COMPUTER-BASED LABORATORY SIMULATIONS AND DEVELOPMENT OF INQUIRY SKILLS IN ELECTRO-CHEMISTRY IN SECONDARY SCHOOLS INSTRUCTION IN BOMET COUNTY

BY

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DECLARATION

Declaration by the Student

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DEDICATION

This piece of work is dedicated to above all God, my creator and my source of knowledge and to my family, Husband Mr. Charles Towett and children, Michelle, Adams, and Laura.

ABSTRACT

Computer technology has advanced to the point where it can significantly enable inquiry learning to be used at various levels, and offer new tools for representing the nature of science in the classroom. Traditional education approaches which are teacher- centered are inadequate in developing scientific skills. The aim of this research was to examine the use of Computer-Based Laboratory Simulations (CBLs) in development of inquiry skills in electro- chemistry in secondary school chemistry instruction, Bomet County. Philosophical paradigm adopted in the study was positivism. It originated in the natural sciences and focuses much on scientific method of testing hypotheses which paves way for further investigations. The study was guided by constructivist theory of learning as advocated by Jean Piaget where learner participates actively in learning process to make meaning out of it. The study used Quasi-Experimental Research Design. Solomon-Four Non-equivalent Groups Design was applied. Four secondary schools in Bomet County were purposively sampled on the basis of availability of computers. Three hundred and sixty-nine subjects took part in the investigation. The four schools were allocated to control and treatment groups by simple random sampling method. All groups of students were taught similar chemistry content (electro-chemistry). However, experimental groups used CBLs approach while the control groups used regular teaching methods (RTM) including teacher demonstrations and lecture. The control group II and experimental group I were pre-tested prior to the implementation of the CBLs treatment. After four weeks, all the groups (four) were post-tested using the Students' Chemistry Achievement Test (SCAT) which was authenticated by education experts and pilot tested before using to validate its reliability. Data was analysed using ANCOVA and one-way ANOVA at a significant level of coefficient alpha (α) equal to 0.05. The findings indicated that computer-based laboratory simulations assisted students in acquisition of scientific inquiry skills ($P<0.05$). These skills were hypothesis formulation, experimental design, data collection and analysis, critical thinking and problem-solving, collaboration, and communication. Computer based laboratory simulation had significant effect on chemistry achievement (P<.0.05). CBL was more effective and efficient method as opposed to traditional method. CBLs strategy as well as RTM had no significant difference based on gender ($P>0.05$). CBLs also had significant influence on attitude of students which enhanced performance in chemistry ($P<0.05$). The study concluded that CBLs had significant influence on achievement in chemistry since it assisted the learner to develop inquiry skills than RTM. The study recommended teacher training colleges and universities to include CBLs as part of their training programmes to empower teachers on the use of new digital approaches. The findings of this investigation will be beneficial to the curriculum developers, Kenya Institute of Curriculum Development (KICD) as well as chemistry instructors on the use of CBLs in teaching chemistry at secondary school level. There is need for a comparative study on learners' motivation and self-concept in chemistry instruction through CBLs approach verses those taught through traditional methods.

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LIST OF ABBREVIATION

ANOVA	Analysis of variance
ASEI	Activity, Student-centered, Experiments Improvisation
CBLs	Computer-based Laboratory Simulations
CEO	County Executive Officer
GOK	Government of Kenya
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examination Council
MDG	Millennium Development Goals
PDSI	Plan, Do, See and Improve
RTM	Regular Teaching Methods
SCAT	Students' Chemistry Achievement Test
SMASSE	Strengthening of Science and Mathematics in Secondary Schools
SPSS	Statistical Package for the Social Sciences
STI	Science, Technology and Innovation
UNESCO	United Nation Educational Scientific and Cultural Organization

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

This section presents the research background information, problem statement and the purpose of the research. Further, it presents the study objectives, research hypotheses, the research questions, justification, and the significance of the study. Lastly, the study discusses assumptions, scope and limitations of the study, variables of the study, theoretical and the conceptual frame-work of the study, definition of the operational terms and the summary of the chapter.

1.2 Background of the Study

Today science and technology is developing rapidly with global education reforms. Scientific methods are now being looked upon to stimulate economic growth of a nation. Chemistry as a subject at the secondary school level assists learners in building fundamental capabilities, understanding and required competence to tackle problems in their setting. Concurring with Keter (2018) chemistry helps learners to develop scientific process skills and competences required for managing perception, classification, estimation, tallying numbers, documenting, communication, forecast, hypothesis, inference, investigation, controlling variable, information interpretation, generalization and despite the applications of chemistry, the subject continues to register low performance.

The inquiry approach, while praised by science instructors, is yet to be prevalent in the classroom, and is frequently misused. This might be as an effect of several factors, including amount of classroom period, lack of effective ways for learners to conduct independent inquiries, the challenge of abstract concepts' incorporation with inquiry, and inadequate teacher experience and expertise. One of the electronic systems that is being incorporated into the classroom to support in the process of learning is the computer. One such area includes computer simulations that have been utilized in learning and training of numerous subjects, such as physics, accounting, medicine and mechanics, with promising results (Omwenga, 2005).

Low achievement in chemistry among secondary school students has been attributed to variety of factors. Okwuduba *et al*. (2018), cited factors that negatively impact chemistry achievement as learners' disinterest and/or having negative attitude towards the subject(chemistry), teacher-related issues such as inadequate preparation and poor teaching, lack of enough skilled chemistry teachers, scarce resources for instruction and use of traditional teaching techniques.

More significantly, the Ministry of Education (MOE) has designated the science laboratory as crucial in the tutoring of sciences because its utilization boosts the accomplishments of the nationwide goals of science education (Government of Kenya, 2020). As a result, the government donated science materials to learning institutions in addition to establishing laboratories for effective teaching and learning of science (Otieno, 2012).

Many changes and reforms are taking place globally and in Kenya demanding greater maximization of efficiency and effectiveness in laboratory use for superior performance in chemistry. This has been hampered by several factors, among them being lack of use of laboratory facilities. This, therefore, calls for computer-based inquiry methods of attaining knowledge in chemistry laboratory today. The study focused on the utilization of Computer Based laboratory simulations (CBLs) in acquisition of inquiry skills on secondary school students' achievement in Chemistry in Bomet County.

In addition to donation physical resources, the Government has also initiated an in-service training programme (INSET) to boost science and mathematics instruction in secondary schools (SMASSE, 2018) (Menjo & Chepkorir, 2013). The INSET was grounded on reports which suggest the need to alter the teachers' attitudes on tutoring of science subjects, also equipping them with proper teaching approaches and enhancement of their content understanding. Concentrating on these three aspects, MOE hoped that they would change the science teaching setting (laboratory and classroom) in order to enhance learners' positive outcomes.

The above interventions were intended to enable science students attain the essential scientific content and process abilities that they harnessed to create an industrialized society envisioned by Kenya's vision 2030. Despite these initiatives, the teaching methods of sciences in Kenya remain teacher centered, with limited use of the science laboratory which Oyoo (2010) argues about and observes that it does not effectively foster development of scientific knowledge and skills in learners. This teaching approach as pointed out in this argument has been associated with candidates constantly performing poorly in sciences which is evident in KNEC science grades for the years 2019 to 2021.

Table 1.1: KCSE- Analysis of science results for years 2019-2021

	2019	**2020**	**2021**
Subjects/mean %	Mean %	Mean %	Mean %
Biology	30.32	27.20	29.23
Chemistry	22.74	19.13	24.91
Physics	36.71	31.33	35.13

Source: KNEC Reports, 2020, 2021 & 2022

The tabulated results show that performance in science has been generally poor, the least being chemistry. The poor performance, particularly in chemistry has been blamed on the use of archaic laboratories when conducting practical examinations (Oduor, 2012). Besides the general poor performance in science, the Kenya National Examination Council (KNEC) reports (2020; 2021; 2022) indicate that candidates are persistently performing poorly in questions that require knowledge of scientific process skills. Also, the same reports show that candidates answer practical questions theoretically.

Chemistry being a prerequisite for many technical and vocational courses in colleges and tertiary institutions, it is obligatory to boost students' success and interest in chemistry learning. The achievement in chemistry's performance is less the expectations that would be needed by Kenya to objectify her objective of industrialization hence becoming, by the year 2030, a middle level income country (Republic of Kenya, 2007). Dismal performance of learners in sciences shows the difficulties that face Kenya in obtaining suitable number of qualified learners registering in technical and scientific disciplines in training institutes.

Recommendations have been made by Keraro *et al.*, (2007) concerning the teaching approaches, instructional resources, school and home associated environmental aspects that could enhance good performance in chemistry. Nevertheless, as the indication available illustrates, attainment in chemistry remains unimpressive and low at the secondary school level. The Government of Kenya participated incredibly in this exertion to restore interest in learning of science, particularly, chemistry. Ajaja (2005) recommends more research on in-cooperation of computer aided instruction on the learning and training of sciences.

Traditional education approaches which are teacher centered are insufficient in inquiry skills, and are likely to compromise the country's objective of forming a scientifically literate society towards vision2030. This investigation sought to fill the existing gap on acquisition of scientific inquiry skills by investigating the using Computer-based laboratory simulations in aiding conceptual understanding of Electro-chemistry in secondary chemistry instruction in Bomet County.

1.3 Statement of the Problem

According to the available research, the majority of Kenyan secondary school learners have insufficient knowledge and grasp of chemical ideas and principles (SMASSE, 2018). Because chemistry is a prerequisite for numerous vocational and technical courses at colleges and other post-secondary institutions, it is necessary to improve students' participation and willingness to master the subject. Most Learners do not acquire scientific skills and also they don’t understand the aim and significance of science in society (Kiboss, 2002). Inquiry-based learning approach improves science education by involving learners in authentic investigations, thus enabling motivating and a more learner-centered environment, while also being utilized to support teaching.

Computer technology has progressed to the era that it can considerably ease the application of inquiry learning on a variety of levels, as well as give new tools for depicting the nature of science in the science rooms. This utilization of technology in provision of new teaching techniques and objectives in science has enormous potential for enhancing scientific learning in the science room, as long as the inherent limits of acquisition are acknowledged and technology is utilized as a tool rather than as a foundation.

While the incorporation of such a teaching/learning technique may help in chemistry teaching, much has not been done in investigating the use of Computer-Based Laboratory Simulations (CBLs) in the tutoring of secondary school chemistry particularly the topic electro-chemistry that has been considered difficult by students who learn it. The utilization of proper teaching equipment and methods is vital to the effectiveness of chemistry teaching and learning. There is still considerable work to be accomplished in terms of making the most use of current educational tools (Bello, 2011). Poor performance in chemistry among secondary school students as reflected in KCSE results has been a concern to educationists in Bomet County. The current investigation attempts to address the gap by examining the use of CBLs in development of learners' inquiry skills in chemistry.

1.4 Purpose of the study

The purpose of this research was to investigate the effectiveness of CBLs on the acquisition of inquiry skills in electro-chemistry in secondary school chemistry instruction.

1.5 Specific objectives

This research was steered by the specific objectives listed below:

1. To investigate the effect of Computer-based laboratory simulations (CBLs) in acquisition of scientific inquiry skills in chemistry.
2. To find out the effectiveness of acquisition of scientific inquiry skills teaching chemistry through Computer-based laboratory simulations (CBLs) strategy as compared to the traditional methods.
3. To find out the gender differences in the outcome of Computer-based laboratory simulations (CBLs) teaching strategy on achievement in chemistry.
4. To investigate how Computer-based laboratory simulations (CBLs), as a teaching technique, affects learners attitude towards chemistry.

1.6 Research questions

1. To what extend does using Computer-based laboratory simulations (CBLs) affect the acquisition of scientific inquiry skills in chemistry?
2. To what extend is the teaching of chemistry by Computer-based laboratory simulations (CBLs) strategy effective in comparison to the traditional techniques in acquisition of scientific inquiry skills?
3. Are there any significant gender differences in secondary learners' attitudes towards chemistry after using Computer-based laboratory simulations (CBLs)?
4. What is the outcome of Computer-based laboratory simulations (CBLs) on secondary school students' attitude towards chemistry?

1.7 Research Hypotheses

In the investigation, the preceding null hypotheses were examined for significance between several variables:

Ho_1: There is no significant impact in acquisition of scientific inquiry skills in Chemistry after utilizing Computer-based laboratory simulations (CBLs) on achievement in chemistry.

HO_2: There is no significant change in achievement scores amongst students instructed using CBLs learning approach and those using Regular teaching methods (RTM) on achievement in chemistry.

HO_3: There is no significant difference in attainment scores among students taught using CBLs learning technique and those using Regular teaching methods (RTM) with regard to gender on achievement in chemistry.

Ho_4: There is no significant difference in attitude between learners who use Computer-based laboratory simulations (CBLs).

1.8 Justification of the study

Science influences a nation and her citizens through the creation of fundamental human desires to political, educational, social, technological, and economic progression. The means by which scientists take while conducting scientific inquiry informs the society on the usefulness of science (Dani, 2009).

Because modern knowledge-based economies rely significantly on technology, clear understanding of chemistry and technology, as well as stronger technical problem-solving abilities, would assist workers to face the difficulties and expectations of the workplace (Effandi & Zanaton, 2006; Porter *et al*., 2007).

Moreover, a contemporary knowledge-based economy can first thrive if its workforce has improved degree of technical abilities and understanding (Wieman & Perkins, 2015). The Information Technology (IT) transformation has been brought about by technological advancement. It is obvious that any society that abandons this change risks exclusion from the global family (SMASSE, 2018).

Consequently, for a country's national development objective to be achieved, its citizens must be scientifically and technologically literate. Thus there is need to arrange secondary school chemistry tutoring methodologies in accordance with twenty-first century competencies (Pacific Policy Research Center, 2010). Problem solving and critical thinking, communication and cooperation, creativity and innovativeness, technology, information and media, as well as life and career skills. The inquiry approach, while praised by science instructors, is yet to be prevalent in the classroom, and is frequently misused. This might be as an effect of several factors, including amount of classroom period, lack of effective ways for learners to conduct independent inquiries, the challenge of abstract concepts' incorporation with inquiry, and inadequate teacher experience and expertise. One of the electronic systems that is being incorporated into the classroom to support in the process of learning is the computer. One such area includes computer simulations that have been utilized in learning and training of numerous subjects, such as physics, accounting, medicine and mechanics, with promising results (Omwenga, 2005). Which are examples of twenty-first-century skills.

According to Alebiosu (2003), the teaching techniques used by a teacher in any particular circumstance are determined by elements such as classroom learning environment, teaching objectives, teacher and student characteristics, and the demands and nature of the topic.

Clearly, the traditional educator as knowledge provider or textbook-guided classroom failed to provide the anticipated result of critical thinking learners. The use of inquiry techniques in the classroom to shift the attention of the learner from teacher-dominated to learner-centered is a widely lauded strategy (Ryder, 2001).

Chemistry is a science subject which is very crucial in Kenyan Secondary Curriculum. It Is a fundamental subject for the synthetic industry, chemical engineering, agricultural science, textile technology, medical sciences, pharmacy, printing technology, to reference just a few (Dani, 2009). “As vital as the subject is and despite of the urge of governments to encourage chemistry instruction, learners still shun the subject” (Jegede, 2003). It has been shown that, majority of learners have phobia for chemistry and thus seeing it as difficult to comprehend, a fact that is attributed to the subject’s abstract nature and the technique (lecture approach) being applied by utmost number of the teachers in chemistry, in Kenya. Learners’ anxiety for chemistry may be attributed to learner’s perception of the complex nature of chemistry (Dani, 2009). Learners’ anxiety for chemistry education progresses to interest loss in the sciences (Hu-Au & Okita, 2021).

(SMASSE, 2018) Observes that most of the learners in Kenyan secondary have insufficient information and comprehension of chemistry principles. The topic electro-chemistry has continually been problematic to grasp by learners or to teach by instructors. In accordance to a SMASSE baseline review 58% and 62% of the teachers and learners respectively interrogated illustrated that electro-chemistry is complex to teach by instructors and learners to grasp, (SMASSE, 2018). This goes in line with the KNEC report which shows the dismal performance on electro-chemistry questions by candidates (KNEC, 2019).

Despite the long prevailing fear and its impact on chemistry, Njoroge *et al.* (2004) recommend more research be done on the outcome of computer simulations on acquisition of scientific inquiry skills among secondary school learners in chemistry in Kenya. Conducting this present investigation therefore, was indeed valuable. It is against these backgrounds that the current study would employ Computer Based Laboratory simulations on acquisition of inquiry skills in electro-chemistry.

1.9 Significance of study

Using CBLs in secondary school is crucial for creating opportunities for learners to learn to work in an information era and help teachers to advance in their teaching of chemistry. With the rapid advancement in technology, there is need to support pre-service teacher training and grow professionally in utilization of ICT in chemistry tutoring. Courses for professional development would allow chemistry teachers to advance themselves on methodologies of integrating CBLs in chemistry instruction in schools.

A technology-rich studying environment is shown by analytical and collaborative methods to learning, increasing integration of information across the curriculum, and a strong emphasis on concept development. As a result, the use of computer in classrooms allows instructors and students to more effectively teach and understand chemistry. This encourages students to develop a positive attitude in chemistry, find meaning in what they study, and use it in a variety of real-world settings.

The Kenya Institute of Curriculum Development (KICD), a body in Kenya tasked to develop and revise syllabi, should incorporate CBLs tools into the content they provide. This would promote more effective teaching approaches that are in tune with the ever-changing technological environment. The research findings would also sensitize school management on the importance of equipping learning institution with current technologies that promote successful learning in their yearly strategic plans. This would enable learners to study to their fullest potential by utilizing latest technologies.

1.10 Assumptions of the Study

The investigation assumed that majority of Kenya Public Secondary Schools possessed computers required for CBLs strategy. Lastly, the research assumed that the poor achievement in chemistry in the Public Secondary Schools in Bomet County was a true reflection of the performance of chemistry in Secondary Schools at KCSE in other sections of Kenya.

1.11 The Scope and Limitations of the Study

The aim of this research was to investigate the use of Computer- based laboratory simulations (CBLs) in enhancing advancement of inquiry skills in electro-chemistry in secondary chemistry instruction in Kenya' Bomet County.

1.11.1 The Scope of the Study

The field of information and communication technology (ICT) is extensive. It is a topic with numerous applications in both industry and education. The investigation emphasizes on the application of CBLs in learning, especially the use of CBLs in the teaching and learning of chemistry. Though there are numerous learner-centered techniques of teaching that can improve learners' chemistry performance, this research exclusively focused on the integration of CBLs and resources related in electro-chemistry teaching and learning.

1.11.2 Limitations of the Study

Because the group sample for this analysis was constrained to a certain educational geographical region, the findings may not accurately reflect entirely all the students. Time, money, and labour restrictions, limited the scope of the research findings. While all schools offer chemistry. Not all have computers to use in teaching. Secondly, most teachers may not have the knowledge and skills to use computers. For this reasons, findings of this study may not apply to all schools.

1.12 Theoretical framework

Constructivism served as the theoretical basis for this research (Piaget, 1983). Constructivists argue that learning occurs in the mind and that what enters the mind is formed by the person through social interaction or knowledge discovery. The learner is emphasized as an active agent in the course of knowledge acquisition in this approach. When individuals actively engage in meaningful activities, they are able to learn. They create a learning mechanism as well as their own distinct version of information, which is influenced by their prior abilities and experiences (Roblyer & Edwards, 2000; Chen *et al*., 2000).

Learning, according to the constructivist point of view, is an active procedure that each individual is involved in creating meaning from physical experiences, text, or dialogue (Kelly, 2013). Active learning occurs when learners are tested to actively use their mental skills while studying. (Hout-wolters, Simons & Volet, 2000). Students actively seek understanding (Kirschner, Martens, & Strijbos, 2004) and are anticipated to design their own learning experiences (Otieno, 2012).

According to Sreelekah (2018), the method is not curriculum-centered but rather learner-centered, and knowledge is built rather than passively absorbed. Students are expected to collect data for science investigations then analyse using scientific method.

Interactive CBLs would allow students to manage the pace and order of their studying, which is linked to this notion (Drillscol, 2000). Learners in CBLs learn the topics on their own with the educator's guide and complete the evaluation questions at the conclusion of the study unit. They are permitted to learn by experimenting and are not informed what will happen, so they must draw their own assumptions, findings, and conclusions.

Learning is accomplished best using hands-on approach by experimentation and learners are left to make their own inferences, choose and synthesis information, hypothesis and make rational decision based on cognitive structures in chemistry.

From this perspective, in order for students to construct new knowledge, chemistry teachers are expected to provide students with learning experiences through CBLs that allow them acquire more information in electro-chemistry and intergrate with their understanding.

1.13 Conceptual Framework

Independent Variables **Dependent Variables**

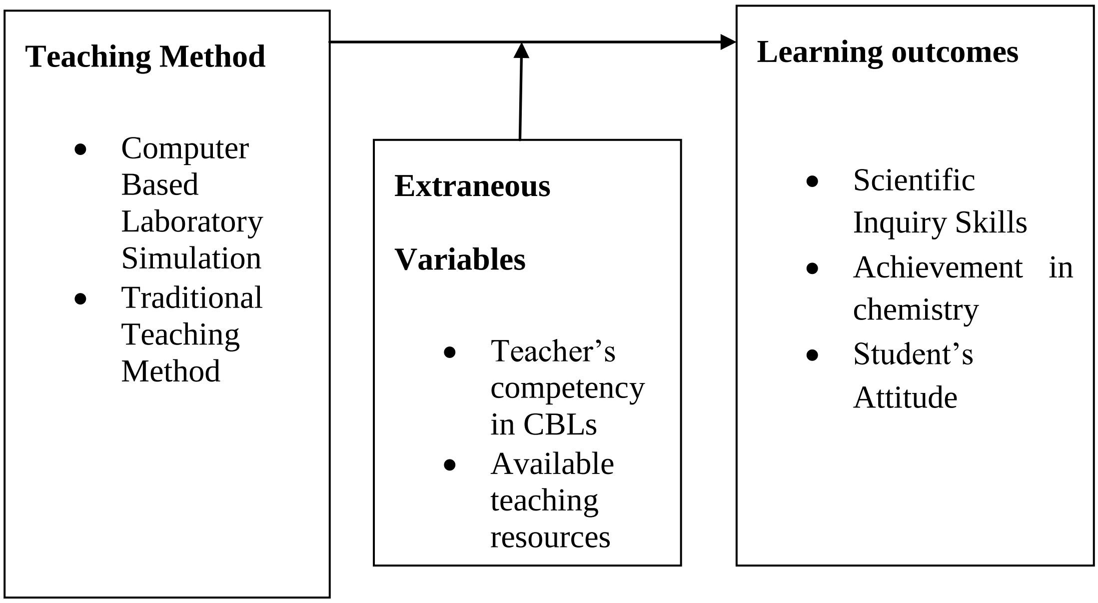

Figure 1.1: Conceptual Framework

Source: Author, 2020

In this research the conceptual framework is diagrammatically represented in Figure 1.13. The relationships between variables of the investigation are shown in Figure 1.13. Students' success and motivation in grasping chemistry would be impacted by the teaching approach in an ideal situation. In practical circumstances therefore, learners' accomplishment and motivation to understand chemistry are influenced by numerous factors including, teacher competency in CBLs, teaching and learning resources as shown in Figure 1.13. These are variables that are extraneous which needed to be managed.

The research used qualified chemistry instructors to regulate the teacher variable since instructor training impacts on how well a teacher will implement a teaching strategy.

In addition, all students were taught the same topic from same curriculum by the teachers who were engaged. What students are taught is determined by their age and, as a result, their class. The study included form four students who were estimated to be of same age. To control for teachers competency in CBLs, the engaged instructors were taken through training, and the application of the CBLs approach intervention to the treatment groups was closely monitored.

1.14 Study Variables

In research, a variable is a quantifiable property that takes on distinct values in different subjects (Mugenda, 1999). They are dependent or independent. The independent variables in this investigation were; Computer based laboratory simulation (CBLs) and Traditional teaching method. Dependent variables were the learning outcomes; Scientific Inquiry Skills, Achievement in chemistry and Student's Attitude towards chemistry. Extraneous variables were Teacher's competency and availability of teaching and learning resources.

1.15 Definitions of Operational Terms

Computer- Based Laboratory Simulation (CBLs) - Covers subject-specific software that enables learners to conduct experiments in a virtual environment. It simulates real world phenomena and places learners in a predictive situation.

Computer-Based Instruction (CBI) - Refers to a software which provides students with instruction in the form of tutorial.

Effect: Refer to what happens because of a cause or a combination of causes. In this study effects shows the condition of students' level of competence in scientific inquiry skills after teaching them using CBLs compared to the use of Traditional Teaching Methods.

Effective learning- Active learning techniques involve the student in the studying process in order to achieve successful grasp of the subject material matter and to establish a good attitude toward the topic.

ICT - is a more specific term that emphasizes the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary storage, enterprise software, audio-visual systems and middleware, which permit users to access, transmit, store and manipulate data

Independent learning- a self- directed learning in which a student acquires knowledge by his or her own effort and develops the inquiry and critical evaluation.

Information age–It is the belief that the contemporary age is characterized by individuals' capability to freely transfer knowledge and to have quick access to information that was previously difficult or impossible to discover.

Inquiry skills – These are manipulative and thinking skills used by scientists in their investigations. In this study, inquiry skills in the learning of chemistry will lead to self-directed learning of the subject.

Integration– This is the procedure for providing equal opportunity and recognition (an ethnic, a racial, or religious group or an individual of such a group)

Multimedia - The phrase is used to distinguish media that use only rudimentary computer display including text-only or traditional forms of printed or hand-produced content. Text, music, still images, animation, video, and interactive content form are all examples of multimedia content.

Regular methods- also called traditional methods and primarily focus on rote education and memorization. It mostly emphasizes on oral presentation of facts.

Science - has always been the study of structure and behavior of the physical and natural world through observation, experimentation and testing of hypotheses through scientific method against the evidence obtained.

Variable- In research, a variable is a quantifiable property that takes on distinct values in different subjects

Vision 2030 - Kenya's development programme towards establishing a prosperous and globally competitive citizen. It is hoped that effective teaching of secondary school chemistry will contribute to the realization of this vision.

1.16 Summary

The section highlights the background of the research on the effectiveness of CBLs strategy on students' success in chemistry. It explains the aim of the research which was to examine the use of CBLs in the establishment of inquiry skills in electro-chemistry in secondary chemistry instruction. The research was intended for examining the influence of the Computer-based laboratory simulations (CBLs) in acquisition of scientific inquiry skills in chemistry. It had the significance of integrating CBLs in tutoring and understanding the present age scholars in Kenya's Secondary Schools. The study hopes to make school management board aware of the need of providing learning institutions with current technology that promotes successful learning in their yearly strategic plans. This ensured that scholars learned with ideal benefit utilizing the modern technology. The chapter discussed the theoretical framework used. Lastly, it provides the definition of operational terms that the current research used.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

General and related literature reviews are presented in this chapter. The general literature review describes available literature on the teaching and learning of chemistry, scientific literacy and science process skills.

In the related literature review, vital facts from a review of an important part of the available literature linked with how computers are integrated in educating and learning of various science subjects including chemistry, CBLs, animations in chemistry education and computer supported inquiry learning are also discussed. Therefore, the section presents the general literature review, the related literature review, empirical literature, and the summary. The empirical literature provided existing literature of computer-based simulation in science learning process. The summary identifies main areas done and highlights the existing knowledge gaps in the literature.

2.2 General Literature review

2.2.1 Overview

General literature review aims to gather significant points from a review of the learning and teaching of chemistry and lays emphasis on learner-centered instruction, it also discusses scientific literacy and science process skills.

2.2.2 Teaching and Learning of Chemistry

Secondary school chemistry helps students to gain information and abilities that are essential in everyday life, as well as to establish positive attitudes toward science. School chemistry ought to be related to students' real-life experiences. There is a need to shift from factual learning through closely directed method to conceptual understanding and the use of learned information and skills to tackle developing difficulties (Kwangmuang, Jarutkamolpong, Sangboonraung & Daungtod, 2021).

Students who graduate from secondary level school must have the ability to apply chemistry in their everyday lives (Orora *et al.,* 2005). A number of syllabuses have come up with the aims of teaching chemistry; to acquire a systematic body of knowledge and develop an understanding of the concepts and principles, laws and theories and applications of chemistry, to develop a scientific attitude, a range of scientific inquiry skills important for scientific investigations and everyday life, to stimulate curiosity interest and enjoyment in chemistry through methods of inquiry and care for environment and to develop an understanding of the consequences of chemistry on humans and their environment.

Effective teaching methodologies that increase learning must be devised and applied in the teaching of chemistry in order for good outcomes to be achieved. Expository techniques cannot meet the changing needs and aims of chemistry instruction, hence a new look at new ways is required (Keraro *et al.,* 2007).

In previous years, science instructors have adopted the constructivist method to help pupils learn more effectively (Trowbridge *et al.,* 2004). Learners, as per Good and Brophy (1995), are considered as not just absorbing knowledge but also developing their own understanding. According to Aslop and Hicks (2013), scientific learning is mostly an active process. As a result, chemistry instruction should emphasize active learner participation, in which students are fully engaged in the process.

What happens in classrooms has a huge impact on the actual outcomes of instruction. Students learn to consider science like a static body of information established on well-defined techniques if scientific information is given in form of absolute truths and proved facts through books and lectures is easily communicated (Roth & Roychoudhury, 2003). For these learners, knowledge entails retaining an information body for subsequent retrieval.

Students who actively participate in scientific processes, on the other hand, learn to grasp the scientific information built on experiences where the relevance of information is argued and theories are not fixed. Knowledge, in this aspect, entails studying experimental methodologies as well as scientific community norms and practices, along with acquiring established current hypotheses and facts within a field (Wheeler, 2000).

Literature in the developed world about teaching science has revealed that laboratory instruction plays a crucial part in the development of scientific knowledge (Hofstein & Lunetta, 2004). However, little is known about how the laboratory is used in the teaching of science in many African countries. The few studies available (Oyoo, 2010; Menjo & Chepkorir, 2013) have focused generally on the teaching of science. Their findings show that the teaching of science is mainly by transmission. This teaching approach limits learners' acquisition of scientific knowledge thus leading to poor understanding of scientific concepts and performance in national examinations. However, none of these studies have specifically focused on laboratory utilization of

CBLs in electro chemistry teaching. Yet, if the laboratory is effectively used it may significantly contribute to understanding of scientific concepts. This study therefore sought to find out effectiveness of CBLs in acquisition of inquiry skills in Chemistry. Moreover, KNEC (2021; 2022) reports indicate that learners have been answering practical questions theoretically and performing poorly in questions that require use of process skills.

Although the persistent poor results in questions that require process skills may be caused by many factors, non-use or ineffective use of the laboratory is the main cause since the science laboratory is the main environment where practical knowledge and specifically process skills are supposed to be acquired through practical activities. Consequently, there is reason to suggest that the laboratory either is being ineffectively used hence contributing to the poor results. For this reason, a study like the current one is justified.

Learning in teacher-centered education emphasizes on mastery of material, with minimal emphasis on the attitudes and skills required for scientific inquiry. The tutor communicates knowledge to the learners, who acquire and retain it. In most cases, there is just recall of answers in knowledge assessment. The curriculum is densely packed with information and a significant numeral of vocabulary words, encouraging a lecture education strategy (Leonard & Chandler, 2003).

In contrast, learning science in a student-centered curriculum is productive and active, it entails exploration and hands-on activities. The purpose is to improve problem-solving and critical thinking and capabilities by introducing and researching pertinent issues whose responses must be determined. The tutor serves as a guide, establishing the environment for students to actively participate in experiments, explain and evaluate facts, and discuss knowledge of the discoveries with peers.

In this technique, the instructor places minimum stress on material memorizing and prioritize more on inquiry and hands-on actions that allow students to gain a better appreciation and understanding of the aspect of science (National Research Council, 1996; Singer *et al.*, 2000). As a result, when students participate in the teaching process actively, their drive to learn is enhanced.

Because computer-based instruction (CBI) delivers customized education, learning occurs at the speed and time frame of the learner (Bello, 2011). CBI boosts student retention and studying rates. According to Coller (2004), instruction complemented by correctly planned CBI is successful than one not using CBI. According to Daulay, Mursid and Baharuddin (2020), there are primarily four types of CBI programs: instructional games, tutorials, and simulations drills and practice.

Kiboss *et al.* (2002) observed that using CBI simulation to teach challenging concepts in Geography, Physics, Mathematics, and Biology was effective. No empirical research has particularly investigated the dynamics of one-on-one computer lessons and their influence on problem solving (Omwenga, 2005). CBLs strategy would indeed be adapted in this research on this basis.

The Inquiry Learning Approach is a teaching style in which students are given endless opportunity to show knowledge of the material presented (Shih *et al.*, 2010). It entails breaking down the topic to be learnt into digestible learning units, each with its own specific goals. According to the findings of research studies on the inquiry learning strategy, there is higher retention and transfer of content, as well as increased involvement and more pleasant attitudes (Wachanga & Mwangi, 2004).

Even when lecturers devote a percentage of their lecture time to elucidate chemistry ideas, traditional lecturing is ineffective in aiding the popular students to grasp abstract chemical concepts (Tenaw, 2015). Furthermore, text and the static pictures in Chemistry textbooks don't appear to assist learners understand concepts or envisioned chemical reactions. Alternative teaching approaches, including the using computer animations in an inquiry approach, according to Sarabando et al. (2014) can assist students grasp chemical ideas. Furthermore, learning actively is one of the instructional techniques that inspire learners to participate cognitively in operations such as debate, hypothesizing, discussion, brainstorming, problem-solving, and explanation. Using an active learning mode of instruction has been found to enhance learners' problem-solving abilities (Hanks & Wright, 2002). In the current investigation, aspects of inquiry learning were introduced into the CBL lesson.

2.2.3 Scientific literacy

Today, many nations consider it vital to build a society of scientifically literate individuals, and it is recognized as one of the primary purposes of science education (Valladares, 2021). It is widely agreed that establishing functional scientific literacy entails giving individuals with a scientific understanding that they can use to make decisions and engage in discussion about scientific and technology concerns outside of formal schooling settings (Ryder, 2001). In this view, training for scientific literacy requires not just teaching science ideas and theories, but also understanding about the nature of these concepts and how they interact with other physical world beliefs (Eichinger *et al.*, 1997).

Scientific literacy is increasingly being defined as the overarching goal of science education (Bybee, 1997). As a result, chemistry education as a scientific field ought to assist learners in developing scientific literacy skills and maturing as a scientifically literate people. Chemistry is a vital subject since it is essential for the effective learning of countless major professions. As a result, it is critical that learners studying chemistry comprehend the subject so as to use their information in their daily interactions with individuals and their ever-changing surroundings. The Kenya KNEC Chemistry syllabus for 2008 to 2012 was planned to offer a valuable educational experience to all learners, regardless if they are going to learn science on other level, through well-designed studies of experimental and practical chemistry and specifically, to empower them to attain sufficient knowledge and understanding to become confident individuals in a world full of technology, ability to develop or take an informed step in scientific matters; Develop skills and talents important to the safety of conduct of science and daily life, such as required for correctness and honesty, insight. Precision, inquiry skills, initiative, objectivity and enable learners to become confident residents in a technological universe and to take an informed decision in matters of scientific merits; stimulation of interest in, and environmental care; and encourage awareness that practicing and learning science are collaborative and cumulative doings that are influenced and limited by ethical, cultural influences and limitations, economic, social and technological.

These objectives can be met only by the instructor providing the appropriate sorts of information to the chemistry learners. Quality education is the foundation of every system of education for generating scientifically literate individuals, and how pupils are taught has a significant impact on what they learn. As a result, in the non-present of talented, qualified, and motivated professional instructors, learners cannot reach high levels of performance. No matter how extensive and well-developed a curriculum is, its achievement is determined by the quality of the instructors who apply it; therefore, no country's system of education can climb beyond its teachers' quality (Ughamadu, 2006).

What happens in the chemistry classroom can be used to assess a chemistry teacher's ability? Despite the recommended guided discovery/inquiry approaches, research has shown that science instructors continue to teach science via the lecture style (Ajaja, 2005).

Recognizing the worldwide significance of scientific knowledge, the Kenyan government tied the fulfillment of Vision 2030's technological, scientific and industrial advancement goals to effective science education (Government of Kenya, 2007). The government intends to achieve Vision 2030 by largely providing learners with scientific information and process abilities for technological and industrial growth, which is a goal of the national education. It is envisaged that acquiring these process abilities and knowledge would move the nation toward realizing Vision 2030, making it more competitive technologically in international markets, by accelerating the transition into an innovation-led and knowledge based economy.

In terms of curriculum, Kenya's 8-4-4 science curriculum states that science is a compulsory subject in primary school, where it is taught as general science and agriculture (Oyoo, 2010; Sifuna & Kaime, 2007). Science is required in secondary school for all students until Form two, afterwards the students must choose two science subjects, at least, when proceeding to Form three, independent of their area of speciality (KIE, 2002). The curriculum also proposes allocating a double lesson each week for activities that are laboratory-based in each science subject so that students may build scientific process abilities. This is founded on the premise that regular laboratory utilization not only allows learners to develop scientific process abilities but also promotes scientific comprehension of concepts.

More crucially, the Ministry of Education, Science (MOE) has designated the science laboratory as vital in science education since its utilization improves accomplishment of national science education objectives (Government of Kenya, 2020). As a result, the government donated science equipment to schools in addition to building laboratories in order to provide atmosphere favorable to good science learning and teaching (Menjo & Chepkorir, 2013).

Aside from the government delivering physical resources, it has also implemented in-service training (INSET) to improve science and mathematics instruction in secondary schools (SMASSE) (Oyoo, 2010; Menjo & Chepkorir, 2013). The INSET is rooted on a baseline study that revealed a need to modify teachers' attitudes toward scientific instruction, prepare them with proper teaching approaches, and increase their topic understanding. It was thought that by following on these three factors, instructors would have the ability to adjust the science tutoring environment (laboratory and classroom) in order to enhance students' learning results.

The primary goal of the INSET is to encourage instructors to adopt 'hands on' and 'minds on' teaching methodologies (Oyoo, 2010). These are techniques that necessitate active participation of learners in learning activities. Such instructional methods necessarily necessitated the utilization of a scientific laboratory. All of these initiatives are designed to guarantee that science students have the necessary scientific knowledge and procedural skills to help them develop the technology society envisioned by Kenya's Vision 2030. Despite these endeavors, science education in Kenya has generally been teacher-centered (with minimal usage of science laboratories), according to Oyoo (2010), which does not successfully support the development of scientific attitudes, knowledge, and abilities. As previously stated, this teaching technique has been linked to learners' persistent poor performance in science in national examinations, as evidenced in KNEC science results reports from 2019 to 2021 (KNEC, 2022).

2.2.4 Science Process Skills

Science process skills are a set of activities done by scientists as they carry on investigations, by observing, classifying, communicating, measuring, inferring and predicting. These skills enable learners to think abstractly and provide solutions for problems existing in daily life. (Njoka, 2020).

Lazarowitz and Huppert (2002) conducted an investigation on using computer simulations to promote science process skills in 10th grade Biology. Their discoveries suggested that computer simulation can assist learners grasp the abilities of graph communication, data interpretation, and variable control in simulated experiments. Mintz (2016) investigated computer simulations as a research instrument. For science learning, inquiry is critical (National Science Education Standards, 2000). Posing hypotheses, performing tests, observing and documenting data, and making conclusions were all part of the inquiry method. Computer simulation has been demonstrated in studies to broaden and improve classroom work. Simulations as inquiry tools, according to their findings, increase motivation and curiosity.

Computer simulations were investigated by Aldrich (2004), in the application of forecasting abilities in a biological computer simulation and discovered that the software of computer-simulation was a useful tool. This contradicts the discoveries of Lazarowitz and Huppert (2002) and Mintz (2016) who discovered that the usage of computer simulations is unlikely to be a substantial influence influencing respondents' motivation. Many of the respondents in their research had previously worked closely with computers. This reduced the novelty, which would otherwise have increased attention. "The laboratory learning setting necessitates essential transition from teacher-directed learning to "purposeful-inquiry" which is more student-directed," with Hofstein and Lunetta (2003), Individual learner can benefit from computer simulations.

2.3 Related Literature Review

2.3.1 Overview

In the related literature review, use of computer simulations in science instruction is presented. It illustrates how computers may be used to enhance Chemistry instruction. Computer-based laboratory simulations (CBLs), animations in Chemistry education and computer supported inquiry learning are also discussed in this section.

2.3.2 Use of Computer Simulations in Science Education

Computer-simulated training allows learners to watch and participate with real-world experiences. Simulation may play a significant role in establishing virtual experiments and inquiry in science courses. Students can use problem-based simulations to test new models, monitor experiments, and increase their intuitive grasp of complicated processes (Daulay, Mursid & Baharuddin 2020). Simulations may also be beneficial for imitating laboratories that would be impossible, impractical, costly, or too hazardous to perform in the real world (Vagale, et al. 2022). Simulations can help with conceptual shift (Windschitl, 2000), give learners open-ended experiences (Sadler *et al.,* 1999), and deliver instruments for scientific inquiry (Stieff, 2003).

Simulations can be useful in scientific teaching when used as supplemental content. Kennepohl (2001) investigated how in a first-year general chemistry course, computer simulations will be advantageous. Hence, discovered that combining simulations with laboratory work is time saving by shortening the laboratory section, and students who use simulations have a little well understanding of the practical aspects connected directly to work in laboratory. The current study sought to determine the effectiveness of computer-based laboratory simulations in the development of inquiry abilities in electro-chemistry among secondary school students.

One of the most potential computer uses in science education, according to Stieff (2003), is using simulations to teach content that can't be tutored by traditional laboratory testing. But, simulation can be as successful as, or perhaps replace, a traditional laboratory? The outcome is that it is dependent on the notion or scenario. Choi and Gennaro (2000), for instance, examined the efficacy of computer-simulated experiences against hands-on laboratory experiences in tutoring the idea of volume displacement to junior high school scholars. They discovered that computer simulations were just as successful as hands-on laboratory experiences. This shows that for some concepts tutoring, like volume displacement, it may be viable to employ a computer-simulated experiment instead of a laboratory experience and receive equal results. This might imply that computer simulations may be utilized to substitute laboratory events that need cognitive participation with the material than psychomotor interactions, such that they don't necessitate as much physical engagement, such as smell, touch, and taste interactions.

Simulations might provide methods for scaffolding gender inequalities in educational contexts. Choi and Gennaro (2000) discovered, for example, that men who had hands–on laboratory skills did well on the posttest than women who had hands–on laboratory experiences. There were no noteworthy variations in performance in comparison males and females in the learning of displacement notion using computer simulation. They did not, however, reach a conclusion about what may be causing the difference in performance between boys and females in hands-on trials, or what characteristics of the simulation would enable gender favoritisms in laboratory resources. More study ought to be conducted to corroborate these conclusions.

Nonetheless, they believe that purpose-driven simulations may be effective tools for addressing some education shortcomings. For example, simulations may be employed to scaffold studying for people whose capacity to imagine is relatively low, which is crucial for understanding system dynamics. The current study aimed at establishing among other things the impact of CBLs teaching approach on chemistry achievement with regard to gender.

2.3.3 Computers in Chemistry Education

In industrialized nations' educational curriculum, technology laboratories and computer-based science, as well as traditional scientific laboratories, are given special attention. One of the goals of the science and technology course is to prepare students to keep up with the rapidly evolving science world and to use the most current technological findings in all fields. The use of computers in education has become unavoidable as an outcome of the fast growth of information and communication technologies. Using technology in education offers students with a more conducive learning environment, fosters interest and a learning-centered culture, and aids in increasing students' motivation. Utilizing technology in this manner is critical to the teaching and learning process (Işman *et al*., 2002). Technological instruments, notably computers, started to be employed in educational settings to create audio visual resources for instance, animation and simulation, leading to the creation of computer-based training methodologies. The computer is just one of several instruments that students use to do science.

For use in the science laboratory, computer software and hardware in the form of sensors and interfaces have been produced. Computer-based labs (CBL) that combine active engagement studying have proved to be effective in overcoming misunderstandings and enhancing conceptual comprehension (Thornton & Sokoloff, 2007). Nevertheless, not all learning institutions have the financial means to supply this sophisticated resource in each scientific laboratory. The remaining issue: are there alternative actions that can be as helpful as these in boosting student knowledge of key scientific concepts? The computer simulation is intended to emulate the CBL laboratory by giving empirical facts as well as a pictorial representation of that information in real-time and in graphs form, in order to generate conflict in cognitive and inspire discussion group of the involved concepts.

The use of CBLs equipment to perform experiments or investigations gives an effective means of gathering empirical data about chemistry phenomena. The question is, how significant is the hands-on or live character of empirical data collection? Other strategies can be used to collect empirical data. Simulation is one such way. A well-crafted and realistic simulation can serve as a visual depiction of a live experiment. Simulations can also provide realistic information that can be utilized external of the simulation, for example, for extended analysis of data.

A variety of learning activities have benefited from the usage of simulations (Steinberg, 2000). Simulations have often been utilized when conducting the experiment in the laboratory which could be difficult or unfeasible. Simulations are also commonly used to teach students to an experimental topic or giving more opportunity to investigate process of experiment. All these programs are designed to aid in the execution of genuine laboratory investigations. However, there has been limited research on using simulations to promote inquiry skills; consequently, the present research attempted to explore the relative efficacy of teaching electro-chemistry by CBLs technique verses traditional methods in acquisition of scientific inquiry skills.

A research of the efficiency of a simulation as an active engagement laboratory practices should be carried out in a zone where there is significant quantity of prior knowledge about learner issues. Active-engagement mechanics using hands-on CBLs have been broadly researched, with well-documented findings (Thornton & Sokoloff, 2007; Steinberg, 2000). Furthermore, numerous evaluation instruments are available to test student conceptual knowledge. These tools have a proven track record of dependability and validity. In beginning kinematics and mechanics, students' distinctive mental and reasoning challenges have been clearly identified. This data was utilized to alter the curriculum and increase student learning. The effectiveness of CBLs was evaluated by examining student grasp of these same concerns following teaching.

Though there are available trustworthy and valid tools to test learners' conceptual comprehension in chemistry, when evaluating this technology’s efficiency, individual student attitudes toward computers and chemistry must be considered as potential limiting influences on studying. Pre- and post-treatment attitude questionnaire can give useful evidence about these potential impacts. Thus, the current study intended to determine if gender and attitudes toward chemistry contribute to differences in high school students' understanding of electro-chemistry principles.

Computer simulations allow pupils to view and participate with real-world experiences. Simulations are helpful for imitating laboratories that would be impossible, impractical, costly, or too hazardous to perform in the real world. Simulations can help with conceptual shift (Stieff, 2003), give open-ended understandings for learners (Sadler *et al.,* 1999), and offer instruments for scientific inquiry (Engel, 2002).

According to Akpan and Andre (2000), a computer simulation in science education is using a computer to model dynamic systems of things in an imagined or real environment. Computer simulations can range from basic two-dimensional or three-dimensional shapes to fully interactive laboratory activities and inquiry settings.

Alessi and Trollip (2001) define simulations in an educational setting as "a strong tool that educates about some part of the environment by copying or recreating it." Learners are not only inspired by simulations, but they also learn by engaging with them in ways that mimic how they might behave in real life. In virtually each case, Reality is made simpler by a simulation by deleting or modifying elements. In this simplified universe, the learner solves challenges, studies processes, gets to grasp the phenomena features and in what way to regulate them, or understands what procedure to take in certain scenarios."

Alessi and Trollip (2001) underlined in their description that simulations simplifies reality by deleting or modifying information. This viewpoint was advanced by Zacharia (2007), who stated that “educational tool such as simulations erase components that are unwanted of real events so as to achieve specified education outcomes." As per Grabe and Grabe (2007), simplicity helps learners to focus on key knowledge or abilities while also making learning more enjoyable. This viewpoint on the usage of simulations is ideal for completing simpler cognitive and behavioral tasks.

Constructivist pedagogy experts, on the other hand, define simulations in education as a real-life scenario simulation shown on a computer (Wilson *et al*., 2019), during which the learner plays an actual part running difficult tasks (Harper, 2000). According to this viewpoint, simulations ought to mimic the complexities of real life so that learners struggle and gain of higher order skills like enquiry, which is seen as crucial for science education (National Science Education Standards, 2000). These simulations immerse students in a setting in which they do integrated activities multiple in order to master sophisticated skills in authentic situations or inquiries (Lajoie *et al*., 2001).

2.3.4 What is a Computer-Based Laboratory (CBL)

CBL is a contemporary technique of science instruction in a laboratory, with learners doing experiments that collect and transfer data straight to a computer. The concept is straightforward: the computer is employed as an instrument of laboratory transforming it into a powerful resource for measuring the tangible world. This is achieved by attaching some of the sensors to it and utilizing the computer's capacity for running the sensor data. This enables students to learn the numerous options that measure a wide range of phenomena in an innovative and subsidiary manner (Kiboss, 2005).

The computer can then assist students in measuring, recording, and graphing values including location, force, light acceleration, speed, pressure, temperature, heart rate, response time, muscle signals, brain waves and numerous other occurrences. These measurements can be stored, studied more, or printed. CBLs make it simple for learners to conduct experiments and view facts presented as a histogram, line graph, or bar graph, either individually or collectively.

CBLs allow for the presentation of graphs alongside the observed occurrence, as well as the storage of information for further study. The learners from the experimental process are not removed; rather, they are provided with strong tools to assist them develop a 'feel' for the facts: information become virtually real as they elucidated their ties to sensory experience.

In a nutshell, Computer-based Laboratories, or CBL, are any laboratories in which a computer collects and presents information directly from the surrounding. CBL technology advancements are often in an instance of improved software and hardware. In terms of hardware, the value of output/input electronics has improved, and more innovative sensors and actuators are now available. Many aspects of development of software are changing. New sub-programs have been added to the software to improve data gathering, data processing (filtering, spreadsheets, smoothing, and so on), data display (different graphical illustrations), and analysis of data (mathematical operations). CBLs has the ability to shift the focus of teaching laboratories away from mundane mechanical operations such as transcribing temperatures from thermometers or charting data and toward more creative components of science such as analysis, hypothesis, and experimentation.

Because the computer may be programmed to construct a graph, the learner can focus on discerning about the data than operating on it. The ease with which data may be collected and processed promotes investigation (Simpson, 2005). There is a wealth of material on the potential applications of CBLs technology in physics, chemistry, and biology teaching, for example Thomas (2001). Trumper and Gelbman (2000), and the list is still growing. Others, such as Balacheff and Kaput (1996), have proposed that CBLs can also be used in mathematics teaching.

CBLs technology provides a variety of learning benefits. These comprise improving students' capability to interpret and produce graphs (Trumper, 1997); real-time data collection, which allows for the repetition of experiments, multiple variable measurement at the same time, and using a long- or short-time range to represent and analyze information graphically, allowing for minimum time spent on obtaining data and lot of time spent on facts interpretation and analysis (Voogt, 2011).

Because of its capacity to offer knowledge during group discussions, CBL enhances group work relationships (Kelly & Crawford, 2019). Linn and His (2000) discovered from their Computer as a Learning Partner study that CBLs are more successful when combined with simulations, because different visuals are feasible for variety of students in complementing configurations. Some investigations have indicated favorable learning effects, and students have evaluated CBL courses positively in some circumstances (Bennet & Brennan, 1996). Moreover, CBLs equips learners with one of the scientists' instruments and allow them to participate in activities similar to those seen in current scientific laboratories (Weller, 2001). The current study sought to establish the use of CBLs in the development of inquiry skills in electro-chemistry among high school students in Bomet County.

2.3.5 Animations for Chemistry Education

Animated depictions of structures and processes assist teachers in communicating fundamental scientific ideas in chemistry and molecular biology. Knowing how students view and grasp such representations benefits the designers of these animations. In particular, instructional designers strive to create visuals that enable students to grasp essential ideas and the links among these concepts (Kelly, 2005).

Visual animations and simulations aid students in understanding challenging topics connected to the dynamics of complicated chemical systems, such as reactions and molecules (Kozma & Russell, 2005). Examining the dynamics of student relationships and how scholars engage with equipments, on the other hand, demands scholarly attention. A group conversation regarding previously seen animations assists students in identifying components of the animation that they may have missed. (Kelly, 2005).

Viewing animations of fundamental chemical processes, on the other hand, has both beneficial and bad effects on students' mental models. It is also proposed that, because students frequently interpret molecular chemistry animations literally, clarifications to remedy misrepresentations be included. These explanations are frequently implemented as student-led dialogues with the assistance of an educational facilitator.

Through the views of, cognitive psychologists, educators, and chemists, much may be learnt about teaching through animations (Jones *et al*., 2005). Such collaborations result in significant research on the integration of visualization in chemical teaching. Making connections between idea fragments encourages students to problem solve and interact with knowledge rather than memorize rules or information bits (Suits, 2003). Using animations in conjunction with computer-based laboratory activities helps students integrate numerous representations of chemical ideas (Suits *et al*., 2005).

Several lab experiments are clearly supplemented with multimedia animations and simulations that depict the phenomena being investigated by learners. Instructors frequently assist scholars in using technology and animations to remain on topic and crack a complicated scientific subject, with coaching supplied as required to continue educational progress among the students. Learners must participate actively in a learning scenario. The instructor serves as the guide. Students actually understand Chemistry and chemical processes when they relate their macroscopic perception of the occurrence to the graphical illustrations (Zacharia, 2007).

For the reason that project-based scientific learning is a prominent approach for science syllabus reform, technologies provide several chances for cooperation and cooperative studying (Harasim, 2012). Students can cooperate with other learners including scientists worldwide by using the Internet. Maor and Taylor (1995) performed a tutor case study that documented a constructivist style to scientific learning and tutoring over the Net. Students in this class collaborated to propose unique research issues that they devised and executed their individual complicated scientific studies. Numerous recent study initiatives have investigated using integrated technology for scientific education. ChemSense, for instance, enables scholars to have knowledge about Chemistry while also creating their personal representations of what they are studying using genuine information (Stanford *et al*., 2002).

According to one survey, more K-12 children turn their home computers as computer games rather than for schoolwork tasks (National Center for Educational Statistics, 2003). Clearly, computer and video animations are a part of K-12 kids' daily life (Simpson, 2005). These similar scholars have high outlooks for their educational situation, which include technological details such as multimedia and complicated interactivity (Squire *et al*., 2005).

Educational simulations and animations, similar to computer games, immerse learners in virtual worlds in which they utilize their skills, reasoning, and knowledge in virtual circumstances (Gredler, 2004). Since learning is multidimensional in general, including how people learn (Gardner *et al.,* 1996), animations and simulations enable multisensory interaction, visuals, and symbolism. Symbols and visualizations improve human being cognitive abilities and aid in the communication of thoughts and data (Tversky, 2001).

Simulations are far more successful than drills and tutorials in increasing flexibility, motivation, efficiency, and learning transfer, while being safer, more suitable, and controlled than real-life encounters (Alessi & Trollip, 2001). Kids nowadays recreate by computer games and playing video, Instant Messaging, watching action movies and watching MTV (Simpson, 2005). Taking pupils out of their familiar environs may have an influence on their motivation and attentiveness as learners (Squire *et al.,* 2005).

The tremendous rise in fame of computer-based gaming inspires instructors to create more engaging means to involve their learners. When technology is introduced and used to assist children in learning, the responses are overwhelmingly favorable (Prensky, 2001). Since gaming is growing more widespread, many institutions and organizations are incorporating game simulations into their programs of training (Aldrich, 2004). And educational simulations which successful combine the assignation potential of games with material that are instructional, and they enjoy these games but not frivolous. As per reports, the US military training spends more than $2 billion. Majority of the training offered to soldiers comprises using simulations and technology for learning (Prensky, 2001). As a result, the current study intended to determine the relative efficacy of teaching electro-chemistry using CBLs technique verses traditional methods in the acquisition of scientific inquiry abilities among secondary school students in Bomet County.

2.3.6 Computer Supported Inquiry Learning

Inquiry learning promotes conceptual transformation by involving learners in tasks that are anticipated to form hypotheses, conduct experiments, develop theories and models and assess them in the same way that scientists do. The purpose of this technique is to carry out investigations that would be carried out in a genuine laboratory setting. Computer simulations, further, offer the ability for students to conduct experiments online, just as they could in a real laboratory setting (Finkelstein *et al.,* 2005). Despite the benefits of employing computer simulations to increase inquiry, there are important difficulties influencing computer aided inquiry learning implementation.

Even though computer literacy and prior knowledge appear to be vital for conducting experiments in a virtual learning setting, Wecker, Kohnle, and Fischer (2007) discovered no noteworthy relationships between step-by-step self-confidence and computer-related knowledge in utilizing computer for acquiring knowledge. The similar research found that learners who are more computer proficient received much less information. The current study attempted to determine if the acquisition of inquiry abilities in CBLs strategy is dependent on strategy training and prior knowledge of science.

Computers have been utilized to construct settings that involve students in scientific inquiry throughout the previous two decades (van Joolingen *et al.*, 2007). They came to the conclusion that computerized inquiry learning improves students' conceptual knowledge (Salovaara, 2005). However, a few investigations have been carried out to compare the accomplishment of scholars doing tasks in a real laboratory setting to that of a virtual laboratory environment, in both that inquiry learning is implemented

(Zacharia, 2007). These findings support the assumption that, when compared to genuine experimental contexts, virtual experimental environments have an equal or superior influence on students' comprehension of scientific concepts (van Joolingen, *et al.,* 2007; Zacharia, 2007).

According to Wecker *et al*. (2007, p.141), "the combination with more computer expertise use limited time on the solo elements for using receptive, offering them limited chance to expound on the data presented in these elements." Other issue that scientific instructors ought to examine is gender inequality in computer-assisted education. Technology is widely assumed that is gender-neutral (Prensky, 2001).

Even though computer-supported learning settings have the potential to provide equal opportunities and democratic, evidence proposes that this complain is no longer valid because interaction via electronic channels doesn’t take into account the gender imbalance and social complexity that exists already in society (Gunn *et al.,* 2002). The discoveries of Mayer-Smitha *et al.* (2000), on the other hand, show that the gender problem shouldn’t be viewed as one that enhances learner participation and achievement. More important than gender are questions about how technology-rich and science learning settings should be constructed, as well as what pedagogical approaches should be employed. As a result, a computer-supported learning setting that promotes inquiry learning ought to be built to provide equitable possibilities (Gunn *et al.,* 2002). This type of learning environment was advantageous to both males and girls. Physics by Inquiry is a curriculum built with pedagogy to engage scholars in active learning while they construct their own knowledge. Hands-on, inquiry-based scientific training is recommended as an effective teaching strategy for assisting students in actively constructing science knowledge in the same manner as scientists do.

Recent discoveries in science education research on studying reinforce the idea that learners generate information via active engagement in the process of learning. The student-centered approach, in which the emphasis is on the students and their learning rather than the instructor, is preferred. With this method to teaching and learning, both students and teachers adjust to new responsibilities. ICT has been proven to have the ability to facilitate understanding-focused scientific instruction and to improve learning in a student-centered setting (Stieff, 2003).

However, dramatic evolvement in teaching approaches and methods to education are urged for in order for ICT to effectively be used in day-to-day education. Both learners and teachers must adjust to their new positions. Such drastic shifts in tutoring style are unlikely to occur overnight. Instructors may require some time to change from a standard tutoring style to a student-centered inquiry-based scientific learning strategy (Karanja, 2013). The research advocates for an activity-based technique that is hands-on but inquiry-oriented in nature to help teachers adapt. The current study aimed to investigate secondary school chemistry teachers' opinions on computer competency levels, and computer access in Bomet County.

A recent study of scientific education in Kenya revealed that most instructors employed transmissivity than participatory pedagogy in their classrooms. Their education strategy is the classic teacher-centered lecture (chalk and talk) method, stressing information and skill transfer and encouraging memory, which is unusual of currently advocated science teaching approaches. Learners who completed successfully their studies often perform badly and are unable to utilize the knowledge they have studied outside of the classroom. The Kenyan government recently updated the curriculum. New subjects and courses have been introduced to reflect modern advances in science, society, and technology breakthroughs. Computer studies, that comprises of computer science and computer literacy courses, is one of the new subjects added to secondary school curriculum (Saputri, 2021).

A minimum school has computer hardware and rudimentary software, but because there are no qualified teachers, thus underutilization of the computers in schools. The majority of computer use is for administrative purposes. In certain circumstances, pupils are taught the most fundamental computer abilities (Omwenga, 2005).

A learning atmosphere that allows learners to actively participate in the process of learning allows them to have control over their education, which leads to improvements in learners' retention and learning on both the developmental and cognitive theoretical bases (Johnson *et al.,* 2000; Springer *et al.,* 1999), resulting in a cooperative classroom climate. Science and technology education are seen as a critical component of Kenya's social and economic growth, as it is in many other nations. However, school-based science education has not represented activities real scientists perform. The wide disparity between scientific means as experienced by the scientific community and the process trained in schools has sparked worldwide concern and spawned propositions for improving the condition by adopting a teaching style in which learners design experiments, manipulate variables and identify problems (Oduor, 2009). The current investigation; thus, attempted to complete the gap by examining the relative effectiveness of teaching secondary chemistry by CBLs strategy in comparison to the traditional approaches in acquisition of scientific inquiry skills in electro-chemistry in Bomet County, Kenya.

2.4 Empirical Review

Okwuduba, Offiah, and Madichie (2018) explored the outcome of computer simulation on the chemistry achievement in secondary school. The research utilized quasi experimental research design where 78 students sampled with 40 representing controlled group and 38 represented experimental group were elected from Awka Education Zone of Anambra State in Nigeria. Pre-tests were given before treatment and results were tested after four weeks of tutoring to obtain post-test results. They used ANCOVA to test the hypothesis of the study based on 5 percent significant level. According to the findings computer simulations were efficient in improving students' success as compared to lecture technique. However, there was no noteworthy change in achievement based on gender difference of the students. The research recommended computer simulation to be used while handling dangerous experiments. The study also suggested that computer simulation ought to be adopted to enhance the achievement of Chemistry in high schools.

Spodniaková (2015) researched the computer simulations and their impact on student's understanding of oscillatory motion. The study was examining the suitability of using computer simulation in specific area of scientific based experience. The study used experimental group and control group to examine the variance in achievement using simulation as well as lecture methods respectively to study oscillatory motion. The result revealed that computer simulation assisted learners to comprehend the basic characteristics of oscillatory motion. It also assisted the learners to use different physics knowledge creatively to understand oscillatory motion. Therefore, the study concluded that computer simulation was better based on ability to use graphics as compared to control class.

Sreelekha (2018a) assessed the impact of computer simulation on physics practical achievement. This was conducted in District III, Lagos State in senior Nigerian secondary schools. They used Quasi-experimental design where a non-random pre-test and post-test were conducted. Multi-stage sampling technique was used to select

219 senior secondary two physics students. Practical physics achievement test, practical skill rating scale as well as students' attitude inventor scales were used to collect information. Analysis of covariance (ANCOVA) was used with 5 percent significance level. Interaction effect was illustrated using graphic method. The study showed that computer simulations representing experimental group had higher mean in both achievement as compared to conventional methods representing controlled group. Therefore, concluding that computer simulation improve learners' achievement in physics practical.

Radulović, Stojanović and Županec (2016) examined the effect of laboratory inquiry-based experiments and computer simulation on performance of students as well as cognitive load in physics teaching. The investigation conducted a comparison of the utilization of computer-based simulation and laboratory inquire-based experiments with tradition approach. A sample of 187 students from secondary schools were selected using convenience sampling technique. A multiple choice was used for measuring performance of the student which was followed by 5 point Likert scale for measuring cognitive load. The significant test at 5 percent was evaluated using analysis of variance and Tukey's post-hoc test. The study found that interactive computer-based simulation and laboratory inquire-based experiments equally contributed to enhancement of performance of students as well as reduce cognitive load than traditional teaching method in Physics. Therefore, that interactive computer-based simulation and laboratory inquire-based experiments are effective teaching instructions.

Chumba, Omwenga, and Atemi (2020) established the impact on the use of computer simulations on learners' academic success in Physics within Ainamoi Sub-County in Kericho County. Computer simulation in Physics was used to examine its effect on attitude as well as academic achievement. Quasi-Experimental was used as the design. A 200 Form 2 scholars' sample and four Physics instructors were chosen to take the Standardized Physics Achievement Test and the Student Questionnaire on attitudes towards Computer Simulated Physics Lesson Scale. The magnetic effect of an electric current was taught to the experimental groups via computer simulation, whereas the control groups were taught using traditional techniques. The results revealed that computer simulation had positive significant influence on attitude towards physics lessons. The data also demonstrated a statistically noteworthy difference in Physics achievement between the experimental and control groups.

Sreelekha (2018b) evaluated the impact of computer simulation and video-based teaching methodologies on scholars' learning of physics practical abilities. The study used quasi-experimental research design with multi-stage sampling on sample of 315 physics students. The study used covariance analysis, marginal means and Scheffe's post-hoc test at 5 percentages. The results indicated that simulations and video based strategies had higher mean in obtaining practical skills than traditional method. There was, however, no statistically substantial difference depending on gender.

Awodun and Oyenyi (2018) established the outcome of instructional simulation on scholars' academic performance in Nigeria. They adopted Pre-test-post-test Quasi-experimental design. Samples of 160 junior secondary school pupils were selected using simple random from junior secondary school in Ekiti State. T-test and Analysis of Covariance were adopted to test hypothesis. There was a substantial change in academic excellence in science between the instructional simulations that represented the experimental group and the control group that represented the traditional technique. The study revealed that computer simulation has a substantial influence on performance when compared to traditional approaches. This study addressed effectiveness of CBLs in development of inquiry skills in chemistry.

Sarabando, Cravino and Soares (2014) investigated the role of computer simulations to student's studying Physics. The mass and weight topic were examined using quasi-experimental research design. Grade 7 students were used where the results revealed that computer simulation assisted students to gain hands on skills. As an outcome, it was suggested that computer simulation be utilized to improve learners' grasp of scientific knowledge.

2.5 Summary of Knowledge Gap

The empirical studies revealed geographical gap where Okwuduba, Offiah, and Madichie (2018), Sreelakha (2018a; 2018b) and Awodun and Oyenyi (2018) conducted their research in Nigeria with different academic system and curriculum. Radulović, Stojanović & Županec (2016) did the research in Turkey with not only different syllabus but also economic difference with Kenya, where the current research was conducted. Contextual gap was found in Spodniaková (2015), Sreelakha (2018a; 2018b), Chumba, Omwenga, and Atemi (2020), Radulović, Stojanović and Županec (2016) and Sarabando, Cravino and Soares (2014) who concentrated on the use of computer-based laboratory simulation on Physics related topics. However, the current research would bridge the gap through investigating on electro-chemistry topic in chemistry. Dismal performance in chemistry has been reported expecially topic electro chemistry. By using CBLs learners are able to visualise electrochemical processes such as migration of ions and flow of electrons.

The current study utilized quasi experimental design, interview schedule, questionnaire and Chemistry Assessment Test. This assisted in filling methodological gap developed by majority of the studies that only used experimental design (Sarabando, Cravino, & Soares, 2014; Awodun & Oyenyi, 2018; Sreelekha, 2018a; 2018b; Chumba, Omwenga & Atemi, 2020; Radulović, Stojanović & Županec, 2016; Spodniaková, 2015; Okwuduba, Offiah, & Madichie, 2018).

According to the reviewed research, computer simulations are useful supplemental resource for classroom education and scientific laboratories. It also suggested that computer simulations may be useful in distant education laboratories. However, this subject is elusive and requires further investigation. According to the reviewed literature, the computer simulations success in scientific education is dependent on how they are included into the curriculum and how the instructor employs them.

Computer simulations are best utilized as supplemental aids for classroom education and laboratory work. Because of their potential to augment constructivist learning, multimedia-enabled, highly interactive, collaborative computer simulations are gaining popularity. They provide inquiry environments as well as cognitive material to scaffold learning and problem-solving abilities. Computer simulations are useful resource for helping learners enhance their prediction abilities, hypothesis generation, and visual interpretation.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This section describes the research design, the area of study, target population, sample and sampling procedures. It covers data collection instruments, data collection techniques, reliability and validity of research instruments and pre-testing of research instruments. Lastly, it provides data analysis, ethical issues, and a summary.

3.2 Research Design

In accordance to Orodho (2003), research design is a strategy used to develop responses to research hypothesis or questions, however Burns and Grove (2003) describe research design as a blueprint for performing with maximum control over aspects that may alter the validity of the deductions. This study used Quasi-experimental designs which enable the researcher to manipulate the experimental group while control group remain without manipulation making it easy to examine the difference between CBLS and traditional method.

Philosophical paradigm adopted in the study is positivism where observation of the reality of science can be done objectively. It originated from the natural sciences and focuses much on scientific method of testing hypotheses which paves way for further investigations (Collis & Hussey, 2014). The aim of this research was to investigate the use of computer-based laboratory simulations (CBLs) in secondary chemistry education in Bomet County in fostering the development of inquiry skills in chemistry.

The design of a quasi-experimental pre-test post-test control group was used. This is due to the fact that the subjects had already been constituted and it was not possible to pick them at random, as school administrators do not permit random assignment of individual respondent once they have been formed. CBLs and Traditional approach formed the independent variables. This was assessed in relation to acquisition of scientific inquiry skills, effectiveness CBLs over traditional method, CBLs based on gender and student attitude as indicators of success in chemistry were dependent variables.

The quasi-experimental design is a quantitative research method which involves manipulation of independent variables without random assignment of participants into groups. It compares two groups with different treatment and finds cause and effect. This design employed experimental approach as well as the use of survey questionnaire and interviews. An experimental design is a powerful strategy that is used to examine hypotheses in order to achieve meaningful inferences between dependent and independent variables (Creswell, 2013).

According to Maxwell (2012), an experimental design was used because respondents were subjected to a variety of situations. Both control and treatment groups determined the genuine impact of the program or intervention. The intervention was administered to the treatment group. The control group, on the other hand, received business-as-usual circumstances, because they only got interventions that they would have received if they had not taken part in the research. The study selected four schools two girls' and two boys' schools which were coded as A, B, C and D. Therefore, one boys' and girls' school were the experimental group (CBLs) and the next control group was represented by one boys' school and one girls' schools. Each school provided 40 students to be used for investigation.

One or more independent variables were modified. The impact of this manipulation on single or more dependent variables were measured, and all other factors were controlled. The effectiveness of CBLs learning strategy was compared with the traditional tutoring technique at the end of a two-week treatment session to assess if it had a meaningful influence on secondary school learners' achievement in chemistry. The experimental design technique was made available to the teachers (Appendix V).

3.3 Study Area

The investigation was carried out in Bomet County, which is located in Kenya's South Rift Valley region. Bomet County is bounded to the south east, south, and south west by Kericho County, to the North West by Nyamira County, and to the east by Nakuru County. The County has a total land area of 2,037.4 Km^2, of which 1,716.6 Km^2 is arable and suitable for farming (Appendix X). Bomet County is one of the economically active parts of the country. Owing to its suitable climate and productive soils, Bomet is densely populated with many secondary school students. Performance of these students particularly in sciences and chemistry in particular has been poor over the past four years consequently engaging in such a study would be a way of rewarding the community by conducting this research in an effort to improve students’ performance in chemistry.

3.4 Target Population

The general population under research is referred to as the target population, and the findings of the inquiry should be generalized to this group (Ogula, 2001). The target population for the study comprised all form four students in secondary schools in Bomet County. Statistics obtained from County Education Office indicated a population of 18659 students in all secondary schools.

The total number of Form four learners in selected schools was 687 and 4 Chemistry teachers from public Secondary Schools in Bomet County. Chemistry teachers from the chosen schools were included in the study since they were in charge of planning and developing a suitable teaching and learning environment. Students in Form 4 were chosen because they had been in the school long enough to display the relevant factors. They had accumulated enough experience to be able to think abstractly.

Table 3.1: Target Population

Coded	**Schools**	**Group**	**Number of Students**
A	Boys School	Experimental group	165
B	Girls School	Experimental group	195
C	Boys School	Control group	180
D	Girls School	Control group	147
Total			**687**

3.5 Sample and Sampling Procedures

Using samples rather than the entire populations was cost-effective and more practicable (Polit & Beck, 2010). A target population was the broad population under research, from which the investigation's findings were to be generalized (Ogula, 2001). This sampling frame was required for picking a representative sample. A sampling frame was constructed in this study using a list of public secondary schools in Bomet County.

To select the four secondary schools from Bomet County and 4 Chemistry teachers for the interview, this study adopted purposive sampling, as well as simple random sampling technique for selecting Chemistry students per school. While utilizing purposive sampling 40 Chemistry students selected from one class were taught using one method. Purposive sampling is commonly employed in qualitative research, according to Parahoo (2006). Purposive sampling entails picking persons who are knowledgeable about the phenomena being examined or who have been identified as prospective data rich examples (Mapp, 2008).

Purposive sampling was adopted as a suitable approach based on conducted pilot study as recommended by Wallen & Fraenkel, 2001. The County Education Office provided a list of secondary schools in Bomet County, from which samples of four schools which offer computer as one of the teaching disciplines were selected using purposive sampling; this is because experimental group needed learners who are computer literate. Form four classes were selected purposively for the study based on the topic electrochemistry covered in form four.

3.6 Sample Size

The sample size must be estimated on the design stage of quantitative research (Wallen & Fraenkel, 2001). As per Polit and Beck (2010), quantitative researchers ought to choose the greatest size sample available to guarantee that the sample is representative of the population target. Because it was nearly impossible to reach all of the schools in Bomet County, only extra county public secondary schools were used. In this study, the sample size comprised the sample for experimental group which had 80 students while the control group had 80 students and 4 Chemistry teachers. The sample also consisted of sample of 205 students which represent 30% of 687 total number of Chemistry students in the four schools who filled the questionnaire. This was obtained based on Mugenda and Mugenda (2003) concept of picking 30% where there was target population of 100 to 1000 respondents. This made a total sample size of 369 respondents. The-sampled schools and respondents are shown in Table 3.2.

Table 3.2: Sampling Frame for Teachers and Students in Bomet County

Coded	Type Schools	Number of Students	Sample of Teachers for interview	Sample of students for questionnaire	Sample for Experimental test
A	Boys (Exp.)	165	1	49	40
B	Girls (Exp.)	195	1	58	40
C	Boys (Cont.)	180	1	54	40
D	Girls (Cont.)	147	1	44	40
Total		**687**	**4**	**205**	**160**

Keys: Exp. – Experimental group, Cont. – Control group for Experimental test

Source: Bomet County Education office (2019)

Therefore, the sample size of 369 respondents comprised of a sample of 4 teachers, 205 students who filled questionnaire and 160 students who were involved in experimental design where 80 represented control group and 80 experimental group as indicated in Table 3.2.

3.7 Data Collection Instruments

The collection of data must be objective, systematic, and repeatable (Gerrish & Lacey, 2010). As per Maxwell (2012), an investigator should obtain facts in the simplest way possible and must not collect any more statistics than necessary. In relation to this study, Student chemistry achievement test (SCAT), questionnaire and interview schedule were preferred tools. These tools were presented as sub-themes.

3.7.1 Student Chemistry Achievement Test

The data collection instrument chosen for this study was the Students Chemistry Achievement Tests (SCAT), which was developed and used to determine the mean achievement score in Chemistry. It comprised of twelve structured questions which were short answered with a 50 mark maximum score based on electro-chemistry, a topic tutored in Form four in accordance to the secondary school syllabus-volume two (KIE, 2002). The topic was chosen since it is regarded as the most difficult topic in chemistry (KNEC, 2022), and its non-practical nature makes it suitable to computer-based laboratory simulations (CBLs) as a teaching technique. The item format with short response was modeled after the KNEC chemistry paper one, which is acceptable because it is the used format at the secondary school level in Kenya (KNEC, 2005). The test questions were organized and classified into three cognitive domain levels based on Bloom's taxonomy of Educational aims in the cognitive domain (Bloom, 1956). They tested the first three cognitive levels of knowledge, understanding and application.

3.7.2 Questionnaire

Because it is less expensive in terms of time, the data was obtained via a self-administered questionnaire. It was a rapid, easy, and low-cost technique of gathering standardized data (Jones & Rattray, 2010). In this investigation, data was obtained using a structured written questionnaire which entailed a quantitative self-report method as defined by Polit and Beck (2010). The fixed choice and open-ended forms of the items were employed in the development of the questionnaire items. These forms were utilized in all of the questionnaire's categories. Questionnaire was developed based on the study objectives, general literature review and the background of the study. This tool was preferred in data collection because it was cost effective and covers a wider area.

Even though it was the simplest option and offers less chance for self-expression, it may leave the respondent with the impression that the researcher imposed an artificial picture of reality (Maxwell, 2012). As a result, this item format must be used with the open ended format. This enables for more spontaneous answers and possibilities for self-expression. Open ended format was used on a subset of the students' questionnaire. Questions that were closed-ended, which are more efficient and require little time from respondents, were utilized (Polit & Beck, 2010). To obtain a higher response rate, the questionnaires were distributed using the drop and collect approach.

3.7.3 Interview Schedule

Formal teacher semi-structured interviews were carried out to obtain data on their reactions to the usage of CBLs to supplement classroom instruction and their perspective of what was actually happening in the chemistry classroom while the students utilized the CBLs software to learn electro-chemistry. Content analysis was used to interrogate the interviews, which validates the learners' point of view. It gave qualitative data to back up the quantitative data from the chemistry achievement test and questionnaire.

3.7.4 Piloting of Research Instruments

A pilot study was done to help guarantee the instrument's validity and reliability, particularly the questionnaire. The interview schedules were also examined based on the study area. Similarly, the chemistry achievement test was also examined to ensure that electro-chemistry questions were assessed as per the secondary school syllabus.

Piloting was an important phase in the questionnaire creation since it allowed the instrument to be evaluated before the core study was underertaken (Parahoo, 2006). The pilot research, like the main study, was done on a limited population sample. It allowed one to ascertain if all the respondents understood the questions the same way, if all of the questions were important and if majority of the instructions were clear. The questionnaire's validity and reliability was tested at the pilot phase (Jones & Rattray, 2010). Pilot participants were taught on how to look for mistakes and difficulties with the questionnaire. The questionnaire's content and structure were revised well.

A pilot test in two schools in neighboring Kericho County, Kenya, was done prior to data collection. The choice of Kericho County was because the two regions have schools with similar physical resources and facilities, to avoid contamination of the sample population. This allowed for an increase in the instruments' validity and reliability, as well as addressing any other issues that may have arose. Furthermore, the acquired data enabled a complete examination of the intended statistical processes.

3.8 Data Collection Procedures

Before collection of data, approval was sought from the School of Education, Department of Centre for Teacher Education, University of Eldoret via a letter, which was then utilized to get a research permit from the National Commission for Science, Technology, and Innovation (NACOSTI). The Bomet County Director of Education and the County Commissioner were both informed, and their consent sought to access schools. The principals and Chemistry instructors of the schools participating were informed of their schools' involvement in the project and their cooperation requested for.

Once the data collection instruments were examined and ascertained to be reliable as well as valid, the questionnaire were handed to the students based on random sampling and collected within the same day to ensure that all information was captured as well as to reduce non-respondents. The interviews were also conducted in a secure and enclosed room to reduce interference.

The achievement tests were administered before, to the experimental and control groups which were taught using CBLs and traditional method, respectively. Then similar exams were administered after students had been taught using the two methods and results were recorded and then analysed.

3.9. Reliability and Validity

As per Polit and Beck (2010), the questionnaire validity was the extent to which the instrument measures what it was supposed to measure. The questionnaire ought to include all facets of the subject being researched. The most often cited validity difficulties in the literature are content and face validity (Parahoo, 2006).

Face validity checks that the questionnaire appears to evaluate the tested idea (LoBiondo-Wood, 2010), and they were examined by having friends test-run the instrument to determine if the items were unambiguous, appropriate and straightforward, as illustrated by Jones and Rattray (2010).

A content validity test ensured that there were appropriate questions covering all parts of the project and that no extraneous questions are addressed (Parahoo, 2006). The content validity of new surveys can be assessed by a team of specialists (Polit & Beck, 2010). The questionnaire was presented to panel of four chemistry teachers to ensure that the items accurately reflect the themes being examined and that the breadth of the questions is appropriate, as indicated by LoBiondo-Wood (2010). The supervisors looked through the questionnaire and interview schedules.

The questionnaire reliability relates to its capacity to provide the similar results when re-administered under the similar circumstances, although it is hard to acquire data replication while working with individuals (Brink, 1991). As a result, supervisors were given the questionnaire and tests to review for relevance to the research.

The chemistry achievement test instrument was pilot-tested to ensure reliability using a co-educational school in Kericho County that wasn't part of the research but had comparable conditions as scores sample. The Cronbach's alpha coefficient was used to compute the test's reliability coefficient (Hopkins, 1998). The Cronbach alpha reliability coefficient approach was utilized to assess the instrument's dependability. By pre-testing the instrument, a reliability test is a means of ensuring the test's dependability. Pre-testing detects problems in research tool that may be fixed later. Furthermore, pre-testing of instruments aids in estimating the time required to deliver the instrument. The test retest reliability of the tool was determined by disbursing it to the same subjects twice and determining the Cronbach coefficient between the results. The alpha coefficient has a value between 0 and 1 and is used to elaborates the extracted reliability of components from questions with two alternative responses; a number greater than 0.7 indicates that the questionnaire is more reliable. An aggregate of 0.756 was obtained, which was more than 0.7, indicating that the questionnaire was credible, as revealed by data analysis.

3.10 Data Analysis

The information from the questionnaire and the chemistry achievement test were coded, screened, and put into SPSS version 21.0 of 2019. Data obtained in chemistry achievement test was evaluated using inferential statistics and specifically Analysis of Covariance (ANCOVA), which was intended to establish the differences between computer-based laboratory simulations and traditional teaching methods at a 5% significance level. Further, Analysis of Covariance Variance (ANCOVA) was used to establish significant differences in mean scores for different schools sampled, in the two tests utilized (post-test and pre-test). Also, Descriptive statistics was utilised, with mean and standard deviation used to present the effect of computer-based laboratory simulation on chemistry achievement.

Utilizing a 5% significance level, Analysis of Variance (ANOVA) statistics were performed to find whether there was a substantial influence on the acquisition of inquiry skills after using CBLs. It was used to test if there existed significant difference between variables. The qualitative data acquired through interview schedules was further tested using content analysis to be able to quantify and analyze presence and relationship of some themes. The statistical analysis of the collected data was presented in form of standard deviations, means, and Frequencies, and were done in tables. Data was represented using line graphs, pie chart and bar graphs.

3.11 Ethical Considerations

Research is considered as a scientific human endeavor that is structured in agreement with a variety of rules, methodologies, norms, and regulations (Gerrish & Lacey, 2010). In accordance to Polit and Beck (2010), when a researcher's intended research affects human people, he or she must deal with ethical concerns. The field of study that analyzes ethical concerns in order to produce standards that protect the rights of human subjects in research is referred to as research ethics (Kathuri & Pals, 1993). As a result, research ethics were followed while conducting the research. The study assured the respondents of the confidentiality of their responses since their identities would not be revealed. The aims and relevance of the study were explained to the respondents. It was clearly made on the reason they had been selected to participate, also their right to decline, accept, or even participation withdrawal in the research (Edwards, 2005), and they all gave informed consent.

3.12 Summary

This study used quasi-experimental design, where manipulation of an independent variable without random assignment of participants to conditions was done. The independent variables were the teaching approaches; Computer based laboratory simulation (CBLs), traditional teaching method and learner's gender. The dependent variables in the study were the learning outcomes; scientific inquiry skills, achievement in chemistry and student's attitude towards chemistry.

This project investigation was carried out in Bomet County in the southern part of the former Rift Valley Province of Kenya. A target population of 687 Form four students and 4 teachers from public secondary schools in Bomet County was used. A sample size of 369 participants which entailed 4 teachers subjected to interview, 205 students who responded to the questionnaire and 160 students who did experimental test. Four (4) secondary schools in Bomet County were purposively sampled based on computer availability. The study had 369 individuals in total. By using simple random sampling procedure, the four learning institutions were assigned to treatment and control groups.

The current study preferred Quasi- experimental design because it can mimic an experiment and provide evidence without randomization. The instruments used in this investigation were a series of questionnaire and the students chemistry assessment test (SCAT) which was verified by supervisors and the heads of Chemistry Departments at the secondary schools sampled. To collect information from students and chemistry teachers, questionnaire and interview schedules were employed. Pilot testing was carried out on the instruments to evaluate their dependability. To guarantee uniformity in the teaching technique across all control and experimental groups, instructional steps were followed in accordance with the planned lesson.

In conclusion, the chapter describes in what way the data obtained was evaluated and presented. Data analysis was done using both qualitative and quantitative methodologies. Ethical issues were also considered to ensure conventional administration of research work.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This section summarizes the findings, including response rate analysis, demographic data, descriptive statistics, and inferential statistics. Findings were presented per objective with analysis, interpretation and discussion. Mean and standard deviation were used in descriptive statistics. Inferential statistics entails correlation analysis, ANOVA and ANCOVA which were used to analyze the relationship between variables based on 5% significant level. Content analysis was conducted for interview schedule which were used in tandem with inferential results. The data was presented in this section using frequency tables, pie charts and graphs.

4.2 Response Rate and Reliability

A response rate of 84.4% was obtained where 173 copies of 205 questionnaires were returned. This enabled the research to proceed with data analysis because over 80% response rate is excellent for analysis according to Mugenda and Mugenda (2003). A test was given to the four schools which were coded A, B, C, and D representing boys experimental group (CBLs), girls experimental group (CBLs), boys control group (traditional) and girls control group (traditional), respectively. Each group consisted of 40 students which were given pre-test before using CBLs and post-test after using the teaching method. Therefore, the response on the test was 100% as anticipated with 40 students in all the groups that is a total of 160 students. The study also used four (4) chemistry teachers who were found in the respective four schools teaching the chemistry class. The response rate was also 100% since all the four chemistry teachers were conveniently interviewed.

Cronbach Alpha was used to test the reliability of questionnaire. The alpha co-efficient ranges from 0 to 1 and was used to elaborate the reliability of components extracted from items with two alternative responses; a value greater than 0.7 indicates that the questionnaire is reliable. Table 4.1 shows the results.

Table 4.1: Reliability of Instrument

Details	Cronbach Alpha	Item
Computer Based Laboratory Simulation and Acquisition of Scientific Skills	.764	6
CBLs Versus Tradition Method on Effectiveness in teaching Chemistry	.704	6
Computer based laboratory simulation and Achievement of Chemistry in Relation to Gender	.733	5
Computer based laboratory simulation and Students' Attitudes	.780	6
Achievement in Chemistry	.801	4
Aggregate Average	**.756**	

Computer based laboratory simulation and acquisition of scientific skills had six items which were reliable since the Cronbach alpha co-efficient was 0.764. Similarly, CBLs versus tradition method on effectiveness in teaching chemistry had six questions which were found to be reliable with Cronbach alpha coefficient of 0.704. The five questions for computer-based laboratory simulation and achievement of chemistry in relation to gender were reliable with Cronbach alpha co-efficient of 0.733. Computer based laboratory simulation in relation to student attitudes was also reliable with Cronbach alpha Co-efficient of 0.780. Finally, achievement in chemistry was also reliable with four questions with 0.801 as Cronbach alpha Co-efficient. According to Jones and Rattray (2010) a threshold of Cronbach alpha above 0.7 is termed as reliable. Hence, all the questions for each objective were reliable with aggregate Cronbach alpha co-efficient of 0.756.

4.3 Demographic Information

Demographic information was given by gender, age and type of school which was collected based on the questionnaire given to students. The information was presented in pie chart format and frequency tables. Gender was therefore, presented in figure 4.1.

Gender

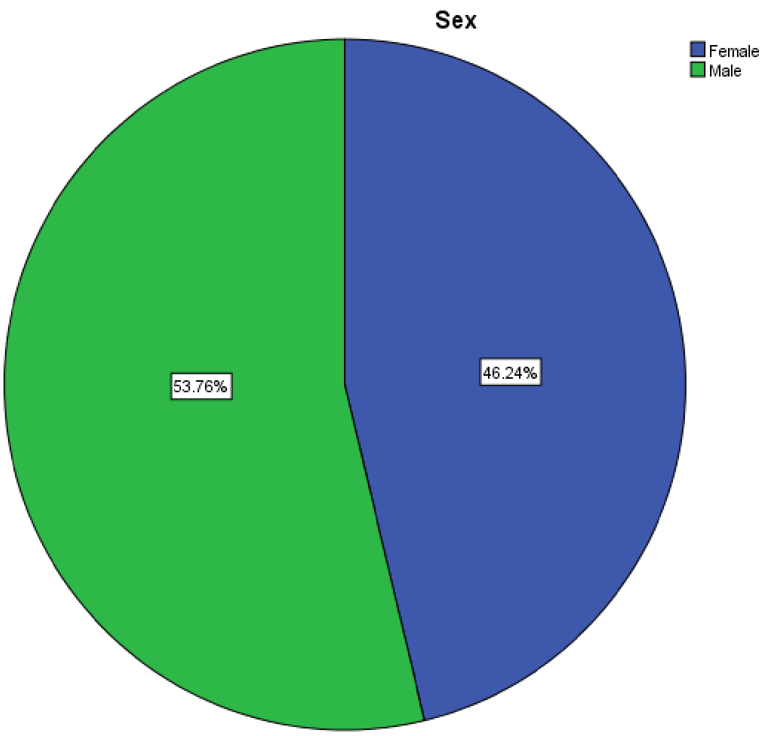

Figure 4.1: Gender of student respondents

Figure 4.1 on distribution of respondents based on gender revealed that male participants were (93) 53.76% while female respondents were (80) 46.24% from the total respondents from the questionnaire. There were slightly more male student respondents (93) than female student respondents (80) students from the collected data. However, for consistencies the Chemistry pre-test and post-test used 40 female and 40 male students for experimental group. Similarly, control group had 40 female and 40 male students. Ages of the students were also examined as indicated in table 4.2.

Table 4.2: Ages of student respondents

	Frequency	Percent
13-14 years	3	1.7
15-16 years	108	62.4
17-18 years	62	35.8
Total	173	100.0

Table 4.2 shows that 108 student respondents came from the age bracket of 15-16 years representing 62.4% of the respondents. It was followed by age bracket of 17-18 years representing 35.8% of the respondents. The students ranged from 13 to 18 years. From these it appears that most students were in the age of 15-16 years, which implies that the school going age for children is 6-7. From the findings, there was no variation in age of the learners in secondary schools.

Table 4.3: Type of School

	Frequency	Percent
A	39	22.5
B	51	29.5
C	43	24.9
D	40	23.1
Total	173	100.0

Table 4.3 represents response based on the Type of schools. The results revealed that school B had the highest number of responses with 29.5% which was followed by

school C with 24.9%, school D with 23.1% and finally school A with 22.5%. Therefore, the girls' schools represented by school B and C were 52.6% while the boys' schools represented by A and D were 48.4% when comparative analysis was conducted. This implies that the results obtained from the four types of school could be used to generalize all public secondary since it consisted of both boys and girls schools proportionately.

4.4 Computer-Based Laboratory Simulations and Acquisition of Scientific Skills

4.4.1: Overview

Computer-based laboratory simulations were investigated in relation to acquisition of scientific skills on achievement of Chemistry. Descriptive results were obtained and discussed from the results of administered questionnaire, content analysis from interviews as well as inferential statistics.

4.4.2: Results obtained from Questionnaire

The results from the administered questionnaire were obtained where a Likert scale of 5 points was used strongly disagree = 1, disagree = 2, neutral = 3, agree = 4 and strongly agree = 5 to obtain the mean and standard deviation as the results presented in Table 4.4 shows. The mean and standard deviations presented in the table were used to describe the relationship in between computer-based learning strategy and acquisition of scientific skills.

Table 4.4: CBLs and Acquisition of Scientific Inquiry Skills

	SD	D	U	A	SA	Mean	Std. Deviation
The school has computer laboratory	0.0%	2.3%	26.6%	50.3%	20.8%	3.8960	.74758
Computers available are used in performing science activities	0.0%	2.9%	28.9%	54.9%	13.3%	3.7861	.70334
Computers were often used for learning science	0.0%	0.6%	17.9%	54.9%	26.6%	4.0751	.68209
Practical lessons are taught using computer-based laboratory simulations in chemistry	0.0%	1.7%	27.2%	57.2%	13.9%	3.8324	.674019
Level of participation in computer-based laboratory simulation for chemistry	0.0%	1.7%	12.1%	59.5%	26.6%	4.1098	.66871
Computer based simulation help you to develop inquiry skills in chemistry	0.0%	1.2%	9.8%	43.9%	45.1%	4.3295	.69975

Results from the analysis presented in Table 4.4 on computer-based laboratory and scientific inquiry skills, revealed that most schools (80%) had computer laboratory giving a mean of 3.8960. Variation in school with computer laboratory was given by a standard deviation of .74758. This implied that a larger proportion of schools in Bomet County used computer laboratory on its availability for CBLs.

Computers available were to a great extent used in performing science activities according to the results (mean of 3.7861). Based on these results a larger proportion of computer applications were used in science activities besides being used for computer lessons.

According to the results from table 4.4, computers were often used for learning science (mean of 4.0751). A standard deviation of .68209 was achieved on the use of computers to learn science. This implied that computer technology was being adopted in chemistry learning process. This tends to support a long-standing argument that the use of computers for instructional purpose increases motivation among learners (Kiboss, 2000).

Practical lessons were taught using computer-based laboratory simulations in electro-chemistry to a great extent (mean of 3.8324). A standard deviation of .67401 represented its variation. This showed that computer-based laboratory simulations were utilizable. This results concurs with findings from SMASSE (2016) in adoption of computer-based laboratory simulation in teaching abstract and difficult lessons that cannot be taught using traditional method.

Level of participation by learners in computer-based laboratory simulation for electro-chemistry was to a great extent (mean of 4.1098). Computer- based laboratory had improved the level of participation among the students during electro-chemistry lessons. However, teachers with knowledge mastery, high morale, and motivation are crucial, as are learner challenges and the ability to promote learning (Zadra, 2000), the use of an effective tutoring technique is crucial to the successful learning and tutoring of chemistry.

Computer-based laboratory simulation assisted students in acquisition of inquiry skills in electro-chemistry (mean 4.3295). A standard deviation of 0.69975 on development of inquiry skills showed high homogeneity. This implies that, performance in chemistry improved through acquisition of inquiry skills. Since, computer-based laboratory simulation provides a platform for student to use computer in learning new ideas and to develop new knowledge.

4.4.3 Results obtained from ANOVA

The study investigated the scientific inquiry skills development in relation to the utilization of computer-based learning simulation using F-test at 5% significant level and the results summarized in Table 4.5.

Table 4.5: ANOVA relationship between CBLs and scientific skills development

			Sum of Squares	Df	Mean Square	F	Sig.
Chemistry achievement * Scientific skill development from CBLs	Between Groups	(Combined)	12.600	16	.788	3.409	.001
	Within Groups		36.087	156	.231		
	Total		41.688	172			

The results in Table 4.5 revealed that scientific skills development through the use of computer-based laboratory simulation had significant effect on the achievement in electro-chemistry ($F = 3.409$, $P = .001 < .05$). This implied that computer-based laboratory simulations approach had significant effect on acquisition of scientific inquiry skills in electro-chemistry. Students develop problem-solving abilities required to tackle scientific questions when they use computers (Salovaara, 2005). Computer-based laboratory simulation assisted students in learning concept that are hard to explain by the teacher using visual and audio explanation as well as it assists in providing hand-on skills in electro-chemistry with vast knowledge on how to conduct practical.

4.4.4 Results Based on Interview Schedules

Interview responses on the question "What is your personal feeling about the use of CBLs in development of inquiry skills in learning and tutoring process of chemistry?" revealed that teachers (75%) supported the use of CBLs in acquisition of scientific inquiry skills. However, the response pointed out weakness of simulation in some of the scientific skills. Teacher 2 from school B alluded that "Despite, the students' developing inquiry skills, the new technology does not provide hands-on skills experience required during science practical. There is need to incorporate lecture method to assist students to conceptualize".

The response to the question "In your opinion which scientific skills have CBLs assisted in developing?" revealed that computer-based laboratory simulation encouraged observation skills, manipulation skills, analytic skills and inquiry skills among the learners. According to teacher from school A, "CBLs assisted the students to observe clearly the chemical changes which are not possible during chemistry practical demonstrations. CBLs sharpen the observation skills enabling students to relate chemical changes and physical changes during chemical reactions, he further added that CBLs provided information on electro-chemistry concepts that were difficult to handle and time consuming", this lends more support to the study by Makau (1999) on Computer instruction as opposed to traditional lessons in which students sit quietly and listen to the teacher teaching chemistry, clarifies otherwise enigmatic themes particularly in scientific discourse.

The response to the question, "Describe in detail how scientific skills are acquired using computer-based laboratory simulations?" indicated that computer-based laboratory simulations assisted students acquire scientific skills by providing them with opportunities to develop their skills in hypothesis formulation, experimental design, data collection and analysis, critical thinking and problem-solving, collaboration, and communication. By engaging in these simulations, students could gain a deeper understanding of the scientific process and develop the skills necessary to succeed in scientific inquiry. According to teacher from school B, "One of the key skills required in science is the ability to formulate hypotheses. Computer-based laboratory simulations assisted by providing students with virtual environments where they could formulate hypotheses and test them. By manipulating variables and observing their effects in the simulation, students could gain a better understanding of the scientific process and develop the ability to formulate testable hypotheses".

The teacher further added that, "Computer-based laboratory simulations also helped students develop scientific skills by allowing them to design experiments in the virtual environment. They could adjust variables, control conditions, and record data in a simulated laboratory setting. Students can use the simulations to collect data and learn how to analyze that data using statistical software or other tools."

Teacher from school A added that, "Beside assisting in laboratory experiment Computer-based laboratory simulations provided students with opportunities to think critically and solve problems by presenting them with complex scenarios that require them to use their knowledge and skills to solve problems. By engaging in virtual experiments and simulations, students could develop their abilities to think critically, solve problems, and make informed decisions based on evidence. It also provided collaboration and communication among the students through create collaborative learning environments where students could share their experiences and ideas, discuss scientific concepts, and learn from one another."

4.4.5 Discussions of Computer-Based Laboratory Simulation (CBLs) and Acquisition of inquiry skills

The findings from student questionnaire concurred with Sreelekha (2018) who found that CBLs had significant impact on practical skills as compared with traditional methods. However, the study did not only examine computer simulation but also examined video-based learning pedagogy in Physics subject rather than Chemistry.

This study found more skills besides inquiry skills which included observation skills, manipulation skills and analytical skills. Sarabando, Cravino, and Soares (2014), computer simulation, on the other hand, allowed grade 7 science students to obtain hands-on experience. In this regard, CBLs is a significant tool in improvement of students' scientific skills. These skills range from practical skills, analytical skills, observation skills and manipulation skills as pointed out by the Chemistry teacher from school A. The assessment of students indicates an improvement in achievement in Chemistry through Chemistry experimental group that was under CBLs. Despite the performance in chemistry, the response from students revealed that they had improved in acquisition of science skills.

The constructivist teaching approaches are firmly ingrained in CBLs approach as indicated by Chemistry teacher from school A, B, C and D. It is student-centred other than teacher-centred, and it allows learners to actively participate in questioning, exploring, and discovering.

CBLs technique has been thought to have the capability of generating inspiration among secondary school learners since it piques their curiosity in the procedure of gaining scientific information and abilities (Gibson and Chase, 2002). According to the findings of this study, CBLs may be extremely successful in improving learners' motivation and achievement in science, as well as the development of scientific process skills (Sola and Ojo, 2007). This finding concurs with current study which would assist in enhancing policies, strategies and legislation of digitization of learning in secondary schools to enhance science related skills.

4.5 CBLs versus Traditional Methods of Teaching on Effectiveness in Teaching Chemistry in Secondary Schools

4.5.1 Overview

Computer- based laboratory simulation was assessed on the effectiveness in chemistry teaching as compared with traditional methods. Mean, standard deviation and ANOVA analysis were conducted on questionnaires. ANCOVA was conducted to establish whether there was a significant change in test results in between the experimental (CBLs) and control groups (traditional method).

The results from questionnaire provided descriptive analysis as well as test if CBLs had significant impact on achievement of chemistry based on its effectiveness. However, ANCOVA results assisted in provision of comparison results of CBLs and traditional teaching style at five percent significant level. The discussions were made based on the results obtained. Interview results were also used to confirm the responses from the students' questionnaire using content analysis.

4.5.2 Results from Questionnaire

Students' questionnaires analysed using the 5 point Likert scale established the mean and standard deviation of comparison between CBLs and traditional teaching method in teaching science in secondary schools. The descriptive results of computer-based laboratory simulation are presented in Table 4.6 below.

Table 4.6 CBLs and its Effectiveness in Teaching Chemistry

	SD	D	U	A	SA	Mean	Std. Deviation
Computer based laboratory simulation improve student understanding more than the traditional teaching method	0.0%	1.2%	15.6%	48.0%	35.3%	4.1734	.72656
Computer based simulation improved innovativeness than traditional methods	0.0%	1.2%	24.3%	61.3%	13.3%	3.8671	.63768
The new computer-based simulation provide added information as compared to traditional methods	0.0%	1.7%	20.2%	60.1%	17.9%	3.9422	.67092
Computer based simulation improved students attitude to chemistry	0.0%	0.0%	24.9%	62.4%	12.7%	3.8786	.60257
Computer based simulation assisted in manipulation of data	0.0%	0.6%	22.0%	61.8%	15.6%	3.9249	.62887
It assisted student to research unlike traditional method	0.0%	1.2%	6.4%	50.9%	41.6%	4.3295	.64798

Table 4.6 presents results for CBLs in comparison with traditional methods of teaching chemistry based on effectiveness in teaching this subject. Computer- based simulation was found to improve understanding of chemistry concepts as compared with traditional teaching methods (mean of 4.1734). However, the variation on improvement of understanding was minimal (standard deviation of .72656). This means that CBLs approach was better in knowledge acquisition as compared with the traditional methods of teaching chemistry.

Vanosdall, Klentschy, Hedges, and Weisbaum (2007) found that use of CBLs technique resulted in greater accomplishment in studying of mixtures and solutions in chemistry other than those tutored using traditional methods. This affirms that CBLs is not a replacement but can be incorporated in different areas in chemistry. The results converge in applicability in teaching abstract topics; also, the current study found that CBLs assists in simulating electro-chemistry besides other topics in chemistry.

According to the results from table 4.6, CBLs improved innovativeness among the learners as compared to traditional methods (mean of 3.871). Its variation indicated high homogeneity in innovativeness improvement (standard deviation of .63768). Therefore, CBLs assisted learners to be more creative and innovative in chemistry than the traditional methods that over depends on teacher expertise and teaching skills, CBLs gives students an opportunity to practice critical thinking skills in a controlled environment.

New CBLs positively added more information compared to traditional methods of teaching chemistry as indicated by the analysis (mean of 3.9422). This implies that majority of the students preferred CBLs approach since it provided more information than traditional methods of teaching chemistry.

Sola and Ojo (2007) focusing on effects of project inquiry on teaching methods on senior secondary students' achievement in separation of mixtures, investigated the impact of inquiry-based teaching models on success of students. According to the findings of this investigation, inquiry approaches of tutoring were extremely helpful in increasing students' success and skill advancement because of more student involvement. This finding concurs with the current study which adopts CBLs approach as a strategy which has impacted positively on learners understanding of chemistry.

The results also revealed that computer-based laboratory simulation improved student's attitude towards chemistry (mean of 3.8786). The variation was homogenous in improvement of student's attitude towards chemistry (standard deviation of .60257). Therefore, students' like chemistry as a subject since computer-based laboratory motivates them to learn. Science-related attitudes tend to influence students' involvement in science as a subject as well as their performance in science (Linn & Hsi, 2000). Other studies have found that a good attitude toward science influences student performance and, as a result, enrolment in this field.

As per the obtained results, computer-based simulation assisted in manipulation of data to a great extent (mean of 3.9249). Its variation on manipulation of data was found to be homogenous across the schools (standard deviation of .62887). Based on visualization and ability to bring out concepts clearly, information is easily passed on to the students through computer simulations. CBLs allow learners to interact with computers reducing risk in dangerous chemistry experiments. Learners in treatment group could observe and discover scientific concepts that were not possible to manipulate using traditional methods. This means that CBLs facilitates acquisition of scientific skills more as compared to traditional methods.

Finally, computer-based laboratory simulation as a technique was found to assist the students in doing more research unlike traditional method (4.3295). The results revealed, therefore, that computer-based laboratory simulation techniques were crucial in developing interest in science. According to the conclusions of this research, CBLs are extremely helpful in improving learners' achievement and inspiration to study science, as well as the growth of scientific process abilities (Sola and Ojo, 2007).

4.5.3 Results obtained from ANOVA

The Results obtained from ANOVA compared traditional method and computer-based laboratory simulation based on the achievement made by students in chemistry.

The ANOVA used f-test at 5 percent significant level to establish the relationship with achievement and the results presented in table 4.7.

Table 4.7 ANOVA relationship CBLs and Chemistry achievement

			Sum of Squares	Df	Mean Square	F	Sig.
Chemistry achievement * CBLs	Between Groups	(Combined)	9.297	11	.845	4.201	.000
	Within Groups		32.391	161	.201		
	Total		41.688	172			

The results of ANOVA analysis presented in Table 4.7 reveal that there existed significant relationship between the adoption of computer-based laboratory simulation and science achievement (F=4.201, P=.000<.05). Therefore, it implies that as the schools intensified the use of CBLs in chemistry, there was noteworthy increase in performance of learners.

4.5.4 Experimental Results

The descriptive results were based on the experimental design, in which the experimental group was taught using computer-based laboratory simulations (CBLs) and the control group was taught using the traditional technique. The experimental group was represented by school A and C while the control group was represented by school B and D. The change in mark was given by the difference between post-test and pre-test market of students.

Table 4.8 Post-test and Pre-test summary

		Pre-test	Post-test	Change in Marks
		Mean	Mean	Mean
Boys School	A (Experimental)	43.55	56.45	12.90
Girls School	B (Control)	43.79	48.16	4.37
Girls School	C (Experimental)	43.82	54.67	10.85
Boys School	D (Control)	44.18	48.86	4.68

According to the results in table 4.8 the pre-test results before treatment ranged from 43.55 to 44.18 marks. After treatment post-test showed higher variation between the experimental group A and C with 56.45 and 54.67 respectively as compared with control group which had 48.16 and 48.86 for school B and D respectively. This was revealed by the change in marks in experimental group with 12.9 and 10.85 as compared with control group with 4.37 and 4.68. This indicates that the CBLs in both girls and boy school performed better as compared to traditional methods of teaching.

Table 4.9: Descriptive Statistics for CBLs versus Traditional Methods

Tradition Method versus CBLs Method	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental Group (CBLs)	11.862[a]	.312	11.245	12.479
Control Group (Traditional)	4.537[a]	.312	3.920	5.154

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 43.8356.

Dependent Variable: Change in Marks

Table 4.9 represents experimental design results where the change in marks between post-test and pre-test were revealed. Experimental group representing CBLs method is seen to have the highest changes in marks of an average positive change of 11.862% (Mean of 11.862). Traditional method had, however, lower than average positive change of 4.532% (Mean of 4.537). CBLs showed improvement of 7.330% than traditional method of teaching chemistry. The technique has been thought to be able to generate inspiration among secondary school learners since it piques their interest in the step to gaining scientific information and abilities (Gibson & Chase, 2002).

4.5.5 Experimental ANCOVA Results

ANCOVA was used in this study to examine comparison between CBLs and traditional methods based on pre-test done by learners from both control and experimental groups respectively. The results were tested based on significances of 5 percent and these are summarized in Table 4.10.

Table 4.10: ANCOVA relationship Traditional method and CBLs method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2260.015[a]	2	1130.008	137.027	.000	.636
Intercept	1020.254	1	1020.254	123.718	.000	.441
Pre	99.850	1	99.850	12.108	.001	.072
Tradition/CBLs	2145.211	1	2145.211	260.133	.000	.624
Error	1294.715	157	8.247			
Total	14311.490	160				
Corrected Total	3554.730	159				

a. R Squared = .636 (Adjusted R Squared = .631)

Dependent Variable: % Change in Marks

The results presented in Table 4.10 indicates that there was a significant difference in change in marks [F (1, 157) =260.133, P=.000<.05] between computer-based laboratory simulation and traditional method of teaching chemistry while adjusting for pre-test. This implies that computer-based laboratory simulation increased significantly the achievement of students after adopting it as opposed to the control group who used traditional method of teaching chemistry. Further, the partial Eta Squared value of 0.624 reveals a strong significant difference in between CBLs and traditional techniques of teaching this subject. Computer-based laboratory simulation had some impact on test taken by the students. This indicates that CBLs should be adopted to supplement traditional methods in chemistry based on significant improvement in achievement of this subject as compared to traditional method.

Figure 4.2 revealed the existence of significant difference between male and female students who used CBLs over traditional method.

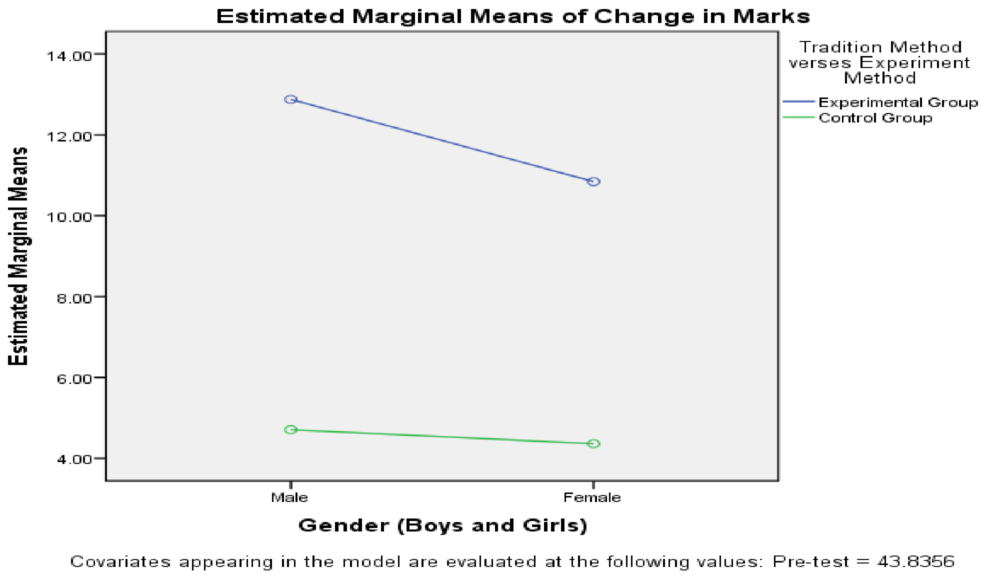

Figure 4.2: Experimental Group (CBLs) versus Control Group (Traditional)

The figure 4.2 revealed a larger marginal difference between control groups (traditional method) with experimental groups (CBLs method) with CBLs being the effective teaching method of electro-chemistry.

Using computer technology allows learners to participate actively in the process of learning, knowledge creation, improve problem-solving abilities, and explore alternate answers (Özmen, 2008).

4.5.6: Results Based on Interview Schedules

Interview responses to “compare the traditional method and computer-based laboratory simulation on effectiveness in teaching chemistry?” showed that teachers (80%) proposed that integrating the two methods of teaching chemistry would benefit the student. “CBLs are more efficient in teaching than traditional demonstration methodology since it assists all students to participate in process of learning” was response from teacher from school A.

Teacher from school B argued that, “Despite us embracing technology there is need for a teacher to facilitate, group students, provide order and provide solution that CBLs cannot provide. Hence both are effective when they are integrated together rather than using traditional method or computer-based laboratory simulation separately”.

As for teacher from school C, “Computer-based laboratory simulation has made students to be proactive towards electro-chemistry lessons. However, the technology has reduced teaching roles to facilitating. Therefore, traditional methods of teaching chemistry have only been modified to accommodate the computer technology”. Teacher from school D alluded that, “Students have improved in chemistry lessons as well as practical lessons since the computer-based laboratory has assisted in providing information”. This is reinforced by Freedman (1997), who proposed that positive attitude toward science is associated with performance in laboratory practical. However, a chemistry teacher who practices teacher-based teaching method, with no hands-on exercises and lack of practical usually reduces learners' enthusiasm in chemistry classes.

In response to the question “Compare the students who used and those who never used the new technology, do you think the students who used CBLs learnt any better?” Teacher from school A responded that, “Students who used CBLs were better in acquisition of scientific knowledge, skills and developed positive attitude towards chemistry”. Teacher from school B commented that, “Students who have been passed through CBLs were better in level of intellectual understanding on different paradigm given by the teacher as well as computer simulations”. While teacher from school C responded that, “Students taught using CBLs were better than those who depended on traditional teaching method”. However, teacher from school D alluded that, “Performance of students have significantly improved in chemistry since the introduction of CBLs”. All teachers seem to approve the use of CBLs in Kenya’s secondary school education system.

On the question “What are the benefits gained by CBLs as opposed to traditional methods of teaching chemistry?” was responded with numerous benefits like creativity, development of observation skills, increased participation, creativity and innovativeness, analytic skills and manipulation skills. According to teacher from school A, “computer-based laboratory simulation had improved analytical, manipulating and observation skills among the learners especially in areas where normal teaching and experiments cannot be effective.”

Teacher from school B mentioned that, “computer-based laboratory simulation has enabled students to gain more knowledge in chemistry both practical as well as theory part”. Teacher from school C said that, “Computer simulation assisted the students gain positive attitude towards chemistry. This study adds to previous research that shows that using computers fosters good student attitudes and has a favorable impact on students' perceptions of science and mathematics (Kiboss, 2002). Therefore, it imposes that CBLs is capable in modification and changing of attitude towards chemistry, since it equips the learner with knowledge and skills suitable for improving the subject.

Teacher from school D added that, “students have been more innovative and creative through active participation in CBLs technique of teaching”. Creativeness and innovation plays an important role in scientific discover which develop positive attitude towards the study of chemistry. From the study all teachers seem to approve the use of CBLs in Kenya's secondary school education system.

4.5.7 Discussion of CBLs versus Traditional Method on Effectiveness in Teaching Chemistry

Okwuduba, Offiah and Madichie (2018) found similar results where there existed significant difference between computer simulation and traditional method of teaching chemistry. Computer simulation method was better than convention method as presented in the current study. Sreelekha (2018a) also found similar results that computer-based laboratory simulation was better than traditional method of teaching Physics, though the study was not conducted in chemistry.

Radulović, Stojanović and Županec (2016) found that interactive computer-based simulation and laboratory inquiry-based experiments were effective instructional methods. This also concurs with Awodun and Oyenyi (2018) findings who reported that computer simulation had significant impact on performance of student in science subjects when compared to traditional methods. From these findings, there was significant improvement in students' achievement in chemistry using computer simulation as opposed to using traditional methods.

Despite the fact that most research has been conducted on physics, Research in learning of chemistry has also revealed similar improvement in students' achievement as compared with traditional method. The CBLs method is used to explain teaching strategies based on scientific inquiry (Kahn and O'Rourke, 2005). The methodology is firmly anchored in constructivist tutoring methods. It is student-centred, other than teacher-centred, and allows pupils to participate actively in questioning, exploring, and discovering.

4.6 Computer-based laboratory simulations and Achievement of Chemistry in Relation to gender

4.6.1 Overview

Computer-based laboratory simulation teaching strategy was assesed in relation to achievement in chemistry with regard to the gender of the respondent. The results were presented using students' questionnaire using the descriptive and ANOVA analysis while ANCOVA analysis was used to examine if gender difference had significant impact on the computer-based laboratory simulation. The study also did content analysis of results from interviewed teachers.

4.6.2 Results from Questionnaire

The results from students' questionnaire were analysed to provide mean and standard deviation. These results are presented in Table 4.11.

Table 4.11: CBLs Teaching Strategy and Chemistry Achievement

	SD	D	U	A	SA	Mean	Std. Deviation
The students worked in groups when carrying out investigations	0.6%	4.6%	0.6%	34.1%	60.1%	4.4855	.78212
Everyone participated in group work	0.6%	1.7%	4.6%	9.8%	83.2%	4.7341	.68101
Boys had more opportunity to use the apparatus than girls	70.5%	4.0%	15.6%	7.5%	2.3%	1.6705	1.12637
New technology directions were clearer than the teacher's directions	5.8%	4.6%	22.5%	37.0%	30.1%	3.8092	1.09625
Gaining access to the chemistry lessons on the computer was easy and exciting	0.6%	1.7%	2.9%	15.6%	79.2%	4.7110	.66275

4.6.3 Discussion of CBLs teaching strategy and Chemistry achievement.

Table 4.11 presents results obtained from CBLs teaching strategy in relation to achievement. From the results the student worked in groups when carrying out investigations as a strategy of using computer-based simulation (mean of 4.4855). Its variation in utilization of groups was homogenous across the schools (standard deviation of .78212). This implied that CBLs assisted students in developing group dynamics.

The results from the analysis indicated that there was high participation of students in group work (mean of 4.7341). Its variation was also homogenous (standard deviation of .68101). Therefore, computer-based laboratory simulation encouraged students' involvement in learning process. Research has shown that CBLs approach to teaching chemistry results in greater advances in topic knowledge, process comprehension, and overall accomplishment.

Amaral, Leslie, and Klentschy (2002) investigated the effect of CBLs method in science and mathematics on fourth and sixth grade pupils in a Latino school district in southern California. According to the study's findings, CBLs strategy resulted in improved competency in science and mathematics subjects. The researchers came to the conclusion that learner-centered activities help students to establish context, develop good attitudes about learning, and participate in meaningful discourse with other students.

4.6.4 Conclusions on CBLSs teaching strategy and Chemistry achievement

There was no gender disparity between learning process among boy and girl students. Since boys had insignificant opportunity in using the equipment than girls (mean of 1.6705), its variation was heterogeneous (standard deviation of 1.09625). Therefore, CBLs had similar application among boys and girls.

This study also revealed that the new technology directions were clearer than the teacher's directions (mean of 3.8092). The new technology directions variation was heterogeneously applied in difference schools (standard deviation of 1.09625). This implies that the CBLs were easy to use in laboratory activities than traditional teacher directed methods. Learning science in a student-centred curriculum is dynamic and positive, involving inquiry and hands-on experiences. The purpose is to improve critical thinking and problem-solving abilities by introducing and researching pertinent issues that must be answered.

The instructor serves as a facilitator, establishing the circumstances for students to actively participate in experiments, evaluate and explain data, and negotiate understandings of the findings with peers. In this method, the instructor places less focus on remembering material and more emphasis on inquiry and hands-on activities that allow students to get a better understanding and appreciation for the nature of science (Singer, Marx, Krajcik & Chambers, 2000). In other words, when students are actively participating in the learning process, their enthusiasm to learn improves. Consequently, having access to chemistry lessons on the computer was simple and engaging when compared to traditional teacher-centered techniques, according to the results (mean of 4.7110). Its variation was found to be homogenous on ease and excitement as a result of CBLs (standard deviation of .66275). CBL was easy and interesting, making it better than the traditional teaching methods. These findings lend support to earlier studies on how computers promotes positive students' attitude towards sciences (Kiboss, 2002, Tanui *et al.,* 2003).

4.6.5 Results obtained from ANOVA

Results obtained from ANOVA were used to examine the influence of CBLs on chemistry achievement. F-test was adopted to test the significance between computer-based laboratory simulation strategy and achievement in chemistry at 5 % significant level. The results obtained from the ANOVA analysis are represented in Table 4.12.

Table 4.12: ANOVA Relationship between CBLs and Chemistry achievement

			Sum of Squares	Df	Mean Square	F	Sig.
Chemistry achievement * Computer based teaching strategy	Between Groups	(Combined)	7.967	14	.569	2.666	.002
	Within Groups		33.721	158	.213		
	Total		41.688	172			

The results obtained from ANOVA presented in Table 4.12 show that computer-based laboratory simulation had significant effect on chemistry achievement ($F = 2.666$, $P=.002<.05$). Therefore, CBLs was an important method in improving the performance of students in chemistry. Learners were able to visualise electro-chemical processes like flow of ions and electrons; this is in line with Sreelekah

(2018a, 2018b). CBLs stimulate meaning, learner's motivation increases thus learning better, and develop more interest in electro-chemistry.

4.6.6 Experimental Descriptive based on gender

Descriptive analysis based on gender between the control groups and experimental groups were analysed based on the chemistry test. The results are summarized in Table 4.13.

Table 4.13: Descriptive Analysis of change in marks based on gender

Students	Comparison	Mean Change in Performance	Std. Deviation of Change in performance	Number of students
Male Students	Experimental Group	12.9025	3.57538	40
	Control Group	4.6825	2.57382	40
	Combined Groups	8.7925	5.16595	80
Female Students	Experimental Group	10.8450	2.79670	40
	Control Group	4.3675	2.51135	40
	Combined Groups	7.6063	4.19488	80
Male and Female Combined	Experimental Group	11.8738	3.35317	80
	Control Group	4.5250	2.53160	80
	Combined Groups	8.1994	4.72830	160

Dependent Variable: Change in Marks

Table 4.13 shows that male students' experimental groups (CBLs) had an average of positive change in marks of 12.9025% which was slightly more than for the females of 11.8738%. In relation to control groups (traditional method), the male students had an average positive change of 4.6825% which also was slightly more than for the female students with 4.3675%. Male and female combined change in chemistry marks for experimental group stands at 11.8738% and controlled group was 4.5250%. This implies that CBLs is suitable for use by both sexes.

4.6.7 Experimental ANCOVA based on gender

ANCOVA analysis was done based on gender of student respondents using traditional method between pre-test and post-test results from chemistry test in relation to the use of CBLs approach in teaching chemistry. This assisted in showing if there existed significant difference between male students and female students after using CBLs. Descriptive statistics reveals that boys were slightly better in chemistry performance in both traditional and CBLs strategies. The information is presented in Table 4.14.

Table 4.14 ANCOVA Results of gender on Traditional Chemistry and CBLs Method of Teaching Chemistry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	171.543[a]	2	85.772	3.980	.021	.048
Intercept	1067.319	1	1067.319	49.530	.000	.240
Pre	115.255	1	115.255	5.349	.022	.033
Gender	56.739	1	56.739	2.633	.107	.016
Error	3383.187	157	21.549			
Total	14311.490	160				
Corrected Total	3554.730	159				

a. R Squared = .048 (Adjusted R Squared = .036)
Dependent Variable: Change in Marks

The results in Table 4.14 show that there was no significant difference in performance in chemistry. [F (1, 157) = 2.633, P=.107>.05] between male and female students with adjustment in pre-test. The partial Eta Squared value of .016 revealed that there was a no significant difference between male and female students in learning electro-chemistry. Therefore, gender had no significant difference in achievement of chemistry. It implies that CBLs method of teaching chemistry can be used by both male and female students to improve performance in chemistry. This appears to confirm previous research indicating that boys and girls are equally motivated to learn sciences (Keraro, Wachanga & Orora, 2007). It contrasts previous research that found out that females had more positive views toward science and is hence more motivated to learn science than males (Hu-Au & Okita, 2021; Dawson, 2000).

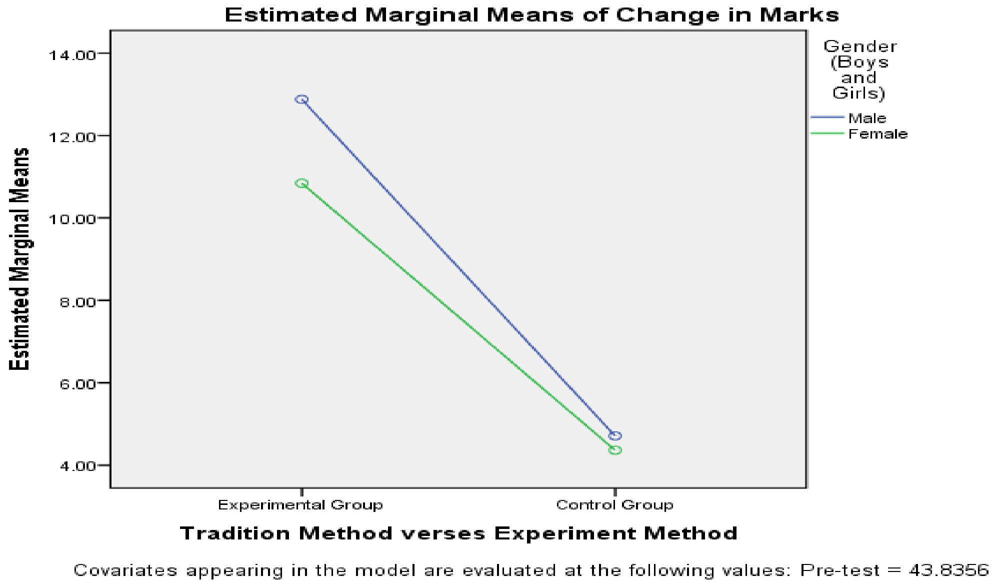

Figure 4.3: Results obtained on the use of CBLs and traditional methods of teaching chemistry with regard to gender

Figure 4.3 reveals that there existed a small margin between boys and girls on control group (traditional method) as compared with experimental group (CBLs). However, the differences between male and female students are not significant despite the male students performing better than the female students in both methods. This implies that during the treatment time, female students were just as eager to learn as male students. Female students were equally motivated to learn electro-chemistry as male students since there was no statistically significant difference between them. Wachanga (2004) observed that teachers offered equal attention to male and female students throughout chemistry lessons and that there was reinforcement of these learners in the subject. The study also guaranteed that the learning process was characterized by positive interdependence and individual accountability. The findings of the present study affirm Wachanga's (2004) findings in terms of student motivation toward sciences.

4.6.8 Results Based on Interview Schedules

Interview responses from chemistry teachers on the question “What is the impact of computer-based laboratory simulation on electro-chemistry lessons?” reveal that there was a positive outcome on performance in chemistry as a result of CBLs. This was indicated by teacher from school A, “Computer-based laboratory simulation has improved acquisition of knowledge in addition to what we teach”. Teacher from school B argued that, “My students have improved in chemistry as a result of theoretical and practical concepts due to utilization of CBLs”. Teacher from school C revealed that, “The learners improved greatly in cognitive understanding of chemistry subject after introduction of CBLs approach”. In addition, teacher from school D responded that, “Electro-chemistry lessons have been simplified through the use of CBLs technology in learning process of the subject”.

Response to the question, “What is the effect of CBLs on chemistry practical?” indicated that the CBLs had positive influence on chemistry practical. Teacher from school A answered that, “Computer-based laboratory simulation assisted in acquisition of problem solving skills in electro-chemistry. This has significantly boosted performance in electro-chemistry practical”. The response of teacher from school B indicated, “The new technology provided information that is crucial in improvement of electro-chemistry practical”. Similarly, teacher from school C and D agreed that, “CBLs integration in chemistry practicals has enhanced acquisition of scientific inquiry skills thus making learning more meaningful”.

The response to “In your opinion does gender difference affect the use of CBLs in chemistry lessons?” indicated that there was no gender disparity among male and female students in using CBLs. The response from teacher of school A revealed that, “Computer-based laboratory simulation has similar ability in understanding electro-chemistry among male and female students”. Similar views were expressed by the teachers from school B, C and D who said that male and female students had the same perception, abilities and involvement in the utilization of CBLs resulting to the same improvement index in chemistry practical.

4.6.9 Discussions of CBls and Achievement in Relation to gender of the respondents

The study findings revealed that the achievement between female students were not different from male students even after introducing the CBLs. Similar results were reported by Okwuduba, Offiah and Madichie (2018) in Nigeria. The results exposed that there was no significant difference in success based on gender. The current investigation also found that CBLs had positive significant influence on achievement of chemistry. These findings are similar to those found by Sreelekha (2018a) who reported that computer simulation had positive impact on achievement in Physics practical. Even though the current study was focused on chemistry subject, the results from Sreelekha (2018a) showed that there was significant impact on students’ achievement when computer simulation was introduced to them.

Awodun and Oyenyi (2018) supported the same results which proved that instructional simulation was better than the traditional methods. The findings of the current study indicated positive significant influence on students’ performance in electro-chemistry irrespective of gender, which concurs with that of Helgeson and

Kumar (2000) who did not find any significant differences between male and female secondary school learners using computers while researching on the effect of gender on computer-based strategy of problem solving.

4.7 Computer-based laboratory simulation and Students' Attitudes

4.7.1 Overview

Effective teaching is normally influenced by student's attitude towards a given subject including Chemistry. In view of these, the present study assessed students' attitude towards learning of electro -chemistry in relation to the introduction of CBLs in the teaching of the subject. The analysis of the data collected in the assessment of student's attitude towards the learning of chemistry using CBLs method was done using descriptive and inferential statistics.

4.7.2 Results obtained from Questionnaire

The student's questionnaire used the Likert scale to extract mean and standard deviation based on the response of students. The obtained mean and standard deviations are summarized in Table 4.15.

Table 4.15: CBLs Teaching methods and students' attitudes

	SD	D	U	A	SA	Mean	Std. Deviation
The chemistry lessons via new technology were innovative and improves creativity	39.9%	35.8%	5.2%	12.7%	6.4%	3.8902	1.01418
Chemistry lessons taught by the teacher were easy	3.5%	8.1%	12.1%	48.6%	27.7%	2.0983	1.23733
Chemistry lessons via new technology were friendly	1.2%	2.9%	9.2%	39.3%	47.4%	4.2890	.84064
Chemistry lessons taught by the teacher were interesting	3.5%	8.7%	7.5%	43.9%	36.4%	2.5087	1.31015
I like chemistry lessons taught with the use of new technology	28.9%	25.4%	21.4%	14.5%	9.8%	4.0116	1.05096
The chemistry lessons taught via the new technology were meaningful	3.5%	1.7%	5.2%	28.3%	61.3%	4.4220	.93447

Table 4.15 illustrates the outcomes of investigation into the relationship between CBLs and students' attitudes. From these results, chemistry lessons taught using new technology were innovative and creative in tone to some extent (mean of 3.8902). The variation was similar across the schools on innovative and creative (standard deviation of 1.01418). Therefore, according to the established findings CBLs encouraged students to be innovative and creative in learning electro-chemistry. The same findings were reported by Sola and Ojo (2007) while investigating the impact of inquiry-based laboratory teaching approaches, that inquiry approaches of teaching were extremely helpful in increasing student accomplishment and skill development. They claimed that student achievement and analytical skills had either been elevated or considerably improved.

The students liked electro-chemistry lessons taught with the use of new technology (CBLs) to great extent (mean of 4.0116). The variation was heterogeneous on the interest in chemistry lessons taught using CBLs (standard deviation of 1.05096).

Therefore, computer-based laboratory simulation was liked by students in electro-chemistry lessons. This study adds to previous research that shows that using computers boosts good student attitudes and improves students' perceptions of science and mathematics (Thomas, 2001).

Chemistry lessons taught applying the new technology were more meaningful (mean of 4.4220). Its variation was similar among the schools on meaningfulness of chemistry lessons using new technology (standard deviation of .93447). Therefore, computer-based laboratory simulations were more meaningful. These results concur with Chumba, Omwenga and Atemi (2020) where there existed positive relationship between the attitude and CBLs approach. This is because student found a sense of belonging and meaningfulness when computer-based learning was adopted.

4.7.3 Results obtained from ANOVA

Results obtained from ANOVA were analysed on the association between student’s attitude in adoption of computer-based laboratory simulation and chemistry achievent. The results used primary data from questionnaire for student’s attitude and Chemistry achievement. This was presented in Table 4.16.

Table 4.16: ANOVA relationship student’s attitude and Chemistry achievement

			Sum of Squares	Df	Mean Square	F	Sig.
Chemistry achievement * Student's attitude	Between Groups	(Combined)	6.898	13	.531	2.425	.005
	Within Groups		34.790	159	.219		
	Total		41.688	172			

Table 4.16 revealed that students' attitude following the results of computer-based laboratory simulation developed favourably. The attitude of the learner had significant outcome on achievement in chemistry according to the results obtained from ANOVA (F=2.425, P=.005<.05). Therefore, the positive attitude developed among students while adopting CBLs enabled them to achieve better results in chemistry. This concurred with Evans et al. (2008) who examined the use of computer-simulated activity used in pre-lab to mentally prepare students for real-world acid-base titration lab activities. As a consequence of their research, they came to the conclusion that the experimental group of pupils had a positive attitude toward learning.

4.7.4 Results Based on Interview Schedules

Interview results in response to the question "What is the attitude of students towards chemistry when computer-based laboratory simulation was used?" revealed that CBLs had assisted learners to develop positive attitude towards the learning of chemistry. The outcomes from teachers in all the schools indicated that students developed positive response towards electro-chemistry that had been for a long time recording low performance. This new technique assisted students to participate actively in the lesson and access information easily.

In response to the question "What is the teachers' attitude towards the use of computers in chemistry?" there was a positive attitude among the teachers' interviewed. Teacher from school A and C agreed that CBLs method had assisted in supplementing chemistry demonstration and sometimes in chemistry lessons. Teacher from school B added that, "CBLs motivated me to hold more practical lessons with the students other than providing theoretical concepts". The response was also similar with that of teacher from school D who integrated the learning process with CBLs.

Simulations provide benefits over undertaking risky, difficult, or impossible tests in terms of time, security, expense, and motivation (Jegede, 2003).

Concerning the question "What is the effect of CBLs on participation of students in Chemistry?" the teacher responses showed overwhelming positive impact on participation of students in chemistry lessons. The response from teacher from school B was, "CBLs increased participation, creativity and innovation in chemistry practical and lessons". This confirms results from Thomas (2001) showing an interactive learning environment with animations and simulations for abstract topics, in which students become actively involved in their learning, allows students to more readily create and grasp complex concepts. Since CBLs is not only interactive but also ensure safety of the students who are learning using the approach. Adoption of CBLs in electro-chemistry will facilitate acquisition of scientific inquiry skills.

4.7.5 Discussions on CBLs teaching strategy and student's attitudes

The results towards this instructional strategy of this study, therefore, reveal that computer-based laboratory simulation has significant impact on the attitude of students towards chemistry both in theory and practical form. These findings are similar to those of Chumba, Omwenga, and Atemi (2020), where computer simulations in Physics were found to lead to significant positive influence on the students' attitude towards physics. However, the present study focused on student's attitude towards chemistry as a subject. This has led to students developing interest in chemistry practical and theory learning, increase in creativity and innovation as well as high student participation in electro-chemistry lessons when computer simulations are used.

4.8 Achievement in Chemistry

4.8.1 Introduction

The students' achievement in chemistry was investigated using student's questionnaire and the result were presented. Correlation analysis was also done to examine interrelationship of variables related with student's achievement in chemistry collected using likert scale.

4.8.2 Results obtained from Questionnaire

Students' questionnaire was used to obtain the mean and standard deviation from the Likert scale. These descriptive statistics of students was utilized in examining the achievement in chemistry subject among the secondary schools. The student questionnaire analysis was presented in Table 4.17.

Table 4.17: Achievement in Chemistry

	SD	D	U	A	SA	Mean	Std. Deviation
There is an improvement in chemistry practical when computer simulation is applied	0.0%	0.6%	12.7%	59.0%	27.7%	4.1214	.69236
Students' science skills improved drastically on utilization of computer simulation method	0.0%	0.6%	21.4%	60.1%	17.9%	3.9538	.64533
Performance in chemistry improved when the teacher incorporated computer simulation method	0.0%	0.6%	12.7%	59.05	27.7%	4.1387	.64100
Student attitudes towards chemistry improved through introduction of computer simulation method	0.0%	0.0%	13.3%	48.6%	38.2%	4.2486	.67476

Table 4.17 relates to descriptive results on achievement in chemistry. The results showed an improvement in chemistry practical lesson while using CBLs application (mean of 4.1214). It was revealed that the use of CBLs approach enhanced student's performance in chemistry. Others have observed a similar occurrence in which the instructor places less focus on remembering material and more emphasis on inquiry and hands-on activities through which students get a better understanding and appreciation of the nature of science (Coller, 2004). As a result, when students are actively participating in the teaching process, their enthusiasm to learn improves.

According to the results from table 4.16, students' science skills improved drastically on utilization of computer simulation method to some extent (mean of 4.1387). The variation in students' science skills was also homogenous among students utilizing CBLs (standard deviation of .64100). This implied that computer-based laboratory simulation improved acquisition of scientific inquiry skills. Sola and Ojo (2007), in their study of the impact of inquiry-based teaching approaches, explained a similar occurrence. According to the findings of this study, inquiry-based teaching strategies are particularly successful in promoting students' accomplishment and skill development in chemistry. They indicated that student achievement and analytical skills had either been elevated or significantly improved.

Performance in chemistry improved to a great extent when the teacher incorporated computer-based laboratory simulation method (mean of 4.1387). CBLs not only improved practical lessons but also enhanced performance in chemistry. This is in line with Omwenga (2005), who observed that CBLs learning environments supports a disciplined inquiry skills and problem solving, implying that the use of technology fosters students' interactions among themselves and with curriculum material in order for inquiry to take place. Computers in education promote critical and higher order thinking skills in students.

Students' attitudes towards chemistry as subject improved through introduction of computer simulation method to a greater extent (mean of 4.2486). CBL's variation on students' attitude towards chemistry was similar on the controlled group (standard deviation of .67476). Therefore, computer-based laboratory simulation improves significantly the attitude of students towards chemistry. The opinions of the students show a highly favorable attitude towards the subject and that the CBLs program was helpful in promoting the students' view of the chemistry classroom environment. This study adds to previous research that computers improves students' attitudes and changes their perceptions of science and mathematics (Kiboss, 2002 & Wekesa, 2003). The students are able to positively contribute, collaborate and inquire resulting to improvement of attitude towards chemistry subject.

4.8.3 Results obtained using correlation analysis

The study adopted correlation analysis of the results obtained from questionnaire in order to examine interrelationship between variables. It enables the study to also test the significance between variable. Correlation analysis was done based on 5% significant level to examine the relationship between scientific skills development, characteristics, students' attitude, computer-based strategies and chemistry achievement. The summary results were presented in table 4.18.

Table 4.18: Correlation Analysis

		Scientific inquiry skill development	Characteristics	Student's attitude	CBLs strategy	Science achievement
Scientific inquiry skill development	Pearson Correlation	1	.522**	.394**	.108	.562**
	Sig. (2-tailed)		.000	.000	.158	.000
	N	173	173	173	173	173
Characteristics	Pearson Correlation		1	.400**	.107	.406**
	Sig. (2-tailed)			.000	.160	.000
	N		173	173	173	173
Student's attitude	Pearson Correlation			1	.010	.469**
	Sig. (2-tailed)				.891	.000
	N			173	173	173
CBLs strategy	Pearson Correlation				1	.768**
	Sig. (2-tailed)					.000
	N				173	173
Chemistry achievement	Pearson Correlation					1
	Sig. (2-tailed)					
	N					173

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.18 presents correlation between scientific inquiry skills development, student's attitude, computer-based teaching strategies and achievement in chemistry. There existed a positive significant correlation between CBLs with science inquiry skills development (r=.562), student's attitude (r=.469) and teaching strategies (r=.768). According to Aldrich (2004), the inquiry techniques introduce students to the essence of science and the scientific enterprise, and they provide an effective approach to meaningful learning. Practical activity that involves both the mind and the hands is an important part of the development of scientific curriculum. Inquiry techniques in chemistry allow teachers to be creative and innovative while also improving students' comprehension of chemical ideas and processes.

4.9 Summary of Findings from the Test of Hypotheses

The findings of the hypotheses were given by the results that follow.

Ho_1: There is no significant impact in acquisition of scientific inquiry skills in chemistry after utilizing CBLs on chemistry instruction. The null hypothesis failed to be accepted. The outcome based on results obtained from ANOVA indicated that CBLs assisted learners in development of scientific skills which had positive influence on students' achievement in chemistry (P<.05). Kenya's education system should adopt CBLs in teaching of electro-chemistry.

HO_2: There is no significant difference in achievement scores amongst learners taught using CBLs learning method and those that using regular teaching methods (RTM) on achievement of chemistry. The results failed to accept the null hypothesis. Therefore, based on ANCOVA results there existed significant difference between CBLs learning approach and regular teaching method (P<.05), where CBLs had better impact on achievement of chemistry in comparison to traditional method.

HO_3: There is no significant difference in achievement scores amongst learners taught using CBLs learning method and those that use regular teaching methods (RTM) with regard to gender on achievement of chemistry. The study accepted the null hypothesis. The ANCOVA results revealed that CBLs learning as well as regular teaching method had no significant difference based on gender (P>.05). This implied that both gender participated equally on using CBLs.

Ho_4: There is no significant impact of CBLs on secondary school learners' attitude towards chemistry in the experimental group. The outcomes failed to accept the null hypothesis. According to Results obtained from ANOVA there was significant change in learners' attitude towards chemistry when tutored by CBLs. Therefore, CBLs improved the attitude of students towards chemistry.

4.10 Summary

It has been established in the study that some schools have established computer laboratories that are usable for CBLs. The computers were used for science activities. The results also indicated that computers were used in learning during chemistry lessons and during presentation of chemistry practical. The results also revealed that the level of learners' participation in CBLs for chemistry was high. CBLs assisted in acquisition of inquiry skills in chemistry. The results revealed that CBLs had significant effect on acquisition of scientific inquiry skills and achievement in Chemistry ($P<.05$). Similar finding was found with Jayantha (2018), on the use of simulation based teaching strategies which significantly increased learner's acquisition of inquiry skills in physics practical. The facilities provided inquiry environments as well as cognitive tools to scaffold learning and allow students to use problem-solving abilities. CBLs are useful tools for helping students enhance their hypothesis generation, visual interpretation, and prediction abilities. In conclusion, computer-based laboratory simulations helped students acquire scientific skills by providing them with opportunities to develop their skills in hypothesis formulation, experimental design, data collection and analysis, critical thinking and problem-solving, collaboration, and communication. By engaging in these simulations, a student gains a deeper understanding of the scientific process and develop the skills necessary to succeed in scientific inquiry.

The results revealed that CBLs enhanced creativity and innovativeness as compared with traditional methods of teaching chemistry. This technique assisted students to gain more information. As it was employed for presenting material, tests and assessment, and delivering feedback, CBLs made teaching more successful than traditional teaching methods. It inspired pupils and encouraged them to participate actively in the learning process. It aided in the development of learners' creativity and problem-solving abilities in learning, as well as their identity and self-reliance. CBLs gave students the drawings, graphics, animation, music, and a plethora of resources to allow them progress at their own speed and in accordance with their specific peculiarities. It was used to regulate a variety of variables that have an influence on learning and cannot be handled using standard educational procedures (Kasli, 2000).

The results also indicated that there was significant association between CBLs and Chemistry achievement ($P<.05$). Pre-test using control group (traditional method) and experimental group (CBLs) showed significant difference in Chemistry performance ($P<.05$). Although it is widely acknowledged that CBLs may improve students' comprehension, the present research has shown that the teaching approaches utilized with simulations have a greater influence on student understanding (Sanger& Greenbowe, 2000).

Computer-based laboratory simulation used groups work when carrying out investigations. Group work assisted the students to participate in chemistry practical lessons. However, there was no disparity in gender on utilization of CBLs for learning electro-chemistry. The new technological direction was also found to be clearer as opposed to teacher's based directions. Therefore, computer-based simulation made electro-chemistry lessons easy and exciting for all the students. When this approach was used, the students' gender does not affect their motivation to learn. This would, therefore, imply that its incorporation in teaching would boost the learning of electro-chemistry in schools. This in turn would improve the low achievement in KCSE chemistry examinations.

Results obtained from ANOVA indicated that computer-based laboratory simulation teaching strategy had significant effect on chemistry achievement ($P<.05$). This implies that CBLs teaching strategy had positive significant influence on performance of Chemistry. CBLs learning as well as regular teaching methods had no significant impact based on gender ($P>0.05$). This appears to confirm previous research indicating that boys and girls are equally motivated to learn sciences (Keraro, Wachanga & Orora, 2002).

The results on CBLs revealed that the new technology increased the skills of innovation and creativity among the science students. Chemistry lessons taught by the teacher were found to be abstract as compared with CBLs which was friendly. CBLs made chemistry lessons enjoyable and meaningful.

Results obtained from ANOVA indicated that computer-based laboratory simulation assisted in improvement of student's attitude which had significant effect on Chemistry achievement ($P<.05$). CBLs assisted students to develop positive attitude towards electro-chemistry. Furthermore, by allowing students to explore the simulated world and conduct simulated experiments at their own leisure, computer simulations boosted students' excitement and motivation. Aldrich (2004) discovered that CBLs helped students enhance their motivation, achieve more, and create positive attitudes in learning sciences. According to research findings in the literature, using computer-based education greatly improved students' attitudes and achievement (Berger, Lu, Belzer, & Voss, 1994).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The section consists of conclusions, recommendations and summary of results, the summary aims were extracted from findings obtained in chapter four. This was used to develop conclusion and recommendations of the study.

5.2 Conclusions of the Study

The present study concludes that CBLs assists learners in acquisition of inquiry skills in chemistry. Slotta (2002) identified four fundamental features of scientific inquiry that may benefit from computer simulations making science accessible, making it visible, assisting students in learning from one another, and assisting students in developing autonomous learning.

Furthermore, CBLs had significant influence on achievement in chemistry. It assisted in improving students' creativity and innovativeness compared to traditional teacher centered instructions. According to Sanger, and Greenbowe (2000) a learner centered teaching with the help of computers, allows learners to cooperate, think critically and identify solution to problems. CBLs method of teaching chemistry assists students to manipulate data in chemistry practical. Computer simulations allowed students to view and participate in real-world experiences. CBLs have the potential to be used for recreating laboratories that would be impractical, costly, impossible, or too hazardous to conduct in the real world (Aldrich, 2004). Simulations help in conceptual shift, open-ended experiences, and safety to learn chemistry in the laboratory and instruments for scientific research and problem resolution.

Computer based laboratory simulation teaching strategy had significant influence on chemistry achievement. This method encouraged group work based investigation and inquiry process. This encouraged high participation of students in the study. CBLs were characterized by ease, exciting and clearer teaching strategy as compared with traditional method. Simulations as an investigative tool increased motivation and curiosity among learners.

Constructivists see science education as a process in which teachers assist students in their own process of developing new understanding (Slotta, 2002). As a result, teachers must evaluate how students create their own knowledge and develop scientific process abilities through supplied learning experiences (Kwangmuang, Jarutkamolpong, Sangboonraung & Daungtod, 2021).

Finally, CBLs impacted positively on the attitude of students towards chemistry. The findings revealed that subjects taught by regular modes were boring, appeared lost or directionless in the absence of teacher leadership, lacked autonomy and self-confidence. This is a problem that, according to other research, causes students to regard themselves as recipients of knowledge rather than creators of knowledge (Keter, 2018). As a result of the use of CBLs, the instructors' position in the teaching learning scenario shifted from authoritative to facilitator. CBL was characterized as friendly and meaningful to students in chemistry learning as opposed to teacher-based techniques.

Also, application of CBLs teaching strategy is gender friendly. This study showed no significant difference between boys and girls in secondary schools learning chemistry using CBLs. This finding concurs with Wachanga & Mwangi (2004) who found out that gender had no significant effect on learners' achievement as compared to other traditional methods, during their investigation on the effects of Cooperative class experiment approach.

5.3 Recommendations

The section provides recommendation of the study as well as suggested recommendation for further areas of study. This is represented as follows;

5.3.1 Recommendations from the Study

Based on the findings of this study, and the subsequent drawn up conclusions, this study recommends the following:

(a) Higher teacher training institutions such as universities should incorporate CBLs in their training programmes to empower teachers to use new digital approaches.

(b) KICD should incorporate CBLs as one of the innovative teaching strategy in secondary chemistry curriculum.

(c) Regular in- service training in workshops, seminars and SMASSE programme to induct teachers in the field to gain knowledge and skills in CBLs.

(d) Information Communication and Technology in secondary science should be incorporated into the curriculum in order to facilitate educational reforms and shift teachers' positions in instructional practices from that of a distributor of information to that of a facilitator.

5.3.2 Suggestions for Further research

1. A comparative study involving the rural and urban school settings to establish the findings concerning socio-cultural regions on implementation of CBLs.

2. There is need for a comparative study on learners motivation and self concept in chemistry instruction through CBLs approach verses those taught through traditional methods.

5.4 Chapter Summary

The study concluded that computer-based laboratory simulation significantly assisted learners in development of inquiry skills in electro-chemistry. CBLs had significant influence on achievement of chemistry as compared with traditional methods of teaching chemistry. The study also concluded that there existed no significant difference across the male and female students on the implementation of CBLs. However, Computer-based laboratory had positively improved the attitude of students towards chemistry subject.

The study recommends that secondary schools should adopt the use CBLs in teaching of chemistry alongside traditional methods. It also proposed that teacher education in higher teacher Education institutions should restructure their curriculum to include the use CBLs in teachers training. This will improve the application CBLs in secondary schools. The study also recommends that secondary science instruction should be restructured so as to enable teachers' integrate with ease the use of CBLs. Suggestion for further research should be based on other subjects.

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APPENDICES

Appendix I: Chemistry Teachers' Interview Schedule

This research is meant for academic purpose only. Its aim is to investigate the use of Computer-based laboratory simulations (CBLs) in teaching and learning Chemistry in secondary schools.

SECTION I:
Background information

PART A: CBLs and Acquisition of Scientific Inquiry Skills

1. What is your personal feeling about the use of CBLs in development of inquiry skills in teaching and learning of Chemistry?

____

____

____

2. In your opinion which scientific skills have computer-based laboratory simulations assisted in developing?

____

____

____

3. Describe in detail how are scientific skills acquired through computer-based laboratory simulations?

____

____

____

PART B: CBLs and Effectiveness in Teaching Chemistry

4. Compare the traditional methods and computer-based laboratory based on effectiveness in teaching Chemistry?

____

____

____

5. Compare the students who did and those who never used the new technology, do you think the students who used CBLs learnt any better?

____

____

6. What benefits are gained by students through computer-based laboratory simulations as opposed to traditional methods?

____

____

PART C: CBLs and Achievement in Chemistry

7. What is the impact of computer-based laboratory simulation on Chemistry lessons?

8. What is the effect of computer-based laboratory simulation on Chemistry practical?

9. In your opinion does gender difference affect the use of computer-based laboratory simulation in Chemistry lessons?

PART D: CBLs and Students' Attitudes

10. What was the attitude of students towards electro-Chemistry when computer-based laboratory simulation was used?

11. What was the teachers' attitude towards the use of computers in Chemistry?

12. What was the effect of computer-based simulation on participation of students in Chemistry?

Appendix II: Students' Questionnaire

This research is meant for academic purpose only. Its purpose is to investigate the use of computer-based laboratory simulations in teaching and learning of Chemistry in secondary schools. You are kindly requested to provide honest and precise responses.

Responses for the questions will be treated confidentially and will be used for the study.

Please tick (√) where applicable or fill in the required information in the spaces provided.

SECTION I

Background information

1. Your sex:

   Female ☐ Male ☐

2. Your age (in years)

   Between 13-14 ☐

   Between 15-16 ☐

   Between 17-18 ☐

   Between 19-20 ☐

   Above 20 ☐

3. Type of school

   Boys boarding ☐

   Girls boarding ☐

   Boys` day and boarding ☐

   Girls' day and boarding ☐

   Mixed day and boarding ☐

   Mixed day ☐

   Other (specify)____

PART B: Computer based laboratory simulation and scientific inquiry skills

Use the letter choices below SA=strongly agree, A=Agree, U=Undecided, D=disagree, SD=strongly disagree

	SA	A	U	D	SD
The school has computer laboratory					
Computer available are used in performing science activities					
Computer was often used for learning science					
Practical lessons are taught using computer-based laboratory simulations in Chemistry					
Level of participation among learners is high in computer-based laboratory simulation strategy.					
Computer based simulation help me to develop inquiry skills in Chemistry					

PART C: Computer based laboratory simulation and traditional methods

Use the letter choices below SA=strongly agree, A=Agree, U=Undecided, D=disagree, SD=strongly disagree

	SA	A	U	D	SD
Computer based simulation created knowledge more than the traditional teaching method					
Computer based simulation improved innovativeness than traditional methods					
The new computer-based simulation provide added information as compared to traditional methods					
Computer based simulation improved students attitude to Chemistry					
Computer based simulation assisted in manipulation of data					
It assisted student to research unlike traditional method					

PART D: Computer based simulation based laboratory and Chemistry achievement

Use the letter choices below SA=strongly agree, A=Agree, U=Undecided, D=disagree, SD=strongly disagree

	SA	A	U	D	SD
The student work in groups when carrying out investigations					
Everyone participates in group work					
Boys had more opportunity to use the apparatus than girls					
New technology directions were clearer than the teacher's directions					

Gaining access to the Chemistry lessons on the computer was easy and exciting

PART E: Computer based laboratory simulation and student attitude

Use the letter choices below SA=strongly agree, A=Agree, U=Undecided, D=disagree, SD=strongly disagree

	SA	A	U	D	SD
The Chemistry lessons via new technology were innovative and increases creativity					
Chemistry lessons taught by the teacher were easy					
Chemistry lessons via new technology were friendly					
Chemistry lessons taught by the teacher were interesting					
I like Chemistry lessons taught without the use of new technology					
The Chemistry lessons taught via the new technology were meaningful					

PART F: Class achievement

Use the letter choices below SA=strongly agree, A=Agree, U=Undecided, D=disagree, SD=strongly disagree

	SA	A	U	D	SD
There is an improvement in Chemistry practical when computer simulation is applied					
Students' science skills has improve drastically on utilization of computer simulation method					
Performance in Chemistry has improved when the teacher incorporate computer simulation method					
Student attitudes towards Chemistry has improve through introduction of computer simulation method					

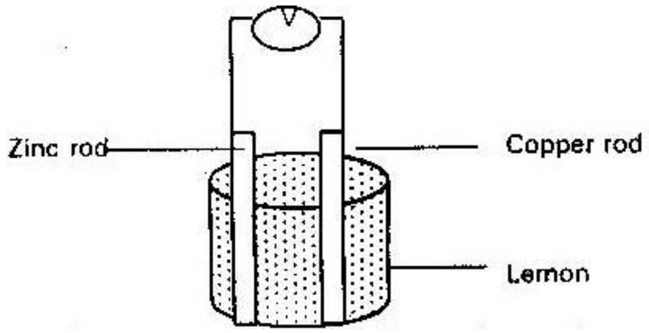
Appendix III: Experimental Design Procedure for the Teacher

1. Divide the form four students into two group randomly (each group should have ten members)
2. Number the groups; group I and group II
3. Take group I to be control group and group II experimental group
4. Give them pre-test on electro-Chemistry and analyze the results.
5. The two groups are taught electro-Chemistry
6. Teach group I using regular teaching methods (conventional method) and teach group two using Computer-based laboratory simulations
7. Compare the two results pre-test and post-test and give conclusion

Appendix IV: Students' Chemistry Achievement Test (Scat)

Admission number: __________________Class: ________________

1. A student set up an experiment as shown in the diagram below



(a) Draw an arrow on the diagram to indicate the direction of the electron flow. Explain your answer (2 mks)

(b) What would be observed on the voltmeter (v) if both rods were Zinc rods? (2mks)

2. Write an equation for the process that takes place at the anode during electrolysis of aqueous sodium sulphate solution using platinum electrodes (2mks)

3 8g of metal M were deposited when a molten salt of M was electrolyzed by passing a current of 0.6 amps for 90 minutes. Relative atomic mass of M= 226: Faraday = 96500 coulombs).

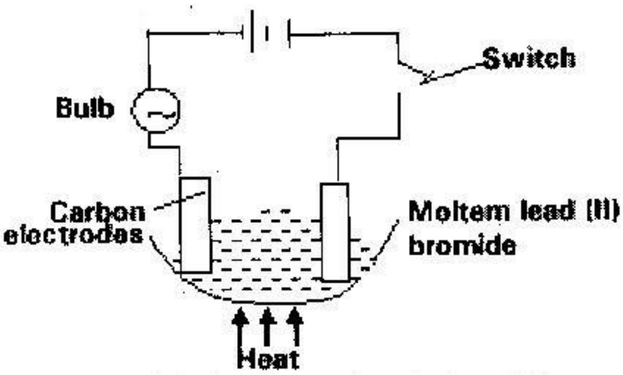
Calculate the amount of electricity in coulomb

(i) Needed to deposit 3.8g of metal M (1mk)

(ii) Needed to deposit 3.8g of metal M (1mk)

(iii) Deduced the charge on the ion of M (1 mk)

4. Study the set up below and answer the question that follow

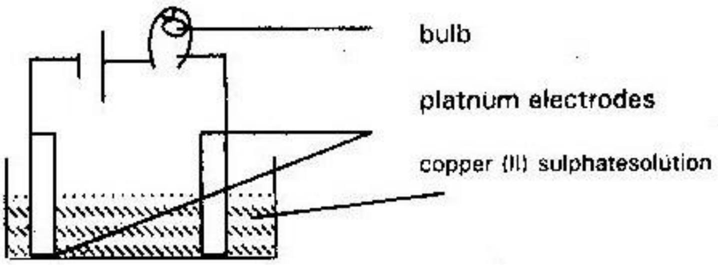


State and explain the observations that would be made when the circuit is completed (3mks)

5. Explain the following observation

A chloride dissolves in water to form an electrolyte while the same chloride dissolves in methyl benzene to form non- electrolyte
(2 mks)

6. The set up below was used to electrolyze aqueous copper (II) Sulphate



(i) Explain why the bulb light brightly at the beginning of the experiment and become dim after sometime.
(2 mks)

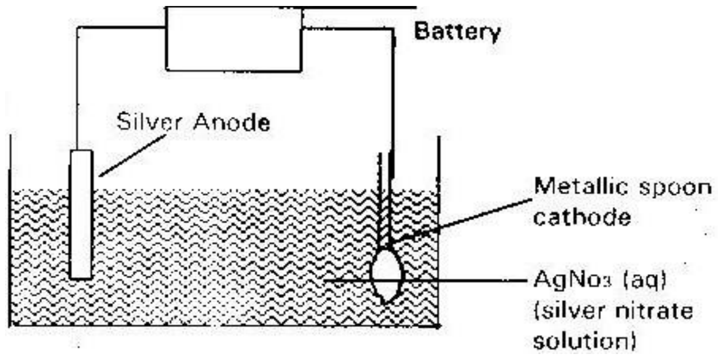
(ii) Write an ionic equation for the reaction that took place at the cathode (1mk)

7. When amount of 1.5 amperes was passed through a cell containing M^{3+} ions of metal M for minutes the mass of the cathode increased by 0.26g. (Faraday = 96500 coulombs)

(a) Calculate the quantity of electricity used
(2 mks)

(b) Determine the relative atomic mass of metal "m"
(2 mks)

8. The set up below was used to electroplate a metallic spoon. Study it and answer the question that follows



(a) Write an ionic equation for the reaction that occurred at the cathode
(1 mk)

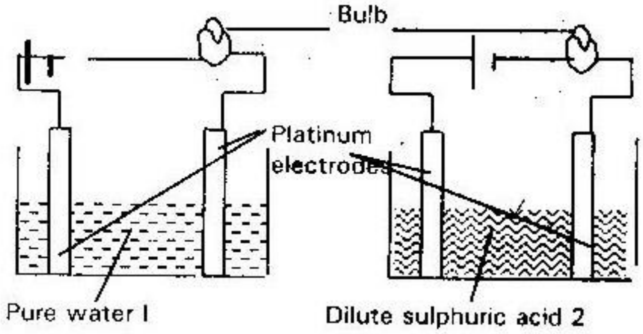
b) State and explain what happen to the anode
(2 mks)

c) During purification of copper by electrolysis 1.48g of copper were deposited when a current was passed through aqueous for 2 ½ hrs

Calculate the amount of current that was passed (3 mks)

(CU = 63:5) (1 Faraday = 96,500 Coulombs)

9. The diagram below represent the set ups that were used to a study the effect of an electric current on pure water and dilute sulphuric acid.



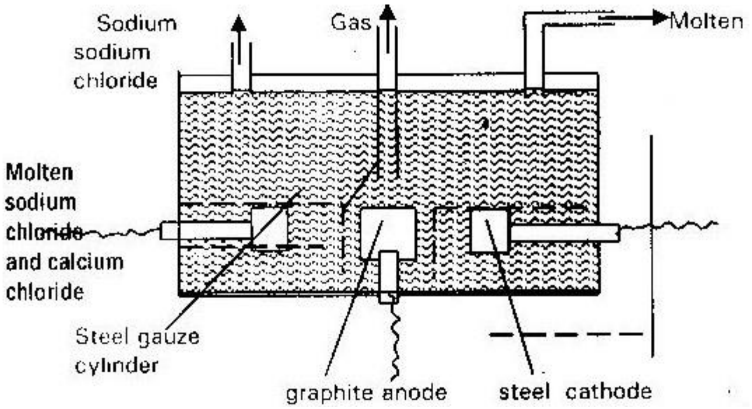
(a) State and explain the observations made when each experiment was started (3mks)

(b) When brine is electrolyzed using inert electrodes, chlorine gas is liberated at the anode instead of oxygen. Explain this observation.
(2mks)

(c) Name the product formed at the cathode.

(1mk)

11. The diagram below shows the extraction of sodium metal using the down cell
Study it and answer the questions that follow



(i) Explain why in this process the sodium chloride is mixed with calcium chloride

(2 mks)

(ii) Why is the anode made of graphite and not steel?

(1 mk)

(iii) State two properties of sodium metal that make it possible for it to be collected as shown in the diagram (2 mks)

(iv) What is the function of steel gauze cylinder?

(1 mk)

(v) Write ionic equation for the reactions which take place at

(a) Cathode

(1 mk)

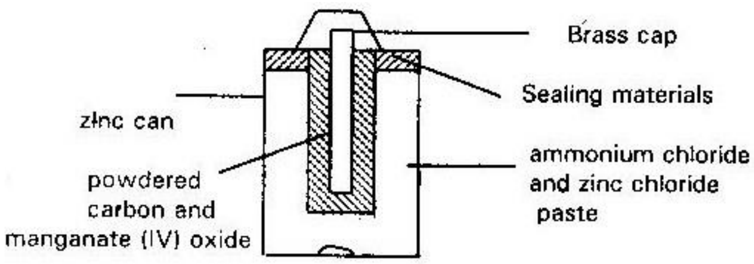
(b) Anode

(1 mk)

(vi) Give one industrial use of sodium metal

(1 mk)

12. The diagram below is a cross- section of a dry cell. Study it and answer the questions that follow



(i) On the diagram, show with a (+ve) sign the +ve (positive terminal)

(1 mk)

(ii) Write the equation for the reaction in which electrons are produced

(1 mk)

(iii) The zinc can hold ammonium chloride and zinc chloride paste. What would happen if the mixture was to become dry? Give a reason
(2mks)

(iv) Give one advantage and one disadvantage of dry cell
(2 mks)

Appendix V: Research Letter from University of Eldoret

University of Eldoret
flame of knowledge and innovation

P.O. Box 1125-30100, ELDORET, Kenya
Tel: 053-2063111 Ext. 242
Fax No. 20-2141257
Email: soe@uoeld.co.ke
www.uoeld.ac.ke

UNIVERSITY OF ELDORET

SCHOOL OF EDUCATION
CENTRE FOR TEACHER EDUCATION

REF: UOE/B/CTE/PGS/033/Vol.1
DATE: December, 17, 2018

The Executive Secretary,
National Council for Science Technology & Innovation
P.O Box 30623- 00100
NAIROBI.

Dear Sir /Madam

RE: RESEARCH PERMIT FOR:
CHEPKORIR SALOME - EDU/DPHL/SE/1001/12

This is to confirm that the above named Post Graduate Student has completed Course Work and has successfully defended her thesis proposal.

She is currently preparing for a Field Research Work on her Thesis Proposal entitled: ***An investigation into the use of Computer Based Laboratory simulations in promoting Development of inquiry Skills in Electro-chemistry in Secondary Chemistry Instruction in Bomet County, Kenya.***

Any assistance accorded to her to facilitate successful conduct of the research and the publication will be highly appreciated.

Yours faithfully,

HEAD
Centre for Teacher Education
UNIVERSITY OF ELDORET
MAIN CAMPUS

Dr. P. Waswa
HEAD, CENTRE FOR TEACHER EDUCATION

c. c. Permanent Secretary
Ministry of Higher Education, Science & Technology,
P. O Box 9583-00200,
Nairobi.

c. c. Post Graduate Coordinator - School of Education, University of Eldoret,

University of Eldoret is ISO 9001: 2015 Certified:

Appendix VI: Letter of Research Authorization from National Council of Science and Technology (NACOSTI)

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/19/67374/27556**

Date: **6th February, 2019**

Chepkorir Salome
University of Eldoret
P. O. Box 1125-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"An investigation into the use of computer-based laboratory simulations in promoting development of inquiry skills in Electro-Chemistry in secondary chemistry instruction in Bomet County"*** I am pleased to inform you that you have been authorized to undertake research in **Bomet County** for the period ending **6th February, 2020.**

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

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

Kalerwa

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Bomet County.

The County Director of Education
Bomet County.

Appendix VII: Letter of Research Authorization from the County Director of Education.

REPUBLIC OF KENYA
MINISTRY OF EDUCATION
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION

Telegrams: "ELIMU",
Telephone: 052-22265
When replying please quote
email:cdebometcounty@gmail.com
Ref/CDE/BMT/ED/AUTH/74/VOL.I/97

COUNTY EDUCATION OFFICE,
BOMET COUNTY,
P.O. BOX 3-20400,
BOMET.

22ND MARCH, 2019

Chepkorir Salome
University of Eldoret
P.O Box 1125-30100
ELDORET.

RE: RESEARCH AUTHORIZATION.

Reference is made to yours from NACOSTI Ref: No NACOSTI/P/19/67374/27556 dated 6th February, 2019 on the above subject.
Permission is hereby granted to carry out research on "***An investigation into the use of computer-based laboratory simulations in promoting development of inquiry skills in Electro-Chemistry in secondary Chemistry instruction in Bomet County"; for*** the period ending 6th February, 2020.

Ensure, you present a copy of the research to County Director of Education-Bomet

This letter should be presented to the principal of the schools visited for the said purpose.

COUNTY DIRECTOR OF EDUCATION
BOMET
P. O. Box 3 - 20400, BOMET
Date: 22/3/2019

INDIATSI MABALE
COUNTY DIRECTOR OF EDUCATION
BOMET COUNTY.

CC
DIRECTOR NACOSTI

Appendix VIII: Letter of Authorization from County Commissioner

OFFICE OF THE PRESIDENT

MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telegrams: "DISTRICTER", Bomet
Telephone: (052) 22004/22077 Fax 052-22490
When replying please quote

COUNTY COMMISSIONER
P.O BOX 71- 20400
BOMET

REF: EDU 12/1 VOL.III/(107)

22nd March, 2019

The Deputy County Commissioners
BOMET

RE: RESEARCH AUTHORIZATION – CHEPKORIR SALOME

The above named person has been authorized to carry out research on **"An investigation into the use of computer-based laboratory simulations in promoting development of inquiry skills in Electro-Chemistry in secondary chemistry instruction in Bomet County"**, by the National Commission for Science, Technology and Innovation vide their letter Ref. No. NACOSTI/P/19/67374/27556 dated 6th February, 2019 for the period ending 6th February, 2020.

Any assistance accorded to her would be appreciated.

F. Khakayi
For: County Commissioner
BOMET

COUNTY COMMISSIONER
BOMET COUNTY
22 MAR 2019
P. O. Box 71-20400, BOMET

Appendix IX: Research Permit from NACOSTI

THIS IS TO CERTIFY THAT:
MS. CHEPKORIR SALOME
of UNIVERSITY OF ELDORET, 130-20210 LITEIN, has been permitted to conduct research in *Bomet County*

Permit No : NACOSTI/P/19/67374/27556
Date Of Issue : 6th February, 2019
Fee Recieved :Ksh 2000

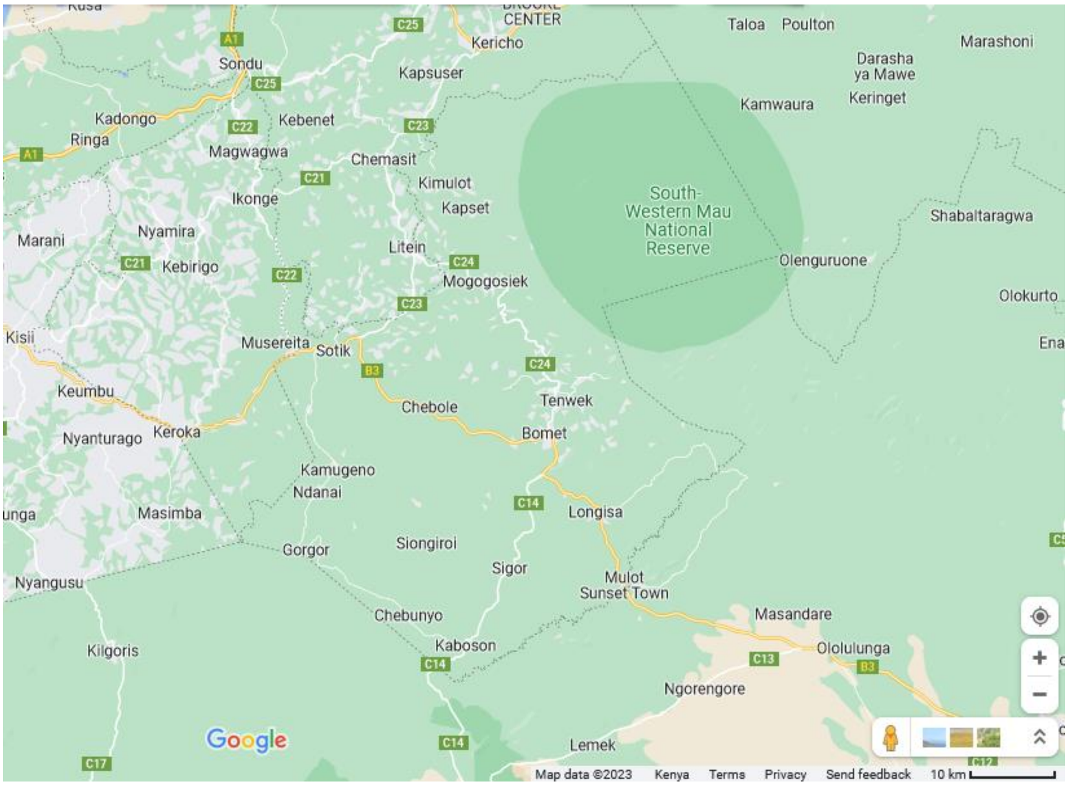
on the topic: *AN INVESTIGATION INTO THE USE OF COMPUTER- BASED LABORATORY SIMULATIONS IN PROMOTING DEVELOPMENT OF INQUIRY SKILLS IN ELECTRO-CHEMISTRY IN SECONDARY CHEMISTRY INSTRUCTION IN BOMET COUNTY*

for the period ending:
6th February, 2020

....
Applicant's Signature

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

Appendix X: Map of Bomet County



Appendix XI: Raw Data

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The school has computer laboratory	173	2.00	5.00	3.8960	.74758
Computer available are used in performing science activities	173	2.00	5.00	3.7861	.70334
Computer was often used for learning science	173	2.00	5.00	4.0751	.68209
Practical lessons are taught using computer based laboratory simulations in Chemistry	173	2.00	5.00	3.8324	.67401
Level of participation in computer based laboratory simulation for Chemistry	173	2.00	5.00	4.1098	.66871
Computer based simulation help you to develop inquiry skills in Chemistry	173	2.00	5.00	4.3295	.69975
Valid N (listwise)	173				

Descriptive Statistics

Dependent Variable: MarksChange

Gender	Quasi	Mean	Std. Deviation	N
Male	Experimental Group	3.5875	5.48014	40
	Control Group	5.4675	3.01351	40
	Total	4.5275	4.49486	80
Female	Experimental Group	7.7625	2.21772	40
	Control Group	6.8575	2.30194	40
	Total	7.3100	2.29157	80
Total	Experimental Group	5.6750	4.65475	80
	Control Group	6.1625	2.75467	80
	Total	5.9187	3.82037	160

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Computer based simulation created knowledge more than the traditional teaching method	173	2.00	5.00	4.1734	.72656
Computer based simulation improved innovativeness than traditional methods	173	2.00	5.00	3.8671	.63768
The new computer based simulation provide added information as compared to traditional methods	173	2.00	5.00	3.9422	.67092
Computer based simulation improved students attitude to chemistry	173	3.00	5.00	3.8786	.60257
Computer based simulation assisted in manipulation of data	173	2.00	5.00	3.9249	.62887
It assisted student to research unlike traditional method	173	2.00	5.00	4.3295	.64798
Valid N (listwise)	173				

Tests of Between-Subjects Effects

Dependent Variable: Change in Marks

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2260.015[a]	2	1130.008	137.027	.000
Intercept	1020.254	1	1020.254	123.718	.000
Pre	99.850	1	99.850	12.108	.001
Quasi	2145.211	1	2145.211	260.133	.000
Error	1294.715	157	8.247		
Total	14311.490	160			
Corrected Total	3554.730	159			

a. R Squared = .636 (Adjusted R Squared = .631)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The student work in groups when carrying out investigations	173	1.00	5.00	4.4855	.78212
Everyone participation in group work	173	1.00	5.00	4.7341	.68101
Boys had more opportunity to use the apparatus than girls	173	1.00	5.00	1.6705	1.12637
New technology directions were clearer than the teacher's directions	173	1.00	5.00	3.8092	1.09625
Gaining access to the Chemistry lessons on the computer was easy and exciting	173	1.00	5.00	4.7110	.66275
Valid N (listwise)	173				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The chemistry lessons via new technology was innovative and increase creativity	173	1.00	5.00	2.0983	1.23733
Chemistry lessons taught by the teacher were easy	173	1.00	5.00	3.8902	1.01418
Chemistry lessons via new technology were friendly	173	1.00	5.00	4.2890	.84064
Chemistry lessons taught by the teacher were interesting	173	1.00	5.00	4.0116	1.05096
I like Chemistry lessons taught with the use of new technology	173	1.00	5.00	2.5087	1.31015
The chemistry lessons taught via the new technology were meaningful	173	1.00	5.00	4.4220	.93447
Valid N (listwise)	173				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
There is an improvement in chemistry practical when computer simulation is applied	173	2.00	5.00	4.1214	.69236
Students' science skills has improve drastically on utilization of computer simulation method	173	2.00	5.00	3.9538	.64533
Performance in chemistry has improved when the teacher incorporate computer simulation method	173	2.00	5.00	4.1387	.64100
Student attitudes towards chemistry has improve through introduction of computer simulation method	173	3.00	5.00	4.2486	.67476
Valid N (listwise)	173				

Tests of Between-Subjects Effects

Dependent Variable: Change in Marks

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	171.543[a]	2	85.772	3.980	.021	.048
Intercept	1067.319	1	1067.319	49.530	.000	.240
Pre	115.255	1	115.255	5.349	.022	.033
Gender	56.739	1	56.739	2.633	.107	.016
Error	3383.187	157	21.549			
Total	14311.490	160				
Corrected Total	3554.730	159				

a. R Squared = .048 (Adjusted R Squared = .036)

Gender (Boys and Girls)

Dependent Variable: Change in Marks

Gender (Boys and Girls)	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	8.795[a]	.519	7.770	9.820
Female	7.604[a]	.519	6.579	8.629

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 43.8356.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Post-test	160	32.00	80.00	52.0350	9.93429
Pre-test	160	19.00	75.00	43.8356	9.62784
Valid N (listwise)	160				

		Pre-test	Post-test	Change in Marks
		Mean	Mean	Mean
School	A (Experimental)	43.55	56.45	12.90
	B (Control)	43.79	48.16	4.37
	C (Experimental)	43.82	54.67	10.85
	D (Control)	44.18	48.86	4.68

Appendix XII: Similarity Report

DrillBit

The Report is Generated by DrillBit Plagiarism Detection Software

Submission Information

Author Name	Chepkorir Salome EDU/DPHL/SE/1001/12
Title	COMPUTER-BASED LABORATORY SIMULATIONS AND DEVEL...
Paper/Submission ID	976163
Submission Date	2023-09-19 20:31:50
Total Pages	163
Document type	Dissertation

Result Information

Similarity 7 %

Exclude Information

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References/Bibliography	Excluded
Sources: Less than 14 Words Similarity	Excluded
Excluded Source	2 %
Excluded Phrases	Not Excluded

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