DOES INQUIRY-BASED LEARNING APPROACH IN CHEMISTRY PRACTICAL LESSONS AFFECT STUDENTS' ATTITUDES AND SELF-EFFICACY IN CHEMISTRY? A CASE OF MERU SOUTH SUB-COUNTY, KENYA

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DECLARATION

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

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DEDICATION

This work is dedicated to the Almighty God who gave me the strength and perseverance to complete it. To my dearest husband Kelvin Makau, my loving parents Mr. and Mrs. Nzomo, my dear sister Scholastica and my supportive siblings, I dedicate this thesis to all of you with heartfelt gratitude and admiration for your unwavering support and love throughout my academic journey. To my loving husband Kelvin, you have been my rock and my biggest supporter. Your love and support have been the driving force behind my success, always encouraging me to persevere. You are the reason why I kept pushing forward even when the going got tough and I could not have accomplished this without you by my side. To my dad and mum, Mr. and Mrs. Nzomo, you have always been my pillars of strength. Your constant encouragement and support have been my inspiration throughout my academic journey. Your love and support have given me the courage and determination to pursue my dreams. To my sister Scholastica, you have been my confidante and cheerleader. Your support and encouragement have been instrumental in helping me achieve my goals. And finally, to my brothers, sisters and relatives, thank you for always being there for me. Your support and encouragement have been invaluable throughout this journey. To all of you, I say thank you. You have all played an integral role in shaping me into the person that I am today.

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LIST OF ABBREVIATIONS AND ACRONYMS

CEMASTEA	Centre for Mathematics, Science and Technology Education in Africa
EFA	Exploratory Factor Analysis
IBL	Inquiry-Based Learning
INSET	In-Service Education and Training
JICA	Japan International Cooperation Agency
KCSE	Kenya Certificate of Secondary Education
KNEC	Kenya National Examinations Council
NACOSTI	National Commission for Science, Technology, and Innovation
PCA	Principal Component Analysis
SMASSE	Strengthening of Mathematics and Science in Secondary Education

DEFINITION OF TERMS

Academic performance	Refers to the learner's accomplishment in Chemistry examinations.
Chemistry	Refers to one of the science subjects taught in secondary schools which studies the chemical composition of substances and chemical reactions.
Chemistry practical work	Refers to teaching and learning of Chemistry through experiments.
Inquiry-Based Learning (IBL)	Refers to a learner-centered teaching strategy where learners are actively engaged in the process of learning through various activities such as observation, carrying out investigations, collection of data, testing of hypothesis, analysis of data and communication of results from concepts studied.
Performance predictors	Refers to students' attitudes and self-efficacy that predict academic performance of students.
Self-efficacy	Refers to student's beliefs of their ability to perform well in Chemistry subject.
Students' attitude	Refers to either positive or negative feelings that students have towards Chemistry.
5E instructional model	Refers to a teaching and learning model which serves as a framework for implementation of inquiry-based learning approach. It consists of 5 phases which include: engage, explore, explain, elaborate and evaluate.
Utilization of IBL	Refers to the use of IBL in practical lessons

ABSTRACT

Chemistry is a crucial subject for a country like Kenya that seeks to be industrialized by the year 2030. Even though the subject is important, performance in the subject has been declining consistently in Kenya. A decline in performance in Chemistry has also been reported in Meru South Sub-County. The decline in performance has been attributed to teacher-centered learning methodologies, negative attitudes of students towards the subject and low self-efficacy. Teachers have been encouraged to use Inquiry-Based Learning (IBL) approach in teaching of Chemistry and particularly in practical lessons because it has been associated with improved attitudes and self-efficacy. However, little is known on the uptake of inquiry-based learning approach by teachers in Chemistry practical lessons and how it is related to students' attitudes and self-efficacy in Chemistry in Meru South Sub-County secondary schools. The purpose of this research was to examine the utilization of inquiry-based learning approach in Chemistry practical lessons, and determine the relationship between the utilization of inquiry-based learning approach and selected performance predictors i.e. students' attitudes and self-efficacy in Chemistry. The study was guided by the Vygotsky's social constructivism theory which emphasizes on the role of social interactions and active construction of knowledge. A mixed method research design was employed in this study. The target population was all secondary schools in Meru South Sub-County. Stratified and purposive sampling was used to select both public and private secondary schools. Purposive sampling was used to select 42 form three Chemistry teachers while 357 students were chosen for the research using basic random selection. Data collection was done using practical lesson observation schedule, teacher's questionnaire, student's questionnaire, and document analysis framework. Results revealed that teachers used inquiry-based learning approach in Chemistry practical lessons once a week (mean = 3.89). Results from correlation and regression analysis revealed that there is a significant positive relationship between inquiry-based learning and students' attitudes towards Chemistry ($r = .9972$, $p = .000$, $t = 58.285$, $p = 0.00$). Besides, it was established that inquiry-based learning is positively associated with students' efficacy beliefs in Chemistry ($\beta = 0.903$, $p < 0.05$). From the study findings, it was concluded that inquiry-based learning approach is an effective teaching technique for enhancing positive attitudes towards Chemistry among students as well as improving their confidence in Chemistry. The study findings are significant in the education sector in improving teacher training programs and calls for shift from teacher-centered teaching methodologies to learner centered teaching methodologies among practicing teachers.

CHAPTER ONE

1.1 Background to the Study

Chemistry is a discipline of science that is concerned with the chemical composition, characteristics and applications of matter (Das, 2018). It forms part of other sciences such as Biology, Agriculture and Physics and therefore, it is recognized as one of the important sciences (Chuks & Chidubem, 2018). Chemistry provides an overview of the world we live in, and understanding of various processes, and the importance of these processes in daily life such as qualitative analysis which can be used to detect metals present in water to ensure water safety (Njagi & Silas, 2015). Chemistry lays the foundation of many industrial processes such as food production, manufacture of medicinal products and textiles among others (Protus & Shikuku, 2020). It also prepares students for professions and occupations at the tertiary level of education, as well as for life in general (Chepkorir et al., 2014). It is therefore a crucial subject for a country that seeks to be industrialized, and hence effective teaching is required.

Despite its relevance, poor performance in Chemistry has been widely reported. For instance, in Nigeria, students are still performing poorly in Chemistry (Okwuduba, & Okigbo, 2018). In Ghana, poor performance in Chemistry has as well been reported (Hanson, 2017). In Uganda, poor performance in Chemistry has been reported which has been attributed to the inability of teachers to make use of Inquiry-Based Learning (IBL) practices in teaching the subject (Ssempala, 2017). In Tanzania, poor science achievement has been linked to a lack of laboratories and non-inquiry-based teaching methods (Kinyota, 2020). This implies that inefficient instruction, instructors' inability to apply an inquiry-based learning strategy, and lack of laboratory equipment are all factors that contribute to low Chemistry achievement. In Kenya, performance of the Chemistry subject has been deteriorating according to the Kenya National Examinations Council (KNEC) reports of 2018 and 2019 since 2015. The lack of inquiry-based learning approaches has been blamed for the poor results (Chepkorir et al., 2014; Hassan & Akbar, 2020; Hushman & Marley, 2015), students' negative attitudes towards Chemistry (Kyalo, 2016; Ogembo et al., 2015) and low self-efficacy (Julius et al., 2018). Therefore, attitudes and efficacy beliefs of students in Chemistry cannot be ignored.

Attitudes are predictors of students' academic success (Liou, 2020; Ramnarain & Ramaila, 2018; Ucar & Sungur, 2017). According to Kousa et al. (2018), students with positive attitudes do better than students with negative attitudes. In a school setting, students have varying attitudes about various courses. Some subjects are their favourites, and they have favourable feelings about them, whereas others are unpopular or difficult, and they have bad feelings about them (Cohen & Chang, 2020). A number of things can have an impact on these attitudes. Motivation and perceptions of the learning environment are two examples of these things (Cohen & Chang, 2020). Anxiety about science, its value, science self-esteem, motivation, love of science, and the dread of failing are all instances of attitude toward science (Uitto, 2014). The development of students' positive attitudes toward Chemistry is very important because attitudes are closely related with academic performance and also attitudes predict behaviors (Cheung, 2009). It is crucial to cultivate positive attitudes towards Chemistry among students as this will have positive impact on performance.

Students' academic success in Chemistry is influenced by their self-efficacy. According to Bandura (1994), personal efficacy judgments influence what students do by affecting the decisions they make, the work they put in, the perseverance and persistence they show when faced with challenges, and the cognitive patterns and emotional reactions they have. People analyze information from four sources to develop their self-efficacy perceptions. The interpreted consequence of one's performance or mastery experience is the most influential source (Featonby, 2012). When outcomes are regarded as successful, self-efficacy rises; when they are interpreted as failures, it falls (Bandura, 1986). The vicarious experience that people have when they see others executing activities is another self-efficacy knowledge (Kirbulut, 2014). The social comparisons formed with other people are a part of one's vicarious experience. These comparisons, when combined with peer modeling, can have a big impact on how self-perceptions of competence in Chemistry evolve. Self-efficacy beliefs are also formed as a result of verbal messages and social persuasions received from others (Aydin & Uzuntiryaki, 2009). Negative persuasions can destroy and erode self-beliefs; positive persuasions can encourage and strengthen. Anxiety and tension are physiological conditions that offer information regarding efficacy beliefs (Pajares, 2003). It's crucial to employ teaching strategies that increase students' efficacy beliefs in sciences particularly in Chemistry.

Negative attitudes toward Chemistry, as well as low self-efficacy in the subject, are key concerns in Kenya (Kyalo, 2016; Julius et al 2018). This has been attributed to teacher-centered methodologies used by teachers such as the lecture method that have a detrimental influence on learners' academic performance, attitudes and beliefs (Chepkorir et al., 2014; Hassan & Akbar, 2020; Hushman & Marley, 2015). Teacher-centered strategies make learners passive instead of actively engaging them in the learning process (Kyalo, 2016; Liou, 2020). Waswa and Cheptinget (2013) argue that the teaching of Chemistry in Kenyan schools is too teacher-centered and this may have adverse effects on students' attitudes and self-efficacy hence the need to embrace the learner-centered instructional strategies.

The learner-centered teaching technique of inquiry-based learning has been linked to favorable views toward Chemistry among students (Aktamis et al., 2016; Dajal & Umar, 2019; Ural, 2016). Inquiry teaching is a constructivist method of instruction that involves students actively participating in thinking rather than passively receiving information from a lecture (Schmid & Bogner, 2017). According to Aktamis et al. (2016), inquiry-based learning improves students' attitudes towards science when compared to traditional learning. Traditional teacher-centered methods, according to Tawfik et al. (2020) lead to rote learning of scientific concepts and should be replaced with student-centered and task-based learning methods. On the other hand, IBL approach is a student-centered method in which students discover everything in their immediate environment, develop strong arguments about the natural and physical world around them based on strong justifications, and grow into individuals who understand the importance of science and construct information (Aktamis et al., 2016). This implies that the utilization of inquiry-based learning practices can enhance positive attitudes towards Chemistry which translates to better performance.

Inquiry-based learning approach has been attributed to increased students’ self-efficacy (Sen & Vekli, 2016). According to Vishnumolakala et al. (2017), guided inquiry enhances the efficacy beliefs of students in Chemistry. Baanu and Oyelekan (2016) argue that students' beliefs in their capabilities highly influence academic achievement. As a result, learners who believe in their own efficacy are more likely to succeed than those who believe in their own inefficacy. According to a study by Farrand et al. (2016), the self-efficacy of junior participants who were engaged in inquiry-based science camp increased after participation. As opined by Nikmah et al. (2020), using the inquiry learning methodology can boost students' self-efficacy in science topics. Besides, Pitaloka et al. (2020) argues that using a guided inquiry learning methodology can help students improve their science literacy and self-efficacy. Self-assessment using the inquiry learning approach had a better impact on self-efficacy and student physics learning outcomes (Rapi et al., 2022). As a result, inquiry-based learning is an educational method that can enhance students' self-efficacy beliefs when applied in the learning process.

Practical work is regarded as vital in Chemistry instruction. It provides the best opportunity for inquiry-based learning implementation (Jerrim et al., 2020). This instructional approach ensures learners are actively engaged in the learning process. Globally, reforms have been made to incorporate inquiry-based learning approach in practical work. In New York, it is well established that incorporating inquiry-based learning into practical teaching improves students' attitudes, motivation, and academic accomplishment (Bittinger, 2015). In New Zealand, inquiry-based learning in practical lessons is known to enhance enjoyment and interest in Chemistry among students (Chairam et al., 2015). In South Africa and in Nigeria, inquiry-based learning in practical lessons is encouraged because it is believed to actively engage learners in the learning process, enhance academic achievement and problem-solving skills as well as improve students' attitudes (Akuma & Callaghan, 2019; Chuks & Chidubem, 2018; Ogunleye & Bamidele, 2010). Therefore, incorporating IBL in practical work is crucial for the success of students in Chemistry.

In Kenya, the government has put efforts to shift teaching methodologies from teacher-centered to inquiry-based learner-centered pedagogies in order to improve performance and develop positive attitudes towards Chemistry (Kiige & Atina, 2016). For example, the Government of Kenya in conjunction with the Japan International Cooperation Agency (JICA) initiated the Strengthening of Mathematics and Science in Secondary Education (SMASSE) project in 1998 intending to improve performance in Sciences and Mathematics (Kiige & Atina, 2016). Besides, the Centre of Mathematics, Science and Technology Education in Africa (CEMASTEA) has been conducting professional development of teachers since the year 2003.

Despite the efforts by the government to improve performance in Chemistry, its performance is still declining as shown in Figure 1.1. In Meru South Sub-County, poor performance in Chemistry has also been reported (Mukami, 2015). According to table 1.1, performance is below average. To improve students' performance in Chemistry, the KNEC report (2018) proposes that teachers use an inquiry-based learning method. However, there is no adequate information on the application of this approach in Chemistry practical lessons, and how it relates with attitudes of students as well as their efficacy beliefs in Chemistry in Kenya.

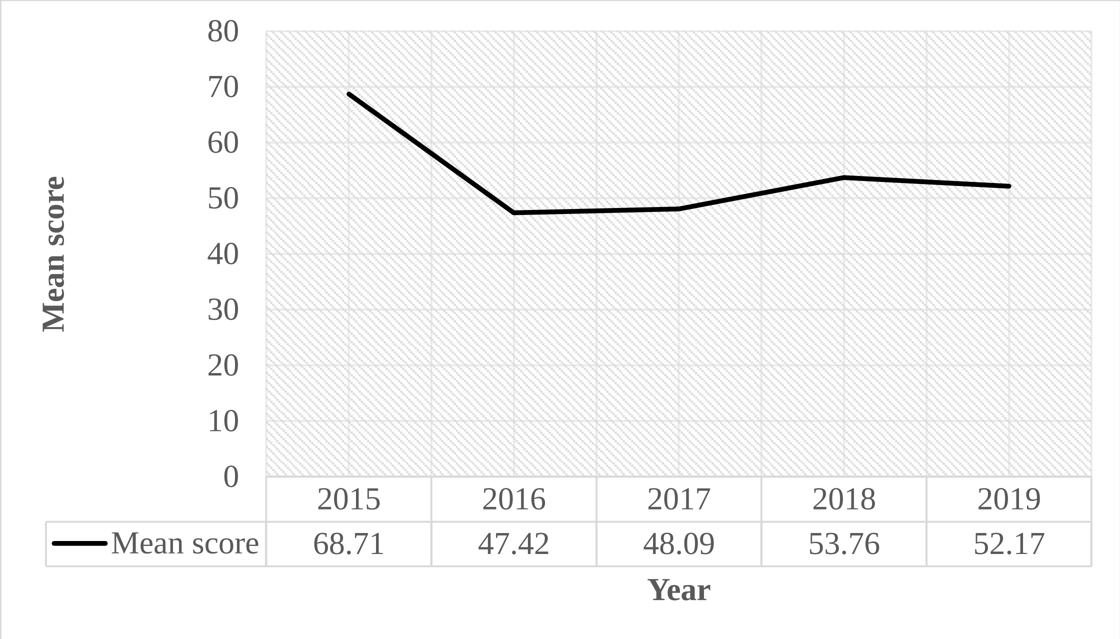

Figure 1.1: Chemistry performance Nationwide for the years 2015-2019

Source: 2018 and 2019 Kenya Certificate of Secondary Education (KCSE) KNEC reports

Table 1.1: Meru South Sub-County Chemistry results (K.C.S.E)

Year	**Mean score**	**Percentage (%)**
2015	4.93	41.08
2016	3.91	32.58
2017	3.83	31.92
2018	3.87	32.25
2019	3.98	33.12

Source: Sub-County Director of Education Office, Meru South Sub-County

As a result, the purpose of this study was to look into the use of inquiry-based learning in Chemistry practical sessions and how it relates to students' attitudes and efficacy beliefs in Chemistry in Meru South Sub-County in Kenya.

1.2 Statement of the Problem

Studies have shown that attitude and self-efficacy are predictors of academic performance in general. In particular, poor performance in Chemistry has been attributed to students' negative attitudes and low self-efficacy. Yet, it is envisaged that the adoption of inquiry-based learning approach would increase students' positive attitudes and self-efficacy in Chemistry. In Kenya, there is scarce literature on relationship between the application of inquiry-based learning approach during Chemistry practical lessons and how it is related to students' attitudes and self-efficacy. This study sought to examine the relationship between the application of inquiry-based learning approach and students' attitudes and self-efficacy in Chemistry in secondary schools in Meru South Sub-County, Kenya, which has continually posted poor performances.

1.3 General Objective

The general objective of this study was to investigate the effect of inquiry-based learning approach in Chemistry practical lessons on students' attitudes and self-efficacy in Chemistry in secondary schools in Meru South Sub-County.

1.4 Specific Objectives

The specific objectives for this study were:

1. To establish the extent to which inquiry-based learning approach has been used in Chemistry practical lessons.
2. To find out the relationship between the use of inquiry-based learning approach and students' attitudes towards Chemistry.
3. To determine the relationship between the use of inquiry-based learning approach and students' self-efficacy in Chemistry.

1.5 Research Questions

The study aimed to address the following research questions in order to accomplish the above goals:

1. To what extent has the inquiry-based learning approach been used in Chemistry practical lessons?
2. What is the relationship between the use of inquiry-based learning approach and students' attitudes towards Chemistry?

3. What is the relationship between the use of inquiry-based learning approach and students' self-efficacy in Chemistry?

1.6 Justification of the Study

The performance in Chemistry, which is one of the crucial science subjects, has been declining nationwide according to the KNEC reports of 2018 and 2019. Meru South Sub-County has also shown a decline in performance as outlined in table 1.1. Kenya has been spending a lot of money on In-Service Education and Training (INSET) and teaching and learning resources, especially in sciences but with very little achievement since the performance is still declining. However, little is known about the uptake of the inquiry-based learning approach in Kenya and particularly in Meru South Sub-County as studies are quite scattered. Njoroge et al. (2014) express the need to conduct studies on how certain variables interact with inquiry-based learning approach to enhance students' performance in sciences. Njagi (2016) recommends more studies about inquiry-based learning which incorporates both qualitative and quantitative methods of data collection in order to make informed conclusions. As a result, the goal of this study was to look into the uptake of inquiry-based learning in Meru South Sub-County, as well as how it relates to students' attitudes and self-efficacy in Chemistry.

1.7 Significance of the Study

This study will help in the realization of Kenya's Vision 2030 which emphasizes on Science, Technology, and Innovation (STI). Chemistry plays an important part in scientific and technological advancements, which can only be reached through high-quality Chemistry instruction and learning. Kenya has implemented the Competence Based Curriculum (CBC) and hence inquiry-based learning will be employed in the Science, Technology, Engineering and Mathematics (STEM) pathway in senior school to equip learners with the required knowledge and skills. Teachers will use the knowledge to maximize the use of IBL in Chemistry lessons. The research will also be of importance to universities and teacher training programs to enhance improvement in the training of Chemistry teachers. Finally, the findings of this study will help educators, curriculum architects, and educational policymakers in putting up policies as well as the implementation of these policies to enhance quality teaching in Chemistry in secondary schools.

1.8 Assumptions of the Study

It was assumed that teachers had the knowledge and skills on inquiry-based learning approach and they practiced it in the classrooms. Also, it was assumed that teachers would be able to isolate teaching and learning skills based on inquiry from the general repertoire of skills. Lastly, it was anticipated that the study participants would provide accurate and truthful data.

1.9 Limitations of the Study

This research was only done in selected secondary schools in Meru South Sub-county, Tharaka Nithi County which include national schools, extra-county schools, county schools and private schools hence the study results would not be generalizable to the entire country. Also, the study was limited to one teaching approach i.e., inquiry-based learning approach in practical lessons, specific teachers and students.

2.0 Delimitations of the Study

This research was conducted in form three Chemistry practical lessons and it focused only on how the inquiry-based learning approach had been used in practical lessons and students' attitudes and self-efficacy in Chemistry.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section covers the review of the related knowledge, theoretical framework, conceptual framework, summary of empirical literature, and research gap in that order.

2.2 Inquiry-based Learning Approach

The origins of the inquiry-based learning approach may be traced back to the writings of Jean Piaget, Lev Vygotsky, and David Ausubel, which developed through a synthesis of many teaching and learning strategies (Chowdhury, 2016). According to Chowdhury, inquiry-based learning is grounded on discovery learning whose key proponent is Jerome Bruner through his cognitive learning theory. It is a constructivist instructional strategy among other strategies such as discovery learning and peer-assisted teaching (Baldock & Murphrey, 2020), where learners are given opportunities to research through experimentation to answer questions among other activities such as observation and testing of hypothesis. Inquiry-based learning refers to learner-centered ways of teaching in which learners are actively engaged in various activities such as question formulation, developing hypothesis, planning and carrying out investigations, providing explanations and communicating their findings with the teacher facilitating the learning process (Eltanahy & Forawi, 2019; Hamed et al., 2020; Schmid & Bogner, 2017). According to the National Research Council (1996), inquiry-based learning refers to;

> A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results.

There are four levels of inquiry-based learning which include confirmatory inquiry, structured inquiry, guided inquiry, and open inquiry (Carmel et al., 2019). According to Akuma and Callaghan (2019), low levels of inquiry need to be implemented first before moving to higher levels of inquiry. In the confirmatory inquiry, learners are given the question and the technique for doing the investigation. Also, in this level, learners are aware of the investigation's results before they conduct it. Therefore, learners carry out the investigation, analyze, and interpret data. In the structured inquiry, students are normally provided with questions and a description of how the investigation should be carried out. It also includes the way the data should be analyzed and therefore the students are left to discover relationships (Carmel et al., 2019). Therefore, students determine ways of reporting the results of their experiences and conclusions. In the guided inquiry, learners are given the question but they are expected to come up with the procedure to answer the questions as well as explanation based on the results (Carmel et al., 2019). Lastly, in open inquiry, students formulate the questions, test hypotheses, conduct investigations, and report their findings. This process includes asking questions, developing and applying models, planning, performing investigations, analyzing, and interpreting data. The levels of inquiry-based learning can be summarized as shown in table 2.1 according to Kinyota (2020).

Table 2.1: Inquiry-based learning levels

	Question	Procedures	Data interpretation
Confirmatory inquiry	Provided	Provided	Provided
Structured inquiry	Provided	Provided	Open
Guided inquiry	Provided	Open	Open
Open inquiry	Open	Open	Open

Each level of inquiry is characterized by particular learning activities. In Chemistry teaching, leaners undergo different levels of inquiry which can be recognized by the different class activities including teachers' and students' roles. In practical settings, some learners might be given the opportunity to come up with research questions while in other settings, the teacher provides the research question for investigations. Also, in some settings, learners might be given the opportunity to design experimental procedures while others, learners might be provided with the experimental procedures by their teachers. Therefore, it depends on the practices of the teachers in terms of the freedom they give to learners when it comes to practical activities. It is important to note that the focus of this study was not on the levels of inquiry-based learning but on the phases of the 5E model which serves as a framework for IBL implementation.

2.3 Practical Work

Practical work refers to hands-on laboratory activities that engage learners in the process of making observations, experimenting and deducing explanations and conclusions based on the findings (Olubu, 2015). It is one-of-a-kind teaching method in which learners work jointly and collaboratively in small groups to study a scientific topic. Laboratory activities have the ability to improve students' achievement, conceptual knowledge, attitudes and cognitive growth, if they are appropriately developed (Kurbanoglu & Akin, 2010). According to Ural (2016), practical work is very important in the teaching of Chemistry. This is because it helps learners understand the theoretical Chemistry concepts, acquire problem solving skills, and supports efficacy beliefs of students in teaching and learning of sciences (Chuks & Chidubem, 2018; Eymur, 2018; Ural, 2016). Learners can as well develop positive attitudes as a result of practical work (Cheung, 2009). Moreover, practical work where inquiry-based learning approach is used has been associated with positive attitudes towards Chemistry among students (Chuks & Chidubem, 2018). According to Hofstein and Lunetta (2004), and Mwangi (2016), laboratory work plays a crucial role in improving students' comprehension of Chemistry concepts as well as enhancing enjoyment in learning sciences. Therefore, practical work is very important in the teaching and learning of sciences.

Practical lessons provide the best opportunities for inquiry learning approach due to the experimental nature of the strategy (Jerrim et al., 2020). However, investigations which focus on the application of this strategy in Chemistry practical lessons are scarce in the research literature (Akuma & Callaghan, 2019). Therefore, this study investigated how inquiry-based learning approach has been used in Chemistry practical sessions in order to address this gap.

2.4 5E Instruction Model

The 5E instructional paradigm is a teaching and learning framework that promotes inquiry learning (Cheng et al., 2016). It is grounded on the social constructivism theory of learning which takes into account learner's prior knowledge and experiences which help in learning new materials and developing their creativity (Yunus & Pammu, 2017). It consists of five phases where learners are engaged and allowed to explore. Opportunities for explanations, elaboration and evaluation are included.

Engagement step takes into account the learner's past experience and knowledge, and therefore the role of the teacher is to trigger the learner's preconceived ideas about the concept under discussion to determine the best way to place the learner in the context of learning (Bybee et al., 2006). This is done through asking questions and defining problems aimed at fully engaging the learners. It is in this phase that curiosity towards the topic is stipulated and any misconceptions that learners have are identified. In the exploration phase, learners are allowed to carry out investigations on the concept under discussion. Learners work collaboratively probably in small groups without direct instruction from the teacher. The teacher in this phase acts as a guide.

The explanation phase is a teacher-directed phase where the teacher gives definitions and explanations of scientific concepts. However, the teacher’s explanations are built on the learners’ explanations, that is, learners are first allowed to give their explanations. It is in this phase that any error or mistake are corrected to ensure effective learning (Ahmad et al., 2018). Learners participate in additional learning experiences that enhance concepts, processes, or abilities during the elaboration phase (Senturk & Camliyer, 2016). It also entails learners applying the acquired knowledge and skills in new situations like the encounter with problems that may require the explanations based on the acquired knowledge. Besides, learners are involved in group discussions which provide opportunities for them to express their understanding. In this phase, learners make connections between the concepts studied and other related concepts.

The evaluation step provides learners with an important opportunity to assess their learning by applying what they have learned (Supasorn & Promarak, 2015). It is a phase where students obtain feedback on the adequacy of their explanations. This phase recommends that teachers come up with formative as well as summative assessments to assess the achievement of the learning objectives.

2.5 Teachers’ utilization of inquiry-based learning in Chemistry teaching

To begin with, there are few studies in the scientific education research literature that focus on teaching techniques related to inquiry-based learning application in practical work (Akuma & Callaghan, 2019). In several Ghanaian junior high schools, Mohammed et al. (2020) discovered only a few instances of inquiry-based learning. Akuma and Callaghan (2019) found that teachers in South African secondary schools were seldom using inquiry-based learning practices. According to them, most of the teachers used traditional instruction method. Jiang and McComas (2015) discovered that higher levels of inquiry-based learning were widely used compared to lower levels of inquiry as reported by the students.

According to Chichekian and Shore (2016), teachers with past inquiry experiences were more likely to adopt an inquiry approach, even if they had little experience in education inquiry settings. The number of years a teacher has taught, the highest degree he or she has earned, and the previous educational and employment experiences were all unrelated to an interest in employing inquiry-based learning approach in the classroom. However, research on how these factors influence the use of inquiry-based learning in classrooms is limited as most of the studies focus on how these factors influence performance of students in certain subjects. On the other hand, professional development of teachers is crucial for effective use of IBL in scientific classes (Aditomo & Klieme, 2020). It is important to understand how teacher characteristics influence classroom practices especially in Chemistry teaching in order to make informed decisions.

In Kenya, few studies have focused on inquiry-based learning approach in teaching of sciences. Nancy (2013) evaluated the role of teacher characteristics on the successful use of IBL in science instruction in pre-schools in Migori County. The research findings showed that teacher characteristics such as teaching experience, type of training institute and professional levels do not influence the use of inquiry-based learning approach. In a separate study, Njagi (2016) discovered that teachers in Meru-South Sub-County were using IBL to teach science in pre-schools. A study by Waswa and Cheptinget (2013) found that Chemistry teachers did not employ the inquiry technique to the level specified in the syllabus. CEMASTEA (2019) discovered that professional development had a beneficial impact on the usage of inquiry-based learning approaches and on students' attitudes toward Mathematics as well as science. However, studies that focus on the association between the use of IBL practices and students' efficacy beliefs and attitudes towards Chemistry in Meru South Sub-County are scarce in research literature. Therefore, this study was conducted to address this gap.

2.6 Inquiry-based learning Approach and Students' Attitudes

Researchers have long been interested in students' attitudes toward Chemistry learning, and there is concurrence on relevance of students' attitudes toward Chemistry lessons in school among scientific theorists and practitioners (Kurbanoglu & Akin, 2010). Positive or negative feelings toward Chemistry are referred to as attitudes. According to Liou (2020), attitudes are important factors that affect students' learning and achievement. This is supported by Kousa et al. (2018), and Ogembo et al. (2015) who argue that attitudes influence academic achievement and therefore, students with positive attitudes are likely to perform better in Chemistry. The improvement of students' favorable attitudes about Chemistry is critical for two reasons. First, research on the association between attitudes and performance revealed that both factors are strongly associated, and it also predicts behaviors (Kurbanoglu & Akin, 2010). Attitudes influence performance of students in Chemistry and therefore, getting to understand the relationship between IBL and attitudes of students is important.

Inquiry-based teaching and learning has been associated with positive attitudes towards science (Aktamis et al., 2016; Chi et al., 2021; Ural, 2016; Wildan et al., 2019). In Turkey, a meta-analysis done by Aktamis et al. (2016) found that in groups where inquiry-based learning was employed, students had much more positive attitudes than the groups where traditional teaching was used. They emphasized that inquiry teaching should be used in learning process to foster positive attitudes towards science. However, this analysis was reported based on only quantitative studies and therefore qualitative studies were left out. Another study done by Ural (2016) found that the use of guided-inquiry learning improves students' attitudes towards Chemistry laboratory. However, Simsek and Kabapinar (2010) found that inquiry-based learning had no effect on students' attitudes towards science. Based on the above studies, it is evident that IBL is instrumental in enhancing positive attitudes towards Chemistry among students.

In Indonesia, IBL is highly encouraged in science teaching. According to Wildan et al. (2019), the use of IBL enhances learners' motivation and leads to positive attitudes towards science. In their study on examining the influence of implementation of step wise inquiry approach on students' scientific attitudes, it was found that in classes where inquiry-based learning was utilized, there were higher scores for scientific attitudes as compared to those undertaking expository approaches. Basically, IBL entails collaborative learning which ensures active learner engagement and increased interest towards learning (Rohaeti, 2020). IBL ensures learners take responsibility of their learning as they are involved in most of the learning activities hence they discover more knowledge leading to better understanding.

In Nigeria, IBL practices have been found to be effective in enhancing attitude of students towards Chemistry. For instance, a study done by Chuks and Chidubem (2018) found that guided discovery improves students' attitude towards Chemistry concepts at senior secondary level. This has been supported by Vincent-Ruz et al. (2020) who found that guided inquiry enhances students' attitudes towards Chemistry. Similarly, inquiry-based learning enhances attitudes of students towards Chemistry (Irwanto, 2022, Johnson, 2021 & Younis, 2017). Another study done by Dajal and Umar (2019) on the impact of guided discovery on students' attitudes in Biology found a significant difference in mean attitude scores between the experimental and the control groups. The studies indicate that learner-centered teaching approaches be used to improve students' attitudes toward science.

In Kenya, few studies have been conducted based on the influence of IBL on students' learning outcomes such as attitudes, efficacy beliefs and performance. For example, CEMASTEA (2019) found that the use of inquiry-based learning approach improved students' attitudes towards Mathematics and science. The other studies looked at the impact of inquiry-based learning on Biology students' academic progress (Joy et al., 2017) and academic achievement and motivation skills in Physics (Njoroge et al., 2014). However, studies that focus on the association between the use of IBL practices and students' attitudes towards Chemistry in Meru South Sub-County are scarce in research literature. Therefore, this study was conducted to address this gap.

2.7 Inquiry-based learning Approach and Students' efficacy beliefs

The belief in one's own ability to achieve a task is known as self-efficacy (You et al., 2021). It demonstrates how confident children are in their ability to perform well in school (Baanu & Oyelekan, 2016). In many respects, such as academic achievement, a strong sense of effectiveness improves human accomplishment and personal well-being. Self-efficacy beliefs are influenced by information from four sources: mastery experiences, vicarious experiences, verbal persuasion and physiological conditions (Bandura, 1994). The most powerful reference of self-efficacy beliefs is stated to be mastery or enactive experiences, which are derived from what one has experienced. Observing a model's performance and comparing it to the observer provides vicarious sensations. Persuasion from others is a relatively poor source of self-efficacy. Physiological reactions such as stress, worry and other feelings perceived as indicators of physical incapacity are the last source of learners' self-efficacy. Some instructional tactics such as collaborative learning, question and answer, and problem-solving tasks, have been positively connected with students' perceived sources of self-efficacy (Cheung, 2015).

According to Baanu and Oyelekan (2016), people who feel highly efficacious can withstand difficulties and carry out tasks to completion, while those with low efficacy beliefs usually avoid challenging tasks. Eymur (2018) opines that learners' efficacy beliefs is a determinant of their performance. A study by You et al. (2021) showed that students' efficacy highly influenced their success in Mathematics. Therefore, it's a key construct that teachers should enhance by using appropriate teaching strategies.

Inquiry-based teaching and learning has been associated with increased students' self-efficacy beliefs (Featonby, 2012; Husnaini & Chen, 2019; Lai et al., 2018; Sen & Vekli, 2016; Vishnumolakala et al., 2017). In Australia, Vishnumolakala et al. (2017) investigated the attitudes, efficacy beliefs and experiences of 559 first-year undergraduate Chemistry students from two cohorts in an inquiry-learning environment. They found that inquiry-based learning experiences develop students' efficacy beliefs in Chemistry.

In Indonesia, a study by Sulistiyo and Wijaya (2020) found that IBL improves students' self-efficacy when compared to scientific learning strategy. This is because inquiry-based learning provides diverse sources of self-efficacy. This study employed the quasi-experimental research design which involved one hundred and ninety-one eleventh grade students. Another study conducted by Husnaini and Chen (2019) found that inquiry-based learning was more effective in improving scientific inquiry efficacy beliefs among learners. Cairns and Areepattamannil (2017) also conducted a study which involved 54 countries. They found that IBL is positively linked with students' confidence in sciences but negatively associated with students' performance in sciences and this was attributed to cognitive overload resulting from the high level of knowledge and skills hence lack of understanding.

In Turkey, inquiry-based teaching is known to influence students' self-efficacy. A study by Kandil and Isiksal-Bostan (2019) found that application of inquiry-based learning improves self-efficacy of students in geometry. Also, Sen and Vekli (2016) argue that the use of technology embedded scientific inquiry improves students' self-efficacy in Biology laboratory. In China, computer-supported science inquiry technique is attributed to increased students' self-efficacy (Lai et al., 2018). In New Zealand, it is evident that efficacy beliefs of students in literature can be improved by the use of inquiry activities, and which translates to improved academic achievement (Featonby, 2012). According to Featonby, self-efficacy and academic accomplishment are inextricably linked.

In Nigeria, a study done by Dangana (2017) found that students who were taught using structured inquiry had increased self-efficacy as compared to students taught through the lecture method. This means that using an inquiry-based learning strategy in Chemistry class can boost students' self-efficacy beliefs, which can lead to improved performance. However, self-efficacy is not only influenced by use of inquiry-based learning approach but also teacher experience (Bagaka, 2011; Hill et al., 2018).

In Kenya, Aurah (2017) looked on the correlation between students' science efficacy, gender, and performance where academic success was strongly linked to students' efficacy beliefs. However, there is scarce literature on relationship between the application of inquiry-based learning approach and students' self-efficacy in Chemistry in Meru South Sub-County. This study therefore was done to address this gap.

2.8 Theoretical Framework

The social constructivism theory by Vygotsky (1978) was used to guide the research. The theory focuses on three key aspects which are social interactions, scaffolding and Zone of Proximal Development (ZPD). According to this theory, learning occurs when students are allowed to interact with each other and with their environment. It emphasizes on social activities and interactions with instructors, classmates and educational resources that have an impact on learners' cognitive and affective development. Social interactions that occur among groups of learners influence the nature of knowledge that is constructed by an individual (Walker & Sampson, 2013).

Scaffolding involves setting up problems that are beyond the learner's zone of actual development but are within the Zone of Proximal Development when suitably structured and supported (Taber, 2015). The level of support reduces as the individual's level of competence increases to the point that they can achieve the mastery of the task unsupported. Scaffolding enables learners to master concepts and build problem-solving skills that were initially beyond their reach (Taber, 2015).

According to Vygotsky, learning occurs in the Zone of Proximal Development which is defined as the distance between the learner's actual developmental level as determined by independent problem solving and the higher level of potential development as determined through problem-solving under adult guidance and in collaboration with more capable peers (Mahalingam et al., 2019). The idea behind the Zone of Proximal Development is that people learn best through collaboration with more knowledgeable persons (Al Mamun et al., 2020).

According to Walker and Sampson (2013), the laboratory should provide a setting where students can interact with the material world using the tools, data collection techniques and models. This is evident in practical lessons where students are provided with opportunities to manipulate materials and apparatus, work collaboratively, carry out investigations, make observations, collect data, test hypotheses and communicate their findings (Perdana & Atmojo, 2019). In the process, learners discuss the meaning and end up creating new knowledge.

During practical lessons, students encounter challenges. A teacher in inquiry-based learning acts as a guide and therefore he/she is required to provide the needed support to the students for example by giving elaborate explanation to a practical and assisting them in completion of the practical tasks. Learners are guided until the point where each learner is able to tackle the same task independently without help from the teacher. Besides, the more knowledgeable learners come in to assist the less knowledgeable where they discuss and guide each other. Scaffolding occurs with teachers providing workbooks and more practical materials to ensure effective practical work. Scaffolding aims at transferring the responsibility of learning to the student (Shabani et al., 2010) and therefore, teachers provide sufficient support for learners to do things on their own. Inquiry-based learning practices ensure that learners are actively engaged in both hands on and minds on activities. Through active engagement, learners are able to understand the concepts under study and this translates to better performance in the subject. This increases their confidence in Chemistry and end up having positive attitudes towards the subject.

2.9 Conceptual Framework

The conceptual framework as shown in figure 2.1 illustrates how the application of inquiry-based learning practices affects students' performance in Chemistry which is determined by their attitudes and self-efficacy. The independent variable is the adoption of inquiry-based learning approach implemented through the 5E model consisting of engagement, exploration, explanation, elaboration and evaluation phases. The dependent variable is performance in Chemistry, where attitudes and self-efficacy are performance predictors. The intervening variables include teacher experience, teacher qualification, training, gender and class size. In this case, inquiry-based teaching and learning can influence students' attitudes and self-efficacy but this would depend on the teacher experience, qualification, training, gender and class size.

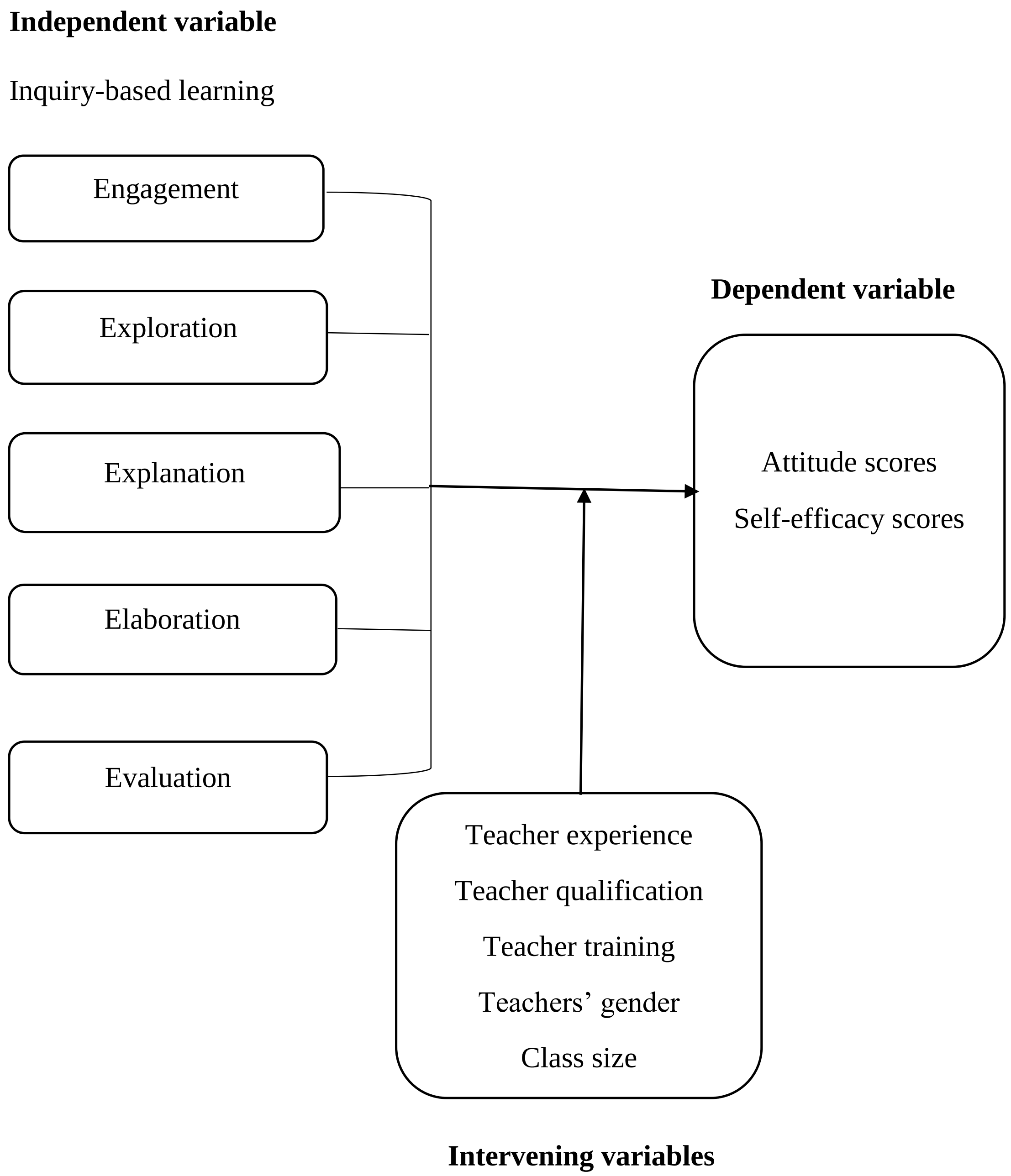

Figure 2.1: Conceptual Framework

2.10 Summary of empirical literature and research gaps

According to the literature, inquiry-based learning is one of the most effective teaching strategies for improving students' positive attitudes and efficacy beliefs. Attitudes and efficacy beliefs highly influence the success of students and therefore, positive attitudes and increased efficacy beliefs are strongly related to academic achievement. Literature highlights that inquiry-based teaching and learning can best be done in practical lessons due to its practical nature.

Many studies have been conducted outside Kenya supporting the idea that inquiry-based learning practices enhances positive attitudes and increased self-efficacy beliefs among learners in science subjects (Aktamis et al., 2016; Dajal & Umar, 2019; Dangana, 2017; Husnaini & Chen, 2019; Ural, 2016; Vishnumolakala et al., 2017). In Kenya, studies concerning inquiry-based learning approach and students' attitudes and self-efficacy in Chemistry are scarce in literature. Some studies have been conducted that focus on other science subjects. For instance, a study done by Njoroge et al. (2014) found that in Physics, the use of inquiry-based teaching approaches enhances students' success in terms of performance and motivation. Joy et al. (2017) found that teaching through inquiry improves academic success in Biology by improving science process skills. On the other hand, few studies have focused on teachers' use of IBL in scientific classes (CEMASTEA, 2019; Njagi, 2016; Waswa & Cheptinget, 2013). Furthermore, studies concerning the use of inquiry-based learning approach and how it's related to students' attitudes and self-efficacy in Chemistry in Meru South Sub-County are scarce in research literature. This research therefore was conducted to address the gaps suggested by Njagi (2016), and (Njoroge et al., 2014).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section explains the study's methodology. The research design, target population, sampling techniques, sample size, research instruments, pilot study, validity, reliability, data collecting methodologies, data analysis, logistical and ethical issues are all presented.

3.2 Research Design

Creswell (2013) describes a study design as a method for collecting, analyzing, interpreting, and reporting data in research investigations. A mixed-methods research strategy was used in this investigation. A mixed-method research design is a method of investigation that considers both qualitative and quantitative data (Tashakkori et al., 2015). In this investigation, a concurrent triangulation mixed method research design was employed which according to Creswell (2014), entails gathering two types of data at the same time, and then integrating the information into the results interpretation. The design was adopted to best understand this phenomenon of the application of IBL approach in practical sessions. The study employed a qualitative method of data collection where classroom observations were made and the data from the observations was coded quantitatively. This made it possible for the qualitative data to be analyzed quantitatively making it easy for deductions to be made from the comparisons of the two data sets.

3.3 Location of the Study

The research was conducted in Meru South Sub-County in Tharaka Nithi County. The sub-county covers an area of 138.8 km^2, with a total of 41 secondary schools: 1 national school, 8 extra-county schools, 9 county schools, 20 sub-county schools and 3 private schools. This area was purposefully selected because of its poor performance in Chemistry as outlined by Mukami (2015) and as shown in table 1.1. Even though low performance is noticeable in other counties, convenience sampling was used to choose Meru South Sub-County. Decision for convenience sampling included limited resources to support travel logistics in other counties and accessibility of the sub-county.

3.4 Target Population

The study targeted all the 62 form three Chemistry teachers and 3,321 form three Chemistry students from 41 secondary schools in Meru South Sub-County. Form three students were selected because at this point they had a better experience when it comes to practical work compared to form one and two students.

Table 3.1: Target Population

Schools	Boys	Girls	Mixed	No. of students	No. of teachers
National	1	0	0	158	3
Extra-county	2	4	2	753	16
County	0	1	8	676	17
Sub-county	0	0	20	1,340	20
Private schools	1	2	0	394	6
Total	4	7	30	3,321	62

Source: Meru South Sub-County Education Office

3.5 Sampling Techniques

Stratified and purposive sampling was employed to select public secondary schools that had well-equipped laboratory facilities in terms of adequate laboratory equipment, chemicals and reagents. It was anticipated that all the secondary schools apart from the sub-county schools were expected to have well equipped laboratory facilities since they are well endowed with resources compared to the sub-county secondary schools. The learning institutions were classified into four groups; national schools, extra county schools, county schools, and sub-county schools, and which were further classified into three categories; boys', girls' and, mixed secondary schools. The national school, all extra-county and county schools were selected for this study. This involved all the boys' secondary schools, girls' secondary schools and mixed secondary schools in the previously mentioned categories. Private schools were purposively chosen because they could not be classified into categories like the public secondary schools. Form three Chemistry instructors were chosen using purposive sampling, whereas students in the observed classrooms were chosen using simple random sampling. This involved selecting 17 students from the observed lessons to complete the questionnaires. According to Creswell (2014), simple random sampling provides an opportunity for each student to be chosen to form the study sample.

3.6. Sample size

The number of students to participate in this study was determined using the Yamane's formula (Yamane, 1967) which is:

$$n = \frac{N}{1+N(e)^2} \text{ hence, } n = \frac{3{,}321}{1+3{,}321(0.05)^2} = 357$$

Where *n* is the sample size, *N* denotes the total population, and *e* denotes the level of precision. The formula was selected for this investigation because the population for the study was known and hence the sample size could be accurately obtained. Table 3.2 illustrates the total number of sampled schools, and number of teachers and students who participated in the study. Therefore, 17 students were chosen from each school to take part in the study.

Table 3.2: Sampling Frame Matrix

Schools	Sampled schools	No. of students	No. of teachers
National	1	17	3
Extra-county	8	136	16
County	9	153	17
Sub-county	0	0	0
Private schools	3	51	6
Total	21	357	42

3.7 Research Instruments

This sub-section covers the instruments that were used in data collection to achieve the goals of the study. To collect both qualitative and quantitative data, a variety of instruments were used which include practical lesson observation schedule, teacher questionnaire, student questionnaire and document analysis framework.

3.7.1 Practical Lesson Observation Schedule

An observation schedule is a document that is created before data collection and specifies the behavior and situational elements that will be observed and documented during the observation (Given, 2012). In this study, a quantitative observation schedule was used (Appendix I). There were two sections; A (protocol 1) and B (protocol 2). Protocol 1 consisted of 10 items where all the steps were covered as per the 5E model. The frequency with which the items would occur in the lesson were recorded in 10 minutes' interval by ticking. Information from Protocol 1 would aid in completion of protocol 2 which had the same number of items as protocol 1. Protocol 2 was based on a 1-5 rating scale as follows; 1-never (0 frequency), 2-rarely (1-2 frequencies), 3-sometimes (3-4 frequencies), 4-frequently (5-7 frequencies) and 5-very frequently (8-10 frequencies). Protocol 1 was completed during the practical lesson and a total of 21 lessons were observed. Protocol 2 was completed after the practical lesson based on the results from protocol 1.

3.7.2 Teacher Questionnaire

The purpose of the questionnaire was to obtain information concerning the characteristics of the teachers and how they utilized IBL approach. There were two components of the teacher's questionnaire with section A and B (Appendix II). The teacher's background information was covered in Section A with 8 items and the frequency with which inquiry-based learning approach was used was covered in Section B, with 10 items. The items were designed from the 5E instructional model and also from the existing literature (Mohammed et al., 2020; Turner et al., 2017). The teacher questionnaires were administered after the lesson observation.

3.7.3 Student Questionnaire

The student questionnaire was divided into three sections, i.e. A, B and C (Appendix III). The background information was covered in Section A which had 4 items. Section B had 15 items for measuring students' attitudes towards Chemistry. The items were graded on a 5-point Likert scale with 5 indicating strong agreement, 4 indicating agreement, 3 indicating uncertainty, 2 indicating disagreement and 1 indicating strong disagreement. Section C had 26 items for measuring the student's self-efficacy in Chemistry. It was based on a 5-point Likert; 5 = Strongly Agree, 4 = Agree, 3 = Not Sure, 2 = Disagree and 1 = Strongly disagree. The instrument for measuring students' attitudes towards Chemistry was adapted from existing literature (Cheung, 2009; Kousa et al., 2018) while self-efficacy instrument was adapted from Lin et al. (2013) and Thomas et al. (2008). The student questionnaires were administered after the practical lesson.

3.7.4 Document Analysis Framework

The framework had 7 items for assessing the nature of practical tasks handled by students during practical lessons (Appendix IV). Student's worksheets were examined during practical lessons where the necessary information was obtained for analysis purposes.

3.8 Pilot Study

To determine the instruments’ validity and reliability, a pilot study was carried out in two secondary schools in Embu County. The selected secondary schools had similar characteristics with the schools which took part in the study, both an extra-county and a county school. During the pilot study, 90 student questionnaires and 2 teacher questionnaires were administered. Besides, 7 lessons were observed to familiarize with the lesson observation schedule as well as determine its validity and reliability. The researcher had fully familiarized with the observation schedule by the seventh lesson and therefore there was no need for more observations.

3.9 Validity of the Instruments

The researcher enlisted the help of supervisors and other specialists from the Department of Education to ensure the research instruments' face and content validity. Besides, the construct validity of the instruments was determined where data was subjected to Exploratory Factor Analysis (EFA) and the Principal Component Analysis (PCA) to determine the structure of the scales. The results from EFA and PCA revealed that some items had low factor loadings and therefore needed to be removed from the scales. However, a decision was made to include them in the final instruments because the sample size could have affected the results. From the piloting, some modifications were made on the research instruments to ensure no important information was missing.

3.10 Reliability of the Instruments

The internal consistency test was computed to determine the reliability of all the research instruments. The degree to which items in the instruments are "at least somewhat, positively inter-correlated" is referred to as internal consistency (Cavas et al., 2013). Cronbach's coefficient alpha is the most frequent statistical metric of internal consistency reliability, which is used in the construction of an instrument to see if items measuring the same concept yield similar results. Research instruments were piloted in two secondary schools outside the study area but with population characteristics similar to the targeted population. Reliability measures of the scales and sub-factors were calculated using the Cronbach alpha internal consistency coefficient.

The test items for the attitude scale were 15, for self-efficacy scale were 26, for inquiry-based learning were 10 and for the observation schedule protocol 2 were 10.

Based on the results, there were two sub-scales for the attitude scale with different reliabilities. Value and beliefs about Chemistry had a reliability of 0.791 while the liking of Chemistry theory and practical lessons had a reliability of 0.770. Therefore, the sub-scales were considered appropriate to measure specified constructs of attitudes.

For the self-efficacy scale, the Cronbach alpha reliability for the items was found to be 0.784. Reliability for the cognitive abilities sub-scale was found to be 0.893 and 0.742 was for ability to communicate, apply and accomplish laboratory activities sub-scale. The sub-scales were therefore considered appropriate to measure students' self-efficacy in Chemistry.

Reliability for the scale measuring the use of inquiry-based learning in the teacher's questionnaire was computed. The reliability for the 10 items was found to be 0.802. This was acceptable as it was above 0.70. The lesson observation protocol 2 had a coefficient of 0.891. In conclusion, all the instruments were found to be reliable for the actual data collection.

3.11 Data Collection Procedures

The researcher obtained approval from the Board of Postgraduate Studies, University of Embu and an authorization from the National Commission for Science, Technology and Innovation (NACOSTI). Permission from Tharaka Nithi County Director of Education, Sub-County director of education in Meru South Sub-County and the school principals was also sought after which the researcher proceeded to the sampled schools to make arrangements for lesson observations. After the arrangements, the researcher visited the sampled schools for lesson observations where 21 practical lessons were observed. Video clips were taken from the practical lessons where the teachers were in agreement. Questionnaires were then administered and respondents were allowed one week to respond. Students' worksheets were obtained during the practical lessons to document the nature of practical activities that learners were exposed to during these lessons.

3.12 Data Analysis

Quantitative data from questionnaires was coded and analyzed with the help of the R software version 4.1.1 and Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics including pie charts, means, percentages and frequencies were used to present the data. Responses from student's questionnaire were rated using Likert scale from strongly agree (5 points) to strongly disagree (1 point). Students' self-efficacy in Chemistry was graded at 3 levels; from 0 to 1.6 as low level of self-efficacy, 1.7 to 3.4 as average level of self-efficacy and 3.5 to 5.0 as high level of self-efficacy.

To establish how inquiry-based learning approach had been used, descriptive statistics such as means and percentages were utilized, and inferential statistics such as the analysis of variance. Analysis of variance was used to determine the influence of teacher characteristics on the utilization of IBL. The utilization of inquiry-based learning was graded from 1 to 5. The conclusion was made based on the mean category, for example, a mean of 4.8 would mean that inquiry-based learning was used in every practical lesson. To establish how the use of inquiry-based learning approach was related to students' attitude and self-efficacy in Chemistry, correlation analysis (Pearson's moment correlation coefficient) and regression analysis were computed using the R software.

3.13 Logistical and Ethical Considerations

The researcher sought approval from the Board of Postgraduate Studies, University of Embu. The researcher also sought authorization from the National Commission for Science, Technology and Innovation (NACOSTI) (Appendix VI). Permission from Tharaka Nithi County Director of Education, Sub-County director of education in Meru South Sub-County, and the school principals was also sought. The researcher visited the sampled schools before data collection to explain the research purpose to the respondents, and plan for lesson observations with the Chemistry teachers. Respondents were assured of the confidentiality of their information and consent was sought from them to take part in the research.

CHAPTER FOUR

RESULTS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the response rates, demographic information and the research findings as per the research objectives. The first objective of the study was to establish how the inquiry-based learning approach has been used in Chemistry practical lessons. The second objective was to find out the relationship between the use of inquiry-based learning approach and students' attitudes towards Chemistry and lastly, to determine the relationship between the use of inquiry-based learning approach and students' self-efficacy in Chemistry. The chapter also includes the interpretation of the research findings and discussion of the results.

4.2 Response Rates

The questionnaire return rate for both the teachers and the students was 100% enhancing credibility of the research findings. This is because the researcher went in person to those that consented and hence there was no non-response bias. All the questionnaires were found eligible for data analysis. Therefore, 42 teacher questionnaires and 357 student questionnaires were used in data analysis.

4.3 Demographic Information of Participants

This section presents the demographic data of the teachers and students who participated in the study.

4.3.1 Gender distribution among teachers

In this study, the gender of the form three Chemistry teachers was examined. The results are shown in figure 4.1.

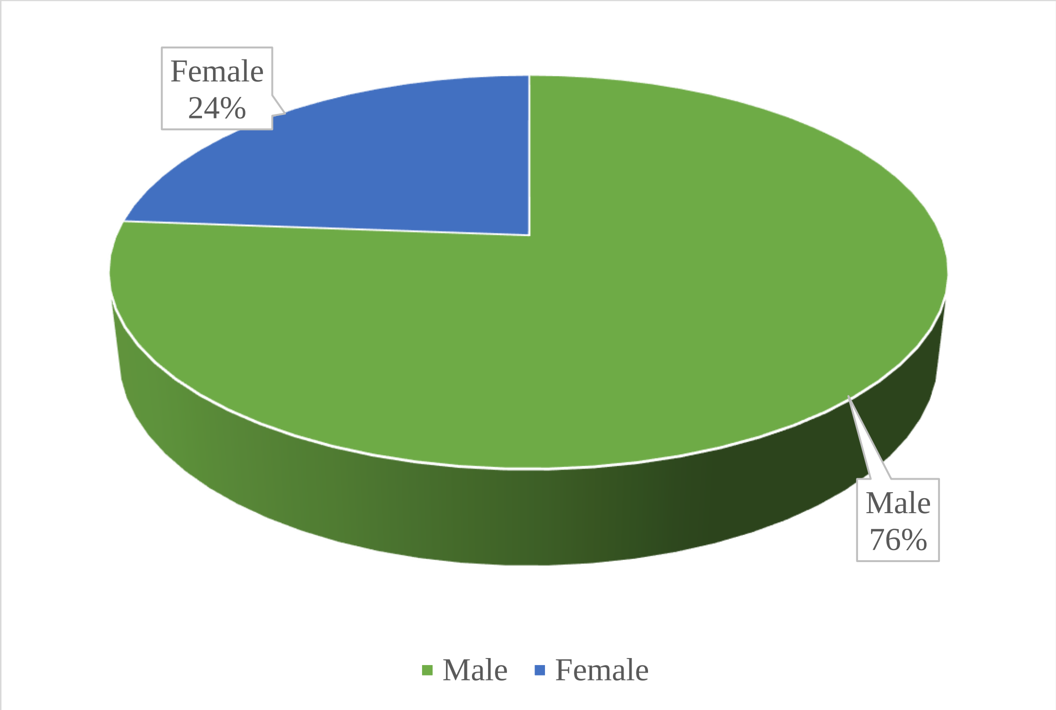

Figure 4.1: Gender distribution of the teachers

Figure 4.1 shows that 76% of the teachers were males while 24% were females, an indication that most of the Chemistry teachers in Meru South Sub-County are males. The results from this study concur with the findings by Kyalo (2016) who found that majority of the Chemistry teachers were males (67%) while 33% were females. This is an indication that there is still gender disparity in terms of those pursuing science subjects especially Chemistry in the higher levels of education.

4.3.2 Highest education qualification

The study investigated the education qualification of teachers. The results are presented in figure 4.2.

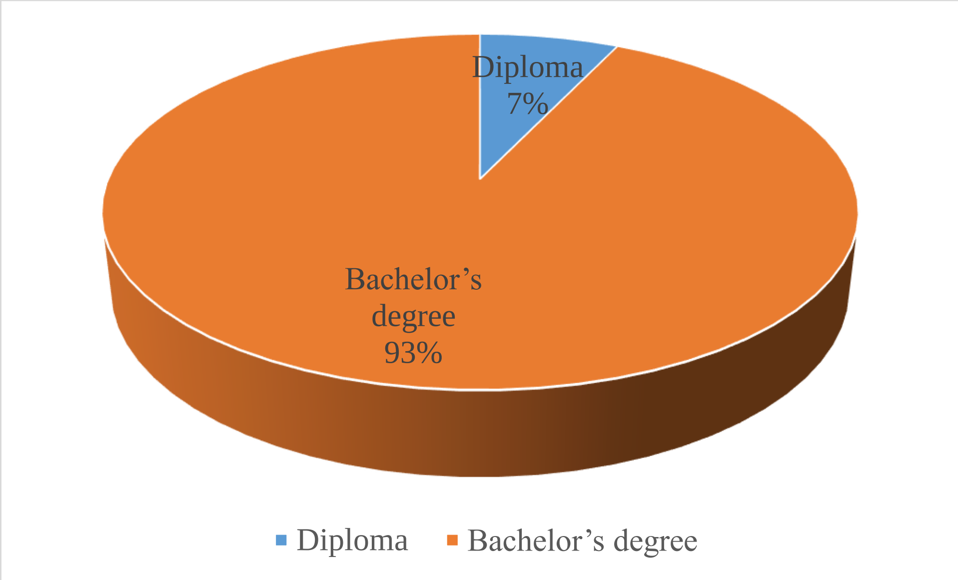

Figure 4.2: Education qualification of the teachers

According to figure 4.2, 93% of the teachers had a bachelor's degree in education (science) while 7% of the teachers had a diploma. This suggest that all the teachers were qualified to teach secondary school Chemistry as all had attained the minimum requirement. A similar finding was discovered by Kilaha (2010) where majority of the Chemistry teachers had a Bachelor of Education (science) degree. This is an indication that most of the teachers teaching Chemistry in secondary schools have the required knowledge and skills to teach the subject.

4.3.3 Teaching experience

The study examined the teaching experiences of the teachers. The results for the teaching experience of the teachers are presented in table 4.1.

Table 4.1: Teaching experience of teachers

No. of years	Frequency	Percentage
0-4	16	38.1
5-9	16	38.1
10-14	6	14.3
15-19	0	0
20-24	2	4.8
25-29	1	2.4
30 and above	1	2.4
Total	42	100

Table 4.1 shows that 76.2% of the teachers had a teaching experience below 10 years while 23.8% had a teaching experience above 10 years. A similar finding was discovered by Njagi (2016) where majority of the teachers (78%) had 0-10 years teaching experience and 22% had 11 and above years of teaching experience. This implies that majority of the teachers had few years of experience in the field.

4.3.4 Teacher professional development (CEMASTEA training)

The study sought to find out whether teachers were trained by CEMASTEA. Results for the professional development of teachers are presented in figure 4.3.

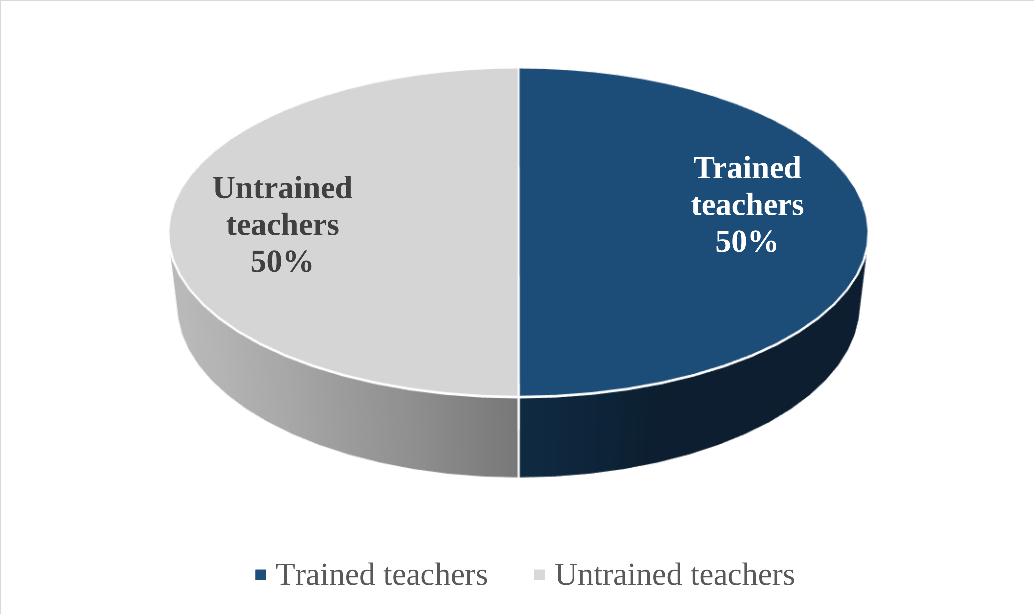

Figure 4.3: Professional development of Chemistry teachers in Meru-South Sub-County

According to figure 4.3, half of the teachers (50%) had been trained by CEMASTEA while the other 50% had not been trained. This implies that half of the teachers in Meru South Sub-County had undergone professional development while half had not. This could be attributed to the newly employed teachers since from their teaching experience, 16 out of 42 had 0-4 years teaching experience which accounts for 38%, implying that the teachers might not have had an opportunity to attend the workshops.

4.3.5 Students' distribution in Chemistry classes

The study examined the class sizes in terms of the number of students. The results are presented in table 4.2.

Table 4.2: Class size distribution of form three Chemistry students in Meru South Sub-County

No. of students	Frequency	Percentage %
20-29	1	4.76
30-39	3	14.29
40-49	7	33.33
Above 50	10	47.62
Total	42	100

Based on table 4.2, out of the 21 classes which were involved in the study, 10 of these classes had 50 students and above, 7 had between 40-49 students, 3 had 30-39 students while 1 had 20-29 students. This implies that most of the teachers handled large classes with over 50 students.

4.3.6 Students' gender

The study examined the gender distribution among the students who participated in the study. The results are presented in figure 4.4.

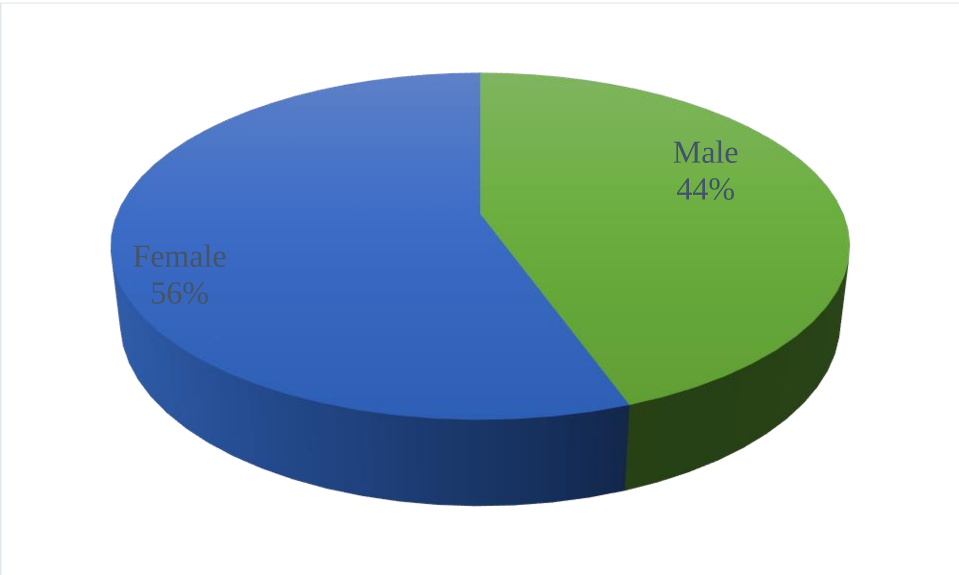

Figure 4.4: Gender distribution among the students

According to figure 4.4, 44% of the students were males while 56% were females. The results show that majority of the students who took part in the study were females. This suggest that in Meru South Sub-County secondary schools, female students are more than male students. A similar finding was discovered in a study done by Kilaha (2010) where there were more female students (51.8%) than male students (48.2%).

4.3.7 Students' performance in Chemistry

Students were asked to indicate their performance in Chemistry in the questionnaire. The results of the student's individual performance in Chemistry are presented in figure 4.5.

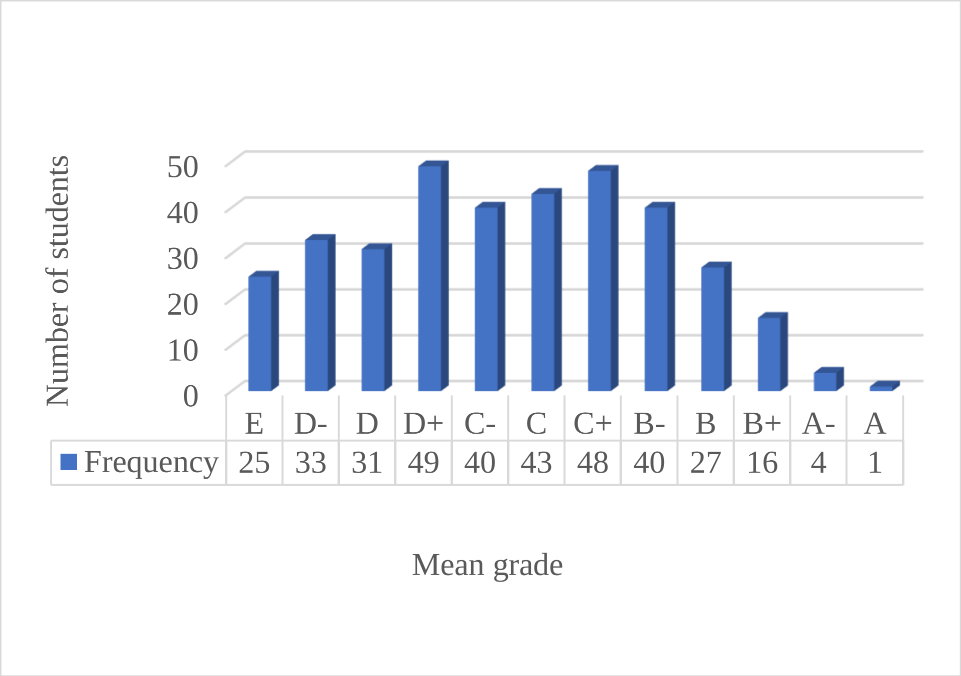

Figure 4.5: Students' performance in Chemistry in the end of term exam

According to figure 4.5, out of 357 students, 49 of them scored a D+ in Chemistry, 48 scored a C+, 43 scored C plain, 40 scored C-, 40 scored B-, 33 scored D-, 31 scored D plain, 27 scored B plain, 25 scored E, 16 scored B+, 4 scored A- and 1 student scored an A plain. The results revealed that the highest number of students scored a D+ followed by C+ while the least scored A plain. However, out of 357 students, 136 (38%) managed to score a mean grade of C+ and above and this could be attributed to positive attitudes towards Chemistry. According to Ogembo et al. (2015), students who perform well in Chemistry usually have positive attitudes towards Chemistry.

4.3.8 Affection for practical lessons

The study examined the students' affect for practical lessons. The students were asked to rate the extent to which they like practical lessons in a scale of 1-3 as follows, 1 indicating Never, 2 – Sometimes and 3 – Always. Also students were asked to indicate whether they like the way practical lessons are conducted or not. The results are presented in table 4.3.

Table 4.3: Students' affection for practical lessons

		Frequency	Percentage
Extent of liking for practical lessons	Always	263	73.7
	Sometimes	94	26.3
	Total	**357**	**100**
Students liking of how practical lesson are conducted	Yes	344	96.36
	No	13	3.64
	Total	**357**	**100**

The results according to table 4.3 show that 73.7% (263) of the students always like practical lessons while 26.3% (94) sometimes like practical lessons. There was no student who indicated that they never liked practical lessons and therefore the category of never was not included in the table. The results suggest that most of the students enjoy being involved in practical lessons hence leading to increased interest in Chemistry. The results concur with the findings by Mwangi (2016) who found that many students enjoy laboratory sessions. This is supported by Hofstein and Lunetta (2004) who argue that practical lessons enhance the motivation to learn science, instills interest towards science and improves attitude of students towards science subjects. On the other hand, practical lessons can be conducted in different ways where learners are given opportunity to interact with the apparatus as well as work in groups to carry out an investigation. Other lessons can be teacher demonstrations where the teacher does most of the practical work. This study investigated whether students like the way practical lessons are conducted. Results from the study show that 96.4% of the students like the way practical lessons are conducted while 3.6% don't like (table 4.3). This suggests that most of the students in Meru South Sub-County enjoy being involved in practical activities. Similar findings were observed by Cheung (2009) who found that both the male and female participants had slightly favorable attitudes towards practical lessons.

4.4 Extent of IBL use in Chemistry practical lessons

This study sought to find out the extent to which teachers used IBL approach. Teacher questionnaires and lesson observations were used to achieve this objective. This section presents the results on IBL use based on the self-reporting by teachers and results from the lesson observations.

4.4.1 Self-reported IBL use

Teachers were asked to rate the extent to which they used IBL practices in a scale of 1-5. The results from teachers' ratings on IBL use are presented in table 4.4.

Table 4.4: Self-reported IBL use

	Every lesson	Once a week	Once a month	Once a term	Never	Av. Item mean
Engagement	**81%**	**14.2 %**	**3.6%**	**0%**	**1.2%**	**4.735**
I assess learners prior knowledge	73.8%	21.4%	2.4%	0%	2.4%	4.64
I make connection between past and present learning experiences for effective learning	88.1%	7.1%	4.8%	0%	0%	4.83
Exploration	**14.3 %**	**58.35 %**	**14.3%**	**4.75 %**	**8.3%**	**3.655**
I allow learners to design and carry out experiments in the laboratory	11.9%	54.8%	16.7%	7.1%	9.5%	3.52
I allow learners to discuss among themselves results from investigations	16.7%	61.9%	11.9%	2.4%	7.1%	3.79
Explanation	**64.2 %**	**27.4 %**	**3.6%**	**1.2%**	**3.6%**	**4.475**
I provide detailed explanations for	69.0%	28.6%	0%	0%	2.4%	3.86

investigations to be undertaken by students						
I ask learners to explain their understanding of the concepts under study	59.5%	26.2%	7.1%	2.4%	4.8%	3.10
Elaboration	**41.7 %**	**22.6 %**	**14.3%**	**13.1 %**	**8.3%**	**3.76**
I provide instances for learners to extent their learned knowledge to get a deeper understanding	38.1%	23.8%	16.7%	14.3%	7.1%	3.71
I allow students to make connections between learned concepts and the world around them	45.2%	21.4%	11.9%	11.9%	9.5%	3.81
Evaluation	**72.6 %**	**23.8 %**	**1.2%**	**2.4%**	**0%**	**4.665**
I pose related questions to students to assess their knowledge and skills	76.2%	21.4%	0%	2.4%	0%	4.71
I give assignments to assess learners understanding.	69.0%	26.2%	2.4%	2.4%	0%	4.62
Total						**4.258**

According to table 4.4, 81% of the teachers indicated that they carry out learner engagement activities in every practical lesson, 14.2% of the teachers indicated that they engage learners once a week, 3.6% of the teachers said they engage learners once a month and 1.2% indicated that they don't carry out engagement activities in practical lessons. On the type of engagement, 73.8% of the teachers indicated that they assess learners' prior knowledge in every practical lesson while 88.1% of the teachers said that they make connections between past and present learning experiences for effective learning in every practical lesson.

In the exploration stage, 14.3% of the teachers indicated that they allow learners to explore in every practical lesson, 58.35% indicated once a week, 14.3% indicated once a month, 4.75% once a term and 8.3% never allowed learners to explore. On the type of exploration activity, 11.9% of the teachers gave students the opportunities to design and carry out experiments in every practical lesson as well discuss among themselves results from investigation (16.7%). A bigger percentage of the teachers (50% and above) said that they conduct these activities once a week.

In explanation phase, 64.2% of the teachers indicated that they provide explanations for investigations in every practical lesson; 27.4% indicated once a week, 3.6% once a month, 1.2% once a term and 3.6% of the teachers never provided explanations for investigations. Based on the activities, 69% indicated that they provide detailed explanation for investigations in every practical lesson while 59.5% indicated that they ask learners to explain their understanding of the concepts under study in every practical lesson.

For the elaboration phase, 41.7% of the teachers indicated that they allow learners to extend their learned knowledge and skills in new situations in every practical lesson, 22.6% indicated once a week, 14.3% once a month, 14.3% indicated once a term while 8.3% did not provide opportunities for learners to extend their learned knowledge.

In evaluation phase, 72.6% of the teachers indicated that they assess learners understanding/achievement of lesson objectives in every practical lesson, 23.8% indicated once a week, 1.2% of them indicated they assess learners once a month and 2.4% once a term. In this phase, all the teachers were engaged in learners' assessment.

The results revealed that each lesson had hooking activities that led students to engage with the lesson ($M = 4.735$). Also, teachers evaluated the understanding of their learners in every lesson ($M = 4.665$) and provided explanations for experimental work in every practical lesson ($M = 4.475$). The frequency to which teachers provided opportunities for learners to extent their knowledge as well as design and carry out experiments was once a week ($M = 3.76$ and 3.655) respectively. The overall mean for the IBL use was 4.255 out of the possible 5 points. This suggests that teachers used IBL once a week. The study results are consistent with previous research. For example, CEMASTEA (2019) found more practice of IBL in Chemistry lessons compared to Physics and Biology lessons. However, this study differs from the findings by

Mohammed et al. (2020) who found that IBL was not a common practice among teachers in Ghanaian schools. This could be explained by the fact that Chemistry teachers in Kenya have had training on IBL and so they tend to use it more.

4.4.2 Observed IBL use

21 lessons were observed with the help of lesson observation schedule with a scale of 1-5 in order to establish the actual practice of IBL in Chemistry practical lessons. The results from the lesson observation are presented in table 4.5.

Table 4.5: Observed use of IBL

	VF	F	SM	R	N	Overall mean
Engagement	**7.1%**	**64.3%**	**28.6%**	**0%**	**0%**	**3.786**
Teacher assesses learners' prior knowledge	9.5%	61.9%	28.6%	0%	0%	3.81
Teacher makes connection between past and present learning experiences for effective learning	4.8%	66.7%	28.6%	0%	0%	3.76
Exploration	**9.6%**	**35.7%**	**33.3%**	**19%**	**2.4%**	**3.310**
Learners are given opportunity to design and carry out experiments in the laboratory	4.8%	23.8%	47.6%	19%	4.8%	3.05
Learners are allowed to discuss among themselves results from investigations	14.3%	47.6%	19%	19%	0%	3.57
Explanation	**16.7%**	**33.4%**	**30.9%**	**19%**	**0%**	**3.476**
Teacher provides detailed explanations for investigations to be undertaken by students	28.6%	42.9%	14.3%	14.3%	0%	3.86
Teacher asks learners to explain their understanding of the concept under study.	4.8%	23.8%	47.6%	23.8%	0%	3.10

Elaboration	**4.8%**	**19%**	**52.4%**	**21.4%**	**2.4%**	**3.024**
The teacher provides instances for learners to extent their learned knowledge to get a deeper understanding.	4.8%	23.8%	52.4%	19%	0%	3.14
Teacher allows students to make connections between learned concepts and the world around them.	4.8%	14.3%	52.4%	23.8%	4.8%	2.90
Evaluation	**14.3%**	**45.2%**	**23.8%**	**16.7%**	**0%**	**3.571**
Teacher asks related questions to students to assess their knowledge and skills.	28.6%	57.1%	9.5%	4.8%	0%	4.10
Teacher gives class assignment	0%	33.3%	38.1%	28.6%	0%	3.05
Total mean						**3.433**

According to table 4.5, 7.1% of the teachers used engagement activities very frequently, 64.3% frequently and 28.6% sometimes. For the exploration, 9.6% of the teachers allowed learners to explore very frequently, 35.7% frequently, 33.3% sometimes, 19% rarely and 2.4% never allowed learners to explore. In explanation, 16.7% gave explanations very frequently, 33.4% frequently, 30.9% sometimes and 19% rarely gave explanations. For the elaboration phase, 4.8% provided opportunities for learners to extend their knowledge very frequently, 19% frequently, 52.4% sometimes, 21.4% rarely and 2.4% never. Lastly, for the evaluation phase, 14.3% assessed learners very frequently, 45.2% frequently, 23.8% sometimes and 16.7% rarely. Based on the results, engagement was carried out frequently (M = 3.786), exploration was sometimes carried out (M = 3.31), explanation was carried out frequently (M = 3.476), elaboration was sometimes carried out (M = 3.024) and evaluation was frequently carried out (M = 3.571). The mean for the five phases was 3.433, suggesting that IBL practices were sometimes carried out.

In order to establish IBL use, results from teacher questionnaires and lesson observations were merged. A comparison between the self-reported IBL use and the observed IBL use was made for triangulation purposes. The comparison results are presented in figure 4.6.

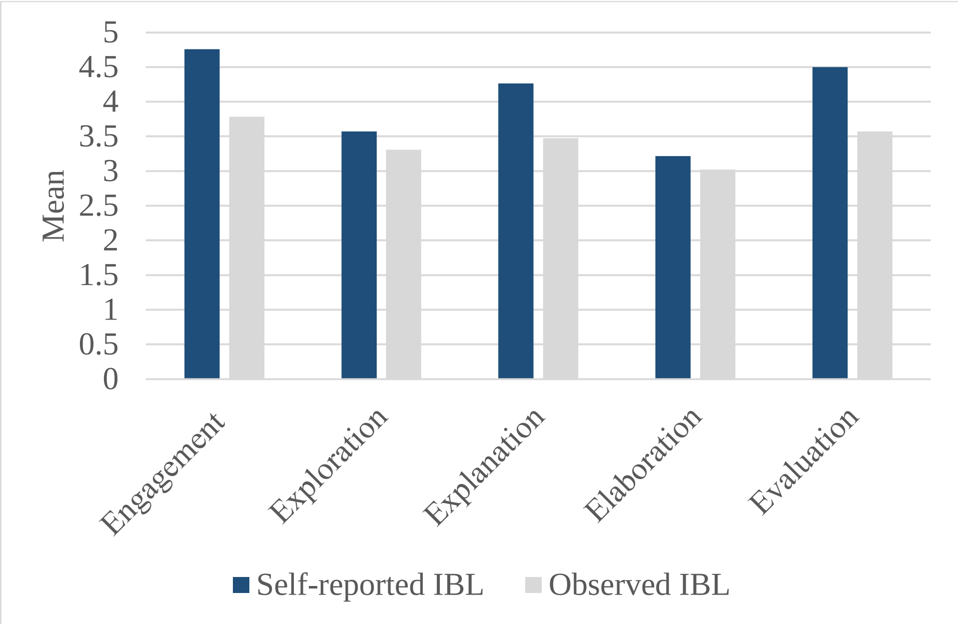

Figure 4.6: Comparison of teachers' self-reported IBL vs. observed IBL

According to figure 4.6, the self-reporting means were higher than the observations' mean in all the phases. Therefore, teachers over reported on the extent to which they have used IBL consistently and with a steady margin. Therefore, in order to determine the actual extent of IBL use, results from lesson observation and teachers' ratings were triangulated. A formula was developed and an over reporting index was calculated. This index refers to the factor by which a compromise between observer bias and self-reported bias is established. The index was computed as shown below.

$$\text{Over reporting index} = \left(\frac{\text{Self reported mean} - \text{Observed mean}}{\text{Self reported mean} + \text{Observed mean}}\right) \times 100$$

$$\left(\frac{4.062 - 3.433}{7.495}\right) \times 100 = 8.39\%$$

The over reporting index was found to be 8.39%. This suggests that the teachers' ratings on IBL use were higher by 8.39%. Since there is a possibility that the observer also underrated, the over reporting index was divided by two. Therefore, the self-reported mean was subjected to a reduction of 4.195% hence the final mean was computed to be 3.89. From this mean, it can be concluded that the extent of teachers' use of IBL in Chemistry practical lessons was once a week. Since the mean was 3.89 out of the possible 5 points, this was expressed as a percentage giving a result of 77.8% and therefore it can be concluded that 77.8% of the lessons used IBL. The results are consistent with the findings by Njagi (2016) who found that teachers were using inquiry-based learning approach in science teaching. However, the research findings contradict the findings by Akuma and Callaghan (2019) who found minimal application of IBL practices in practical work. As noted earlier, teachers in Kenya have had training on IBL and so they tend to use it more. Professional development helps teachers to perfect on their teaching methodologies. This has helped to transform the design of practical from traditional oriented laboratory work to IBL oriented laboratory work.

Based on the study findings, it can be deduced that when asked for self-report on the extent to which they use IBL, Chemistry teachers give a steady but consistent overrating of about 4.195%. This is supported by O'Sullivan (2006) who opines that teachers may not report on their actual classroom practices and therefore data gathered from them may not be sufficient hence the need for other better ways of understanding teachers' practices.

This study also examined students' worksheets to find out the kind of activities learners are engaged in. The results are presented in table 4.6. Based on the table, it is clear that all the teachers provided research questions for investigations (100%) hence learners were not given opportunity to develop research questions. 38.1% of the teachers allowed learners to design procedures for investigations while 61.9% did not. All the teachers (100%) allowed learners to make observations, collect and analyze data. Also, 81% of the teachers provided opportunities for learners to extend their knowledge and skills to new situations while 19% did not. Finally, all the teachers did an evaluation for achievement of lesson objectives. This is in agreement with the results from the lesson observation where only 14.3% of the teachers said they allow learners to design and carry out experiments in the laboratory in every practical lesson. However, all the teachers gave learners the opportunity to make observations from the experiments, collect and analyze data as well as evaluating the learners' understanding. Therefore, it can be concluded that teachers actually carried out the IBL practices but the use of IBL was limited. According to Aditomo and Klieme (2020), for IBL to be effectively implemented, there is need for support and extensive training of teachers.

Table 4.6: Activities learners engage in during practical lessons

IBL practices	**Yes** **F (%)**	**No** **F (%)**
The teacher provides research questions to students for investigations	21 (100%)	0 (0%)
The teacher allows learners to develop research questions	0 (0%)	21 (100%)
Students develop/design procedures for investigations	8 (38.1%)	13 (61.9%)
The teacher provides procedures for investigations	21 (100%)	0 (0%)
Learners make observations, collect and analyze data	21 (100%)	0 (0%)
Students are allowed to apply knowledge learned into new situations	17 (81%)	4 (19%)
Students are given tests/questions to evaluate their understanding	21 (100%)	0 (0%)

4.4.3 Influence of teacher characteristics on IBL use

Teachers were asked to report on their gender, qualification, experience and training in the questionnaires. An ANOVA was computed whose goal was to check whether there is a significant difference in the utilization of inquiry-based learning and gender, qualification, experience or training. The results are presented in tables 4.7, 4.8, 4.9 and 4.10 respectively.

Table 4.7: Influence of gender on the practice of IBL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.344	1	6.344	.239	.628
Within Groups	1063.775	40	26.594		
Total	1070.119	41			

Table 4.7 shows that F (1, 40) = 0.239, p = 0.628. The results suggest that there is no significant difference in the utilization of inquiry-based learning in reference to the gender of teachers, p > 0.05. Therefore, this suggests that male teachers and female teachers in Meru South Sub-County use IBL almost in the same way.

Table 4.8: Influence of education qualification on the practice of IBL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.529	1	.529	.020	.889
Within Groups	1069.590	40	26.740		
Total	1070.119	41			

According to table 4.8, F (1, 40) = 0.20, p = 0.889. The results suggest that there is no significant difference in the utilization of inquiry-based learning in reference to the education qualification of teachers, p > 0.05.

Table 4.9: Influence of teaching experience on the practice of IBL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	156.436	5	31.287	1.233	.314
Within Groups	913.683	36	25.380		
Total	1070.119	41			

Table 4.9 shows that $F(5, 36) = 1.233$, $p = 0.314$. The findings suggest that there is no significant difference in the utilization of inquiry-based learning among teachers with different teaching experiences, $p > 0.05$.

Table 4.10: Influence of professional development on the practice of IBL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	188.595	1	188.595	8.558	.006
Within Groups	881.524	40	22.038		
Total	1070.119	41			

According to table 4.10, $F(1, 40) = 8.558$, $p < 0.05$. The findings suggest that there is a significant difference between trained and untrained teachers in terms of utilization of inquiry-based learning. This suggest that trained teachers had acquired additional knowledge and skills and hence practiced inquiry-based learning more than untrained teachers. The results revealed that gender, education qualification and teaching experience do not influence the IBL use. The results are consistent with the findings by Chichekian and Shore (2016) who discovered that the teaching experience of a teacher, education qualification and prior educational and work experiences were not related to an inclination toward using inquiry in the classroom. Therefore, the use of IBL is not influenced by gender, education qualification and teaching experience but it is strongly influenced by teacher professional development.

4.5 Correlation between inquiry-based learning and students' attitudes towards Chemistry.

The study sought to find out the relationship between IBL and students' attitudes towards Chemistry. Student questionnaires were used to find out attitude of students towards Chemistry. The results of the students' attitudes towards Chemistry are presented in table 4.11.

Table 4.11: Students' attitudes towards Chemistry

Items	SA	A	NS	D	SD	M	SD
1. I know that I will require Chemistry knowledge in my future career	48.5%	36.7%	10.9%	2%	2%	4.28	.880
2. When I do practicals, I am able to come up with answers to challenging tasks on Chemistry	26.1%	47.1%	16.2%	8.4%	2.2%	3.86	.972
3. Chemistry is a crucial subject that people need to study	45.1%	31.4%	13.2%	5.3%	5.0%	4.06	1.118
4. I like attempting challenging tasks in Chemistry	31.9%	47.9%	10.9%	7.6%	1.7%	4.01	.941
5. I feel empowered when I am doing experiments in the laboratory	52.7%	37.5%	6.2%	2%	1.7%	4.38	.824
6. Chemistry is important for providing solutions to daily life problems	24.4%	32.2%	26.6%	12%	4.8%	3.59	1.122
7. I intend to take a career related to Chemistry to get a good job in future	44.8%	20.7%	16.2%	8.1%	10.1%	3.82	1.348
8. We have interesting exercises in Chemistry	30.5%	44.8%	11.2%	9.2%	4.2%	3.88	1.075
9. I will be happy to dedicate most of my time in doing experiments	49.3%	32.8%	9.5%	4.8%	3.6%	4.19	1.035

11. It is important for people to get an understanding of Chemistry since it influences their lives	23.8%	34.7%	24.6%	9%	7.8%	3.58	1.172
12. I like to do Chemistry experiments	37.3%	39.8%	13.2%	5.3%	4.5%	4.00	1.060
13. I enjoy Chemistry lessons	50.1%	38.9%	6.2%	3.9%	0.8%	4.34	.827
14. Given an opportunity, I can carry out a project in Chemistry	37.5%	30.5%	16%	8.4%	7.6%	3.82	1.234
15. Chemistry is an easy subject	22.4%	34.7%	17.6%	13.2%	12%	3.42	1.297
Overall item mean	37.5%	36.4%	14.2%	7%	4.9%	3.945	1.065

SA = Strongly Agree, A = Agree, NT = Not Sure, D = Disagree, SD = Strongly Disagree

According to table 4.11, 85.2% of the students agreed that they enjoy Chemistry lessons. Besides, 90.2% of the students agreed that they feel empowered when doing experiments in the laboratory while 77.1% agreed that they like to do Chemistry experiments. Looking at the overall percentages, the biggest number of the students agreed with the items while a few disagreed with the items. The means of the items ranged between 3.42 and 4.38. The overall mean was 3.945, approximately 4.0, with a standard deviation of 1.065. CEMASTEA (2019) opines that a general score that is beyond three on a Likert scale is considered high, and it indicates a positive attribute of the variable measured. Therefore, the results from this study suggests that students' attitudes towards Chemistry in Meru South Sub-County are positive. Similar findings were obtained where students developed positive attitudes towards Chemistry as a result of active engagement through group work (Vishnumolakala et al., 2017). In addition, Wahyudiati et al. (2020) found that student teachers had positive attitudes towards the learning of Chemistry. However, students may exhibit negative attitudes towards Chemistry and this could be brought about by the way teachers teach the subject material (Al-najdi, 2013).

4.5.1 Correlation Analysis

This study sought to find out the relationship between inquiry-based learning and students' attitudes towards Chemistry. Pearson's Moment Correlation Coefficient was computed followed by a simple linear regression. The results from the correlation analysis are presented in table 4.12.

Table 4.12: Pearson's correlation between inquiry-based learning and students' attitudes towards Chemistry

		Inquiry-based learning
	Pearson Correlation	.9972
	Sig. (2-tailed)	.000
Attitudes	N	21

Table 4.12 shows that r = .9972, p = .000, at 95% confidence interval. The results suggest that there is a strong positive correlation between inquiry-based learning and students' attitudes towards Chemistry. This is consistent with the findings by Riegle-crumb et al. (2019) who found that there is a positive association between IBL and students' interest in science. Besides, Sesen and Tarhan (2013) discovered that training that focuses on inquiry-based laboratory activities results in significantly higher favourable views toward Chemistry and laboratory activities meaning there is a positive relationship between the two aspects. However, the results of this study contradict the findings by Simsek and Kabapinar (2010) who found that IBL had no effect on attitudes of students towards science. This could have been explained by the short period of the intervention as outlined by the researchers.

4.5.2 Regression Analysis

The statistical assumptions of linearity, independence, homoscedasticity and normality were checked before the regression analysis (Zach, 2020). The results are presented in figure 4.7 (linearity), figure 4.8 (homoscedasticity), figures 4.9, 4.10, 4.11 (normality) and table 4.12 (independence).

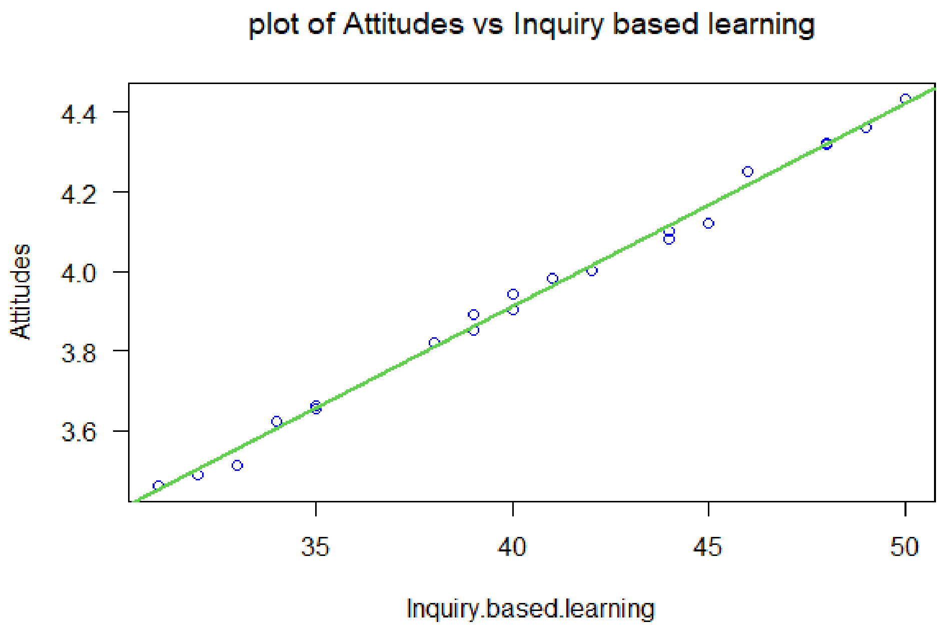

Figure 4.7: Scatter plot of inquiry-based learning vs. attitudes

Equation of the line; Y = 1.869 + 0.51X

Figure 4.7 shows that there exists a linear relationship between utilization of inquiry-based learning and students' attitudes towards Chemistry.

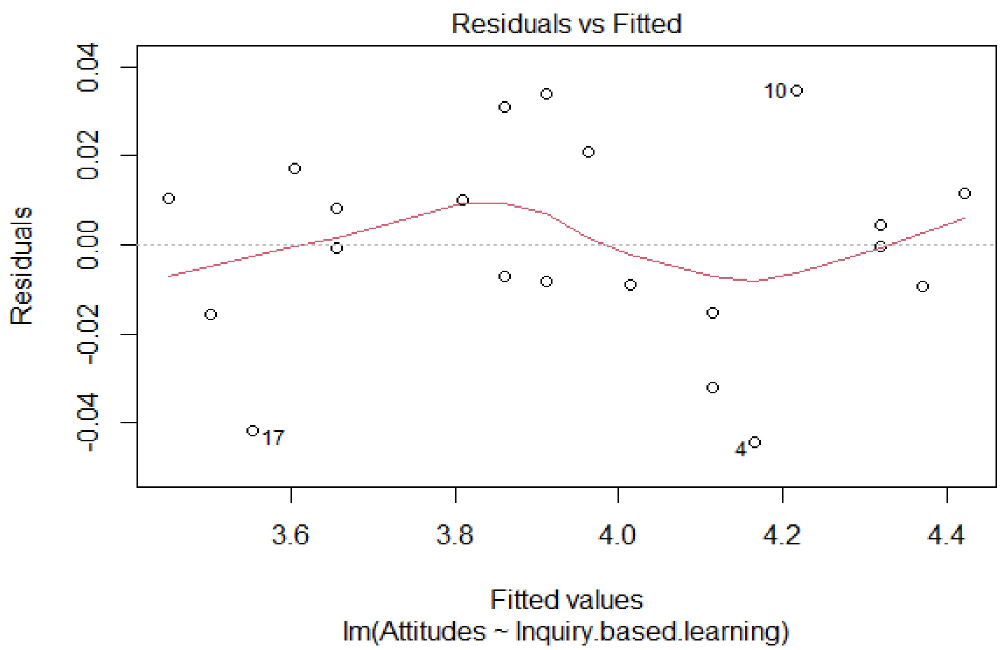

Figure 4.8: Plot of Residuals vs. Fitted values

Figure 4.8, which shows a plot of fitted values vs residuals suggests that the variance of residuals is the same hence homoscedasticity principal was not violated.

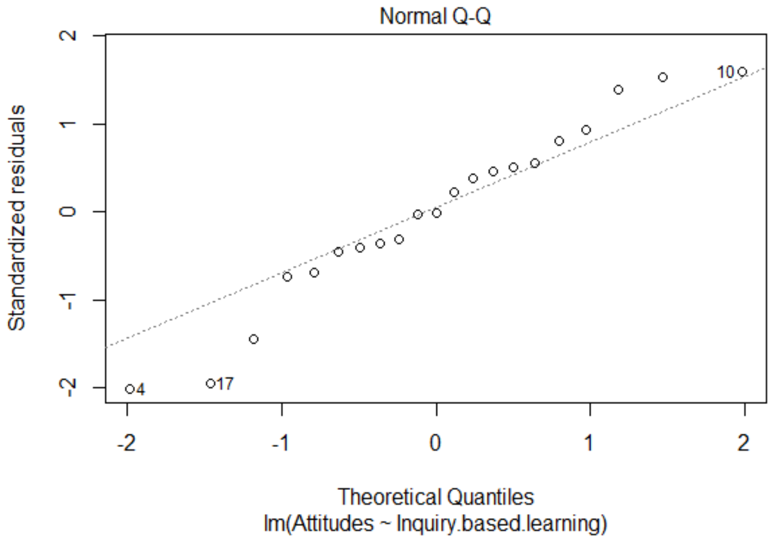

Figure 4.9: Q-Q plot for normality test

Figure 4.9 shows that the normality principle was upheld.

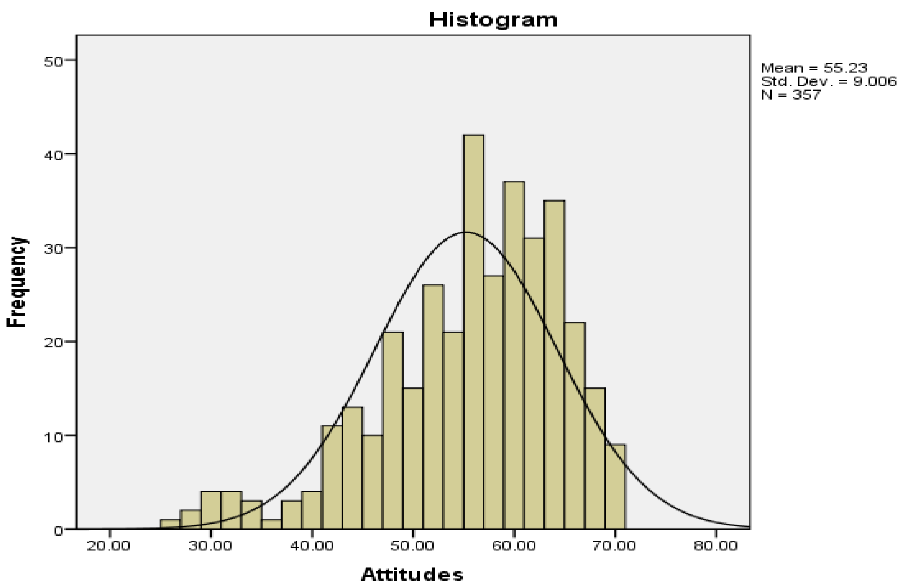

Figure 4.10: Histogram for students' attitudes towards Chemistry.

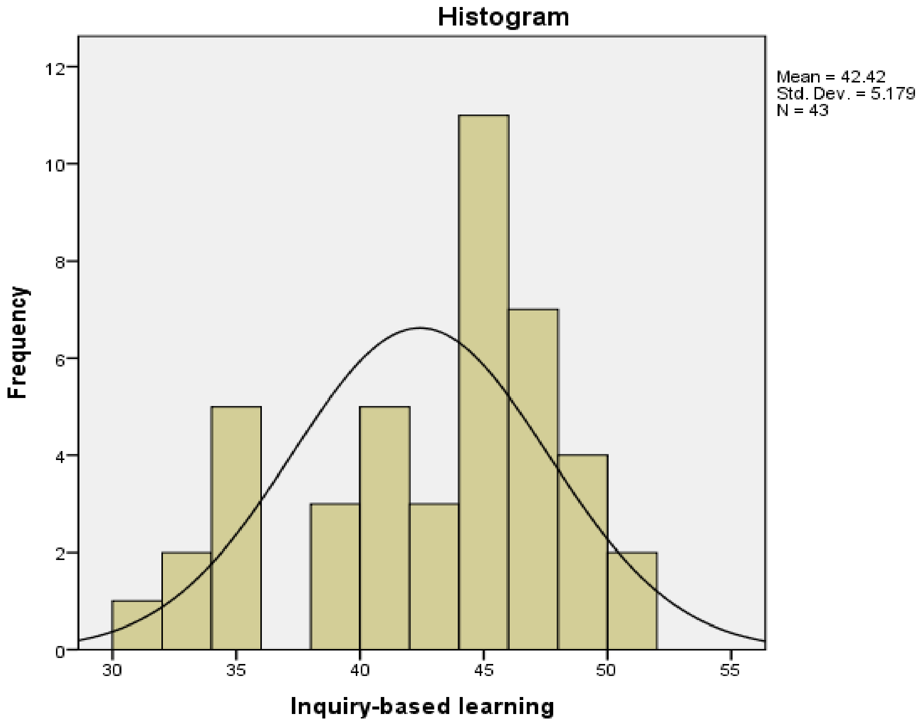

Figure 4.11: Histogram for the utilization of inquiry-based learning

Figure 4.10 and 4.11 are histograms showing students' attitudes towards Chemistry and the utilization of inquiry-based learning. The findings suggest that the data was normally distributed. The Durbin-Watson test value according to table 4.13 is 1.908 approximately to 2.0 implying that there is no autocorrelation and therefore independence assumption was met. Values in the range of 1.5 to 2.5 are considered to be quite typical by test statisticians and values outside this range may be cause for concern (Glen, 2016).

The regression analysis results which include the fitness of the model, and distribution of coefficients are presented in this section. The fitness of the model is presented in table 4.13

Table 4.13: Model Fitness of IBL vs attitudes

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.997	.994	.994	.022923	1.908

According to table 4.13, $R^2 = 0.994$ (99.4%). The results suggest that IBL explains 99% of the variations in students' attitudes towards Chemistry. The Analysis of Variance indicates whether the dependent variable is significantly explained by the dependent variable (Mungeria, 2021). The ANOVA results are presented in table 4.14.

Table 4.14: Analysis of Variance; IBL vs attitudes

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.785	1	1.785	3397.116	.000
	Residual	.010	19	.001		
	Total	1.795	20			

Table 4.14 indicates that the model was statistically significant, $F(1,19) = 3397.116$, $P = .000$. This suggests that IBL is a good predictor of attitudes of students towards Chemistry. This is in agreement with Rohaeti (2020) who opines that collaborative works allow students to solve problems with their peers while they construct knowledge and improve their performance during the activities which then lead to improved attitudes. Besides, Koksal and Berberoglu (2014) in a repeated analysis of variance found that there is a positive effect of guided-inquiry instruction on students' attitudes towards science ($\eta^2 = 0.07$). This suggests that the use of IBL can lead to increased attitudes of students towards science subjects.

The regression coefficients were computed and the results are presented in table 4.15.

Table 4.15: Distribution of Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.869	.036		52.019	.000
	Inquiry-based learning	.051	.001	.997	58.285	.000

According to table 4.15, β= 0.997, $p < 0.05$. The results suggest that there is a strong relationship between inquiry-based learning and students' attitudes towards Chemistry. Besides, a unit increase in the utilization of IBL can lead to 0.051-unit increase in positive attitudes towards Chemistry. The results concur with the findings by Chi et al. (2021) who discovered that students who reported having more inquiry-based science practices had a significantly higher interest in broad science, enjoyment of science and science self-efficacy. However, in as much as inquiry-based science activity is essential to nurture students' science-related attitudes and beliefs, its effectiveness depends on how teachers are involved during the inquiry process (Chi et al., 2021). This suggests that the more a teacher effectively employs the inquiry approach in teaching, the more students develop interest in Chemistry.

4.6 Relationship between inquiry-based learning and students' self-efficacy in Chemistry

This study sought to find out the relationship between inquiry-based learning and students' self-efficacy in Chemistry. Questionnaires were used to determine the efficacy beliefs of students in Chemistry in a scale of 1-5. The results of the students' self-efficacy in Chemistry are presented in table 4.16.

Table 4.16: Students' self-efficacy in Chemistry

Item	SA	A	NS	D	SD	M	Std. Dev
1. I'm aware that Chemistry-related concepts are present in a range of everyday situations.	29.7%	39.2%	20.4%	6.2%	4.5%	3.835	1.062
2. I can evaluate the solutions of Chemistry problems	13.2%	44%	25.5%	13.2%	4.2%	3.487	1.016
3. I am confident that I can comprehend even the most challenging Chemistry materials.	25.8%	38.7%	20.7%	10.4%	4.2%	3.716	1.088
4. I am sure I can come up with solutions to daily challenges by using Chemistry	12%	38.4%	25.5%	14.6%	9.5%	3.289	1.146

5. In Chemistry classes, I am able to comment on concepts provided by my classmates.	29.4%	47.9%	11.2%	9.2%	2.2%	3.930	.988
6. I know how to organize apparatus for Chemistry practicals	44.8%	33.3%	14%	5.9%	2%	4.132	.993
7. I get more understanding of Chemistry by doing practicals than theory	52.9%	27.2%	12.3%	5.9%	1.4%	4.247	.979
9. I am able to use science related strategies to get solutions to daily challenges	17.9%	36.7%	26.6%	12.3%	6.4%	3.473	1.116
10. In Chemistry classes, I am able to express my own opinions clearly	24.4%	37.8%	17.9%	13.2%	6.7%	3.599	1.182
11. I am able to make a good choice on a formula to find a solution to a Chemistry problem	20.4%	35.3%	30.3%	8.7%	5.3%	3.569	1.073
12. When it comes to interpreting graphs and charts linked to Chemistry, I am confident.	23.8%	40.6%	19.6%	10.9%	5%	3.672	1.105
13. I am sure I can come up with answers to solve a Chemistry problem	13.7%	44.5%	25.5%	10.1%	6.2%	3.496	1.048
14. I can make remarks on a specified Chemistry concept	29.7%	43.1%	17.9%	6.4%	2.8%	3.905	.989
15. I am sure I can carry out practical activities in the Chemistry laboratory successfully	42%	40.1%	12%	4.2%	1.7%	4.165	.914
16. I am sure I will get an excellent grade in Chemistry	63.9%	21.3%	12.3%	2%	0.6%	4.459	.826
17. I can easily explain Chemistry topics to others	25.2%	35.3%	28.9%	6.7%	3.9%	3.712	1.04
18. I am able to gather data during the Chemistry practicals	31.7%	44.3%	15.1%	7.6%	1.4%	3.972	.948
19. I am confident I can master the skills taught in Chemistry	31.1%	43.7%	18.5%	4.5%	2.2%	3.969	.937

20. I am sure I can transfer the Chemistry learned knowledge to everyday experiences	27.2%	42%	18.5%	8.1%	4.2%	3.798	1.059
21. I am sure I can do a great work on Chemistry tasks given in class	37.3%	35.3%	19%	5.6%	2.8%	3.986	1.021
22. I am sure I can master the basic concepts in Chemistry	31.9%	45.7%	14.8%	4.5%	3.1%	3.989	.963
23. I am sure I can use equipment in the Chemistry laboratory	60.5%	30.3%	6.4%	0.6%	2.2%	4.462	.826
24. I feel comfortable to talk about Chemistry concepts with my course mates	48.7%	38.9%	7.3%	2.2%	2.8%	4.286	.907
25. In Chemistry lessons, I can present my ideas properly	24.4%	37%	24.4%	9%	5.3%	3.661	1.102
26. I think I am successful in Chemistry	43.1%	30.3%	16.8%	4.8%	5%	4.017	1.117
Overall Mean	**32.2%**	**38%**	**18.5%**	**7.5%**	**3.8%**	**3.873**	**1.018**

According to table 4.16, 85.2% of the students agreed that they will get an excellent grade in Chemistry with an item mean of 4.459. Also, 90.8% of the students said that they are confident of using equipment in the Chemistry laboratory with an item mean of 4.462. For all the other items, the biggest number of students agreed with items where the item means ranged between 3.289 and 4.462. The overall mean of students' self-efficacy in Chemistry was 3.873, with an overall standard deviation of 1.018. According to Mazana et al. (2018), a mean above 3.0 indicates high self-efficacy while a mean below 3.0 indicates low self-efficacy. Besides, CEMASTEA (2019) opines that a general score that is beyond three on a Likert scale is considered high, and it indicates a positive attribute of the variable measured. Besides, small standard deviations occur where there is concurrence on the items among the students. Therefore, based on the results, students in Meru South Sub-County had high self-efficacy in Chemistry. Similar findings were revealed in the study by Baanu and Oyelekan (2016). Also, Ramnarain and Ramaila (2018) found that students' efficacy beliefs were slightly above neutral with students displaying a favorable opinion of self-efficacy.

4.6.1 Correlation Analysis

The results from the correlation analysis between inquiry-based learning and students' self-efficacy in Chemistry are presented in table 4.17.

Table 4.17: Pearson's correlation between inquiry-based learning and students' self-efficacy in Chemistry

		Self-efficacy
Inquiry-based learning	Pearson Correlation	.903
	Sig. (2-tailed)	.000
	N	21

According to table 4.17, r = 0.903, p = 000 at 95% confidence interval. The results establish that there is a strong positive relationship between inquiry-based learning and students' self-efficacy in Chemistry. This finding is supported by Husnaini and Chen (2019) who opines that inquiry-based learning is effective in improving efficacy beliefs of students in scientific inquiry. This suggests that the more a teacher practices inquiry-based learning, the higher the students' self-efficacy in Chemistry.

4.6.2 Regression Analysis

Before carrying out the regression analysis, statistical assumptions of linearity, independence, homoscedasticity and normality were checked. Results for the linearity assumption are presented in figure 4.12.

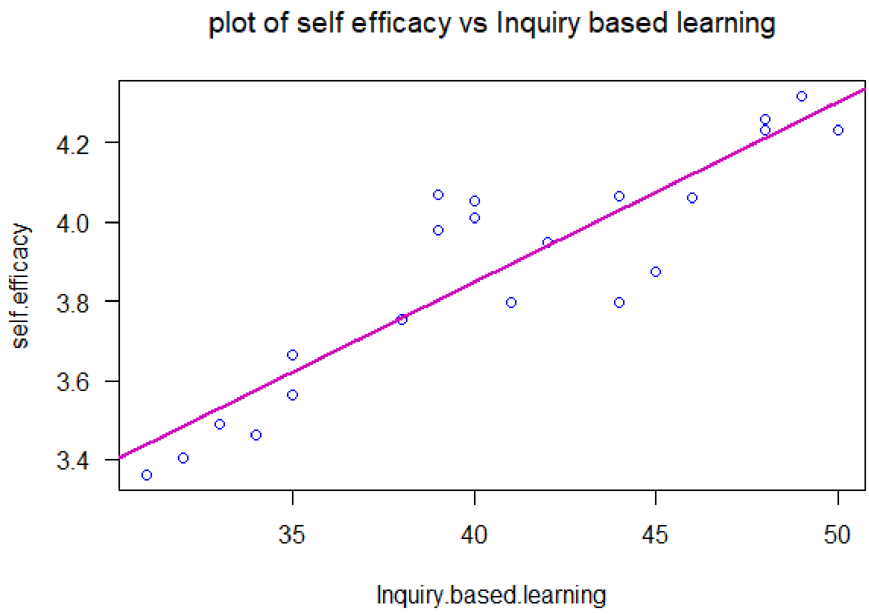

Figure 4.12: A plot of self-efficacy vs inquiry-based learning

Equation of the line is; Y = 2. 024623 + 0.045586X, R^2 = 0.8155.

According to figure 4.12, majority of the points align along the line of best fit. In general, as the level of inquiry-based learning rises, so does the level of student self-efficacy. This shows that there exists a linear relationship between utilization of inquiry-based learning and students' self-efficacy in Chemistry. The homoscedasticity and normality assumptions were met as shown in figures 4.13, 4.14, and 4.15. The Durbin-Watson test value according to table 4.18, is close to 2.0 implying that there is no autocorrelation and therefore independence assumption was met.

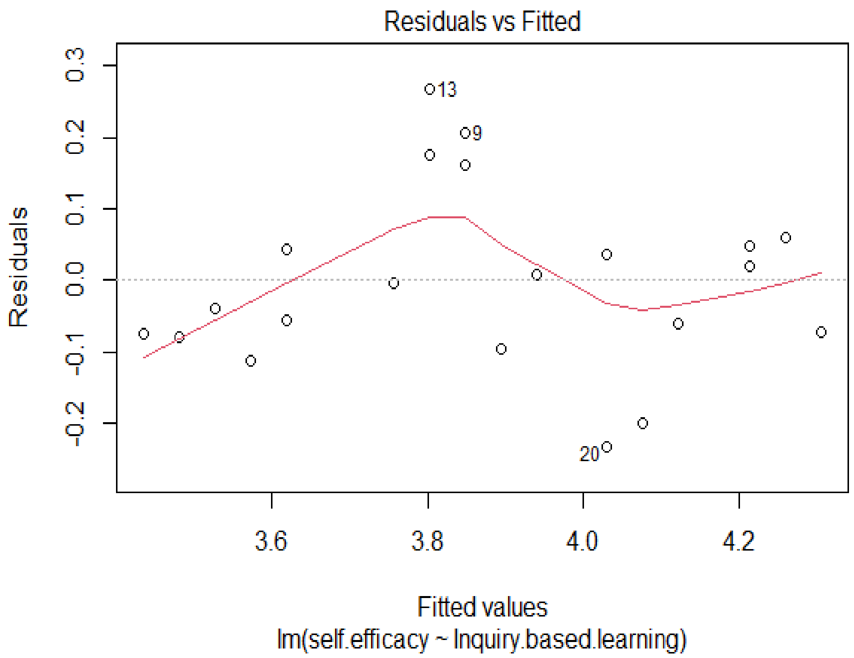

Figure 4.13: Residuals vs. fitted values; self-efficacy and inquiry-based learning

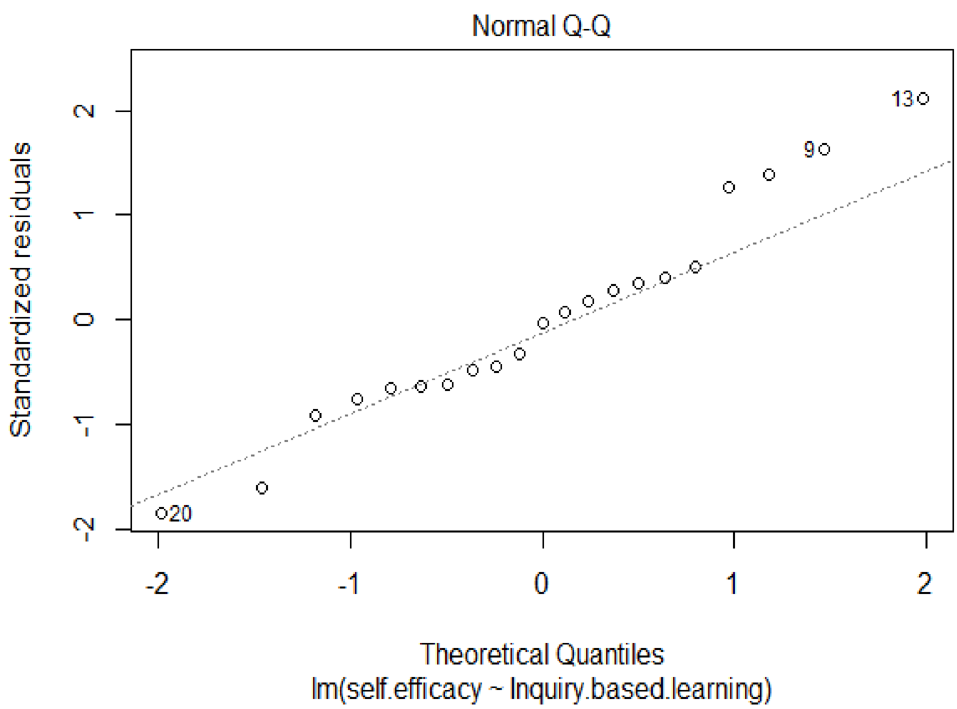

Figure 4.14: Q-Q plot for self-efficacy

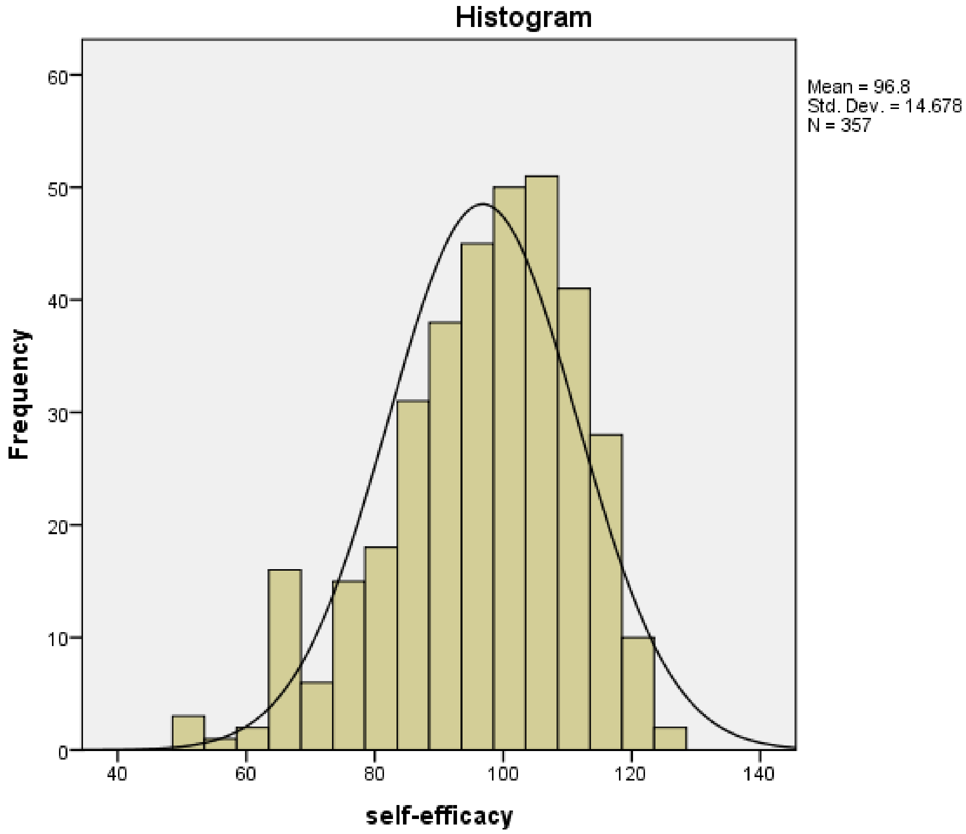

Figure 4.15: Histogram for students' self-efficacy

The results from regression analysis are presented in tables 4.18, 4.19 and 4.20.

Table 4.18: Model Fitness of IBL vs self-efficacy

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.903	.8155	.8057	.1302	2.190

According to table 4.18, $R^2 = 0.8155$ (81.55%). The results suggest that about 82% of students' efficacy beliefs in Chemistry are influenced by IBL. The remaining percentage goes to the other factors which could have an influence on students' self-efficacy in Chemistry such as mastery experiences, verbal persuasion, physiological states and vicarious experiences. The Analysis of Variance was carried out. The results are presented in table 4.19.

Table 4.19: Analysis of Variance; IBL vs self-efficacy

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.42339	1	1.42339	83.954	.000
	Residual	.32213	19	.01695		
	Total	1.746	20			

Table 4.19 shows that F (1,19) = 83.954, P = .000, hence the model was statistically significant. This suggest that IBL is a good predictor of efficacy beliefs of students in Chemistry. The results agree with the findings by Eymur (2018) who found that, inquiry learning enhances the efficacy beliefs of students in Chemistry. Besides, Sen and Vekli (2016) argue that the use of an inquiry-based education strategy improves science teachers' perceptions of their efficacy beliefs in experimental work.

The regression coefficients were computed and the results are presented in table 4.20.

Table 4.20: Distribution of coefficients

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.024623	.204076		9.921	.000
	Inquiry-based learning	.045586	.004975	.903	9.163	.000

According to table 4.20, $\beta= 0.903$, $p < 0.05$. The results suggest that there is a strong relationship between inquiry-based learning and students' self-efficacy in Chemistry. Besides, a unit increase in the utilization of IBL can lead to 0.046-unit increase in efficacy beliefs of students in Chemistry. The results concur with the findings by Tawfik et al. (2020), who opines that inquiry-based instruction, when compared to more didactic techniques, leads to greater gains in self-efficacy as students engage in problem-solving activities. Madden (2011) found that after participating in demanding inquiry-based laboratories, freshman Biology honors students felt more secure about understanding science. However, the results contradict the findings by Cairns and

Areepattamannil (2017) who found that IBL was negatively associated with students' learning outcome in terms of their performance. Therefore, it can be concluded that IBL has a positive impact on students' efficacy beliefs in sciences.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the findings and the conclusions based on the findings. The chapter also presents the recommendations and suggestions for further studies.

5.2 Summary of the research findings

This section presents a summary of the study's findings based on the research objectives which include: establishing the extent to which inquiry-based learning has been used in Chemistry practical lessons, determining the relationship between the use of inquiry-based learning and students' attitudes towards Chemistry and lastly determining the relationship between inquiry-based learning and students' self-efficacy in Chemistry.

5.2.1 IBL use in Chemistry practical lessons

This study sought to find out the extent to which the inquiry-based learning approach had been used in Chemistry practical lessons in Meru South Sub-County. The study found that teachers in Meru South Sub-County made use of inquiry-based learning approach in Chemistry practical lessons once a week. Besides, 77.8% of the practical lessons used IBL based on the study results. Triangulation of both self-reported and observed IBL use revealed that when teachers are asked to give a report based on their teaching, they tend to over-report by 4.195%. Based on the findings of this study, some of the teacher characteristics such as gender, academic qualification and teaching experience do not influence the use of IBL. However, professional development of teachers such as training by CEMASTEA influences the use of IBL where trained teachers tend to use the IBL approach more in practical lessons compared to the untrained teachers.

5.2.2 Relationship between inquiry-based learning and students' attitudes towards Chemistry

The research examined whether there is a relationship between the use of inquiry-based learning approach and students' attitudes towards Chemistry. The findings of the study suggest that the use of inquiry-based learning influences students' attitudes toward Chemistry. The Pearson's moment correlation coefficient revealed that there is a strong positive association between inquiry-based learning and students' attitudes towards Chemistry (r = .9972, p = .000). The results from regression analysis revealed that 99% of students' attitudes in Chemistry are influenced by the use of IBL approach (R^2 = .994, F (1,19) = 3397.116, P = .000). Besides, the results from the scatter plot diagram revealed that when the use of IBL is high, students' attitudes towards Chemistry are positive.

5.2.3 Relationship between inquiry-based learning and students' self-efficacy in Chemistry

This study sought to find out whether there is a relationship between inquiry-based learning and students' efficacy beliefs in Chemistry. The study discovered a link between inquiry-based learning and students' self-efficacy in Chemistry. According to Pearson's correlation coefficient findings, there is a substantial positive association between inquiry-based learning and students' self-efficacy in Chemistry in secondary schools (r = 0.903, p = 000). The scatter plot revealed that the efficacy beliefs of students in Chemistry increase with increased use of inquiry-based learning. Also, results from regression analysis revealed that about 82% of students' self-efficacy in Chemistry is influenced by the use of inquiry-based learning (R^2 = 0.8155, F (1,19) = 83.954, P = .000).

5.3 Conclusion

This study has established the extent to which inquiry-based learning approach has been used in Chemistry practical lessons and how the use of this approach influences students' attitudes and self-efficacy in Chemistry. The results suggest that most of the teachers actively engaged learners in the teaching and learning of Chemistry which translates to improved attitudes towards Chemistry, enhanced efficacy and improved academic performance. On the other hand, there is need for observations when evaluating teachers in terms of their effectiveness in using specific teaching methodologies to obtain more accurate information since they tend to over report when asked to give a report on their teaching practices. Based on the study findings, it is evident that the use of inquiry-based learning approach has a positive influence on students' attitudes and efficacy beliefs in Chemistry. As a result, inquiry-based learning should be used to improve students' attitudes and efficacy beliefs in science subjects, particularly Chemistry, as it has been found to be one of the most effective techniques.

The findings from this study are supported by Vygotsky's social constructivism theory which emphasizes on social activities and interactions with instructors, classmates and educational resources that have an impact on learners' cognitive and affective development. Collaborative learning is a key aspect of social constructivism. The inquiry-based learning approach is a strategy that encourages collaborative learning and hence the negotiation of knowledge which translates to effective learning in terms of attitudes, confidence in students' capability and improved performance. The use of practical work helps students conceptualize theoretical concepts. This allows students to understand the theoretical concepts better and therefore can develop positive attitudes towards the subject. Once the students have a positive affect towards the subject, they can dedicate most of their time to reading, and their understanding of the subject increases. This translates to confidence in mastering the Chemistry concepts and hence improved performance in the subject.

5.4 Recommendations

Based on the findings, the study recommends the following:

1) Education policy makers should come up with policies that guide the implementation of learner-centered teaching methodologies such as inquiry-based learning approach in teaching of sciences.
2) Teacher training institutions such as colleges and universities should expose teacher trainees to IBL to ensure they obtain the required knowledge and skills for effective teaching.
3) Institutions dealing with the professional development of teachers should extend the training on IBL to all teachers to ensure all the teachers have the adequate knowledge and skills to employ this approach in the teaching of Chemistry.

5.5 Suggestions for further studies

1) A similar study should be conducted to find out how the use of inquiry-based learning influences students’ performance in science subjects including all the categories of schools in Kenya.
2) The study recommends further studies on the interaction effect of inquiry-based learning on learning outcomes in other classes other than the form three

classes, which should capture learners’ experiences in inquiry-based learning through interviews or focus group discussions.

3) Since the study did not focus on specific levels of inquiry-based learning, the study recommends further studies on the relationship between the use of specific levels of inquiry-based learning and students' learning outcomes in Kenya.
4) Further research should be carried out to determine the effectiveness of other learner-centered teaching approaches such as project-based learning and flipped classrooms in teaching and learning of science subjects in Kenya.

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APPENDICES

APPENDIX I: PRACTICAL LESSON OBSERVATION SCHEDULE

SECTION A: OBSERVATION PROTOCOL 1

Lesson No………………… Date……………………

Teacher…………………… Form: …………....

Materials………………………………………………………………………………

Sub-topic………………………………………………………………………………

Lesson objective(s): By the end of the lesson, the learner should be able to;

……………………………………………………………………………………..

Inquiry-based learning practices	**Frequency in a 10-minutes interval (Tick) (A practical lesson takes 80 minutes)**							
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Engagement								
Teacher examines learners past knowledge and gives them opportunity to question.								
Teacher makes connection between past and present learning experiences for effective learning.								
Exploration								

Learners are given opportunity to design and carry out experiments in the laboratory.								
Learners are allowed to discuss among themselves results from investigations.								
Explanation								
Teacher provides detailed explanations for investigations to be undertaken by students.								
Teacher asks learners to explain their understanding of the concept under study.								
Elaboration								
The teacher provides instances for learners to extent their learned knowledge to get a deeper understanding.								
Teacher allows students to make connections between learned concepts and the world around them.								
Evaluation								

Teacher asks related questions to students to assess their knowledge and skills.								
Teacher gives class assignment/administer a test to assess learners understanding.								

SECTION B: PROTOCOL 2

Protocol 2 will be used to tabulate the frequency of inquiry-based learning approach in Chemistry practical lessons. It is based on a scale 1-5 as outlined: 1 = never, 2 = Rarely, 3 = sometimes, 4 = frequently and 5 = very frequently.

Inquiry-based learning practices	**Very frequently 5**	**Frequently 4**	**Sometimes 3**	**Rarely 2**	**Never 1**
Engagement					
Teacher examines learners past knowledge and gives them opportunity to question.					
Teacher makes connection between past and present					

learning experiences for effective learning					
Exploration					
Learners are given opportunity to design and carry out experiments in the laboratory					
Learners are allowed to discuss among themselves results from investigations					
Explanation					
Teacher provides detailed explanations for investigations to be undertaken by students.					
Teacher asks learners to explain their understanding of the concept under study.					
Elaboration					
The teacher provides instances for learners to extent their learned					

knowledge to get a deeper understanding.					
Teacher allows students to make connections between learned concepts and the world around them.					
Evaluation					
Teacher asks related questions to students to assess their knowledge and skills.					
Teacher gives class assignment/administer a test to assess learners' understanding.					

APPENDIX II: TEACHER QUESTIONNAIRE

The questionnaire is designed for teachers to rate how often they use inquiry-based learning practices in Chemistry practical lessons. The information will be anonymous and confidential. You are therefore kindly requested to provide honest and accurate information.

SECTION A: DEMOGRAPHIC CHARACTERISTICS

Please tick in the boxes provided.

1. Gender: Male ☐ Female ☐

2. Highest Education Qualification

   Diploma ☐ BED ☐ Master's degree ☐ PhD ☐

3. Teaching experience (years)

   0-4 ☐ 5-9 ☐ 10-14 ☐ 15-19 ☐ 20-24 ☐ 25-29 ☐

   30 and above ☐

4. Number of students in class

   20-29 ☐ 30-39 ☐ 40-49 ☐ Above 50 ☐

5. What was the form three Chemistry mean grade in the latest exam?

   E ☐ D- ☐ D ☐ D+ ☐ C- ☐ C ☐ C+ ☐ B- ☐ B ☐

   B+ ☐ A- ☐ A ☐

6. Have you been trained by CEMASTEA?

   Yes ☐ No ☐

   If yes, please indicate the year(s) when you were trained;

a. .... e....................

b. .... f...................

c. ....

d. ....

7. Have you had any other training or seminar on how to teach Chemistry?

   Yes ☐ No ☐

   If yes, please specify...

8. How many laboratories do you have in your school?.....................

9. Is the laboratory(s) well equipped?....................

10. How many Chemistry practical lessons do you conduct within a period of 2 weeks for form three students?......................

11. Other than during normal lessons, how many Chemistry practical sessions do you conduct in a period of 1 month for form three students?.............

12. How many Chemistry practical tests e.g. paper three do you conduct in a period of 1 year for form three class?..................

SECTION B: USE OF INQUIRY-BASED LEARNING

This section is based on a 5-point Likert scale: 5 = Every Lesson (EL), 4 = Once a Week (OW), 3 = Once a Month (OM), 2= Once a Term (OT), and 1 = Never (N). Please indicate the extent to which you utilize the listed inquiry-based learning practices in Chemistry practical lessons by **ticking** in the respective column.

Inquiry-based learning practices	EL	OW	OM	OT	N
I assess learners' prior knowledge					
I make connection between the past and present learning experiences for effective learning					
I allow learners to design and carry out experiments in the laboratory					
I allow learners to discuss results from investigations					
I provide detailed explanations for investigations to be undertaken by students					
I ask learners to explain their understanding of the concepts under study					
I provide instances for learners to extent their learned knowledge to get a deeper understanding.					
I allow students to make connections between learned concepts and the world around them					
I pose related questions to students to assess their knowledge and skills					
I give assignments to assess learners' understanding.					

APPENDIX III: STUDENT QUESTIONNAIRE

This questionnaire aims to gather information on students' academic achievement, self-efficacy and attitudes towards Chemistry. Don't include your identify or the name of your institution anywhere in this questionnaire. The information will be confidential and used exclusively for research reasons. As a result, you are respectfully urged to answer the questions truthfully. Your contribution will be greatly valued.

SECTION A. BACKGROUND INFORMATION

Please tick in the boxes.

1. Gender: Male ☐ Female ☐

2. What did you score in the last Chemistry examination?

   E ☐ D- ☐ D ☐ D+ ☐ C- ☐ C ☐ C+ ☐ B- ☐ B ☐ B+ ☐

   A- ☐ A ☐

   Indicate the marks scored in;

   Paper 1...................marks

   Paper 2...................marks

   Paper 3...................marks

3. Do you like practical lessons? Please tick the extent to which you like them in the spaces provided.

   Always ☐ Sometimes ☐ Never ☐

4. Do you like the way practical lessons are conducted? (Tick in the spaces provided)

Yes ☐ No ☐

SECTION B. STUDENT'S ATTITUDE TOWARDS CHEMISTRY

This section consists of 15 items on student's attitudes towards Chemistry lessons. Please **tick** in the boxes the level to which you agree with the statements.

5 = Strongly Agree (SA), 4 = Agree (A), 3 = Not Sure (NS), 2 = Disagree (D), and 1= Strongly disagree (SD).

Item	**SA**	**A**	**NS**	**D**	**SD**
I know that I will require Chemistry knowledge in my future career					
When I do practicals, I am able to come up with answers to challenging tasks on Chemistry					
Chemistry is a crucial subject that people need to study					
I like trying to solve new problems in Chemistry					
I feel empowered when I am doing experiments in the laboratory					
Chemistry is important for bringing solutions to daily life problems					
I intend to take a career related to Chemistry to get a good job in future					
We have interesting exercises in Chemistry					
I will be happy to dedicate most of my time in doing experiments					
Chemistry is one of my favorite subjects					
It is important for people to get an understanding of Chemistry since it influences their lives					

Chemistry lessons are interesting					
I like to do Chemistry experiments					
Given an opportunity, I can carry out a project in Chemistry					
Chemistry is an easy subject					

SECTION C. STUDENT'S SELF-EFFICACY IN CHEMISTRY

Please **tick** in the boxes the level to which you agree with the statements.

5 = Strongly Agree (SA), 4 = Agree (A), 3 = Not Sure (NS), 2 = Disagree (D), and 1= Strongly disagree (SD).

Item	**SA**	**A**	**NS**	**D**	**SD**
I know that a variety of daily life events entail Chemistry-related concepts					
I can evaluate the solutions of Chemistry problems					
I am sure I can understand the most difficult materials presented in Chemistry					
I am sure I can come up with solutions to daily challenges by using Chemistry					
I am able to make remarks on ideas presented by my course mates in Chemistry lessons					
I know how to organize apparatus for Chemistry practicals					

I get more understanding of Chemistry by doing practicals than theory					
I am confident of doing experiments with teacher's guidance					
I am able to use science related strategies to get solutions to daily challenges					
In Chemistry classes, I am able to express my own opinions clearly					
I am able to make a good choice on a formula to find a solution to a Chemistry problem					
I feel confident when I interpret graphs/charts related to Chemistry					
I am sure I can come up with answers to solve a Chemistry problem					
I can make remarks on a specified Chemistry concept					
I am sure I can carry out practical activities in the Chemistry laboratory successfully					
I am sure I will get an excellent grade in Chemistry					
I can easily explain Chemistry topics to others					
I am able to gather data during the Chemistry practicals					
I am confident I can master the skills taught in Chemistry					

I am sure I can transfer the Chemistry learned knowledge in everyday experiences					
I am sure I can do a great work on Chemistry tasks given in class					
I am sure I can master the basic concepts in Chemistry					
I am sure I can use equipment in the Chemistry laboratory					
I feel comfortable to talk about Chemistry concepts with my course mates					
In Chemistry lessons, I can present my ideas properly					
I think I am successful in Chemistry					

APPENDIX IV: DOCUMENT ANALYSIS FRAMEWORK

The purpose of the document analysis framework is to assess the nature of practical tasks on students' worksheets.

Statement	**Yes**	**No**
The teacher provides research questions to students for investigations		
The teacher allows learners to develop research questions		
Students develop/design procedures for investigations		
The teacher provides procedures for investigations		
Learners make observations, collect and analyze data		
Students are allowed to apply knowledge learned into new situations		
Students are given tests/questions to evaluate their understanding		

APPENDIX V: RESEARCH AUTHORIZATION

REPUBLIC OF KENYA

MINISTRY OF EDUCATION SCIENCE AND TECHNOLOGY
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION

Telegrams: "Elimu", Chuka
Telephone: Chuka 630353
FAX: 064 630166
Email: *tharakanithicountyedu@gmail.com*
When replying please quote:

COUNTY DIRECTOR OF EDUCATION
THARAKA NITHI
P.O. BOX 113-60400
CHUKA.

TNC/ED/GC/GEN/5.VOL.III/99

22[nd] October 2021

Christine Mueni Nzomo
P.O Box 6-60100
EMBU

RE: RESEARCH AUTHORIZATION

I am pleased to inform you that you have been authorized to undertake research on the following subject matter. **"Does inquiry-based learning approach in Chemistry practical lessons affect student's attitudes and self-efficacy? In Meru South Sub-County, Tharaka Nithi County, Kenya"**

On completion of the research, you are expected to give a hard copy and a soft copy of the research report/theses to this office.

The research Authorization is granted to all existing rules and regulations in force from time to time and observance of covid-19 guidelines and protocols as recommended by the relevant government MDAs.

Good luck!

FOR: COUNTY DIRECTOR OF EDUCATION
22 OCT 2021
THARAKA NITHI
P. O. Box 113 CHUKA

George Ndentu
For: County Director of Education
THARAKA NITHI

APPENDIX VI: RESEARCH PERMIT

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 783473

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