hooper, S. & Rieber, L. P. (1995). *Teaching with technology*. In A. Ornstein (Ed.), *Theory and practice of teaching* (pp. 154-170). New York: Allyn & Bacon
- Hooper, S., & Hannafin, M. J. (1991). *The effects of group composition on achievement, interaction, and learning efficiency during computer used cooperative instruction*. *Educational Technology Research and Development, 39*(3), 27-40.
- Hootstein, E. W. (1994). Motivating middle school students to learn. *Middle School Journal, 25*(5), 31-34.
- Huang, H. M., & Liaw, S. S. (2005). Exploring users' attitudes and intentions toward the Web as a survey tool. *Computers in Human Behavior, 21*(5), 729-743.

- Hudig, J., Scheepers, A. W., Schippers, M. C., & Smeets, G. (2021). Motives for studying and student wellbeing: Validation of the motivational mindset model. *Frontiers in Psychology, 12*, 753987.
- Hung, D, Looi, C. K., & Koh, T. S. (2004). Situated cognition and communities of practice: First-person ‘lived experiences’ vs. third-person perspectives. *Educational Technology & Society, 7(4)*, 193–200
- Hung, D., & Khine, M. S. (Eds.). (2006). *Engaged learning with emerging technologies*. Springer.
- Huntley, M. A., Rasmussen, C. L., Villarubi, R. S., Sangtong, J., & Fey, J. T. (2000). Effects of standards-based mathematics education: A study of the Core-Plus Mathematics Project algebra and functions strand. *Journal for Research in Mathematics Education, 31(3)*, 328-361.
- Hussain, S. Ali, R. Khan, M. Ramzan, M., & Qadeer, Z. (2011). Attitude of secondary school teachers towards teaching profession. *International Journal of Academic Research. 3(1)*, 985-990.
- Hykle, J.A. (2011). Interrelationships among Cognitive Controls, Gender Science Achievement, and Science Process Skills. University of Cincinnati. in Mathematics Achievement: A Comparative Study. „Social Science” 42,
- Jacobbe, T., & Horton, R. M., (2010). Elementary school teachers’ comprehension of data displays. *Statistics Education Research Journal, 9*, 27-45.
- Jencks, C. (1979). *Who gets ahead? The determinants of economic success in America*. New York: Basic Books

- Jesse, S. N., Twoli, N. W. & Maundu, J. N. (2014). Enhancement of science performance through computer assisted instruction among selected secondary school learners in Kenya. *Kentucky Journal of Excellence in College Teaching and Learning*, 12(4), 40-51.
- John Dewey (1896) *The early works (Vol. 5. pp. 96-109)*. Carbondale: Southern Illinois University Press.
- John, P. (2002). Quantitative methods. In D. Marsh & G. Stoker (Eds.), *Theory and methods in political science* (2nd ed., pp. 184-211). New York, NY: Palgrave Macmillan.
- Johnson, D. W., & Johnson, R. T. (1996). Cooperation and the use of technology. In D. H.
- Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2010). The horizon report.
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 3(7), 14-26.
- Jonassen, D. H., Carr, C., & Hsiu-Ping, Y. (1998). Computers As Mindtools For Engaging Learners In Critical Thinking. *TECH Trends-Washington DC-*, 43, 24-32.
- Jones, A. (2004). A Review of the research literature on barriers to the uptake of ICT by teachers. *British Educational Communications and Technology Agency*. Retrieved May 20, 2015 from <http://www.becta.org.uk>. 218

- Jones, G. A., Langrall, C. W., & Mooney, E. S. (2007). Research in probability: Responding to classroom realities. *Second handbook of research on mathematics teaching and learning*, 2, 909-955.
- Joseph, G. (2013). A Study on School Factors Influencing Students' Attitude Towards Learning Mathematics in the Community Secondary Schools in Tanzania: The case of Bukoba Municipal Council in Kagera Region. (Masters dissertation). Retrieved from <http://repository.out.ac.tz/919/>
- Jules-Van-Belle & Soetaert, 2001. Breakdown into the virtual user- involved design and learning. *Journal of Technology and Teacher Education*, 8(2), 31-42.
- Kans, M., & Claesson, L. (2022). Gender-Related Differences for Subject Interest and Academic Emotions for STEM Subjects among Swedish Upper Secondary School Students. *Education Sciences*, 12(8), 553.
- Kareem, A. A. (2015). Effects of Computer Assisted Instruction on Students' Academic Achievement and Attitude in Biology in Osun State, Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies*, 6(1), 69-73.
- Kargiban, Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, 5, 201-232
- Kauchak, D. & Eggen, P. D. (1993). *Learning teaching. Research-based methods*, 6th ed. Boston: Pearson.

- Kazima, M. (2006). Students' perceptions of fairness in probability games. *African Journal of Research in Mathematics, Science and Technology Education*, 10(1), 25-35.
- Kiboss, J. K., & Tanui, E. K. (2013). Effects of e-learning program in accounting on students' achievement and motivation to learn double entry bookkeeping. *Journal of Education and Practice*, 4(9), 50-57.
- Kirby, P. C. (2004b). *Comparison of I CAN Learn® and traditionally-taught 8th grade student performance on the Georgia Criterion-Referenced Competency Test*. New Orleans, LA: Ed-Cet, Inc.
- Kiwanuka, H. N., Van Damme, J., Anumendem, D. N., Van Den Noortgate, W., Namusisi, S. (2015). Factors affecting Mathematics achievement of first-year secondary school students in Central Uganda. *South African Journal of Education*, 35(3), 1-16.
- Konold, C. (1989). Informal conceptions of probability. *Cognition and Instruction*, 6, 59–98.
- Konold, C., Pollatsek, A., Well, A., Lohmeier, J., & Lipson, A. (1993). Inconsistencies in students' reasoning about probability. *Journal for Research in Mathematics Education*, 24, 392-414.
- Koparan, T., & Yilmaz, G. K. (2015). The Effect of Simulation-Based Learning on Prospective Teachers' Inference Skills in Teaching Probability. *Universal Journal of Educational Research*, 3(11), 775-786.

- Korte, W. B., & Husing, T. (2007). Benchmarking access and use of ICT in European schools 2006: Results from head teacher and a classroom surveys in 27 European countries, *elearning papers*, 29(10), 1-6.
- Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
- Krishnamachari, S. (1988). *The use of computer simulations in teaching probability*. Unpublished doctoral dissertation Teachers College, Columbia University, New York.
- Kulik, C. & Kulik, J (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior*, 7, 75-95.
- Kundu, A., and Ghose, A. (2016). The Relationship Between Attitude and Self Efficacy in Mathematics Among Higher Secondary Students. *IOSR Journal of Humanities and Social Science (IOSR-JHSS) Volume 21, Issue 4, Ver. 05 PP 25-31*
- Kunene, H., & Bansilal, S. (2011). Grade 11 Mathematics Learners Approaches to Working with Vertical and Horizontal Shifts of Parabolas. *Mathematics, Science and Technology Education for Empowerment and Equity*, 159.
- Kupari, P., & Nissinen, K. (2013). Background factors behind mathematics achievement in Finnish education context: Explanatory models based on TIMSS 1999 and TIMSS 2011 data. IEA CONFERENCE 2013, Proceedings. Retrieved from

https://www.iea.nl/fileadmin/user_upload/IRC/IRC_2013/Papers/IRC2_013_Kupari_Nissinen.pdf

- Lamb, S., & Fullarton, S. (2001). Classroom and school factors affecting mathematics achievement: A comparative study of the US and Australia using TIMSS of the US and Australia using TIMSS. *Australian Council for Educational Research*.
- Lee, H. S., Rider, R. L., & Tarr, J. E. (2005). Making connections between empirical data and theoretical probability: Student's generation and analysis of data in a technological environment. *Manuscript currently under review*.
- Li, M., Zhang, Y., Liu, H., & Hao, Y. (2018). Gender differences in mathematics achievement in Beijing: A meta-analysis. *British Journal of Educational Psychology*, 88(4), 566-583.
- Liao, Y.C. (2007). Effects of computer-assisted instruction on students' achievement in Taiwan: A meta-analysis. *Computer and education*, 48, 216-233.
- Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in (2004) gender and performance in mathematics: A meta-analysis. *Psychological Bulletin*, 136, 1123–1135.
- Lindgren, R., & Schwartz, D. L. (2009). Spatial learning and computer simulations in science. *International Journal of Science Education*, 31(3), 419-438.

- Linn, M. C., Chang, H. Y., Chiu, J., Zhang, H., & McElhaney, K. (2010). Can desirable difficulties overcome deceptive clarity in scientific visualizations? *Successful remembering and successful forgetting: A Festschrift in honor of Robert A. Bjork*, 239-262.
- Lipnevich, A. A., MacCann, C., Krumm, S., Burrus, J., & Roberts, R. D. (2011). Mathematics attitudes and mathematics outcomes of US and Belarusian middle school students. *Journal of Educational Psychology*, 103(1), 105-118.
- Liu, Y. & Thompson, P. (2007). Teachers' understanding of probability. *Cognition and Instruction*, 25, 113-160.
- Mahmud, R., & Ismail, M. A. (2010). Impact of training and experience in using ICT on in-service teachers' basic ICT literacy. *Malaysian Journal of Educational Technology*, 10(2), 5-10.
- Mann, D., Shakeshaft, C., Becker, J., & Kottkamp, R. (1999). *West Virginia's basic skills/ computer education program: An analysis of student achievement*. Santa Monica, CA: Milken Family Foundation.
- Manuguerra, M., & Petocz, P. (2014). Learning and teaching probability in the 21st Century. *Macquarie University, NSW Australia. ICOTS9*.
- Marsh, H. W., Martin, A. J., and Cheng, J. H. (2008). A multilevel perspective on gender in classroom motivation and environment: Potential benefits of male teachers for boys? *Journal of Educational Psychology*, 100, 78–95.

- Martin, M.O., Mullis, S. & Foy, P. (2008). *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
- Marzano, R. J. (1998). *A theory-based meta-analysis of research on instruction*. Aurora, CO: Mid-continent Regional Educational Laboratory.
- Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child development research*, 1-10.
- Mathematical Sciences Education Board. (1990). *Reshaping school mathematics: A philosophy and framework for curriculum*. Washington, DC: National Academy Press
- Mathew Myers, J., & Halpin, R. (2002). Teachers' attitudes and use of multimedia technology in the classroom: Constructivist-based professional development training for school districts. *Journal of Computing in Teacher Education*, 18(4), 133-140.
- Mauro, C. (1994). *Teacher Development in Computer Based Education: Helping others to excel*. M.Ed Thesis, University of Lethbridge Nduati, C. S. (2015).
- Mayer, R. E. (1996). Learners as information processors: Legacies and limitations of educational psychology's second metaphor. *Educational Psychologist*, 31(3/4),

- Mazana, Y. M., Suero Montero, C., & Olifage, C. R. (2019). Investigating students' attitude towards learning mathematics.
- McDowall, T., & Jackling, B. (2010). Attitudes towards the accounting profession: an Australian perspective. *Asian Review of Accounting*, 18(1), 30-49.
- McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp.575-596). New York, NY: Macmillan.
- McNabb, D. E. (2004). Research methods for political science: Quantitative and qualitative methods. New York, NY: M.E. Sharpe, Inc.
- Merriam, S. B., & Caffarella, R. S. (1999). *Learning in adulthood: A comprehensive guide (2nd.)*. San Francisco: Jossey-Bass Publishers.
- Mezirow, J. (1991). *Transformative dimensions of adult learning*. San Francisco, CA: Jossey-Bass
- Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research. *Journal for research in Mathematics Education*, 30(1), 65-88.
- Midgley, C., & Urdan, T. C. (1995). Predictors of middle school students' use of self-handicapping strategies. *Journal of Early Adolescence*, 15, 389–411.

- Mignani, S., Ottaviani, M. G., & Ricci, R. (2014). Teaching statistics at secondary education in Italy: Some issues on large scale standardized test results. *ICOTS9*.
- Miheso, M. (2002). Factors Affecting Mathematics Performance Among Secondary Schools Learners, In Nairobi Province, Kenya. *npublished*.
M. Ed. Thesis. Kenyatta University, Nairobi.
- Mihindo, W. J., Wachanga, S. W., & Anditi, Z. O. (2017). Effects of Computer-Based Simulations Teaching Approach on Students' Achievement in the Learning of Chemistry among Secondary School Students in Nakuru Sub County, Kenya. *Journal of Education and Practice*, 8(5), 65-75.
- Miller, T. (2009). *Television studies: The basics*. Routledge.
- Moore, D. S. (1997). New pedagogy and new content: The case of statistics. *Internationa statistical review*, 65(2), 123-137.
- Moore, P., & Fitz, C. (1993). Gestalt theory and instructional design. *Journal of Technical Writing and Communication*, 23(2), 137-157
- Morgil, I., Yavuz, S., Oskay, Ö. Ö., & Arda, S. (2005). Traditional and computer-assisted learning in teaching acids and bases. *Chemistry Education Research and Practice*, 6(1), 52-63.
- Morrison, G. R., Ross, S. J., Morrison, J. R., & Kalman, H. K. (2019). *Designing effective instruction*. John Wiley & Sons.
- Moshman, D. (1982). Exogenous, endogenous, and dialectical constructivism. *Developmental Review*, 2, 371-384

- Mugenda, O. M. (1999). *Research methods: Quantitative and qualitative approaches*. African Centre for Technology Studies.
- Mugenda, O., & Mugenda, A. (2003). *Research methods: Quantitative and Qualitative methods*. Nairobi: Acts Press.
- Murphy, K. L., & Cifuentes, L. (2001). Using web tools, collaborating, and learning online. *Distance Education*, 22(2)
- Mwalongo, A. (2011). Teachers' perceptions about ICT for teaching, professional development, administration and personal use. *International Journal of education and development using information and communication echnology*, 7(3), 36.
- Mwei, K.P., Too, K.J. & Wando, D. (2011). The effect of computer-assisted instruction on students' attitudes and achievement in matrices and transformations in secondary schools in UasinGishu District, Kenya. *International Journal of Curriculum and Instruction*, 1 (1), 53-62
- Namlu, A., & Ceyhan, E. (2002). *Computer anxiety: A study on university students*. Eskisehir: Anadolu University Publishing.
- National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. Reston, VA: Author
- Naylor, C. (2001). *Teacher workload and stress: An international perspective on human costs and systemic failure*. BCTF Research Report. Retrieved March 04, 2023, from <https://files.eric.ed.gov/fulltext/ED464028.pdf>
- Nduati, C. S. (2015). *Effect of Computer Assisted Learning on Secondary School Students' Achievement in Chemistry in Murang'a South Sub-County*,

Murang'a County, Kenya (Unpublished MED Thesis: Kenyatta University; Nairobi).

Necessary, J. R., & Parish, T. S. (1996). "The relationships between computer usage and computer-related attitudes and behaviors." *Education*, 116(3), 384-224

Nicolaidou, M., & Philippou, G. (2003). Attitudes towards mathematics, self-efficacy and achievement in problem solving. *European Research in Mathematics Education III. Pisa: University of Pisa*, 1-11.

Norris, C., Sullivan, J., Poirot, T., & Soloway, E. (2003). No access, no use, no impact: Snapshot surveys of educational technology in K-12, *Journal of Research on Technology in Education*, 36(1), 15-27.

Nur, M. A. (2010). Factors that Influence Secondary School Students 'Performance in Mathematics in Banadir Region, Somalia. Unpublished Master 's thesis, Kenyatta University, Nairobi, Kenya.

Nurhikmah H, N. H., Febriati, F., & Ervianti, E. (2021). The Impact of Computer-based Test and Students' Ability in Computer Self-Efficacy on Mathematics Learning Outcomes. *Journal of Education Technology*, 5(4), 603-610.

Ogembo, J. O. (2012). Determinants of Students' Poor Performance in Chemistry in Public Schools of Kwale County, Kenya. Unpublished MED thesis in the School of Education of Kenyatta University, Nairobi.

- Ogembo, J. O. (2017). Effects of Computer Assisted Learning on Instruction in Organic Chemistry in Public Secondary Schools in Kwale County, Kenya. Doctoral dissertation, Kenyatta University, Nairobi.
- Oginni, O. I., & Popoola, A. A. (2013). Effects of Mathematics Innovation and Technology on Students Academic Performance in Open and Distance Learning (ODL). oasis.col.org
- Ojeda, L., & Flores, L. Y. (2008). The influence of gender, generation level, parents' education level, and perceived barriers on the educational aspirations of Mexican American high school students. *The Career Development Quarterly*, 57(1), 84-95.
- Olakanmi, E. E., Gambari, I. A., Gbodi, E. B. & Abalaka, E. A. (2016). Promoting intrinsic and extrinsic motivation among chemistry students using computer assisted instruction. *International Journal in Education Science*, 12(2), 155-168.
- Olga, P. (2008). *The effects of computer-assisted instruction on the Achievement, attitudes and retention of fourth grade Mathematics course*. A PhD Thesis, Middle East Technical University.
- Onatsu-Arvillomi, T. P., & Nurmi, J.-E. (2002). The development of achievement strategies and academic skills during the first year of primary school. *Learning and Instruction*, 12, 509–527.
- Ormrod, J. E. (1999). *Human learning* (3rd ed.). Upper Saddle River, NJ: rentice-Hall

- Orora, W., Keraro, F. N., & Wachanga, S. W. (2014). Effects of cooperative e-learning teaching strategy on students' achievement in secondary school Biology in Nakuru County, Kenya. *Sky Journal of Educational Research*. 2(1), 001-009.
- Otach, O. (2008). Abolishing school fees in Africa: Lessons from Ethiopia. Ghana, Kenya, Malawi and Mozambique.
- Otieno, K. O. (2010). Teaching/learning resources and academic performance in mathematics in secondary schools in Bondo District of Kenya. *Asian social science*, 6(12), 126.
- Palloff, R. M., & Pratt, K. (1999). *Building learning communities in cyberspace*. San Francisco, CA: Jossey-
- Papanastasiou, E.C., & Angeli, C. (2008). "Evaluating the use of ICT in Education: Psychometric properties of the survey of factors affecting 227
- Papert, S. (2nd Ed.) (1993). *Mindstorms: Children, computers, and powerful ideas*. New York: Harper Collins Publishers
- Patel D. B. (2013). "Construction and effectiveness of computer aided instruction (CAI) programme for the units of science and technology of standard VIII", *International Journal of Research in Education*, Vol. 2, Issue 1, pp. 112–115.
- Pawlak, M. (2022). Research into Individual Differences in SLA and CALL: Looking for Intersections. *Language Teaching Research Quarterly*, 31, 200-233.

- Pedretti, E., Mayer-Smith, J., & Woodrow, J. (1999). Teaming technology enhanced instruction in the science classroom and teacher professional development. *Journal of Technology and Teacher Education*, 7(2), 131- 143.
- Pelgrum, W. J. (2001). *Obstacles to the integration of ICT in education: results from a worldwide educational assessment*. *Computers & Education*, 37, 163- 178.
- Pelgrum, W. J. (2005). *ICT Integration, Data from International Cooperative Studies*. *Computers & Education*, 37
- Pelgrum, W.J. & Plomp, Tj. (1991) *The use of computers in education worldwide Results from the IEA "Computers in Education" survey in 19 educational systems* Oxford Pergamon Press
- Pepper, S.C. (1942). *World hypotheses: A study in evidence*. Berkeley, CA: University of California Press.
- Pereira-Mendoza, L. (2002). Would you allow your accountant to perform surgery? Implications for the education of primary teachers. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on the Teaching of Statistics*. Hawthorn, VIC: International Statistical Institute.
- Pfannkuch, M., & Ziedins, I. (2014). A modelling perspective on probability. In E. J. Chernoff, & B. Sriraman (Eds.), *Probabilistic thinking: resending plural perspectives* (pp. 01–116). New York: Springer

- Phillips, D. C. (2005). Theories of teaching and learning. In *A companion to the philosophy of Education*. Blackwell Synergy: Online Journals for Learning, Research, and Professional Practice. Retrieved March 26, 2007, from http://www.blackwellreference.com/subscriber/tocnode?id=g978140514051_5_chunk_g978140514051519
- Piaget, J. (1972). *The principles of genetic epistemology* (W. Mays trans.) New York.
- Plomp, T., Anderson, R. E., Law, N., & Quale, A. (2009). Cross-national information and communication technology. *Policies and Practices in Education*, 83-102.
- Pratt, D. (2000). Making sense of the total of two dice. *Journal of Research in Mathematics Education*. 31, 602–625.
- Pratt, D. (2011). Re-connecting probability and reasoning about data in secondary school teaching. *Paper presented at 58th ISI World Statistics Congress*, Dublin, Ireland.
- Pratt, D., & Ainley, J. (2014). Chance re-encounters: Computers in probability education revisited. In T. Wassong (Ed.), *Mit Werkzeugen mathematik and stochastik lernen—using tools for learning mathematics and statistics* (pp. 165–77). Wiesbaden: Springer Fachmedien.
- Prawat, R. S. (1996). Constructivisms, modern and postmodern. *Educational Psychologist*, 31(3/4), 215-225.

- Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychology, 29*(1), 37-48.
- Pytel, B. (2007). Laptops: Jury is out: High schools are pulling 1-on-1 laptops after disappointing results. *Suite101.com*. Retrieved from <http://www.suite101.com/content/laptops-jury-is-out-a21072>
- probability. *Journal of Statistics Education, 12*, 1-17.
- Read, M., & Marsh, D. (2002). Combining quantitative and qualitative methods. In D. Marsh & G. Stoker (Eds.), *Theory and methods in political science* (2nd ed., pp. 231-248). New York, NY: Palgrave Macmillan.
- Resnick, L. B. (1987). Learning in school and out. *Educational Researcher, 18*, 13-20
- Riegle-Crumb, C., Farkas, G., & Muller, C. (2006). The role of gender and friendship in advanced course taking. *Sociology of Education, 79*, 206–228.
- Ringgold, T. L. (2001). *The evaluation of computer attitudes and the validation of computer self-efficacy scales of minority students at an urban community college in Baltimore City, Maryland*. Morgan State University.
- Robinson, J. P., & Lubienski, S. T. (2011). The development of gender achievement gaps in mathematics and reading during elementary and middle school: Examining direct cognitive assessments and teacher ratings. *American Educational Research Journal, 48*, 268–302.

- Ross, C. E., & Broh, B. E. (2000). The roles of self-esteem and the sense of personal control in the academic achievement process. *Sociology of Education*, 73(4), 270-284.
- Rostvik, C. M., & Fyfe, A. (2018). Ladies, gentlemen, and scientific publication at the Royal Society, 1945-1990. *Open Library of Humanities*.
- Rozell, E. J., & Gardner, W. L. (1999). Computer-related success and failure: a longitudinal field study of the factors influencing computer-related performance. *Computers in Human Behavior*, 15(1), 1-10. 229
- Russell, G., & Bradley, G. (1997). *Teachers' computer anxiety: Implications for professional development*. *Education and Information Technologies*, 2(1), 17-30
s. 432–445
- Sadker, M., & Sadker, D. (1986). Sexism in the classroom: From grade school to graduate school. *Phi Delta Kappan*, 68, 512–515.
- Salau, M. (2000). Options in sustaining mathematics as the language science and technology in the 21st century. In *Annual Conference of Mathematics Association of Nigeria (MAN)*.
- Sanders, J. (2005). Gender and technology in education: A research review. *Seattle: Center for Gender Equity. Bibliography retrieved March, 20, 2006*.
- Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The journal of the learning sciences*, 3(3), 265-283.

- Schau, C., Stevens, J., Dauphine, T., & del Vecchio, A. (1995). The development and validation of the survey of attitudes towards statistics. *Educational and Psychological Measurement*, 55(5), 868–875.
- Schwartz, G., Yerushalmy, M., & Wilson, B. (Eds.). (1993). *The geometric supposer: What is it a case of?* Hillsdale, NJ: Erlbaum
- Serin, O. (2011). The effects of the computer-based instruction on the achievement and problem-solving skills of the science and technology students. *TOJET: The Turkish Online Journal of Educational Technology*, 10(1), 103-201.
- Shaughnessy, J. M. (1992). Research in probability and statistics: Reflections and directions. In D. A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 465 – 494). New York: Macmillan.
- Shaughnessy, J. M. (2003). Research on students' understandings of probability. In J. Kilpatrick, W. G. Martin, & D. Schifter (Ed.), *A Research Companion to Principles and Standards for School Mathematics* (pp. 216 – 226). Reston, VA: National Council of Teachers of Mathematics.
- Shaughnessy, J. M. (2007). Research on statistics learning and reasoning. *Second handbook of research on mathematics teaching and learning*, 2, 957-1010.
- Shaw, B. A. (2004). *The relationship of teacher quality variables to technology integration in K–12 schools*. The University of Texas at El Paso.

- Short, D. (2002). *Computer-based mathematics instruction: Automated remedial branching* (Unpublished doctoral dissertation). California State University.
- Siddiqui, U., & Khatoon, T. (2013). Teaching physical science: should we implement teacher-centered CAI or student-centered CAI at secondary school level in India?. *European Scientific Journal, ESJ*, 9(10), 136-149.
- Siemens, G. (2004). *A learning theory for the digital age*. Retrieved March 26, 2007 from <http://www.elearnspace.org/Articles/connectivism.htm>
- Sife, A. S., & Benard, R. (2013) Persistence and decay of web citations used in theses and dissertations available at the Sokoine National Agricultural Library, Tanzania. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 9(2), 85-94.
- Sifuna, D. N. (2004). The illusion of universal free primary education in Kenya. *Wajibu*, 19(2), 5-8.
- Silverman, D. (2000). *Doing qualitative research: A practical handbook*. London: Sage.
- Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *The Journal of Educational Research*, 95(6), 323-332.
- Sivin-Kachala, J. (1998). *Report on the effectiveness of technology in schools, 1990-1997*. Washington, DC: Software Publishers Association.

- Skinner, B. F. (1954). *Teaching Machines and Programmed Learning*. Washington, DC: Department of Audiovisual Education, National Education Association.
- Skinner, B. F. (1960). *Teaching Machines and Programmed Learning*. Washington, DC: Department of Audiovisual Education, National Education Association, 1960.
- Slouti, D., & Barton, A. (2007). Opportunities for practice and development: Newly qualified teachers and the use of information and communication technologies in teaching foreign language in English secondary school context. *Journal of In-service Education*, 33(4):19.
- Smaldino, D. E. (2002). *The forum report: E-learning adoption rates and barriers*. In A. Rossett (Ed.), *The ASTD e-learning handbook* (pp. 19–23). New York: McGraw-Hill
- Smarkola, C. (2007). Technology acceptance predictors among student teachers and experienced classroom teachers. *Journal of educational computing research*, 37(1), 65-82.
- Smetana, L. K., & Bell, R. L. (2012). Computer simulations to support science instruction and learning: A critical review of the literature. *International Journal of Science Education*, 34(9), 1337-1370.
- Snee, R. D. (1993). What's missing in statistical education? *The American Statistician*, 47, 149–154.
- Soeder, K. L. (2001). *The effect of computer-aided instruction on mathematics achievement* (Unpublished doctoral dissertation). Immaculata University, Immaculata, PA.

- Steele, H. (2006, March). The “gender gap” in computing: Implications for teacher education. In *Society for Information Technology & Teacher Education International Conference* (pp. 811-816). Association for the Advancement of Computing in Education (AACE).
- Steinberg, E. R. (1984). *Teaching computers to teach*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Sternberg, R. J. (2004). *Psychology*. Belmont, CA: Wadsworth.
- Sternberg, R. J., Grigorenko, E., & Bundy, D. A. (2001). The predictive value of IQ. *Merrill-Palmer Quarterly*, 47(1), 1-41.
- Stohl, H. (2005). Probability in teacher education and development. In G. A. Jones (Ed.), *Exploring probability in school: challenges for teaching and learning* (pp. 345 – 366). New York: Springer.
- Stratham, D. S., & Torell, C. R. (1996). *Computers in the classroom: The impact of technology on student learning* (Doctoral dissertation, Army Research Institute). Retrieved from <http://www.temple.edu/lss/htmlpublications/spotlights/200/spot206.htm>
- Swarts, P. & Wachira, E. M. (2010). *Tanzania: ICT in education situational analysis*, Global School and Communities Initiative
- Syyeda, F. (2016). Understanding Attitudes Towards Mathematics (ATM) using a Multimodal modal Model: An Exploratory Case Study with Secondary School Children in England. Cambridge Open-Review Educational

Research e-Journal, 3, 32-62. Retrieved from
http://corerj.soc.srcf.net/?page_id=224

Tabrani, Z. A., & Masbur, M. (2016). Islamic Perspectives On The Existence Of Soul And Its Influence In Human Learning (A Philosophical Analysis Of The Classical And Modern Learning Theories). *JURNAL EDUKASI: Jurnal Bimbingan Konseling*, 1(2), 99-112.

Talanquer, V. (2014). Threshold concepts in chemistry: the critical role of implicit schemas. *Journal of Chemical Education*, 92(1), 3-9.

Tapia, M., Marsh, G. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, 8, 1-8.

Tapscott, D. (1998). *Growing up digital: The rise of the Net generation*. New York: McGraw-Hill

Taub, G. E., Benson, N., & Szente, J. (2014). Improving Mathematics: An Examination of the Effects of Specific Cognitive Abilities on College-age Students' Mathematics Achievement. *International Journal for the Scholarship of Teaching and Learning*, 8(2), 8-15.

Taub, G. E., Keith, T. Z., Floyd, R. G., & McGrew, K. S. (2008). Effects of general and broad cognitive abilities on mathematics achievement. *School Psychology Quarterly*, 23(2), 187-198

Tella, A. (2007). The Impact of Motivation on Student's Academic Achievement and Learning Outcomes in Mathematics among Secondary School Students in Nigeria. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(2), 149-156.

- Tezci, E. (2009). Teachers' effect on ICT use in education: The Turkey sample. *Procedia-Social and Behavioral Sciences*, 1(1), 1285-1294.
- Tobias, S. (1987). Succeed with math. The College Board Publication. Retrieved April 7, 2010, from http://www.collegeboard.com/html/store_help.html
- Toprakci, E. (2006). Obstacles at integration of schools into information and communication technologies by taking into consideration the opinions of the teachers and principals of primary and secondary schools in Turkey. *Journal of Instructional Science and Technology (e- JIST)*, 9(1), 1- 16.
- Torell, C. R. (1996). *Computers in the classroom: The impact of technology on student learning* (Doctoral dissertation, Army Research Institute). Retrieved from <http://www.temple.edu/lss/htmlpublications/spotlights/200/spot206.htm>
- Trowbridge, W. L., Bybee, W. R. & Powell, P. C. (2004). *Teaching Secondary School Science: Strategy for Developing Scientific Literacy*. 8th ed, New York: Education Inc.
- Tsai, M., & Tsai, C. (2003). "Students computer achievement, attitude and anxiety, the role of learning strategies". *Journal of Educational Computing research*, 28(1), 47-61.
- Turner, J. C., & Meyer, D. K. (2009). Understanding motivation in mathematics: what is happening in classrooms?. In *Handbook of motivation at school* (pp. 541-566). Routledge.

- Umoinyang, I. E. (1999). Student Socio-Psychological Factors as determinants of achievement in senior secondary mathematics. Unpublished Ph. D. Thesis, University of Ibadan, Ibadan.
- UNESCO (2002). *Information and Communication Technology in Education. A Curriculum for Schools and Programme of Teacher Development*. Paris: UNESCO.
- UNESCO and Commonwealth of Learning (COL) (2004). *Schoolnet Toolkit*. Bangkok: UNESCO; Vancouver: Commonwealth of Learning.
- Upadyaya, K., & Eccles, J. S. (2014). Gender differences in teachers' perceptions and children's ability self-concepts. InI. Schoon & J. S. Eccles (Eds.), *Gender differences in aspirations and attainment: A life course perspective* (pp. 79–100). Cambridge, UK: Cambridge University Press.
- University Press.
- Ursini, S., & Sánchez, G. (2008). Gender, technology and attitude towards mathematics: a comparative longitudinal study with Mexican students. *ZDM, 40*(4), 559-577.
- Ursini, S., Sanchez, G., Orendain, M., & Butto, C. (2004). El uso de la tecnología en el aula de matemáticas. *Enseñanza de las Ciencias, 22*(3), 409-424.
- Usluel, Y. K., Askar, P., & Bas, T. (2008). A structural equation model for ICT usage in higher education. *Educational Technology & Society, 11*(2), 262-273. 235

- Van Mier, H. I., Schleepen, T. M., & Van den Berg, F. C. (2019). Gender differences regarding the impact of math anxiety on arithmetic performance in second and fourth graders. *Frontiers in psychology*, 2690.
- van Veen, K. (2008). Analysing teachers' working conditions from the perspective of teachers as professionals: The case of Dutch high school teachers. In *Critiquing praxis* (pp. 91-112). Brill.
- Vanderlinde, R., van Braak, J., & Hermans, R. (2009). Educational technology on a turning point: curriculum implementation in Flanders and challenges for schools. *Educational Technology Research and Development*, 57(4), 573-584.
- Veen, W. (1993). The Role of Beliefs in the use of Information Technology: Implication for Teachers Education or Teaching the Right Things at the Right time. *Journal of Information Technology in Teacher Education*.
- Vekiri, I., & Chronaki, A. (2008). Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school. *Computers & education*, 51(3), 1392-1404.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.
- Verhoeven, J. C., Heerwegh, D., & De Wit, K. (2010). Information and communication technologies in the life of university freshmen: An analysis of change. *Computers & Education*, 55(1), 53-66.

- Von Glaserfeld, E. (1991). *Knowing without metaphysics: Aspects of the radical constructivist position*. In F. Steier (Ed.), *Research and reflexivity* (pp. 553-571). London: Sage.
- Von Glaserfeld, E. (1995). *A constructivist approach to teaching*. In L.P. London: Sage Steffe & J. Gale (Ed.s), *Constructivism in education* (pp. 3-16). London: Sage
- Von Glaserfeld, E. (1987). *The construction of knowledge: Contributions to conceptual semantics*. Intersystems Pub.
- Von Glaserfeld, E. (1995). *Radical Constructivism: A Way of Knowing and Learning*. *Studies in Mathematics Education Series: 6*. Falmer Press, Taylor & Francis Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007.
- Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological process* Cambridge, MA: Harvard University Press.
- Vygotsky, L.S. (1986). *Thought and language*. Cambridge, MA: MIT Press
- Wangid, M. N., & Widyastuti, P. (2021). Effect Of Gender And Department On Motivation, Self-Efficacy, And Perception As Teacher Of Pre-Service Teacher Students. *Multicultural Education*, 7(6), 6-8.
- Wanjala, M. (2005). Effectiveness of computer-based instruction versus conventional methods on students' attitude, motivation and achievement in the teaching of mathematics in secondary schools of Bungoma District. Unpublished Master's Thesis, Moi University, Eldoret, Kenya.

- Wanjiru, B.N., Miheso-O'Connor, M. & Ndethiu, S. (2015). Effects of mathematical vocabulary instruction on students' achievement in mathematics in secondary schools of Murang'a County, Kenya. *Proceedings of the 4th International Conference on Education*. Nairobi, Kenya: Kenyatta University
- Wanyonyi, P. W. (2013). *An Assessment of Factors Affecting Students' Performance in Mathematics at KCSE Level in Secondary Schools in Kakamega County, Kenya* (Doctoral dissertation).
- Watson, A. (2006). *Raising achievement in secondary mathematics*. McGraw-Hill Education (UK).
- Watson, J. M. (2001). Profiling teachers' competence and confidence to teach particular mathematics topics: The case of chance and data. *Journal of Mathematics Teacher Education* 4(4), 305 – 337.
- Wekesa, D. W., Wekesa, E. W., & Amadalo, M. M. (2013). A computer mediated simulation module for teaching cell division in secondary school biology. *International Journal of Educational Research and Development*. 2(5), 114-130.
- Wekesa, E., Kiboss, J., & Ndirangu, M. (2006). Improving students' understanding and perception of cell theory in school biology using a computer-based instruction simulation program. *Journal of Educational Multimedia and hypermedia*, 15(4), 397-410.

- White, H. (2001, May). Combining quantitative and qualitative approaches in poverty analysis. Paper presented at the Global Development Network, Washington, DC, USA.
- Wilkins, J. L., & Ma, X. (2003). Modeling change in student attitude toward and beliefs about mathematics. *The Journal of educational research*, 97(1), 52-63.
- Wilson, B. G. (1997). Reflections on constructivism and instructional design. In C. R. Dills & A. J.
- World Bank, (2007). Developing Science and Mathematics and ICT education in SSA. Patterns and providing practices. World Bank working Paper No 101, Washington, D.C.
- World Bank. (2008). The road not traveled (MENA Development Report). The International Bank for Reconstruction and Development/ The World Bank, Washington, D.C.
- Yadavalli, R., & Manda, M. S. L. (2014). The Effect of Gender, Medium of instruction, Parent's Educational and Socio-Economic background on Children's Conceptions and Abilities in Graphical Representation and Interpretation of Geometrical Concepts.
- Yaghi, H. M., & Ghaith, G. M. (2002). Correlates of computing confidence among teachers in an international setting. *Computers in the Schools*, 19(1-2), 81-94.

- Yilmaz, N. P. (2011). Evaluation of the technology integration process in the Turkish education system. *Contemporary Educational Technology*, 2(1), 37-54.
- Yusuf, M. O., & Afolabi, A. O. (2010). Effects of computer assisted instruction (CAI) on secondary school students' performance in biology. *TOJET: The Turkish Online Journal of Educational Technology*, 9(1), 62-69.
- Zan, R., & Di Martino, P. (2007). Attitude toward mathematics: Overcoming the positive/negative dichotomy. *The Montana Mathematics Enthusiast, onograph*, 3(2007), 157-168.
- Zuckerman, M., Kieffer, S. C., & Knee, C. R. (1998). Consequences of self-handicapping: Effects on coping, academic performance and adjustment. *Journal of Personality and Social Psychology*, 74,1619–1628.

APPENDICES

Appendix 1: County and Sub-County Schools with ICT Infrastructure in

Kisii County

1. Bishop Mugendi Nyakegogi	21. Itierio boys	42. St Dominic Rusinga secondary
2. Nyamagwa SDA	22. Itierio girls	43. St John's Nyamagwa boys
3. Mariwa	23. St Peters suneka	44. Boitangare mixed day/boarding.
4. Riagumo	24. Nyamagesa DEB	45. Nyagancha mixed sec
5. Tabaka township	25. Mobamba COG	46. Sameta Boys
6. Riosiri	26. St Lwanga Ichuni	47. Riobara mixed sec
7. Nyabigena	27. Moi Gesusu	48. Nyamonema mixed sec
8. Nduru boys	28. Nyanturago	49. Sameta mixed sec
9. Nduru girls	29. Ibacho	50. St Mary's Nyamagwa girls
10. Moniaku	30. St Marks Mokorogoinwa	51. Nyabonge mixed
11. Nyangweta SDA	31. St Joseph Mukaa Matobo	52. Rianchore mixed sec
12. Bogichoncho	32. Majimazuri	53. Nyaguku mixed sec
13. Boruma secondary	33. Nyachogochogo	54. Gekongo DEB
14. Kenyerere mixed	34. Ikenye	55. Rianyanchuba mixed
15. Nyakome friends.	35. Naikuru	
16. Kereri girls	36. St Theresa's Nyangusu	
17. St Patrick's Mosocho	37. Nyamache boys	
18. St Paul's Amasago	38. Mochengo	
19. Keoke	39. Nyaboterere	
20. Matongo secondary	40. Getai	
	41. Gionseri SDA	

Source: Kisii County 2018

Appendix 2: Students Questionnaire (SQ)

Introduction

The following statements are meant to elicit information about your experiences teaching and learning mathematics. To the best of your ability, express your thoughts on each of the assertions. Thank you very much for agreeing to participate in our initiative.

Section A: Background characteristics

1. What is your sex? (tick one) Boy () Girl ()
2. What is your age? Below 16 () 16 – 18() Above 18 ()
3. What is your residential status as a student?
 - (i) Boarder: Boy () Girl ()
 - (ii) Day scholar: Boy () Girls ()
 - (iii) Mixed: Boarding & Day Boy () Girls ()

Section B: Your Feelings about Mathematics

This section contains statements regarding how you might feel about mathematics. There aren't any right or wrong answers. Read each item carefully and mark the box that most closely matches the statements that best describe your emotions in each circumstance. Note: SA= Strongly agree, A= Agree, N=Neutral, D= Disagree, SD = Strongly disagree

Statements	SA	A	N	D	SD
Mathematics is an important and worthwhile subject.					
I'd like to improve my mathematical skills.					
Solving Probability problems gives me a fantastic sense of accomplishment.					
Mathematics aids in the development of the mind and the teaching of critical thinking.					
Mathematics plays an important role in daily life.					
One of the most important topics for people to study is					

probability in Mathematics.					
No matter what I decide to study, high school math courses e.g probability would be extremely beneficial.					
Outside of school, I use probability in a variety of ways.					
One of my most despised subjects is mathematics.					
When I'm dealing with Probability, my mind becomes blank and I can't think clearly.					
I get nervous when I'm studying maths.					
I'm not a mathematician, and it makes me uncomfortable.					
In a math lesson of probability, I'm always under a lot of pressure.					
When I hear the word mathematics, I get a negative reaction.					
Even the prospect of having to solve a probability problem makes me uneasy.					
Mathematics does not frighten me in the least.					
When it comes to mathematics, I am very self-assured.					
Mathematical problems of probability are not too difficult for me to solve.					
Any math class I take, I anticipate to do fairly well.					
In math class, I am constantly perplexed.					
When it comes to mathematics, I have a feeling of insecurity.					
I have a natural aptitude for mathematics.					
I believe I am capable of learning probability.					
Math has always been one of my favorite subjects in school and probability topic					
Mathematics is tedious and boring.					
I enjoy solving new probability problems.					
I would rather complete a probability assignment than write an essay.					
In college, I'd like to stay away from math.					
Mathematics is one of my favorite subjects.					
I am more at ease in a math class than in any other.					
Probability is a fascinating topic to study.					
I am willing to take more maths than is required of me.					
During my studies, I intend to take as much mathematics as possible.					
Math appeals to me because it is a difficult subject.					

I believe that studying probability is beneficial.					
I believe that studying probability aids me in solving problems in other areas.					
I am confident in sharing my own thoughts on how to approach a challenging math topic like probability					
In math class, I am at ease answering questions.					
In my work life, having a solid math background could be beneficial.					
I think I'm really excellent at probability problems.					

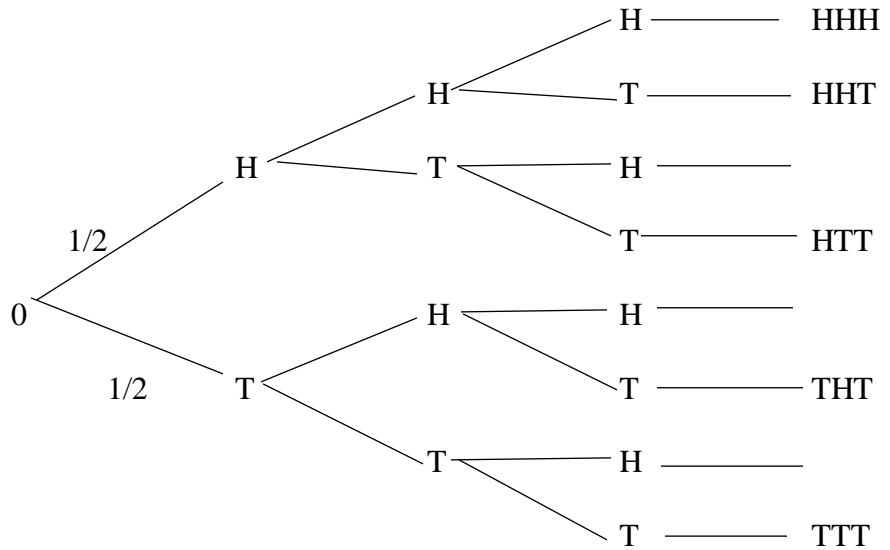
Appendix 3: Pre-test Students' Mathematics Test (PRESMT)

Time: 1 Hour 15 Minutes

Answer all questions in the spaces provided. All your workings MUST be included.

Section A (30marks)

1. A girl tossed a coin 3 times. Complete the tree diagram below and use it to answer questions (i) to (v) 2mks



Find the probability of getting

(i) One head 2mks

(ii) Two heads and tail in that order 2mks

(iii) Three heads 2mks

(iv) At least one head 2mks

(v) No head 2mks

2. Two marbles are drawn in turn from a bag containing 3 red marbles, 6 white marbles, 7 black marbles and 9 green marbles.

(a) If this is done with replacement, determine the probability of drawing

(i) Two white marbles 2mks

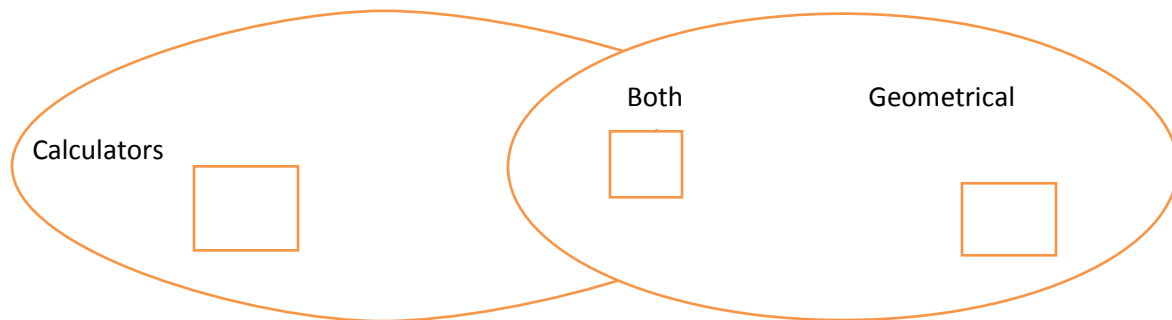
(ii) A black then a green marble 2mks

(iii) No red marble 2mks

(b) If the drawing of the marbles is done without replacement, determine the probability of drawing two white marbles (2mks)

3. In a class of 30 students, 24 have mathematical calculators, 18 have geometrical sets and 14 have both the mathematical calculators and geometrical sets.

(a) Fill in this diagram to show the number in each category. (2mks)



(b) What is the probability of selecting a student at random who has

(i) Only a calculator 1mk

(ii) A calculator or geometrical set 2mks

4. A pack of fifteen playing cards has six of the cards being red and the rest are black.

(i) What is the probability of choosing a red card at random from the pack? (2mks)

(ii) If you pick a card at random from the pack, replace it and then pick another, what is the probability of picking

(a) Two black cards? (2mks)

(b) Red and black cards (2mks)

Section B (20marks)

Answer all questions in this section

5. A box contains 5 red biro pens, 4 black biro pens and 6 green biro pens. If three pens are picked once at random, find the probability that:

(i) All the biro pens are red 3mks

(ii) The biro pens are of the same colour 3mks

(iii) The biro pens are one of each colour 2mks

(iv) None of the biro pens is red 2mks

6. Two dice are thrown up once. Fill the table below to show the sum of the faces appearing at the top 2mks

		First die					
		+	1	2	3	4	5
Second die	1	2					
	2						
	3						
	4			7			
	5						
	6						12

- (a) What is the sample size (1mk)

Using the table, find the probability of getting a sum of;

- (b) 3 or 4 (2mks)

- (c) Odd number (2mks)

- (d) 3 and 4 (1mk)

- (e) 4 and 7 or 12 (2mks)

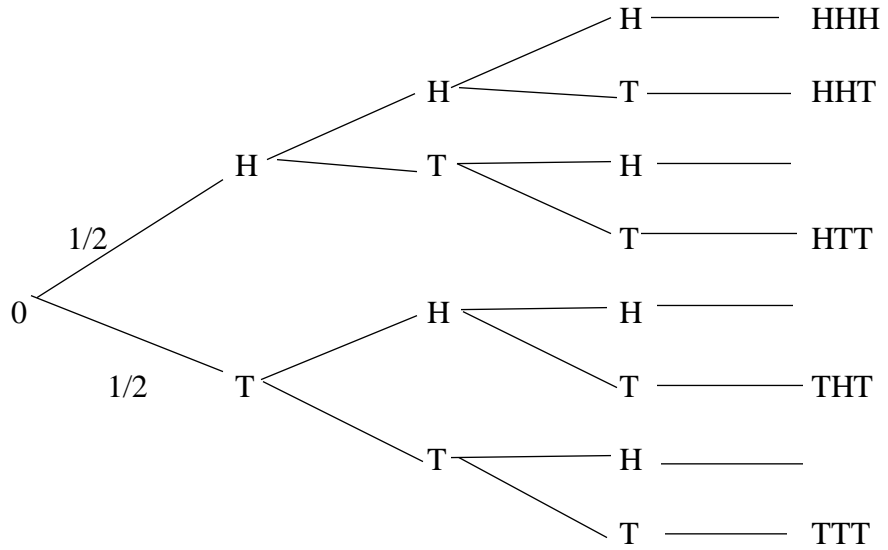
Appendix 4: Post-test Students' Mathematics Test (POSMT)

Time: 1 Hour 15 Minutes

Answer all questions in the spaces provided. All your workings MUST be included.

Section A (30marks)

1. A girl tossed a coin 3 times. Complete the tree diagram below and use it to answer questions (i) to (v) 2mks



Find the probability of getting

(vi) One head 2mks

(vii) Two heads and tail in that order 2mks

(viii) Three heads 2mks

(ix) At least one head 2mks

(x) No head 2mks

7. Two marbles are drawn in turn from a bag containing 3 red marbles, 6 white marbles, 7 black marbles and 9 green marbles.

(c) If this is done with replacement, determine the probability of drawing

(iv) Two white marbles 2mks

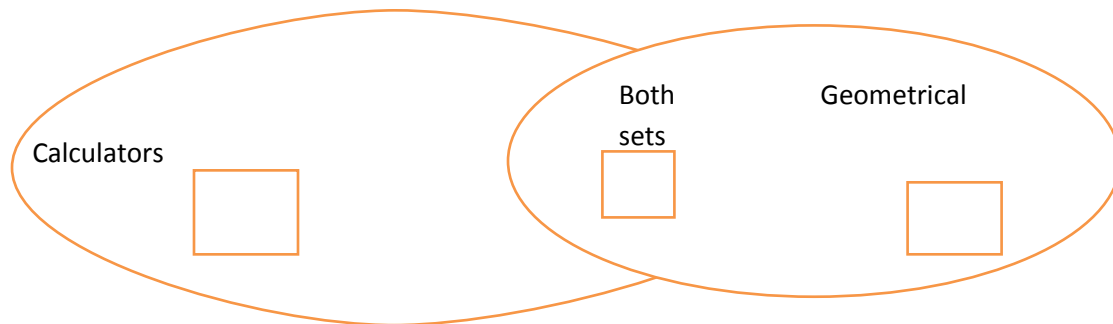
(v) A black then a green marble 2mks

(vi) No red marble 2mks

(d) If the drawing of the marbles is done without replacement, determine the probability of drawing two white marbles (2mks)

8. In a class of 30 students, 24 have mathematical calculators, 18 have geometrical sets and 14 have both the mathematical calculators and geometrical sets.

(c) Fill in this diagram to show the number in each category. (2mks)



(d) What is the probability of selecting a student at random who has
 (iii) Only a calculator 1mk

(iv) A calculator or geometrical set 2mks

9. A pack of fifteen playing cards has six of the cards being red and the rest are black.

(iii) What is the probability of choosing a red card at random from the pack? (2mks)

(iv) If you pick a card at random from the pack, replace it and then pick another, what is the probability of picking
 (c) Two black cards? (2mks)

(d) Red and black cards (2mks)

Section B (20marks)

Answer all questions in this section

10. A box contains 5 red biro pens, 4 black biro pens and 6 green biro pens. If three pens are picked once at random, find the probability that:

(v) All the biro pens are red 3mks

(vi) The biro pens are of the same colour 3mks

(vii) The biro pens are one of each colour 2mks

(viii) None of the biro pens is red 2mks

11. Two dice are thrown up once. Fill the table below to show the sum of the faces appearing at the top 2mks

		First die					
		+	1	2	3	4	5
Second die	1	2					
	2						
	3						
	4			7			
	5						
	6						12

(f) What is the sample size (1mk)

Using the table, find the probability of getting a sum of;

(g) 3 or 4 (2mks)

(h) Odd number (2mks)

(i) 3 and 4 (1mk)

(j) 4 and 7 or 12 (2mks)

Appendix 5: Mathematics Teachers Interview Schedule (MTIS)

The purpose of this interview is to learn about your experiences with Computer Based Simulation (CBS) in the teaching and learning of Probability in Mathematics. Your information will be kept strictly secret and used solely for the purposes of this study. Your help is much valued.

- i. How would you rank the performance of Probability, Mathematics in your school, in your opinion? [Investigate: What are the reasons for this level of performance?]
- ii. What are your thoughts on the learning conditions for children at your school? [Explore: CBS hardware and software availability and use]
- iii. What is the method that you prefer to use the most? [In teaching probability, look for conventional vs. CBS].
- iv. What are some of the reasons why you think the strategy you just described is the best? Professional development of the teacher
- v. What are some of the specific ICT technologies you employ in probability, Mathematics teaching and learning?
- vi. What are your students' reactions to CBS -enabled lessons? (Probe for response based on overall level of achievement, level of ability in Mathematics, attitude towards Mathematics and sex)
- vii. What are some of the difficulties you have in your school when utilizing CBS to teach probability, Mathematics, workload?
- viii. What, in your opinion, should be done to improve the use of CBS in Probability, Mathematics teaching and learning?


Appendix 6. Students Attitude towards Mathematics

Statement	SD		D		N		A		SA		Total	
	f	%	f	%	f	%	f	%	f	%	f	%
Mathematics is an important and worthwhile topic.	3	1.5	185	93.4	10	5.1	-	-	-	-	198	100
I'd like to improve my mathematical abilities.	5	2.5	6	3.0	30	15.2	77	38.9	80	40.4	198	100
Solving a math problem gives me a fantastic sense of accomplishment.	3	1.5	2	1.0	5	2.5	104	52.5	84	42.4	198	100
Mathematics aids in the development of the mind and the teaching of critical thinking.	2	1.0	10	5.1	31	15.7	100	50.5	55	27.8	198	100
Mathematics plays an important role in daily life.	5	2.5	2	1.0	15	7.6	93	47.0	83	41.9	198	100
One of the most important subjects for people to study is mathematics.	1	0.5	5	2.5	16	8.1	81	40.9	95	48.0	198	100
No matter what I decide to study, high school math courses would be extremely beneficial.	6	3.0	3	1.5	16	8.1	92	46.5	81	40.9	198	100
Outside of school, I use math in a variety of ways.	5	2.5	12	6.1	19	9.6	94	47.5	68	34.3	198	100
One of my most despised subjects is mathematics.	5	2.5	4	2.0	27	13.6	112	56.6	50	25.3	198	100
When I'm dealing with mathematics, my mind becomes blank and I can't think clearly.	51	25.8	64	32.3	47	23.7	28	14.1	8	4.0	198	100
I get nervous when I'm studying maths.	71	35.9	69	34.8	34	17.2	12	6.1	12	6.1	198	100
I'm not a mathematician, and it makes me uncomfortable.	63	31.8	72	36.4	31	15.7	22	11.1	10	5.1	198	100
In a math lesson, I'm always under a lot of pressure.	96	48.5	61	30.8	19	9.6	13	6.6	9	4.5	198	100
When I hear the word mathematics, I get a negative reaction.	77	38.9	74	37.4	19	9.6	18	9.1	10	5.1	198	100
Even the prospect of having to solve a math issue makes me uneasy.	81	40.9	67	33.8	28	14.1	11	5.6	11	5.6	198	100
Mathematics does not frighten me in the least.	66	33.3	65	32.8	36	18.2	21	10.6	10	5.1	198	100
When it comes to mathematics, I am very self-assured.	29	14.6	31	15.7	38	19.2	75	37.8	25	12.6	198	100
I can solve issues in mathematics without too much difficulty.	11	5.6	15	7.6	63	31.8	80	40.4	29	14.6	198	100
Any math class I take, I anticipate to do fairly well.	20	10.1	19	9.6	57	28.8	81	40.9	21	10.6	198	100
In math class, I am constantly perplexed.	15	7.6	15	7.6	43	21.7	87	43.9	38	19.2	198	100

Appendix 7: Location and Administrative Areas of Kisii County, Kenya



Appendix 8: Research Authorization Letter


KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke P.O. Box 43844, 00100
Website: www.ku.ac.ke NAIROBI, KENYA
Tel. 8710901 Ext. 57530

OUR REF: E83/33384/14 Date: 27th August, 2019

The Director General,
National Commission for Science, Technology & Innovation
P.O. Box 30623-00100,
NAIROBI


Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MR. MONYORO MOGIRE REG. NO. E83/33384/14

I write to introduce Mr. **Mogire** who is a Postgraduate Student of this University. he is registered for Ph.D. Degree programme in the **Department of Educational Communication & Technology** in the School of Education.

Mr. **Mogire** intends to conduct research for Ph.D. Thesis entitled, "**Computer Assisted Learning and Learner Achievement in Probability in Secondary Schools in Kisii County, Kenya**"


Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

RM/cao

Committed to Creativity, Excellence & Self-Reliance


Appendix 9: Research Liscence


REPUBLIC OF KENYA


NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **384041** Date of Issue: **19/September/2019**

RESEARCH LICENSE



This is to Certify that Mr.. Wilfred Momyoro of Kenyatta University, has been licensed to conduct research in Kisii on the topic: COMPUTER ASSISTED LEARNING AND LEARNER ACHIEVEMENT IN PROBABILITY IN SECONDARY SCHOOLS IN KISII COUNTY, KENYA for the period ending : 19/September/2020.

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