UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF INQUIRY-BASED LEARNING ON SENIOR HIGH SCHOOL STUDENTS' ACADEMIC PERFORMANCE IN ELECTRICITY AND MAGNETISM CONCEPTS

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DECLARATION

STUDENT'S DECLARATION

I, **STEPHANIE ASSUAH,** declare that the thesis, with the exception of quotations and references contained in published works which have been identified and duly acknowledged, is entirely my original work, and that part of it has been presented for another degree in this university or elsewhere.

SIGNATURE:……………………………….

DATE:…………………………...………….

SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised by the guidelines on supervision of thesis laid down by the University of Education, Winneba.

SUPERVISOR: DR. I.K.ANDERSON

SIGNATURE:……………………………….

DATE:…………………………...………….

DEDICATION

I dedicate this work to my beloved family, whose unwavering love and support have been a constant source of inspiration and encouragement throughout this journey.

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ABSTRACT

The purpose of this study was to explore how inquiry-based learning impacts the academic performance of senior high school students in understanding electricity and magnetism concepts. The study adopted an action research design and utilised the purposive sampling technique to select an intact class of (52) students for the research. The study sought to answer three research questions: 1. What is the effect of inquiry-based learning on students' academic performance in electricity and magnetism concepts? 2.What is the differential effect with respect to gender in inquiry-based learning on students' academic performance in electricity and magnetism concepts? 3. What perceptions do students have towards the use of inquiry-based learning approach in the teaching and learning of electricity and magnetic concepts. Data were gathered using achievement tests and questionnaire, and analysed using descriptive and inferential statistics. The findings of the study indicated that students exhibited a notable improvement in academic performance from the pre-test (Mean= 7.51) to the post-test (Mean= 11.52). The t-test analysis revealed a statistically significant difference between the pre-test mean score and the post-test mean score ($p = 3.7326 \times 10^{-20}$, sig. at 0.05). Also, the findings revealed that inquiry-based learning approach had a positive and equitable effect on the academic performance of both male (Mean= 11.53) and female (Mean=10.56) (SHS) students in electricity and magnetism concepts. The t-test analysis of the post-test scores revealed no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction (p= 0.1811521, not sig. at 0.05). Moreover, the findings of the study revealed that SHS students have overwhelmingly positive views on the use of inquiry -based learning approach in the teaching and learning of electricity and magnetism concepts. In light of these findings, it was recommended that science teachers, more specifically physics teachers, should consider incorporating inquiry-based learning approach to improve student learning outcomes. Teachers are urged to master various instructional methods and actively seek feedback for continuous improvement. Also, policymakers and educators should collaborate to promote widespread adoption of inquiry-based learning approach, recognizing its positive impact. Support and resources for teacher training in inquiry-based learning approach are recommended, with a focus on professional development programs. Furthermore, government and educational bodies should sponsor workshops and seminars, while curriculum planners are advised to incorporate inquiry-based learning approach in developing the science curriculum. Additionally, publishers are encouraged to produce textbooks using the inquiry-based learning format.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter provides the essential context for the study, detailing its background, the problem being addressed, the study's purpose, the research questions guiding the study, and the study's significance. Additionally, it discusses the limitations and delimitations identified during the research process, along with explanations of any abbreviations utilised in the study. The concluding part of the chapter outlines how the study is organised, offering a roadmap for the reader to understand the subsequent sections and their flow.

1.1 Background to the Study

It is globally recognised that the development and application of science and technology are vital for a country‘s developmental efforts (Azure, 2015). Science education is needed in Ghana to produce the necessary human resources and skilled labour force to manage our local industries (Azure, 2015). A country‘s development rests on science and its application in the world of work and industry and competent workers and citizenry need a sound understanding of science and mathematics (Shadreck & Mambanda, 2012; Anamuah-Mensah & Asabere-Ameyaw, 2004). A strong science and technology base, therefore, constitutes the currency for the social and economic transformation of nations (Anamuah-Mensah & Asabere-Ameyaw, 2004).

Physics is a physical science subject that studies about matter and energy (Azowenunebi, 2019). The study of physics is crucial to understanding the world around us, the world inside us, and the world beyond us (Gibbs, 2010). According to

Olarinoye (2000), physics is the most utilised basic science subject in most technology and technology-related professions. This merely indicates the enormous role physics plays in the technological growth of any nation and therefore, must not be undermined. It is pertinent to note that the technological growth of a nation leads to its social and economic development (Olarinoye, 2000). Despite its importance,it appears students' academic performance over the years in physics has been below expectations, especially in the study of electricity and magnetism

Electricity and magnetism are considered a central area of physics and science curricula at primary, secondary as well and tertiary levels of education (Gunstone, Mulhall, & McKittrick, 2009). There are more opportunities for practical investigations offered by electricity and magnetism including that for knowledge demonstration and understanding through both talk and activity for children (Glauert, 2009). Additionally, electricity and magnetism as one of the basic areas and important topics in physics have applications encompassing many aspects of our everyday life. However, this area has been reported to have several concepts in which students find difficulty and develop views that are different from those accepted scientifically (Turgut, Gürbüz, & Turgut, 2011; Li, 2012). Electricity and magnetism-related concepts are particularly problematic due to their abstract and complex nature making their understanding difficult for students (Arnold & Millar, 1987; Mulhall, et al., 2001; Mioković et al., 2012). Several researches show that students have misconceptions and many common difficulties in understanding concepts related to electricity and magnetism topics (McDermott & Shaffer, 1992; Shaffer & McDermott, 1992; Maloney et al., 2001; Küçüközer & Kocakülah, 2007; Afra et al., 2009; Pollock, 2009; Glauert, 2009; Hussain et al., 2012; Li, 2012; McColgan et al., 2017). Studies revealed that some of the students‘ misconceptions and difficulties are not adequately addressed by traditional teaching methods (McDermott & Shaffer, 1992; Hussain et al., 2012; Li, 2012).The teaching methods employed by teachers in teaching science have a great impact on the understanding and interest developed by students in the science subject (Issaka, 2014). Inappropriate teaching methods contribute to the low participation and performance of students in science (O'Connor, 2002).

For many years, traditional methods such as lecture methods and demonstrations have been the most widely used instructional strategy in schools, colleges and universities in sub-Saharan Africa like Ghana (Cashin,1990). In a traditional class, the subject matter is nearly always delivered in a monologue fashion in front of a passive audience (Mazur, 1997; Maloney et al., 2001; Muise, 2015; Uwizeyimana et al., 2018). While using a traditional teaching strategy, it is not easy to provide adequate opportunities for students to critically think in the course of developed arguments. It has been found in most universities by many science educators that the traditional methods in the classroom are less effective in both teaching and learning (Antwi et al., 2014).

As students are active constructors of their knowledge (Arnold & Millar, 1987), student-centered teaching strategies help students construct knowledge on their own and enhance their conceptual understanding. Science educators have emphasised the need to produce students who are skilled in solving basic problems within their immediate environment through analysis and experimentation. According to Issaka (2014), students are expected to adopt a scientific way of life based on pragmatic observation and investigation of phenomena and this could be achieved through the use of inquiry-based learning.

Inquiry refers to seeking explanations or information by posing questions (Harlen, 2013). Inquiry-based learning is an instructional practice where students become the centre of the learning experience and take ownership of their learning by posing, investigating, and answering questions (Caswell & LaBrie, 2017). Several studies have reported the benefits of inquiry-related teaching approaches, suggesting that these techniques foster students' understanding of scientific processes, scientific literacy and critical thinking among other competencies (Cavallo et al., 2004; Glasson & McKenzie, 1998; Haury, 1993).

1.2 Statement of the Problem

Interactions with physics students of Shama Senior High School revealed that they appear to have difficulty understanding Electricity and Magnetism thereby yielding low students' academic performance. Several studies show that students have misconceptions and many common difficulties in understanding concepts related to electricity and magnetism topics (Li, 2012; McColgan et al., 2017; Li & Singh, 2017). This may be linked to the predominant use of lecture-based teaching methods by physics teachers. This teaching approach aligns with previous research by Coffie et al. (2020), highlighting the prevalence of teacher-centered techniques such as lectures and question-and-answer sessions among physics educators. Nevertheless, it has been widely acknowledged by science education researchers that the lecture method has limited effectiveness in fostering effective teaching and learning, as noted by Antwi et al. (2014) in various schools in Ghana.

Consequently, to address the difficulties faced by physics students at Shama Senior High School, the inquiry-based learning method was proposed and adopted. It sought to assess the influence on students' academic performance in the complex concepts of

Electricity and Magnetism. By shifting from the traditional lecture-centric approach to a more interactive and exploratory method, this study sought to uncover the likely effect of inquiry-based learning in enhancing students' understanding and academic performance in electricity and magnetism concepts.

1.3 Purpose of the Study

The purpose of the study was to determine the effect of inquiry-based learning on senior high school students‘ academic performance in electricity and magnetism concepts at Shama Senior High School.

1.4 Objectives of the study

The objectives of the study were to:

1. assess the effect of inquiry-based learning on students‘ academic performance in electricity and magnetism concepts.
2. assess the differential effect with respect to gender of inquiry-based learning on student academic performance in electricity and magnetism concepts.
3. identify students‘ perceptions towards the use of inquiry-based approach in the teaching and learning of electricity and magnetism concepts.

1.5 Research Questions

The following questions guided the objectives of the study:

1. What is the effect of inquiry-based learning on students‘ academic performance in electricity and magnetism concepts?
2. What is the differential effect with respect to gender of inquiry-based learning on student academic performance in electricity and magnetism concepts?
3. What perceptions do students have towards the use of inquiry-based approach in the teaching and learning of the concepts of electricity and magnetism?

1.6 Null Hypotheses

The following null hypotheses were tested for statistically significant effect:

$H0_1$. There is no statistically significant effect of inquiry-based learning on students' academic performance in electricity and magnetism concepts

$H0_2$. There is no statistically significant difference in the academic achievement of male and female students in electricity and magnetism concepts when exposed to inquiry-based learning.

1.7 Significance of the Study

The study would help Senior high school students to understand the concepts of electricity and magnetism thereby improving their academic performance. Science teachers could adapt this teaching strategy (inquiry-based learning) in helping SHS students improve their conceptual understanding of other Physics topics. The study could contribute to the broader field of educational research by adding to the body of evidence on the effectiveness of inquiry-based learning. Policymakers could find invaluable insights from the study, which could potentially steer educational policies towards the integration of inquiry-based methodologies. The findings can be used to support or challenge existing theories and models of teaching and learning in science education, thereby advancing our understanding of how students best acquire knowledge in this domain.

1.8 Delimitations of the Study

The investigation specifically examined the effect of inquiry-based learning on students' academic performance in electricity and magnetism concepts. The duration of the inquiry-based learning intervention was limited to 6 weeks, and the academic performance of students was measured using pre- and post-tests consisting of standardised multiple-choice questions. The study did not consider the influence of individual students' characteristics (e.g., prior knowledge, learning styles) or teacher-specific factors in the analysis.

1.9 Limitations of the study

The health status, mood and test anxiety of the research participants may influence their response to the data collection instruments. Therefore, the study's findings may not be directly applicable to all students or educational settings. Factors such as the specific demographics of the participants, the instructional context, and the implementation of inquiry-based learning could limit the generalisability of the results. If the assessment does not comprehensively capture the full range of knowledge and skills in these areas, the study's findings may not fully reflect students' true academic performance.

1.10 Organisation of the Study

The study report was divided into five chapters. The first chapter served as the introduction to the study This chapter provides the essential context for the study, detailing its background, the problem being addressed, the study's purpose, the research questions guiding the study, and the study's significance. Additionally, it discusses the limitations and delimitations identified during the research process. Chapter two was devoted to the review of literature on the effect of inquiry-based learning on senior high school students‘ academic performance. Chapter three focused on the method used to gather data in the study. Chapter three contains the research approach and research design used in this study. It also discusses the population of the study, the sampling and sampling technique, the research instrument that will be used to collect data for this study, validity and reliability of the research instruments, pre-intervention activities, intervention, post-intervention activities, data analysis procedure and ethical consideration. Chapter Four presented and discussed the findings. Finally, chapter five, which was the final chapter, consisted of a summary, conclusions, recommendations, and suggested areas for further study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

This chapter discusses the review of existing literature related to the study. Literature was collected from variety of sources that are intimately linked to the study‘s theme and purpose. This chapter presents various concepts used in the research and further elucidates the theories that provide further explanations to the study. Thematic areas covered include: theoretical framework, conceptual framework of the study, empirical review of related studies, concept of academic performance, measurement of academic performance, influence of teaching methods on students‘ academic performance, some studies on students‘ conceptual understanding of electricity and magnetism, identification of students‘ misconceptions in electricity and magnetism, remedies to overcome students‘ misconceptions in electricity and magnetism, concept of inquiry, inquiry-based learning, types of inquiry-based learning, models that are used in inquiry-based learning, methods and techniques used in inquiry-based learning, evaluation in inquiry-based learning, importance of inquiry-based learning in science education, different roles of teachers in inquiry-based learning ,different roles of students in inquiry-based-learning , inquiry based-learning environment and its characteristics, misconceptions concerning inquiry-based learning and challenges encountered in an inquiry-based learning environment and summary of the chapter.

2.1 Theoretical Framework

A suitable theoretical framework for the study of the effect of inquiry-based learning on students' academic performance in electricity and magnetism is the Discovery Learning Theory and the Constructivist theory of learning.

According to Bruner (1961), discovery learning is a learning model that uses inquiry-based constructivist learning theory that occurs in problem-solving situations where learners learn through existing knowledge and previous experience to find facts and relationships with new material being studied (Bruner, 1961). Through discovery learning, the teacher provides opportunities for his students to become problem solvers, scientists, historians, or mathematicians (Kementerian,2014).

To anticipate misconceptions or incomplete or unorganized knowledge, discovery learning is developed by integrating guidance into learning activities. Furthermore, discovery learning with the existence of guidance is referred to as a guided discovery learning model. Guided discovery learning is still centered on students and the teacher acts as a guide (Mayresta & Guspatni, 2022). Guidance given by the teacher is limited, because if there are too many guidelines for discovery, then learning will be similar to direct learning, and thus learning loses its benefits (Yang et al., 2010). Learning that is promoted in guided discovery is to foster learners' ability in discovery, exploration, problem-solving and independent thinking, and creation and discovery through creative learning. In guided discovery learning, students can actively and positively participate in learning and integrate and construct their knowledge (Shieh & Yu, 2016). Guided discovery learning is learning with the pattern of the scientific method to find problem-solving by students in groups with steps starting from stimulation, problem statement/identification, data collection, data processing, and verification (Yerizon et al., 2018).

The constructivist theory of learning posits that learning is an active process where individuals construct knowledge and understanding through their experiences and interactions with the environment. Learners actively engage in sense-making activities by connecting new information or experiences with their existing knowledge and mental frameworks (Rau, 2018)

According to Jonassen (1991), constructivism emphasizes the learner's role in constructing meaning rather than passively receiving information. It views learners as active participants who actively build their understanding of the world based on their unique experiences and interpretations. This active construction of knowledge occurs through processes such as reflection, interpretation, and problem-solving.

In the constructivist view, learners bring their prior knowledge, beliefs, and experiences into the learning process. This prior knowledge serves as a foundation upon which new information is assimilated, accommodated, and integrated. Ausubel (1968) introduced the concept of "advance organizers" as a way to activate learners' existing knowledge and provide a framework for organizing new information.

Vygotsky's sociocultural theory, a significant influence on constructivist theory, emphasizes the social nature of learning. Vygotsky (1978) proposed the Zone of Proximal Development (ZPD), which refers to the gap between what a learner can achieve independently and what they can accomplish with assistance from a more knowledgeable other. Within the ZPD, learners are guided and supported by teachers, peers, or more experienced individuals, enabling them to reach higher levels of understanding and competence.

The constructivist theory of learning also highlights the importance of authentic and meaningful learning experiences. Dewey (1938) argued that learning should be situated in real-world contexts and involve hands-on activities, problem-solving, and exploration. Authentic tasks and real-world applications allow learners to connect their knowledge to practical situations and develop a deeper understanding of the subject matter.

In the context of inquiry-based learning, the Constructivist Learning Theory aligns well with the principles of this instructional approach. Inquiry-based learning encourages students to actively explore, investigate, and construct their understanding of concepts through hands-on activities, experimentation, and problem-solving. It promotes the development of critical thinking skills, reflection, and metacognition, which are central tenets of constructivism.

Within the Constructivist Learning Theory framework, the Zone of Proximal Development (ZPD) by Lev Vygotsky could also be relevant. The ZPD refers to the difference between what a learner can achieve independently and what they can accomplish with guidance or assistance from a more knowledgeable individual, such as a teacher or peer. In an inquiry-based learning setting, teachers can provide scaffolding and support to help students navigate challenging tasks and gradually build their understanding of magnetism and electricity concepts.

By employing the Constructivist Learning Theory as a theoretical framework, the study can explore how inquiry-based learning fosters students' active engagement, knowledge construction, and the development of critical thinking skills. It can also examine the role of social interactions and instructional support in facilitating learning and academic performance in electricity and magnetism concepts.

2.2 Conceptual Framework of the Study

Figure 1 shows a diagrammatic representation of the conceptual framework of the study. It involves three main stages. These are the input stage, the process stage and the output stage.

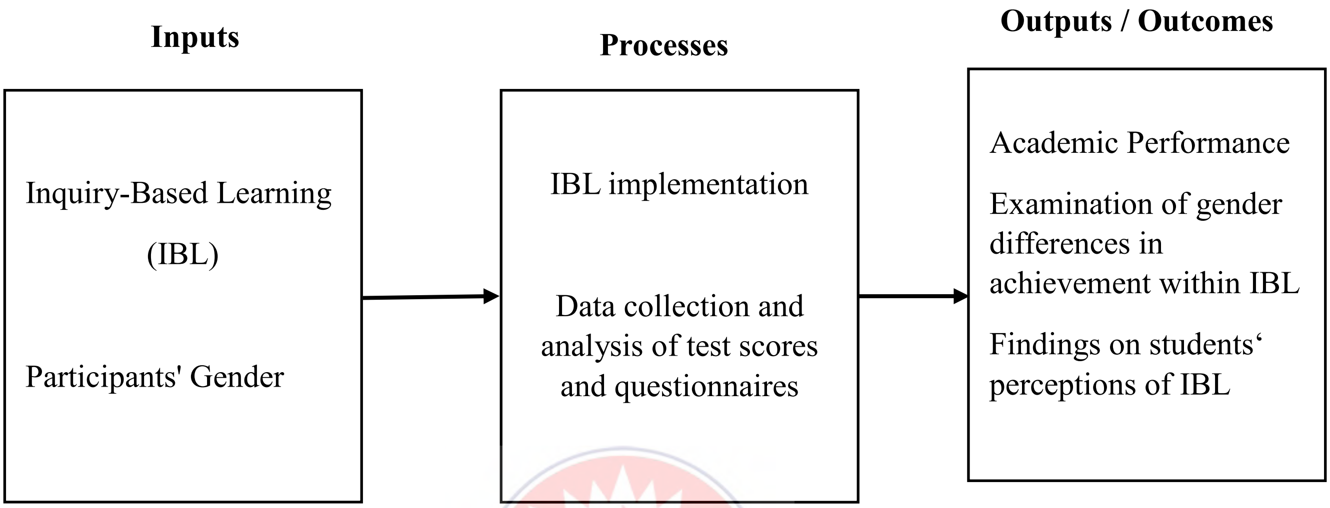

Figure 1: Conceptual Framework Underpinning the Study

2.2.1 Input stage

In this action research, the main area of interest is the introduction of inquiry-based learning methods into the teaching of magnetism and electricity concepts. Inquiry-based learning involves guiding students to actively explore and understand concepts through hands-on experiences, critical thinking, and problem-solving. Additionally, the gender of participants is considered a potential factor that could influence how the inquiry-based learning approach impacts their academic progress.

2.2.2 Process stage

The heart of this research involves the implementation of inquiry-based learning strategies within the classroom environment. This means that rather than relying solely on traditional lecture-style teaching, students will engage in interactive activities and discussions. These activities will encourage them to investigate concepts related to magnetism and electricity on their own, promoting a deeper understanding of the subject matter. Throughout this process, data will be collected at various stages to evaluate the effectiveness of the approach.

The data collection process begins with an initial assessment that gauges the participants' baseline understanding of magnetism and electricity concepts before the inquiry-based learning approach is introduced. As the action phase unfolds, inquiry-based learning methods are integrated into the teaching process. Data on student‘s academic performance will be collected as well as their perceptions of IBL in teaching Electricity and Magnetism Concepts

2.2.3 Output stage

During the output stage of this action research, the following insights will be gleaned: a comprehensive analysis of participants' academic progress or improvements in their understanding of magnetism and electricity concepts; a gender-based analysis aimed at comparing the effects of the inquiry-based learning approach on male and female participants, shedding light on any potential differences; and a thorough evaluation of participants' perceptions regarding their experience with the inquiry-based learning approach, providing valuable feedback for enhancing teaching practices and refining the implementation of the approach in the future.

2.3 Empirical Review of Related Studies on the Inquiry-Based Learning Approach

Choudhary and Khushnood (2021) carried out to explore the impact of inquiry-based instruction on students‘ attitudes and academic achievement towards Physics at the secondary level. A sample of 50 science students was randomly selected from the population. Pretest and posttest equivalent group experimental design was used in this study. The data was collected by administrating a pretest, posttest, and attitude towards physics questionnaire. The experimental group received inquiry-based instruction while the control group received instruction by lecture method. The performance of the experimental group on the post-test was found better than the control group. Moreover, inquiry-based instruction had a positive impact on the improvement of students‘ attitudes towards physics. The findings revealed that inquiry-based instruction is more effective than the lecture method for learning Physics. Efforts must be tailored to teach physics through the inquiry method as it helps improve attitude towards physics and enhance academic achievement.

Issaka (2020) investigated the impact of using inquiry-based teaching methods on students‘ academic achievement and retention of concepts in integrated science against the traditional method in some selected senior high schools in the Obuasi Municipality. The study also investigated the difference in the mean achievement score between male and female students taught integrated science using inquiry-based methods. The sample for the study was 292 students in SHS two from Christ the King Catholic Senior High School and Obuasi Secondary Technical in the Obuasi Municipality. The sample was obtained through a random sample technique. The experimental group received instructions in integrated science using the inquiry-based method of teaching whereas the control group were taught with the traditional method. The data were collected through the use of a pretest-posttest research design and were analysed according to the research question for the study. The main research question for the study was: What is the effect of the inquiry-based method of teaching on students‘ achievement and retention of concepts in integrated science? The results from the study indicate that the students in the experimental group performed better than the students in the control group. The findings also show that students who were instructed with the inquiry-based method have higher retention capacity than their counterparts' students who were exposed to the traditional method. There was a slight gender disparity in the achievement and retention capacity of both male and female students taught integrated science with inquiry-based methods in favour of the male. This means that the inquiry-based method is very rewarding to students in terms of achievement and retention regardless of gender.

Enebechi (2021) investigated the effect of the Inquiry-based Learning Approach on Senior Secondary School Students' retention in biology. The influence of gender on the mean retention scores of students when taught biology with inquiry-based learning (IBL) approach was also investigated in the study. The interaction effect of gender and strategy was also investigated. Two research questions were posed and three null hypotheses were formulated to guide the study. Quasi-experimental design of a pre-test post-test non-equivalent control group was used for the study. The population of the study comprised 2624 SS II biology students. A sample size of 139 SS II biology students was used for the study. Two instruments were used for data collection in this study namely: Biology Achievement Test (BAT) and Biology Retention Test (BRT). The same test (BAT) was used as a pretest, posttest, and retention test (RT). At each stage after the pre-test, the items were reshuffled. The research questions were answered using mean and standard deviation, while Analysis of covariance (ANCOVA) was used to test the hypothesis at a 0.05 level of significance. The results of the study revealed that the IBL approach is more effective than the conventional approach in enhancing students' retention in Biology. Secondly, the IBL approach enhances gender parity as it concerns students' retention in Biology. Based on these findings, the educational implications were identified and highlighted. It was recommended among others that Biology teachers should adopt the use of an inquiry-based learning approach in their lessons to enhance students' retention ability in biology.

Njoroge et al. (2014) examined the effects of an inquiry-based teaching approach on Secondary School Students' achievement and motivation in Physics in Nyeri County, Kenya. The study adopted a quasi-experimental research design. Solomon-four non-equivalent groups design was involved. A stratified random sampling technique was used to select four boys' and four girls' at county secondary schools in Nyeri, County. The four schools in each category were assigned to treatment and control groups by simple random sampling technique. Each group had one boys' and one girls' county secondary school. Each school provided one form two class for the study and a total of 370 students were involved. Students in all the groups were taught the same physics content but the experimental groups were taught using the IBL approach while the control groups were taught through Regular Teaching Methods (RTM) such as lecture method and teacher demonstrations. The experimental group I and the control group II were pre-tested before the implementation of the IBT treatment. After four weeks, all four groups were post-tested using the Students' Physics Achievement Test (SPAT). The instrument had been validated by five experts in education and pilot-tested before use to estimate its reliability. The reliability coefficient using K-R21 was 0.87. The acceptable threshold for the reliability coefficient is 0.7 and above. The instruments were scored and data were analyzed using a t-test, one-way ANOVA and ANCOVA at a significance level of coefficient alpha (α) equal to 0.05. The findings of the study showed that the Inquiry-Based Teaching (IBT) approach resulted in higher student scores in achievement in physics.

Abdi (2014) examined the effect of inquiry-based learning methods on students' academic achievement in science courses. A total of 40 fifth-grade students from two different classes were involved in the study. They were selected through the purposive sampling method. The group which was assigned as the experimental group was instructed through an inquiry-based learning method whereas the other group was traditionally instructed. This experimental study lasted eight weeks. To determine the effectiveness of the inquiry-based learning method over traditional instruction, an achievement test about sciences which consisted of 30 items was administered as pre-test and post-test to students both in the experimental and control groups. For the statistical analysis, Analysis of Covariance (ANCOVA) was used. The results showed that students who were instructed through inquiry-based learning achieved a higher score than the ones who were instructed through the traditional method.

Mwenda and Ndayambaje (2021) examine the effect of inquiry-based teaching on secondary students' academic achievement in Biology. A total of 94 Form Three students from two different secondary schools in the Ilala district in Dar es Salaam – Tanzania were involved. A pre-test and post-test quasi-experiment research design was adopted for the study where students in one school were involved in inquiry-based teaching and those from the other school were conventionally instructed. To determine the effect of inquiry-based teaching, an achievement test in coordination in plants was administered as a pre-test and post-test to both groups. The test generated quantitative data that was analysed through descriptive statistics and inferential statistics where independent samples T-test was used. Findings indicated that students taught through inquiry-based teaching performed better than those taught through conventional methods.

Assuah et al. (2022) examined the effect of inquiry-based learning on senior high school

students achievement in plane geometry using the pre-test-post-test randomized experimental design. The one-way ANOVA after inquiry-based learning showed a significant effect on student scores, $F(1, 118) = 363.41$, $p < .05$). Furthermore, independent samples t-test findings for the post-test showed statistically significant differences between the experimental and control post-test scores ($t = -22.68$, $p< .05$, C. I = [-24.29, 20.40]). The study implies that students can make connections with the content they learn. They may also comprehend the themes rather than simply recalling rules and formulas. The study concludes that inquiry-based learning improves senior high school students‟ achievement in plane geometry.

None of the literature above studies focused on the effect of inquiry-based learning on students‟ academic performance in electricity and magnetism in the Ghanaian setting, hence this study was conducted to fill this gap.

2.4 Concept of Academic Performance

Academic performance is a multidimensional construct composed of the skills, attitudes, and behaviours of a learner that contribute to academic success in the classroom (Hijazi & Naqvi, 2006). The implication of this definition is underscored by research which repeatedly demonstrates that the vast majority of students who withdraw from school do so for no reason other than poor academic performance (Hijazi & Naqvi, 2006). A student‟s academic performance is an objective score of attainment after a specified instructional program. Academic performance is seen as the knowledge attained or skills shown in the school subject. To indicate such performance, test scores or marks are assigned by the teachers. It is the institutional evaluation of the classroom work based on the grades awarded. Academic performance according to Akinboye (2004), is of two categories that are positive (good) and negative (poor) performance.

Academic performance as a variable in students' learning has been an area of concern in present-day research. Ogunduku and Adeyemo (2010) defined academic performance as the exhibition of knowledge acquired or skills developed by students in the school subjects. It is the degree of performance in the subject as exhibited by a student. Academic performance is the exhibition of knowledge attained or skills developed by students in the school subject usually designed by test scores or by marks assigned by teachers which can be low or high. Academic performance means how well one does in school. Poor grades are considered bad academic performance.

According to Cambridge University Report (2003), Academic performance is usually described in terms of examination scores. Academic performance refers to what skills the student has learned and is usually measured through an assessment like performance tests, performance assessments and portfolio assessments (Santrock, 2006). The assessment provides information on the anecdotal report of the student`s academic performance over a given period. Academic performance which is measured by the examination results is one of the main objectives of the school. Academic performance involves three concepts; the ability to study, retain and recall facts, being able to study effectively and see how facts fit together and form larger patterns of knowledge and being able to think for yourself concerning facts and thirdly, being able to communicate (Coulson, 2008). According to Pruett (2010), is the level of performance attained via the combination of inputs from students' motivation and conduct. Adediwura and Tayo (2007) asserted that academic performance is generally referred to how well a pupil is accomplishing his or her tasks and studies, but there are quite several factors that determine the level and quality of pupils` academic performance. This, no doubt supports the view of Nicholas (2004) that the most current information on improving academic performance shows that there are three conditional influences linked to levels of academic performance among school pupils.

These influences according to the information include high-quality parenting (the degree to which a young star is provided with an enriched, warm and responsive learning and home environment), high-quality child-care environments (stimulating activity and nurturing as reflected in high-quality parenting) and high-quality first-grade classrooms (with a focus on literacy instruction, evaluative feedback, instructional conversation, and encouraging child responsibilities).

The Academic Performance Index (2013) revealed that academic performance is how students deal with their studies and the responsibilities given to them by their teachers. Louis (2012) indicated that academic performance is the ability of students to obtain high grades and standardized test scores in school subjects, especially subjects that are part of the core academic curriculum. Lavin (2001) gives an objective definition of the term academic performance as traditionally used, the term academic performance refers to some method of stating or expressing a student‘s academic rank. Generally, this is a grade for a particular subject area or an average for all subjects expressed on a 0-to-100 or another quantitative scale.

Ijaiya (2014) noted that academic standard refers to what students should be able to know and be able to do. It should provide explicit expectations for students at each grade level along with an explicit description of the content knowledge and academic skills that are required. Also, Oloyede (2006) noted that academic performance is the actual performance of students in academic subjects and basic knowledge. Bello (2006) stated that examination is the most viable instrument to measure students‘ academic performance. Oloyede (2006) opined that the outcome of the examination results will determine who gets promoted to the next class or otherwise.

Abdul (2002) defined academic performance as the student‘s level of attainment in the grade point average of subjects offered in his/her year examination. Adefila (2004) had written answers to graded questions or exercises in one of the most popular, reliable and convenient methods of assessing students‘ progress and performance. It was further asserted in the same study that questions and exercises reflect the content of the lesson and help considerably towards objective assessment of the student‘s academic output. Oke (2003) stated that students' academic performance is germane to their performance in academic endeavours. He asserts that students‘ academic performance is the measure of how well they have mastered the learning tasks presented to them the way they handle controversial issues and pass relevant judgment and the level at which they pass an examination. In the same vein, Oloyede (2006) asserted that students‘ academic performance is the main focus of overall educational performance. Academic performance is referred to as educational outcome. It is a yardstick used to determine how far a student has mastered a subject of study within a given period. Academic performance is a viable tool that can be used to determine and predict the standard of any educational system in Nigeria in terms of its efficiency and effectiveness. It portrays the quality of education offered in Ghana.

Popoola (2010) defined academic performance as an expression used to present a student's scholastic standing and which is a function of various factors such as the method of teaching, teachers‘ qualifications, child's home background, school environment, attitude, and interest among others.

Academic Performance is described as the quality and quantity of a student`s work (Akanni, & Feyisetan, 2011) defined academic performance as what encompasses the student`s ability and performance. The researchers express the outcome of learning that has been acquired by the learner which may be in the form of poor academic performance or good academic performance. They further expresses the delivery of the skills and knowledge that has been learnt in the school setting and this can be known through the testing of the school pupils, by giving them some questions to respond to either in writing or oral form, from which the academic performance can be ascertained or determined. Academic performance is an objective score of attainment after a specific instructional program (Yara, 2009).

2.6 Some Studies on Students' Conceptual Understanding of Electricity and Magnetism

Several types of research show that students have misconceptions and many common difficulties in understanding concepts related to electricity and magnetism topics (Li, 2012; McColgan et al., 2017; Li & Singh, 2017). Most of the reported studies have been conducted on students while few involved physics teachers (Gunstone et al., 2009; Van der Merwe & Gaigher, 2011). While conducting their research using conceptual understanding tests and semi-structured interviews, Küçüközer and Kocakülah (2007) identified some additional misconceptions to already identified students‘ misconceptions about simple electric circuits through literature. Those newly identified students‗ misconceptions are the idea that ―no bulb lights if the switch is off" and ―bulbs connected in parallel give better light than those connected in series". It was argued that the misconceptions were most likely due to students‗ everyday languages and prior teaching as highlighted in the literature (Küçüközer & Kocakülah, 2007).

Likewise, Turgut et al. (2011) found that a considerable number of students have misconceptions about electric current concepts. Students could not distinguish between some concepts such as potential difference, current, power, and energy because they were using them interchangeably (Turgut et al., 2011). Authors argue that most of these misconceptions are originated from students‗ experiences of daily life.

Moreover, the reported potential sources of misunderstandings were instructional practices, textbooks and excessive reliance on daily language (Turgut et al., 2011). In 2009, Glauert conducted a qualitative study on twenty-eight learners aged five and six by using interviews and field notes to investigate how young children understand electric circuits. These children were shown different circuits and asked to predict whether those circuits would work and explain why (Glauert, 2009). Even if the relationship between practical competences, predictions and explanations was found to be not straight forward for these children, the range of responses showed similarities to those of older students reported in previous research (Glauert, 2009). T

A study conducted by Husain et al. (2012) on first-year electrical engineering students using concept tests and interviews revealed that students relied heavily on Ohm‗s law. Students considered the current to be a prime concept. Students believed that when there is no current, there is also no voltage and therefore no resistance (Hussain et al., 2012). Both teachers and students have been reported to hold some misconceptions that are hard to give up especially when they had such beliefs for a long time.

The study conducted by Gunstone et al. (2009) on eight senior secondary school physics teachers and three authors of physics textbooks that were in use during the period of investigation revealed a wide range of perceptions among physics teachers about difficulties of both the concepts of direct current (DC) electricity and the instructional methods used to teach the subject matter (Gunstone et al., 2009). For some teachers and one author, the levels of conceptual understanding of the concepts of DC electricity were of particular concern. The connection between the extent to which interviewed physics teachers understood concepts of DC electricity themselves, their perceptions of learning electricity, and the difficulties of teaching electricity were found to be weak. Some teachers considering this area easy to teach tended to have simple views of learning and understanding of concepts of DC electricity, while those with more informed views of learning tended to have a better understanding of the concepts of DC electricity and a good judgment on difficulties of teaching this area (Gunstone et al., 2009). The authors claimed that the found inadequacies among teachers would most likely be associated with inadequacies in the contents and quality of undergraduate physics teaching. It was found that some undergraduate physics programs focus more on complex mathematical representations and solutions to more complex problems while little or no attention is paid to concepts such as voltage, potential difference, and electromotive force (Gunstone et al., 2009). Even if the reflection on the nature of complex and abstract physics concepts is expected for undergraduate study, two physics teachers showed clearly that the experience of being interviewed led them to reflect on the nature of some concepts of DC electricity for the first time. Therefore, the expectation of reflection on the nature of complex and abstract physics concepts was not met by either of these physics teachers (Gunstone, et al., 2009). A study revealed that some of the students�Ÿ misconceptions and difficulties are not adequately addressed by traditional teaching methods (McDermott & Shaffer, 1992). So, further work on teaching and learning activities to help rectify students‟ misconceptions is needed (Hussain et al., 2012).

2.7 Identification of Students' Misconception in Electricity and Magnetism

One of the aims of physics education research is to determine how to assist students in their understanding of the discipline. This includes determining what difficulties and misconceptions students have with physics concepts, why they have these difficulties and misconceptions, and how to address these difficulties and misconceptions (Turgut et al., 2011; Moodley & Gaigher, 2019).

The assessment of the student‟s learning is of critical importance in terms of revealing effective pedagogical learning tools and strategies. Formative assessments designed to enhance teaching and learning help teachers and students to seek information about the state of the student‟s learning and then use the acquired information to adapt teaching and learning to meet the student‟s needs (Dufresne & Gerace, 2004). Formative assessments should be frequently arranged during instruction in various forms to monitor learning progress as highlighted in the literature (Yadav, 2005). In fact, by using validated physics surveys on various topics, one can probe the extent to which students master those concepts after traditional instruction and assess innovative curricula and pedagogies (Li & Singh, 2017).

Several assessment tools currently exist in physics education. Those assessment tools have been designed to cover different physics domains including force (Hestenes et al., 1992), direct current (Engelhardt & Beichner, 2004), electricity and magnetism (Maloney et al., 2001; Ding et al. 2006; Turgut et al., ,2011). This section provides some conceptual tests and assessments designed to test students' misconceptions of electricity and magnetism. The Conceptual Survey of Electricity and Magnetism (CSEM) is one of the broad survey instruments designed in 2001 by Maloney et al. (2001) to assess students‘ knowledge of electricity and magnetism. This survey consists of a 32-question, multiple-choice test (Maloney et al., 2001). While designing CSEM, the authors were interested in designing a qualitative instrument that would allow them to assess both students‘ initial knowledge of electricity and magnetism and the effect of various forms of instruction on changing students‘ initial knowledge facilitating comparisons among courses and instructional methods (Maloney et al., 2001).

Engelhardt & Beichner (2004) designed two versions of the Determining and Interpreting Resistive Electric Circuit Concepts Tests (DIRECT) to assess students‘ understanding of a variety of DC resistive electric circuit concepts. These tests could be useful in evaluating curriculum or instructional methods as well as providing insight into students‘ conceptual understanding of DC circuit phenomena (Engelhardt & Beichner, 2004). The Electrical Current Conceptual Tests (ECCT) are other multiple tests that have been developed to investigate 10th-grade students‘ understanding of electric current (Turgut et al., 2011). Teachers have been recommended to use these tests for even formative evaluation. Even though these multiple tests cannot investigate students‘ answers in deep, they can be easily administered to a large number of students. Moreover, they are objective due to scoring and can be easily analyzed. Therefore, instead of using interviews, one-phase tests, and two-phase tests, the researcher may prefer to use three-phase tests (Turgut et al., 2011).

Moreover, in their study, McColgan et al. (2017) used the Parallel Circuit Conceptual Understanding Test (PCCUT) to test students' conceptual understanding of parallel resistors. Moreover, the same test was used to explore the possibility of profiling students according to their understanding. The PCCUT instrument focused on six domains including the meaning of parallel, practical knowledge of current, voltage, resistance, circuit connection as well and mental model (McColgan et al., 2017). It was argued that PCCUT is a valid and reliable instrument to measure students' basic knowledge and identification of their difficulties in parallel resistors before they start the introductory course in electricity.

The Electricity and Magnetism Conceptual Assessment (EMCA) is another test that has been designed to assess students' conceptual understanding of electricity (McColgan et al., 2017). Li and Singh (2017) have also developed and validated a 30-item multiple-choice test on magnetism called Magnetism Conceptual Survey (MCS). This test was designed to assess introductory physics students' understanding of magnetism concepts and to explore the difficulties students have in interpreting magnetism concepts (Li & Singh, 2017). The following section reports some possible remedies to overcome students' misconceptions about electricity and magnetism

2.9 Remedies to Overcome Students' Misconceptions in Electricity and Magnetism

Successful implementation of teaching strategies to help students overcome their misconceptions requires knowledge about students' possible misconceptions and their prior knowledge (Turgut et al., 2011). Teachers need to identify students' prior knowledge and misconceptions before introducing the new concept to students. This will ease the identification of appropriate teaching strategies helping students to overcome their misconceptions (Uwizeyimana et al., 2018). However, being aware of students‘ misconceptions is not enough for teachers to correct those misconceptions as they may even emerge during instruction. Therefore, good guidance will help students to avoid misinterpretation of the new concepts leading to modification of what they are taught and observed based on prior knowledge (Li, 2012). After introducing new ideas or cultural tools where necessary and providing support and guidance for students to make sense of these new ideas for themselves, teachers have to listen and diagnose how the instructional activities are being interpreted to inform further action (Driver et al., 1994).

Different instructional strategies have been used to improve students‘ conceptual understanding of electricity and magnetism. However, a key question that remains largely unanswered is whether instructional strategies that yield high conceptual understanding gains represent permanent impacts or if their effects are long-lived (Pollock, 2009). It has been reported that by using pre-post testing, there is a possibility that students‘ performance might represent some form of conceptual rote learning which would likely disappear over time scales much beyond the examination schedule of individual classes (Pollock, 2009). Therefore, there is great interest in research investigating the effects of instructional strategies to improve students‘ conceptual understanding of electricity and magnetism.

One of the proposed remedies for students‘ misconceptions about electricity and magnetism is the identification and clarification of students‘ prior knowledge and misconceptions. This is done by using questionnaires before the introduction of electricity and magnetism lessons. This strategy allows educators to explain related concepts with correct reasoning to help students to get rid of those misconceptions. The success of this approach requires good content knowledge on the topic for educators, libraries and well-equipped laboratories (Muthiraparampil, 2012). In fact, by using this approach, teachers can easily guide students to gain scientifically accepted conceptions by using appropriate teaching methods to help students overcome their misconceptions (Turgut et al., 2011)

Constructive approaches like problem-based learning (PBL) and inquiry-based approaches which are student-centred were also recommended to enhance students' knowledge of electricity and magnetism (Afra et al, 2009). One reason for the broad, intuitive appeal that has driven the growth of constructivism as an instructional model may be that it includes aspects of Piagetian and Vygotskian learning theories; explicitly, the importance of determining prior knowledge, or existing cognitive frameworks to drive conceptual change (Cakir, 2008). According to Cakir (2008), conceptual change can be seen in terms of recognizing, evaluating, and reconstructing. The individual needs to recognize the existence and nature of their current conceptions decides whether or not to evaluate the utility and worth of these conceptions, and whether or not to reconstruct these conceptions (Cakir, 2008). A model of conceptual change that was developed by Posner et al. (1982) at Cornell University describes learning as a process in which a learner changes his/her conceptions by capturing new conceptions or exchanging existing conceptions for new ones (Cakir,2008). Research reported that there are analogous patterns of conceptual change in learning. For the conceptual change model, sometimes students assimilate new concepts by using existing concepts to deal with new phenomena. However, when the students' current concepts arc inadequate to allow them to understand some new phenomenon successfully, they have to replace or reorganize their central concepts by using accommodation (Cakir,2008). One of the different conditions of the accommodation process to take place is that there must be dissatisfaction with the existing conceptions. An individual has to hold a store of unsolved puzzles or anomalies and lost faith in the capacity of his current concepts to solve these problems. Secondly, the individual must be able to grasp how experience can be structured by a new concept sufficiently to explore the possibilities inherent in it. Moreover, any new concept adopted must at least appear to have the capacity to solve the problems generated by its predecessors. Finally, the new concept should have the potential to be extended. to open up new areas of inquiry (Cakir, 2008)

Furthermore, other actively engaging teaching methods including concept maps (Cakir, 2008; Turgut et al., 2011), demonstrations, cooperative learning and hands-on activities that can address students‘ misconceptions have been highlighted (Turgut et al., 2011). The Interactive Engagement (IE) methods that have been introduced to bridge the gap between conceptual understanding and problem-solving ability may also help students overcome their misconceptions (Gok, 2012; Li & Singh, 2017). The IE methods are those methods designed at least in part to promote conceptual understanding through the interactive engagement of students in heads-on and hands-on activities which yield immediate feedback through discussion with peers and/or instructors (Gok, 2012). Peer instruction, tutorials, and simulation activities are some methods of interactive engagement methods. Peer Instruction has been reported to be effective in increasing students‘ mastery of both conceptual reasoning and quantitative physics problem-solving (Mbonyiryivuze et al., 2018).

Peer Instruction is one of the popular pedagogies that was developed and popularized by Mazur at Harvard University in 1991. While developing Peer Instruction, Mazur could improve his Harvard undergraduates‘ conceptual understanding of introductory physics (Gok, 2012). Peer Instruction is a widely used pedagogy in which lectures are interspersed with short conceptual questions (ConcepTests) designed to reveal common misunderstandings and to actively engage students in lecture courses (Fagen et al., 2002). The fundamental goal of implementing a peer instruction strategy in class is to exploit student interaction during lectures and focus students‘ attention on underlying concepts (Fagen et al., 2002). Besides emphasizing physics concepts, this teaching method is also used to achieve students' performance in physics problem-solving (Yadav, 2005). For peer instruction, lectures consist of several short presentations on key points. Each presentation is followed by a ConcepTest which is a short conceptual question on the subject being discussed (Yadav, 2005). The students are first given time to formulate answers and then asked to discuss their answers with each other. Using this teaching method, the students are forced to think through the arguments being developed. Moreover, this provides a way to assess students' understanding of the concept for both students and teachers (Fagen et al., 2002). Peer Instruction has been acclaimed to be an easy-to-use method that fosters active learning in secondary schools, undergraduate, and graduate classrooms across the globe (Schell & Butler, 2018). Research has confirmed that courses that integrate Peer Instruction produce greater student achievement compared to traditional lecture-based courses. Moreover, Peer Instruction has been reported to produce a host of valuable learning outcomes, including better conceptual understanding, more effective problem-solving skills, increased student engagement, and greater retention of students in science majors (Schell & Butler, 2018). It was recommended by

(Yadav, 2005) that formative assessment should be frequently arranged during instruction in various forms to monitor learning progress. Moreover, he suggested that the use of ConceptTest-type questions suggested in the Peer Instruction manual (Gok,2012), checkpoints and questions provided in the Fundamental of Physics Book by Halliday Resnick and Walker (Halliday, Resnick, & Walker, 1997) can be useful.

2.10 Concept of Inquiry

According to Bogar (2018), the term inquiry pertains to the general attributes of student-directed questioning and problem-solving. Llewellyn (2005) mentioned that inquiry defines a learning process which involves an active interaction with the environment and a constant construction and reconstruction of knowledge through this interaction. Anderson (2007) pointed out that ―what is called inquiry learning in the literature is very similar to what others call constructivist learning" (p. 809). By this definition, constructivist methods of learning set the base for inquiry-based learning. Besides being student-centred, these methods operate by connecting new learning to existing cognitive structures, they are dependent on discursive, socialized instructional environments, and they involve a collaborative and cooperative learning process between students, teachers and other disciplinary masters (Bruner, 1961; Dewey, 1997; Piaget, 1972; Prince & Felder, 2006; Vygotsky, 1978). Despite having been defined in many different ways, inquiry has not been defined clearly, and neither have its uses in different educational contexts (National Research Council [NRC], 1996). To shed light on this problem, the National Research Council (2000) has published a book titled *Inquiry and National Education Standards: A Guide for Teaching and Learning*. A clear rationale for the use of inquiry in instructional settings has been provided in this book. Nevertheless, differences still exist in the way researchers interpret inquiry.

According to Anderson (2007), three different forms of inquiry exist in the National Science Education Standards (NSES), namely scientific inquiry, inquiry learning and inquiry teaching. Although they have many similarities, these three forms of inquiry are also different from one another. Firstly, scientific inquiry refers to the work of scientists, the nature of scientific investigations and science processing skills. Secondly, inquiry learning relates to an active process of learning based on constructivist learning. Lastly, although there are various types of inquiry teaching such as partial inquiry and full inquiry, the National Science Education Standards mention that there is no clear distinction between them.

The points mentioned below are noted as the fundamental features of classroom inquiry in the ―Inquiry and the National Science Education Standards”:

In the realm of education, learners are captivated and invigorated by queries steeped in scientific inquiry. These questions, rooted in the foundations of science, serve as catalysts, igniting curiosity and prompting active engagement. What sets these inquiries apart is the emphasis placed on evidence — a cornerstone that guides learners on their quest for understanding.

Evidence, regarded as the linchpin, takes precedence in the minds of these inquisitive minds. It becomes the lens through which they perceive the world, enabling them to construct and meticulously evaluate explanations. Armed with this empirical support, learners embark on a journey of formulation, crafting coherent and logical explanations that unravel the complexities of scientifically oriented questions.

Yet, the process does not culminate here. In their pursuit of knowledge, learners delve into the realm of comparative analysis, meticulously weighing their explanations against alternative viewpoints, especially those deeply rooted in scientific understanding. This critical evaluation sharpens their cognitive faculties, fostering a deep appreciation for the nuances of scientific thought.

However, the journey is incomplete without the vital element of communication. Learners, now equipped with substantiated explanations, step into the arena of dialogue. Here, they not only share their findings but also justify their propositions, articulating the rationale behind their scientific conjectures. In these moments of articulation, education transcends the boundaries of classrooms, paving the way for a generation of thinkers and communicators deeply immersed in the ethos of scientific inquiry.

This multifaceted process, as outlined by the National Research Council (2000), underscores the essence of scientific education. It nurtures not only knowledgeable minds but also discerning thinkers, individuals capable of deciphering the intricate tapestry of the world through the lens of evidence and inquiry.

The educational reforms (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996, 2000, 2012) underline that the primary objective of science education is to develop an understanding of scientific inquiry for all students until they graduate from high school. Moreover, these reforms highlight that if students develop their understanding of scientific inquiry, they will easily participate in complex practices in the science classroom. Argumentation is a significant feature of the scientific inquiry process, which is often neglected in the classroom. Argumentation in science is neither a heated dispute between rivals that result in a winner and a loser, nor an effort to reach a compromise. It is basically a mode of ~~l~~logical discourse whose goal is to tease out the relationship between ideas and evidence" (Duschl, Schweingruber, & Shouse, 2007, p. 33). As a result, scientific argumentation is the basis for the development, evaluation, and justification of scientific knowledge, and it is what makes science a different way of knowing (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002)

2.10 Inquiry-Based Learning

When educational activities are observed from past to present, it is seen that the roots of inquiry-based learning extend back to the famous philosopher Socrates and that it is not exactly a new method. Socrates pioneered this method by using the inquiry-based learning approach, also known as ―Socratic Learning" that gives the opportunity to deeply examine ideas and opinions. Inquiry-based learning, which has often been brought to the agenda since the first years of the 20th century, has been a topic taken up by many famous scientists like Dewey (1933), Bruner (1960), and Suchman (1961). Today, the focus is on teaching and learning processes that are rooted in the rapid development of scientific knowledge and on teaching ―how to learn", how to do research and find information, and how to use the information by applying inquiry-based learning. Along with individual skills, it aims to develop team work and communication skills (Bozkurt, Orhan, & Kaynar, 2008).

Inquiry-based learning is a learning approach that enables the learners to be active throughout the learning process by making them ask questions, analyze the information and inquire. It develops the skill of using scientific processes (putting forth the problems, planning experimental processes, making guesses, generating hypotheses, collecting and analyzing data and interpreting the results) and it makes the learners use their creativity (Burden & Byrd, 2003; Duran, 2015; Hammerman, 2006; Llewellyn, 2002; Marek & Cavallo, 1997; Perry & Richardson, 2001). Inquiry-based learning approach is handled as a centralized and effective approach in science education by National Science Education Standards (NSES), which is assigned by the National Research Council (NRC) in the United States. It is also described as a multi-dimensional process in which students make observations, ask questions, research the already existing information from books and other sources, plan their research, compare already existing information with experiment results, use tools to analyze, interpret, discuss and put forth hypotheses, explanations and results (NRC, 2000, 2007).

Students in science courses use inquiry not only to understand the truths about nature and the things that are happening around them but also to reach the ideas and theories that will help them in explaining the factual situations they have observed like scientists (Harlen, 2004). Thanks to inquiry-based learning, the focus of science education has changed from memorizing concepts and phenomena to effectively using both scientific processing skills and critical thinking skills (Zacharia, 2003) because inquiry-based science learning moves away from book-based, passive observations of phenomena, directly focuses on teaching the principals and laws of science, and adopts a student-based, active understanding that makes students develop their research by thinking on their own (Jorgenson, Cleveland, & Vanosdall, 2004). In science courses where inquiry is the focus, students not only learn science topics, but also skills such as logical thinking, asking questions, doing research and solving daily problems (Germann, 1994). Howe (2002) stated that the use of inquiry-based learning approach in science teaching in all levels of education is highly suggested and explained the rationale of inquiry-based learning as making students acquire the ability to ask questions, determine the learning material, collect information about the unit and reach conclusions. He also stated that when the students are given the opportunity to discuss the results, learning becomes more meaningful and permanent.

Many researchers stated that inquiry-based learning approach is effective in making students learn to do scientific research like scientists and in developing their higher-level thinking skills (Walker & Zeidler, 2007; Wenk, 2000). Llewellyn (2002) stated that the inquiry-based learning approach makes students gain the required skills to become free individuals and life-long learners. Martin, Sexton, Franklin and Gerlovich (2005) indicated that in inquiry-based learning, examining, inquiry and discovery processes are indispensable for an effective science education. They also stated that students grow up to become individuals who learn how to learn when they structure their learning with these processes. According to Tatar (2006), students develop their psycho-motor skills by interacting with instruments and develop their cognitive skills by paying attention to the process and interpreting cause-effect relations. Lawson (2010) defended that inquiry-based learning approach develops students‛ creativity, academic success, critical thinking skills and problem-solving skills by putting forth many research findings. In addition to these, inquiry-based learning approach is effective on the development of scientific literacy and understanding of scientific processes (Alkan-Dilbaz, 2013; Domjan, 2003) strengthens vocabulary and conceptual knowledge (Lloyd & Contreras, 1987), develops critical and creative thinking skills (Babadoğan & Gurkan, 2002), develops their understanding of the nature of science (Bianchini & Colburn, 2000), and enables them to have a positive attitude towards science and science education (Narode et al., 1987).

Since it is a student-centred learning approach that prioritizes critical thinking, solving problems, making decisions and asking questions, inquiry-based learning allows students to develop the skills they need throughout their lives. Thus, it helps students to handle the problems they encounter (Branch & Solowan, 2003). One of the skills that is used and developed in the process of inquiry-based learning is the skill of creative thinking. Creative thinking skill enables the individual to approach events from different perspectives, understand them differently and enables them to think about what hasn‘t been thought. In inquiry-based learning, creative thinking is required to generate hypotheses about the stated research problem. Creative thinking skills need to be used in trying to apply new methods for collecting data, creating solutions and reaching a conclusion by interpreting findings (Hassard, 2005; Lim, 2001).

In activities based on inquiry, students investigate the events and phenomena both individually or in groups and reach conclusions. Students manage the research activities by themselves, ask questions, plan new activities, create conclusions and confirm the information that they have learned (Branch & Oberg, 2004; Bransford et al., 2000; DeBoer, 1991; De Jong & Van Joolingen, 1998; Jensen, 1998; Lawson, 1995). This situation makes students take responsibility, express themselves and increase their self-confidence. If students are provided with research experiences, positive changes can occur in both their cognitive structures and their attitudes towards science (Basaga, Geban, & Tekkaya, 1994).

Individuals who get the taste of learning and who are active in the process of learning by inquiry-based learning would desire to sustain this for the rest of their lives. They would take their places in society as solution-oriented, productive individuals who act bravely against the problems they face. After all, inquiry-based learning aims to prepare the learners as researchers, problem finders, problem solvers, thinkers who make their interpretations and individuals who are confident in their fields (Mui, 2010; Spronken-Smith et al., 2008).

Since scientific inquiry is a process that focuses on research instead of conclusions, it is very important for teachers who apply this method to help the students focus on the research itself instead of reaching absolute conclusions (Lim, 2001). Even though it is an undeniable fact that the most original scientific reasoning is the one in which students create their own questions, plan their experiments and reach conclusions by collecting data, when students' age groups and levels are considered, learning environments in which questions and data are given and students take an active part in analyzing and reaching conclusions are also based on scientific inquiry.

Inquiry-based learning can be applied by using different learning methods in the scope of the constructivist theory such as project-based learning, problem-based learning, cooperative learning and example-based learning. These methods start with a problem and stress the process of creation of information by students. All these methods include inquiry in different forms. These methods that support inquiry and constructivist approach make students learn science meaningfully (Brooks & Brooks, 1993; Eick & Reed, 2002; Mintzes et al., 1997; Tobin & Tippins, 1993).

For learning-teaching processes that are structured by inquiry-based learning approaches to reach their aims, both students and teachers have to know the roles that they were given in the process and fulfil their responsibilities.

2.11 Types of Inquiry-Based Learning

In literature, it is seen that there are different levels of learning inquiry, and teachers are classified with different names when the roles that they take on are considered (Herron, 1971; Schwab & Brandwein, 1962). The most widely accepted classification is the one done by Colburn (2004). According to Colburn (2004), there are three main types of inquiry-based learning: structured inquiry, oriented (guided) inquiry and open inquiry.

2.11.1 Structured Inquiry

It is the type of inquiry in which the teacher determines the subjects and teaches the subjects step by step. Here, the teacher can structure and limit the scope of subjects and activities (Bogar, 2018). This method is accepted as a teacher-based method since the teacher takes on an active role in the process. The teacher determines and provides everything, from the question he or she asks to the research method, from answering the questions to the method itself (Keller, 2001; Spaulding, 2001). Just like cooking a dish by looking at a book of recipes, these types of inquiries are made by students as they are. It is often used in classes since it is more convenient for teachers. These are not the types of inquiry where students need to think when inquiring. Students are not mentally active in these inquiries. Thus, students may become demotivated during the process (Keller, 2001).

2.11.2 Guided Inquiry

It is stated by some researchers that this type of inquiry is a combination of structured and open inquiries (Bogar, 2018). In this type of inquiry, the teacher states the focal questions and supervises the approaches that students use when answering these questions. Here, the teacher guides the students in choosing materials, research techniques, etc. and asks questions (Bogar, 2018). The teacher does not directly give information to students but structures the new problems intended for the solutions of the problem he/she has asked. The teacher helps the students become responsible for their actions and learning (Bogar, 2018). The students investigate the given questions, create solutions and make generalizations. Students gain inquiry skills for the inquiries that they will make independently in the future. In the guided inquiry process, the activity of asking questions is done by the teacher and the activities of planning the process and acquiring results are done by students (Colburn, 2000; Colburn, 2004; Gormally, Brickman, Hallar, & Armstrong, 2011; Lim, 2001; Llewellyn, 2002; Martin-Hansen, 2002; Olson & Loucks-Horsley, 2000; Spaulding, 2001; Tatar, 2006).

2.11.3 Open Inquiry

It is the highest level of inquiry where students decide what is important in the subject that they are learning and determine the activities and the research by themselves (Bogar, 2018). It is accepted as completely student-centred. Here, since the students even determine the subjects that they will learn, a true process of working like a scientist is observed. Therefore, in the process of open inquiry, the activities of asking questions, planning the process and reaching conclusions are done by the students, and they are directly responsible for their learning (Blanchard et al., 2010; Keller, 2001; Llewellyn, 2002; Tatar, 2006). Thus, the teacher has a smaller role in this type of inquiry

2.12 Models that are used in the Process of Inquiry-Based Learning

Inquiry models are presentations that are created to understand how events that cannot be directly observed occur (Branch & Oberg, 2004). Inquiry models support the roles of teachers and students and can be used for many purposes in education (Donham, 2001). Various educational models were designed to be used in inquiry-based learning approaches. Educational model means an organized application that includes the organization of some steps, movements and decisions for education. Educational models are created considering the nature of research, scientific information, process of science and the purpose of learning (Carin & Bass, 2001).

Even though there are differences in the application of these models, the main focus of them all is to guide students in understanding the nature of science. When these models are investigated, it is seen that they are based on the constructivist theory (Bybee, 1997; Carin & Bass, 2001; Eisenkraft, 2003; Lawson, 1995; Llewellyn, 2002). Some of these models are as follows:

2.12.1 John Dewey's Inquiry-Based Learning Model

In Dewey's model, in the first ―asking questions" stage, students' enthusiasm is raised by questions that would make them think and their sense of curiosity is increased for discovery. In the second stage, they collect raw information by starting to do research. In the third stage, the configuration of the knowledge is realized by combining and relating the collected information and preliminary knowledge through new thoughts, ideas and experiences. In the third ―discussion" stage, the knowledge is shared with other individuals, and the results are compared. Projection, which is the final stage, is the remembering of the whole process (Çepni, 2005).

2.12.2 Guided Discovery Model

Students who are newly starting to learn through research can feel constrained and may need a guide until they achieve inquiry skills. Also, from the perspective of the teacher, they can feel constrained by the freedom that the students are given until they gain the necessary research skills since they are used to receiving the information passively (Bogar, 2018). It is very convenient to use the guided discovery model to avoid these situations. With this model, by learning the ways of thinking, the students gain the ability to do research independently in the future (Howe & Jones, 1993).

Throughout the process of discovery, students think about the potential ideas and create their ideas. Students are given freedom by the teacher to solve problems. However, they are also guided during the process. Instead of directly telling them what to do during the research, they are guided to create their discoveries through questions or clues (Şensoy, 2009).

2.12.3 E Model

Stages of the 3E Model developed by Lawson (2010):

1. *Exploration:* In this stage, students learn to do research and make discoveries through their studies. The teacher does very little guiding at this stage. Students try to solve the problems by trying to develop different perspectives.
2. *Explanation:* It is the stage where the concepts that were used in the exploration stage are explained. The explanations can also be done by the teacher.
3. *Expansion:* This is the stage where the information learned is applied to other situations. By using what they have learned properly, students make their learning meaningful and permanent (Kanlı, 2007).

2.12.4 4D Model

One of the models that is proper for effective research is the 4D Model (Coghlan, Preskill, & Tzavaras Catsambas, 2003). The steps of the model are as follows:

1. *Discovery:* In this stage, the participators have conversations and share their experiences.
2. *Dream:* Based on the information obtained from conversations, participators engage in imagination. A wide and whole-thinking activity is done with various visualizations and creative exercises.
3. *Design:* A decision is made concerning strategy, process and system regarding what was imagined.
4. *Evaluation:* The participators begin to apply the visions and private propositions that were discussed in the previous stages. This stage continues with first the participants' application of changes, then their follow-up of the process and discussions held for the new research.

2.12.5 5E Education Model

This model is based on Piaget's cognitive development model. It was shaped by constructivist learning and consists of 5 stages (Şensoy, 2009):

1. *Enter/Engage:* This stage includes the efforts that are made to attract the students' attention and invoke their enthusiasm for learning.

2. *Explore:* The aim here is to make students gain a general experience. In this stage, students who are quite active in the process make observations about the solution of a determined problem, generate hypotheses, collect data, analyze data, check the validity of the hypotheses that they have generated, put forth their ideas by working collaboratively, broaden their perspectives by listening to others and move towards creative thinking.

3. *Explain:* In this stage, the teacher asks questions and makes scientific explanations to students to make sure they have fully understood the study, explanations and commentaries that were made towards the solution of the problem.

4. *Elaborate:* This stage entails doing exercises, revising and applying what they have found out to other situations. Making what is learned more meaningful, developing knowledge and skills and deeper learning are the goals of the activities in this stage.

5. *Evaluate:* In the evaluation stage, the learned information, skills and the products made by students are examined. Students' skills of using what they have learned in different situations are evaluated. In other words, not the memorized but the absorbed is evaluated.

2.12.6 7E Education Model

The 5E Model was developed by Bybee (2003) and Eisenkraft (2003) and re-interpreted as the 7E model.

The stages of the 7E model according to Eisenkraft (2003) are explained as follows:

1. *Elicit:* This stage includes the determination and execution of the preliminary knowledge that is very effective in the learning process.

2. *Engage:* Activities that interest the students are done in the engagement stage.

3. *Explore:* In this stage, students notice the simple relations by making observations, testing hypotheses, generating new hypotheses and recording the ideas that were achieved by discussion.

4. *Explain:* In this stage, the questions ―What, Why and How" are tried to be answered.

5. *Elaborate:* In this stage, students are asked to create alternate solutions to the problem. In this process, by transferring what they have learned to new situations, problems and hypotheses, students can review some or all of the activities.

6. *Evaluate:* It is the stage where students' knowledge and skills are evaluated.

7. *Extend:* This stage includes the application of learned information to new situations and the consolidation of the knowledge

2.13 Methods and Techniques Used in Inquiry-Based Learning

When the features of inquiry-based learning are examined, it is seen that they are intermingled with and supported by some learning experiences and approaches. These learning experiences and approaches are the following:

Problem Solving: It is the scientific approach an individual uses to solve problems that seem inextricable (Owens et al., 2002). Inquiry-based learning usually starts with problems, and the inquiry process is completed by using the scientific research steps (determining the problem, defining the problem, generating hypotheses, testing hypotheses, and interpreting conclusions) that are used in solving the problems (Fansa, 2012; Owens et al., 2002).

Experiment: Experiment in science education is students' discovery process of knowledge by using instruments, doing and observing. Students use problem-solving steps and learn how to do scientific research while conducting experiments (Fansa, 2012).

Sightseeing-Observation: Through the observation technique, students gain the opportunity to examine the assets and events in their natural environment in a planned and objective way (Çepni et al., 2020). In inquiry-based learning, sightseeing observation is also a method used in testing hypotheses.

Brainstorming: It is the process of producing original and creative ideas to find a solution to problems. Since it is important to put as many different ideas as possible in the brainstorming technique and not to intervene in the formation of ideas, it is often used in inquiry-based teaching (Sönmez, 2008).

Example Case: In this method, problems that are encountered in real life are brought to class and learning experiences are enabled by finding solutions to these problems. In inquiry-based learning, the example case method is used in the first step of the loop, which is drawing attention (Çepni et al., 2006).

Discussion: This method is used to encourage students to think about a subject and explain the points that are not clearly understood (Demirel, 2004). The discussion method is often used by students in inquiry-based learning in the stages of revealing the already existent knowledge, making guesses and interpreting.

Question-Answer: It is a technique that enables the students to gain the habits of talking and speaking. The question-answer method in inquiry-based learning is a method that is used both between teachers and students and among students when they are making inquiries (Çepni et al., 2006).

Simulation: It is a teaching technique that enables the students to make educative works in class by approaching an event as if it is real (Demirel, 2004). In inquiry-based learning, since students are interested in working on an artificial situation that is similar to a real-life one, it is beneficial to use this technique to make the students learn contradictory and difficult concepts.

Role Play: In this technique, the individual puts him/herself in someone else's place by leaving his/her true role and feelings aside. The individual may also show what he/she would do and feel in a certain circumstance as a result of his/her actions. In a sense, role-playing is the demonstration and discussion of a problem by using actions (Açıkgöz, 2009).

Group Work: Students who are aiming to learn come together in groups. The individuals who participate in group work during the inquiry process gain the skills of discussion, responsibility-taking, critical and creative thinking.

Presentation: It is defined as a verbal way of communication that is used to give information about various subjects (Sönmez, 2008). The presentation method is used in the last phase of the inquiry-based learning loop.

2.14 Evaluation in Inquiry-Based Learning

Evaluation in an inquiry-based learning approach is implemented with a focus on enriched learning in order to determine what each student has learned and understood, whether there are missing or unclear information and what students can do with what they have learned, and it may pursue different goals (Bogar, 2018). In this regard, evaluation may be on a scale varying from the questions the teacher asks during lessons, to exams given at the end of units and to exams that are administered at the province or country level. In inquiry-based learning, there are two types of evaluations: *formative evaluation* and *performance evaluation.* Formative evaluation is a type of evaluation that can be conducted at any time and enables the teacher to meet students' needs in the best way possible. Performance evaluation is another type of evaluation which is conducted at the end of learning activities to determine the activities' effect on students' learning (Cianciolo et al., (2006). Even though formative evaluation is particularly significant for planning and guidance, it is not effective enough to assist in making great decisions with regards to teaching policies or vocational development planning. Concerning all these, the importance of performance evaluation can easily be observed (Alvarado & Herr, 2003).

A variety of evaluation tools can be utilized in inquiry-based learning. The most preferred of these exclusive (process-oriented / authentic) tools are student portfolios, rubrics, concept maps, monitoring charts and self-evaluation forms (Rahayu et al. 2011).

Authentic Assessments: Authentic (process-oriented) evaluations are defined as evaluation strategies which are unconventional, student-oriented, substantive, interesting and appropriate for students. Multiple choice and true-false questions serve as a tool to evaluate the information memorized by students (Llewellyn, 2002).

Student Portfolios: Student portfolios are files or envelopes including and proving students' achievements, studies, and performances they have kept or performed. Student portfolios facilitate students' study reviews according to particular criteria and make it easier to judge and evaluate any progress shown by students (Trowbridge, Bybee, & Powell, 2000).

Rubrics: Rubrics are guides that enable marking student performance criteria and performance at different levels. It is a set of pre-defined criteria to grade student exams, portfolios or performances. When rubrics are used in science and technology classes, students can clearly understand what is expected from them, and it makes the learning process much more meaningful (Korkmaz, 2004).

Concept Maps: A concept map is the graphical representation of concepts and inter-relationships between different concepts (Novak & Gowin, 1984). In an evaluation with concept maps, the grade system for a concept map could be used in different ways as an evaluation criterion. For instance, all concept map grades in class can be averaged and maps can be evaluated as ―good”, ―average”, or ―bad” (Duban & Yaşar, 2007).

Monitoring Charts: Monitoring charts are charts which include observation records of what is expected from a student during inquiries (Llewellyn, 2002).

Self-evaluation: Self-evaluation implies getting feedback from the students about how they see their individual and group performances. Self-evaluation can vary from a form of a control list and questionnaire to a format which includes the reflections that students have produced in their essays. However, all self-evaluations have one common point: students review what they have learned identify the areas where they have problems become aware of their progress and become aware of their responsibilities (Trowbridge et al., 2000).

Evaluation and learning are two inseparable processes, and they are in a cyclical relationship. In this way, the evaluation conducted after every teaching process lays the foundation for the first steps of the new learning process. When students participate in the evaluation process, they realize what is expected of them and how much they have achieved as a result of their effort, which motivates them to learn and achieve. Inquiry-based learning is a method which aims to improve students‘ cognitive, affective and motor skills.

In this context, inquiry-based learning is an appropriate method in terms of effective teaching and evaluation by making both the teacher and the students engaged, evaluating their achievements gained in cognitive, affective and motor fields, being as open-ended as possible and thus revealing dimensions that are missing as well as gains.

2.15 The Importance of Inquiry-Based Learning in Science Education

The basic benefits provided by Inquiry-Based Learning are listed below:

The integration of active learning methodologies into educational practices has proven to yield multifaceted benefits for students. Through extensive research spanning diverse contexts and periods, scholars have identified a plethora of advantages associated with active learning approaches.

One of the primary merits lies in the substantial enhancement of students' academic performance and their proficiency in interpreting data, as asserted by Mattheis and Nakayama in 1988. Active learning methodologies also serve as a catalyst for nurturing various essential skills among students. This includes the ability to collect, sort, question, and classify knowledge, thereby providing students with invaluable opportunities for intellectual growth. Scholars such as Hinrichsen et al. (1999), Rutherford and Ahlgren (1991).

Moreover, active learning ensures a lasting impact on the educational journey by promoting permanent learning, a concept championed by White et al. (1999). Quintana et al. (2005), further emphasized the significance of active learning in facilitating a profound understanding of the fundamental nature of scientific knowledge.

Beyond academic achievements, active learning techniques profoundly influence students' motivation, as evidenced by the research of Bayram et al. (2013). Furthermore, these methodologies instil crucial life skills, teaching students the art of sharing resources to collaboratively solve problems, a principle championed by Wenk (2000) and Wood (2003).

Active learning not only enriches the individual's knowledge but also nurtures habits of continuous learning. Arthur (1993), posited that active learning fosters a culture of habitual lifelong learning, encouraging individuals to remain intellectually curious throughout their lives. Moreover, Vural (2004), highlighted the importance of creative thinking in active learning, emphasizing the need for students to analyze information critically and develop problem-solving skills.

A social dimension emerges as active learning facilitates social interaction and elevates students' reasoning skills, a phenomenon explored by Shih et al. (2010). These methods empower students to comprehend the foundations of their learning process, shaping their epistemological beliefs, as articulated by Shih et al. (2010) and Wilke and Straits (2005).

Furthermore, active learning polishes essential cognitive faculties, nurturing critical thinking, scientific processing, and problem-solving skills, as observed in the studies of Bell, Smetana, and Binns (2005), Bybee (2006), and Chung and Behan (2010). It encourages students to articulate their ideas, probe into questions, and experiment with novel approaches, a concept championed by Hamm and Adams (1992).

In addition to intellectual growth, active learning significantly contributes to students' social and mental development, as highlighted by Dyasi (1999). These methodologies also elevate learning skills to higher planes, an assertion corroborated by Wilke and Straits (2005). Furthermore, active learning plays a pivotal role in enhancing students' scientific literacy, conceptual understanding, and fostering positive attitudes towards science, as evidenced by the research of Haury (1993), Lloyd and Contreras (1987), and Rakow (1986).

Active learning operates on the principle of learning by doing and living, a philosophy propagated by Tatar and Kuru (2006). This immersive approach not only boosts confidence in scientific subjects but also effectively facilitates science education, a concept explored by Brooks and Brooks (1993), Eick and Reed (2002), and Mintzes, et al. (1997).

Importantly, active learning does not discriminate based on learning speeds; it acts as a supportive framework for slow learners, as evidenced by Kyle (1980), while simultaneously challenging fast learners to hone their thinking skills, a principle emphasized by Davis (1993). Moreover, active learning initiatives play a pivotal role in cultivating a positive attitude towards science among students, an essential aspect outlined by Tsai and Tuan (2006).

In essence, active learning stands as a cornerstone in the realm of education, fostering holistic development and empowering learners with skills and attitudes that are indispensable in the dynamic landscape of the modern world.

2.16 Different Roles of Teachers in Inquiry-Based Learning

Upon examining the literature, it becomes evident that a great number of research teachers play an important role in inquiry-based teaching (Crawford, 2000; Keys & Bryan 2001; Llewellyn, 2005; Sandoval et al., 2002; Wallace & Kang 2004).

However, teachers' role in inquiry-based teaching has been expressed by researchers in various ways, some of which are as follows:

In the realm of inquiry-based learning, the teacher assumes a distinctive role, acting as a guide and facilitator in the students' journey of knowledge acquisition and exploration. Through extensive research and scholarly discourse, several key facets of the teacher's role in inquiry-based learning have been elucidated, shaping a comprehensive understanding of its impact on the educational landscape.

Central to this approach is the teacher's deliberate abstention from directly imparting information to students. Instead, the teacher undertakes the pivotal task of steering students through the intricate process of information generation, a practice supported by the works of Battista (1999) and Bolton et al. (2009), and others. The teacher, in this capacity, activates students' innate curiosity and fosters a profound understanding of scientific concepts, a transformative process documented by Flick (2000), Hogan and Berkowitz (2000), and Tseng et al. (2013).

Moreover, the teacher acts as a catalyst in channelling students' textbook-oriented learning habits into self-driven research questions, as emphasized by Keys and Kennedy (1999). Functioning as a facilitator, the teacher not only respects diverse learning styles but also creates an inclusive environment, recognizing individual differences as highlighted by Battista (1999), Keller (2001), and Duban (2008).

In the context of inquiry-based learning, the teacher assumes the responsibility of enhancing scientific literacy among students, a task meticulously undertaken as demonstrated by Zion and Slezak (2005). By cultivating motivation, the teacher ensures students' active engagement in their academic pursuits, a practice advocated by Crawford (2000) and Tseng et al. (2013). The teacher's guidance extends to the development of uniform thinking strategies, essential for the students' learning experience, an endeavour underscored by Duban (2008) and Sönmez (2008).

Furthermore, the teacher's role extends to creating diverse learning environments tailored to students of varying levels, a practice essential for inclusive education and extensively researched by Keller (2001), Tseng et al. (2013), and Windschitl (2003). This inclusivity is further enhanced by the teacher's role as an astute observer, closely monitoring students' progress during their research process, an approach advocated by Llewellyn (2002).

Inquiry-based teaching demands the teacher to be an organizer, orchestrating environments that facilitate experiential learning through carefully curated activities (Dickson, 2002; Wadsworth, 1978). The teacher, in this context, helps students articulate their thoughts, initiating group activities to foster collaborative learning, a principle emphasized by Bolton et al. (2009), Dickson (2002), and Wadsworth (1978).

In this pedagogical approach, the teacher embodies innovation and investigation, encouraging students to explore beyond the classroom, a transformative process delineated by Crawford (2000), Joyce and Calhoun (1996), and Wu and Hsieh (2006). The teacher's collaborative spirit further augments the learning experience, creating an atmosphere conducive to holistic education, a principle highlighted by Crawford (2000), Lechtanski (2000), and Wu and Hsieh (2006).

Furthermore, the teacher's commitment to understanding students' prior knowledge, integrating it seamlessly with new concepts, underscores the importance of bridging gaps in understanding, a practice initiated by Crawford (2000). The teacher, as a lifelong learner, continuously evolves by embracing the latest developments in their field, seeking novel teaching and assessment methods, thereby embodying a spirit of adaptability as articulated by Crawford (2000).

Crucially, the teacher employs diverse techniques to pose questions, stimulating critical thinking and encouraging scientific inquiry, a practice integral to the development of high-level thinking skills, a principle underscored by Llewellyn (2002).

In essence, the inquiry-based learning approach necessitates the teacher to be an astute mentor, observing and guiding students at every stage of their learning journey. By embracing this multifaceted role, the teacher becomes the cornerstone upon which students build their understanding, fostering a generation of inquisitive, critical thinkers ready to navigate the complexities of the modern world.

In the intricate tapestry of inquiry-based learning, the teacher's role further unfolds as a steadfast guide, ensuring that the students' educational odyssey is not confined to the four walls of the classroom. The teacher meticulously shapes learning experiences, not only within traditional confines but also in the laboratory, the schoolyard, and the broader community, encouraging students to explore the real-world applications of their knowledge, a principle championed by Llewellyn (2002).

Crucially, the teacher assumes a pivotal role in prompting students to think beyond the surface, fostering a depth of understanding that transcends mere memorization. This intellectual prodding, masterfully executed by the teacher, is instrumental in initiating students into the realms of critical thinking, scientific processing, problem-solving, and high-level cognitive abilities, pivotal skills outlined by Tseng et al. (2013). As a result, the teacher becomes not just an educator but a mentor, shaping the very fabric of students' intellectual capacities.

In the ever-evolving landscape of education, the teacher embraces innovation, not just in teaching methods but also in the methodologies of inquiry. By being investigative and encouraging students to embark on their own quests for knowledge, the teacher not only imparts information but instills a spirit of curiosity and discovery, laying the foundation for lifelong learning, a principle ardently championed by Crawford (2000), Joyce & Calhoun (1996), Lechtanski (2000), Wu and Hsieh (2006).

Furthermore, the teacher operates on a collaborative ethos, recognizing that learning is most potent when it is a collective endeavor. By fostering an environment where ideas are shared, debates are encouraged, and collaboration is prized, the teacher molds students into adept communicators and team players, skills indispensable in the modern professional landscape, as elucidated by Crawford (2000), Lechtanski (2000), and Wu and Hsieh (2006).

Additionally, the teacher acts as a bridge, connecting the familiar territory of students' prior knowledge with the uncharted waters of new learning. This delicate integration ensures a seamless transition, allowing students to build upon what they already know, thereby enhancing their confidence and comprehension, a strategy thoughtfully implemented by Crawford (2000).

The teacher, as a reflective practitioner, constantly refines their craft. By seeking out innovative teaching and assessment methods, the teacher adapts to the changing needs of students and the evolving landscape of education, embodying the spirit of continuous improvement and adaptability, as underscored by Crawford (2000).

In this intricate dance of mentorship, observation, and inspiration, the teacher guides students through the labyrinthine corridors of inquiry-based learning. Through their wisdom, dedication, and innovation, the teacher not only imparts knowledge but also nurtures the very essence of inquiry, shaping individuals who are not just educated but enlightened, not just skilled but insightful, and not just learners but lifelong scholars. In this profound way, the teacher becomes the beacon, illuminating the path to intellectual enlightenment and empowering generations to come.

2.17 Different Roles of Students in Inquiry-Based Learning

In inquiry-based learning, students have the most significant role. This process involves students to be active throughout the implementation. Students' roles in inquiry-based learning are listed below

In the dynamic realm of inquiry-based learning, students take centre stage, transforming into active participants and architects of their educational journey. Through a multitude of research findings and scholarly insights, the profound impact of inquiry-based learning on students' cognitive, social, and emotional development becomes apparent, painting a vivid picture of its transformative influence on the modern educational landscape.

At the heart of this approach lies students' engagement in critical analysis and problem-solving. They grapple with the complexities of issues introduced to them, utilizing acquired information to generate innovative solutions, an empowering process meticulously documented by Carin and Bass (2001), Lim (2001), and

Şenocak and Taşkesenligil (2005). Within this framework, curiosity becomes a driving force, propelling students to make astute observations, as observed by Budak-Bayır (2008).

Crucially, students do multiple hats within group dynamics, embracing duties and responsibilities, fostering a sense of accountability and teamwork, a principle underscored by Alvarado & Herr (2003), Çalışkan (2008), Gallagher-Bolos, & Smithenry (2004), and Şenocak & Taşkesenligil (2005). In this interactive space, students find the freedom to express themselves, their thoughts, and their unique perspectives, a practice highlighted by Budak-Bayır (2008).

Inquiry-based learning not only imparts knowledge but also empowers students to take charge of their learning journey. They become architects of their own understanding, transforming information into meaningful knowledge, a process exemplified by Keselman (2003) and Lawson (2010). Through this active engagement, students gain a heightened metacognitive awareness, planning meticulously, reflecting on their studies, and evaluating their progress, as articulated by Krajcik et al. (1998).

Crucially, this approach instills confidence in students, fostering a culture where risk-taking is encouraged and appreciated. Olson & Loucks-Horsley (2000) document how students, aware of the value of their ideas, embrace challenges with newfound courage. In the realm of inquiry-based learning, students also refine their communication skills, expressing their thoughts through diverse mediums such as reports, drawings, graphics, and tables, a practice championed by Şenocak & Taşkesenligil (2005).

Moreover, students navigate the intricate process of inquiry with a scientist's precision, honing their observational skills and learning through hands-on experiences, as noted by Llewellyn (2002). They become adept in organizing research, collecting data, developing theories, and testing them, showcasing a scientific acumen underlined by Gallagher-Bolos & Smithenry (2004).

Inquiry-based learning not only encourages exploration but also nurtures a culture of inquiry. Students formulate questions that demand further research, engage in deductive reasoning, and generalize specific observations, as illuminated by Budak-Bayır (2008), Gallagher-Bolos and Smithenry (2004), Lim (2001), and Lindquist (2001). They actively plan methods to validate their ideas, testing and expanding their theories, exhibiting high-level thinking skills as noted by Martin-Hansen (2005) and Correiro et al. (2008).

In essence, inquiry-based learning transforms students into intellectual explorers, fostering not just knowledge but wisdom, not just skills but acumen, and not just learners but thinkers. Through this approach, students are not just educated; they are equipped with the tools to unravel the complexities of the world, making them active contributors to the tapestry of human knowledge and progress.

In conclusion, in an inquiry-based learning approach, students undertake important roles and they are expected to plan, conduct and evaluate their learning processes. Furthermore, they have roles such as behaving like a researcher, identifying a problem within a group by collaboration, developing theories to solve the problem, collecting data to test the theories, obtaining results by evaluating the data and sharing with others what they have concluded.

2.18 Inquiry-Based Learning Environment and Its Characteristics

For inquiry-based learning to be realized, students must be provided with a learning environment which enables them to generate new ideas, deepen their understandings, learn to think critically and gain various experiences (NRC, 2000).

The characteristics of the inquiry-based learning environment are as follows (Llwellyn, 2002, p. 60-61). The questions ―What if?" and ―I wonder…" are commonly used in class, there are concept maps on the walls, there is evidence of students studying outside the classroom as well, students‘ desks are arranged in pairs, in triple or quadruple groups. These classes are learning centres for individual and group studies, bookshelves in classrooms contain novels, other books, magazines and other resources, the teacher‘s desk is not located in the centre or front of the classroom; it is rather located on one side or at the back of the classroom, there is a chest or box in the classroom to keep the portfolios and magazines for students, all the materials are placed in boxes or chests in a way that they can be easily reached, a video system is in place to record students‘ presentations and watch them later to evaluate their performance, and computers are accessible for students to access information outside the school building as well.

These kinds of inquiry-based learning environments with the above characteristics are effective learning environments where students can find answers to their questions on their own, since inquiry-based learning is an efficient approach that focuses on question-asking, critical thinking and problem-solving. The last part of the quote ―If you tell me, I will forget. If you show me, I will remember. If you make me, do it, I will learn." sums up the core of inquiry-based learning (Macy, 2003).

In an environment where students are responsible for and supportive of their self-learning, they will be able to interpret the data they have collected, explain their observations, cases and facts and have the confidence to state the relations among different variables (Al-Naqbi, 2010).

Students should have the right to speak during the process of inquiry-based learning which is also considered as a student-centered approach. Although there is a pre-determined learning environment in the first days of school, students' opinions have to be taken into consideration and new regulations should be set based on their opinions later on (Llewellyn, 2002). It will also be a step forward in effectively establishing a learning-teacher process, and preparing a learning environment in line with the requirements of an inquiry-based learning approach.

2.19 Misconceptions Concerning Inquiry-Based Learning

The studies which investigate the reasons why inquiry-based learning is not used in class reveal that teachers have misconceptions about this method (Costenson & Lawson, 1986; Trowbridge & Bybee, 1996). Llewellyn (2002) lists these misconceptions as the following:

Having students do hands-on experiments means that they are using inquiry-based learning. In inquiry-based learning, what the students need to do is not clear, which creates chaos in class. Inquiry-based learning can be taught without paying attention to knowledge of a particular subject. Real inquiry occurs when students form their questions and pursue them on their own. Inquiry-based learning means making students follow the exact steps given by the "scientific method". Inquiry-based learning is only appropriate for primary education students. Inquiry-based learning means constantly asking questions to the students. All science subjects should be taught with inquiry-based teaching methods. In the inquiry-based teaching method, the teacher is prepared to answer any kind of questions. Learning cannot be evaluated in inquiry-based education. Inquiry-based learning applies only to successful students. Inquiry is softened science-making, and it does not relate to scientific context. Inquiry-based learning can be implemented easily since experiment kits are used.

2.20 Challenges Encountered in Inquiry-Based Environment

Some challenges encountered in science teaching in an inquiry-based environment are given below:

It remains unclear what inquiry helps to structure (Campbell et al., 2011). The integration of inquiry-based learning in classrooms presents various challenges. Firstly, there is a scarcity of compelling examples demonstrating how inquiry serves as an effective teaching strategy within classrooms, a concern highlighted by Campbell et al. (2011). Additionally, a lack of clear collaboration between inquiry-based learning and scientific content complicates its incorporation, as pointed out by Windschitl, Thompson, and Braaten (2008).

Moreover, the current curriculum tends to be content-heavy, leaving limited space for the in-depth exploration that inquiry-based teaching demands. This imbalance in curriculum design, noted by Cheung (2008) and Hackling (2005), results in inquiry-based methods consuming a significant amount of instructional time. Managing classrooms becomes challenging due to the high number of students, extensive materials, and complex experiments, creating difficulties for educators, as emphasized by Cheung (2008) and Hackling (2005).

Furthermore, teachers often struggle to navigate and oversee the intricate processes of student inquiry. The complexity of guiding students through these processes becomes apparent, leading to challenges in managing and controlling the inquiry-based learning environment. These challenges are highlighted by Campbell et al. (2011) and Keller (2001).

In addition, students encounter hurdles in proposing research questions relevant to the subject matter, thereby impeding the natural flow of inquiry-based learning, as identified by Harlen (1997). Within this framework, the reluctance of teachers to respond to students' queries becomes a substantial hurdle, a phenomenon noted by Harlen (1997). This hesitation is often exacerbated by teachers' perceived lack of expertise in their respective fields, leaving them feeling ill-equipped to address the challenging questions posed by their students. The inadequacy in teachers' knowledge, as discussed by Deters (2005) and Pierce (2001), further underscores the complexities faced in the successful implementation of inquiry-based learning methodologies in educational settings.The reasons indicated above account for why teachers do not prefer inquiry-based learning when choosing their teaching methods.

2.21 Drawbacks of Inquiry-Based Learning

Although there are many benefits to inquiry-based learning, as mentioned above, there are also a few drawbacks to this approach. When teachers are introduced to this method of teaching, many teachers are concerned with the amount of time it takes in preparation and implementation. Baker et al. (2008), discussed that the teachers that they interviewed saw scheduling and time constraints associated with inquiry learning as a serious to moderate problem. Yet, they stated although initial preparation is time-consuming, their time commitments decrease significantly each year once they have developed lessons.

Herman and Knobloch (2004), found there was a larger workload in developing the constructivist units but recommended that teachers need to consider the payback of their additional time investment when developing and using constructivist units of study.

Ward (2001), also recognized the primary concern of using the constructivist approach is the time required to conceive and design the activities. Ward then followed this concern with the discussion of the tremendous number of ideas available on various websites and in publications. Ward also addressed the classroom management concerns associated with inquiry. Ward found ―the time spent dealing with distractions [associated with inquiry] was well worth it. This class no longer had difficulty remembering [the material]. The understanding gained from this activity also transferred to [other material].

Another concern of teachers associated with time is that in many cases, such as initially learning how to add and subtract, direct instruction can get the job done much more quickly (Santrock, 2001, p. 375). Other material may also be seen as more quickly taught through direct instruction, but teachers must also consider students ‗comprehension and understanding of the material. Direct instruction may quickly allow the students to regurgitate a procedure, but not understand the how or why of the procedure that they have imitated, which would decrease the students ‗ability to retain and reuse the procedure.

The study by Baker et al. (2008), also found teacher and student attitudes were a moderate to slight problem. Teachers must believe in and actively use a method of teaching before students will buy into it. Baker et al. (2008), found that teachers must feel comfortable with instructional methods and accept them before they will use them consistently. The teachers' attitude directly affects students _attitudes, as do students_ interests and feelings of connectedness and relevance of the material.

Herman and Knobloch (2004), reported that teachers should anticipate mixed attitudes from students who have not experienced constructivist activities in previous learning experiences. Constructivist activities can confuse students and teachers due to the dramatic change in roles and students _perceptions of how instructional methods impact their learning. Herman and Knobloch recommended gradually modifying units of study, incorporating pieces of constructivist methods over time, to create a less drastic change for students. They also found that students who were not accustomed to constructivist instruction did not know how to handle a new freedom in the classroom which led to classroom management issues. However, students quickly adapted by the second week to the new situation and became actively engaged.

Although there is agreement on the contribution of constructivist approaches to factors such as knowledge retention, student satisfaction, motivation, and critical thinking, there is much less agreement on its role in knowledge acquisition (Burris & Garton, 2007). Burris and Garton found that students who were taught with the more traditional approach tended to score higher on content knowledge assessments than students taught with constructivist approaches. While students [taught with constructivist instruction] may have a deeper understanding of the material, that understanding is not represented at the content knowledge level (Burris & Garton, 2007, p.113).

Conversely, Herman and Knobloch (2004) reported that students comprehended more through the constructivist approach as compared to the traditionalist approach. Other disadvantages to inquiry learning are: that students can end up with the wrong solution, use inefficient strategies to discover information, or never discover what it is they are trying to find out or why (Santrock, 2001). This is why teachers must be facilitators of learning and guide students in the right direction. Lemlech (1998), discussed that the teacher‘s primary role during inquiry revolves around raising questions that guide the student‘s investigation. Questioning [by the teacher] becomes imperative because it is a means to the end (Ward, 2001, p. 96). In discussions with students, the teachers‘ questions should act as a springboard for discussions rather than focusing on the right answer, which is sometimes the only focus of teachers. To take it a step further, the research of Sandifer (2005), emphasized the importance of using inquiry-based learning to help students conclude. The study found that constructivist teachers often skipped concluding sense-making sections of some activities, which made it difficult for students to conclude the inquiries that they made. Sandifer also found that teachers tended to reveal in advance the ideas that the students were supposed to construct. If students already know the answer they are supposed to find, then the inquiry is not present because students are not figuring it out for themselves, so in turn, they are not constructing their knowledge.

2.22 Summary of Literature Review

This chapter provides a comprehensive review of relevant literature of the study. The reviewed literature was organised into themes to act as framework to the field of inquiry and covers: theoretical framework, conceptual framework and empirical review of related studies. The literature reviewed indicates the role of inquiry based-learning in improving students learning outcomes.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter describes the methodology used for the study. It includes research design, population, research instrument, validity and reliability, data collection procedure including pre intervention procedures, the intervention and the post-intervention activities.

3.1 Research Design

Action research design was employed for this study. Action research is categorised as one of the quantitative research designs. According to Sagor and Williams (2016), action research focuses on the development, implementation, and testing of a programme, product or procedure. Action research has grown in popularity throughout the past two decades (Schmidt, 2002). It is becoming a more accepted tool for teachers to assess their teaching strategies and reflect upon their effectiveness. James and Augustin (2018) define action research as an increasingly popular movement in educational research that encourages teachers to be reflective of their practices to enhance the quality of education for themselves and their students. The significance of using this design is to focus on some occurrence or entity and also, this approach seeks to uncover the interaction of major factors which use characteristic of the observable facts (Bartlett & Vavrus, 2016) and also help provide a means to understand the essence of the school-based research experience.

3.2 Research population

A research population is generally a large collection of individuals or objects that is the main focus of scientific inquiry and it is for the benefit of the population that research is done (Polgar & Thomas, 2011). The population of Shama Senior High School at the time of the study was 1,584 students. This population comprised 1034 males and 550 females. In this study, the target population consisted of all science students enrolled at Shama Senior High School. The accessible population, from which the study participants were drawn, specifically included Form 2 Physics students at the same school.

3.3 Sampling Technique and Sample

Sampling refers to the process of selecting a portion of a population (Alvi, 2016). According to Clifford et al. (2007), the size of the sample selected for a study is immaterial and depends solely on what the researcher is researching into.

For this study, the researcher employed a purposive sampling technique to select form 2 General Science students comprising 52 students (18 females and 34 males) as a sample for the study. It is the researcher's class and is familiar with the students. As the class's teacher, the researcher had direct access to the students, making it easier to collect data and conduct the study efficiently. The established teacher-student relationship could help build trust and cooperation, as the students were more likely to be comfortable and open with the researcher. This could have led to more accurate and reliable data.

3.4 Research Instruments

According to Fraenkel and Wallen (2009), an instrument is a device that is used by a researcher to gather data to from a sample. Arikunto (2006) states that the kinds of instruments are normally tests, questionnaires, interviews, observations, rating scales, and document analysis. In this study, the research instruments that were used in the study for data collection were tests and questionnaires.

3.5.1 Tests

According to Frankel et. al., (2012), a test can be used as a means to measure an individual‘s knowledge in a given area or subject to access the effectiveness of programme. Two tests were adminstered: The pre-intervention test which was (administered before the intervention) and the post-intervention test which was (administered after the intervention). The tests consisting of 20 multiple choice items, were used to collect quantitative data on students‘ academic performance before and after intervention activities. A sample of the pre-intervention test and post-intervention test can be found in Appendices A and C.

3.5.2 Questionnaire

According to Arikunto (2010), a questionnaire is several literal questions that are used to get information from the respondent in terms of personality/self-report. A 5-point Likert scale (ranging from strongly disagree to strongly agree) questionnaire consisting of 10 items which are closed-ended was used to collect data on students‘ perception of inquiry-based learning strategy that was used to teach Electricity and Magnetism concepts. The sample of the questionnaire can be found in Appendix E.

3.7 Validity of Research Instruments

Validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration (Bybee, 2014). There are various types of validity, which include construct validity, content validity, criterion-related validity, and face validity (Gall & Borg, 2007). Of these, content validity which is, defined as the degree to which a measure covers the range of meanings included in a concept (Bybee, 2014), was considered relevant.

To determine the content validity of the research instruments, two lecturers' together with the researcher's supervisor were made to review the items to assess their relevance and suitability.

3.8 Reliability of Research Instruments

Instruments were trial tested on senior high school students of the same characteristics who are not part of the main study. The instruments were administered to the students on the trial test twice. The time gap between the two administrations of the instruments was one week. The duration of one week was thought sufficiently long for the students not to remember their previous responses (in the first administration of the instruments). Data from the first and second administrations of the instruments were used to compute the reliability of the instruments. The reliability of the students' questionnaire was estimated using the Cronbach alpha coefficient. A coefficient value of 0.76 was obtained. According to Bhandari (2020), a Cronbach alpha value above 0.70 is presumed to be in the range of acceptable internal consistency. The test-retest method was also used to estimate the reliability of the performance test items and a correlation coefficient value of 0.78 was obtained indicating that the test items are reliable.

3.9 Data Collection Procedure

Data collection involves three main activities and there are pre-intervention activities, intervention activities and post-intervention activities. Details of each activity is described as follows;

3.9.1 Pre-Intervention Activities

The pre-intervention test, comprising 20 multiple-choice items centered on concepts in electricity and magnetism and was meticulously designed. The pre- intervention test was administered to the General Science students with a duration of 30 minutes. Afterwards, the responses were collected together in a bigger envelope, marked, scored and recorded.

Details of the lesson plan is shown below:

Week 1: Introduction to Magnetism

Objectives: Students should be able to distinguish between magnet, magnetic and non-magnetic materials and describe the magnetic field.

Lesson 1: Introduction to Magnetism (2 hours)

- Teacher engaged students by presenting a variety of objects and asked them to sort them into magnetic and non-magnetic objects.
- Teacher facilitated a class discussion to explore students' prior knowledge and misconceptions about magnets.
- Teacher introduced key vocabulary terms: magnet, magnetic, and non-magnetic materials.
- Teacher conducted hands-on activities where students experimented with magnets and observed their properties.

- Teacher explained the concept of a magnetic field and its influence on magnetic materials.
- Teacher concluded the lesson with a reflection activity to consolidate learning.

Week 2: Magnetization and Demagnetization

Objectives: Students should be able to :

i. Outline the processes involved in magnetization and demagnetization.

ii. Investigated the factors that affected the strength of a magnet produced by the electrical method.

Lesson 2: Magnetization and Demagnetization (2 hours)

- Teacher began the lesson by reviewing the concept of magnetism from the previous week through questions and waiting for their responses.
- Teacher introduced the processes of magnetization and demagnetization, discussing how materials became magnetic or lost their magnetism.
- Teacher conducted hands-on activities where students magnetized and demagnetized objects using different methods.
- Teacher guided students to investigate the factors that affected the strength of a magnet produced by the electrical method.
- Teacher engaged students in a group discussion to share their findings and observations.
- Teacher concluded the lesson by summarizing the key concepts and allowing students to ask questions.

Week 3: Magnetic Domains and Hysteresis

Objectives: Students should be able to:

i. Explained the concept of magnetic domains.

ii. Explained hysteresis.

Lesson 3: Magnetic Domains and Hysteresis (2 hours)

- Teacher began the lesson by reviewing the previous lessons' content on magnetization and demagnetization.
- Teacher introduced the concept of magnetic domains and explained how they contributed to the magnetic properties of materials.
- Teacher conducted a visual demonstration or used interactive simulations to help students visualize magnetic domains.
- Teacher explained hysteresis and its significance in magnetic materials.
- Teacher engaged students in hands-on activities where they observed and recorded hysteresis loops for different materials.
- Teacher facilitated a class discussion to analyze the results and discuss the implications of hysteresis.
- Teacher concluded the lesson with a reflection activity to reinforce learning.

Week 4: Uses of Magnets and Ferromagnetic Materials

Objectives: Students should be able to

i. Describe the uses of magnets and ferromagnetic materials.

ii. Explain the concept of the electromagnetic field.

Lesson 4: Uses of Magnets and Ferromagnetic Materials (2 hours)

- Teacher engaged students by presenting real-world examples of magnets and ferromagnetic materials.
- Teacher facilitated a class discussion to explore the various applications and uses of magnets.
- Teacher introduced the concept of an electromagnetic field and its relationship with magnets and ferromagnetic materials.

- Teacher conducted hands-on activities where students investigated the behaviour of magnets and ferromagnetic materials in different situations.
- Teacher divided students into groups and assigned them specific applications of magnets to research and present to the class.
- Teacher concluded the lesson with a discussion on the importance and impact of magnets and ferromagnetic materials in everyday life.

Week 5: Magnetic Forces on Current-Carrying Conductors

Objectives: Students should be able to list and explain the factors that affected the magnetic force on a current-carrying conductor in a uniform magnetic field and explain the forces set up between parallel current-carrying conductors in a uniform magnetic field.

Lesson 5: Magnetic Forces on Current-Carrying Conductors (2 hours)

- Teacher began the lesson by revisiting the concept of magnetism and its relationship with electrical currents.
- Teacher reviewed the right-hand rule and its application in determining the direction of the magnetic force on a current-carrying conductor.
- Teacher explained the factors that affected the magnetic force on a current-carrying conductor, such as the strength of the magnetic field, the current magnitude, and the length of the conductor.
- Teacher conducted hands-on activities where students explored the relationship between these factors and the resulting magnetic force.
- Teacher introduced the concept of parallel current-carrying conductors and the forces that arose between them in a uniform magnetic field.
- Teacher engaged students in a group activity where they set up and observed the forces between parallel current-carrying conductors.

- Teacher facilitated a class discussion to analyze the observations and discuss the factors influencing the forces.
- Teacher concluded the lesson by summarizing the key concepts and allowing students to ask questions.

Week 6: Electromagnetic Fields and Applications

Objectives: Students should be able to :

i. Describe the torque produced by a current-carrying rectangular coil in a uniform magnetic field.

ii. Describe the force exerted on a charged particle moving in electric and magnetic fields and their applications.

iii. Describe electromagnetic switches. Investigated the use of a relay to switch on a motor or fan or light.

Lesson 6: Electromagnetic Fields and Applications (2 hours)

- Teacher began the lesson by reviewing the previous lessons' content on magnetic forces and current-carrying conductors.
- Teacher introduced the concept of torque and explained how it was produced by a current-carrying rectangular coil in a uniform magnetic field.
- Teacher conducted a demonstration or used interactive simulations to illustrate the torque concept.
- Teacher discussed the force exerted on a charged particle moving in electric and magnetic fields and explored its applications.
- Teacher presented examples of electromagnetic switches and explained their working principles.
- Teacher conducted hands-on activities where students constructed a simple circuit using a relay to switch on a motor, fan, or light.

- Teacher allowed students to explore different applications of relays and discussed their findings as a class.
- Teacher concluded the lesson with a reflection activity to consolidate learning and emphasize the real-world relevance of electromagnetic fields and applications.

3.9.2 Intervention Activities

A lesson plan was designed for six-weeks with two-hour lessons each week. The lesson plan emphasized inquiry-based teaching and learning methods, including hands-on activities, group discussions, and student-led investigations. The lessons were sequenced to build upon previous knowledge and progressively explore more complex concepts related to Electricity and Magnetism.

3.9.3 Post-Intervention Activities

After a week of the intervention the students were given the post-intervention tests. At the end of the test, the scripts were collected and scored to generate data for the post-intervention. A 5-point Likert scale (ranging from strongly disagree to strongly agree) questionnaire consisting of 10 items which are closed-ended were administered a week after the test. This was done to collect data on their perception of inquiry-based learning and teaching to present concepts in Electricity and Magnetism. Data collected from the responses to the of the tests and questionnaires items were organised and used to statistically test the null hypotheses that were formulated prior at a 0.05 significance level.

3.10 Data Analysis Procedure

The data were analysed statistically after collection. Statistical tools such as SPSS (Statistical Package for the Social Sciences) version 25 and Microsoft Excel 2009 as well as statistical methods such as paired t-test were employed to validate whether or not there was a significant difference between students' scores on the pre-and post-intervention tests. Where necessary measures descriptive statistics were used to describe the data. Analysed questionnaire data were organized into frequencies and percentages.

3.11 Ethical Considerations

An introductory letter was obtained from the Department of Physics Education, Winneba was sent to the school to ask permission for the conduct of the study. The researcher ensured that students were made aware of the purpose of the study and their rights as students. Students were assured of the confidentiality of the data collected.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter is dedicated to showcasing the details of the lesson plan, representation of results by each research questions. And also, findings of the research study undertaken to determine the effect of inquiry-based learning on students' academic performance in Electricity and Magnetism concepts.

4.1 Presentation of the Results by Research Questions

The data analysed to address the formulated research questions are presented in the same sequence as the research questions.

Research Question 1: **What is the effect of inquiry-based learning on students' academic performance in electricity and magnetism concepts**?

This question was posed to determine the effect of inquiry-based learning on students' academic performance and their results before intervention and after the intervention activities are shown in Table 1.

Table 1: Results of students test scores before and after intervention activities Week by Week

Student ID	Pre-intervention test (Max=20)	Post-intervention test						
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Average
1	6	11	10	11	12	14	14	12
2	8	10	10	11	11	14	16	12
3	10	12	13	15	14	17	19	15
4	12	11	16	15	16	19	19	16
5	2	5	4	4	6	8	9	6
6	4	6	7	9	9	7	10	8
7	6	5	6	7	7	9	14	8
8	7	7	7	11	11	13	17	11
9	8	10	11	12	12	15	18	13
10	12	15	15	17	17	18	20	17
11	3	5	6	6	7	5	7	6
12	5	8	8	10	10	12	12	10
13	6	6	7	8	8	10	15	9
14	8	9	9	12	13	17	18	13
15	7	2	4	4	6	9	11	6
16	7	12	11	12	12	14	17	13
17	9	9	11	17	13	15	19	14
18	0	2	6	6	5	8	9	6
19	2	4	10	7	6	9	12	8
20	3	3	9	7	5	11	13	8
21	6	10	6	13	8	12	11	10
22	7	9	12	11	12	13	15	12
23	9	8	13	10	13	14	16	12
24	3	9	7	14	7	13	10	10
25	5	8	11	12	11	14	16	12
26	12	12	15	13	15	16	19	15
27	7	6	9	7	9	10	13	9
28	8	8	12	11	12	13	16	12
29	5	6	8	7	8	9	10	8
30	12	11	15	14	15	16	19	15
31	5	8	12	11	12	13	16	12
32	12	9	13	11	13	15	17	13
33	12	8	14	13	14	16	19	14
34	8	9	12	11	12	13	15	12
35	8	10	15	15	15	16	19	15
36	9	7	12	11	12	13	17	12
37	10	11	14	13	14	15	17	14
38	13	12	15	14	15	16	18	15
39	12	9	13	11	13	14	18	13
40	8	5	9	7	9	10	12	9
41	7	6	9	8	9	10	12	9
42	5	6	10	9	9	11	14	10
43	10	11	14	11	14	15	19	14
44	15	16	18	16	18	20	20	18
45	12	14	16	15	16	15	20	16
46	4	5	6	6	6	5	8	6
47	5	6	9	7	9	10	13	9
48	6	5	9	9	9	11	12	9
49	9	7	10	11	10	10	12	10
50	13	15	17	16	17	17	20	17
51	4	4	7	6	7	8	8	7
52	5	5	9	8	9	11	12	9

The results of Table 1 reveal that a total number of 52 students were given a pre-test using the traditional method of learning specifically the lecture method. And their score was recorded. For a period of six weeks, inquiry-based method was used as an intervention and students' performance after each week of intervention improved incrementally.

Table 2: Results of each Student in the Pre-intervention and post-intervention Test

Student ID	Pre-intervention test	Post-intervention test(average)
1	6	12
2	8	12
3	10	15
4	12	16
5	2	6
6	4	8
7	6	8
8	7	11
9	8	13
10	12	17
11	3	6
12	5	10
13	6	9
14	8	13
15	7	6
16	7	13
17	9	14
18	0	6
19	2	8
20	3	8
21	6	10
22	7	12
23	9	12
24	3	10
25	5	12
26	12	15
27	7	9
28	8	12
29	5	8
30	12	15
31	5	12
32	12	13
33	12	14
34	8	12
35	8	15
36	9	12
37	10	14
38	13	15
39	12	13
40	8	9
41	7	9
42	5	10
43	10	14
44	15	18
45	12	16
46	4	6
47	5	9
48	6	9
49	9	10
50	13	17
51	4	7
52	5	9
Mean	7.51	11.52

Table 3: Summary of t-test results on The Pre-intervention and Post-intervention Test

Tests	Number	Mean Max=20	Mean Diff.	Standard Deviation	p-value	Remarks
Pre-intervention test	52	7.51	4.01	3.37	3.73262 x 10-20	Significant
Post-intervention test	52	11.52		3.85		

P > 0.05= Not Significant, P < 0.05 = Significant

In the realm of education, the quest for effective teaching methods continually evolves, aiming to enhance student learning and comprehension. Table 3, presented in this study, delves into the pre-intervention and post-intervention test scores of students undergoing instruction in Electricity and Magnetism through an inquiry-based learning approach. The pre-intervention test yielded a mean score of 7.51, a figure that significantly rose to 11.52 in the post-intervention test. This substantial increase, amounting to a mean difference of 4.01, sparked a comprehensive analysis to understand the impact of this teaching methodology.

A critical statistical tool, the t-test, was employed to discern the significance of the observed differences between pre-intervention and post-intervention scores. The calculated p-value, an astonishingly low 3.73262×10^{-20}, stood far below the conventional significance level (alpha = 0.05). This outcome led to the rejection of the null hypothesis (Ho1), indicating a profound and statistically significant difference between the pre-intervention and post-intervention test scores when inquiry-based learning was applied in teaching Electricity and Magnetism concepts.

These results echo the findings of previous studies, notably Choudhary and Khushnood (2021) and Njoroge et al. (2014). Choudhary and Khushnood's research revealed that inquiry -based learning method is more effective than the lecture method which underscored the superior efficacy of inquiry -based instruction over traditional lecture methods in teaching Physics. Similarly, Njoroge et al.'s study highlighted that an inquiry-based teaching approach led to higher academic performance in physics. These congruent findings across studies underline the robustness of the inquiry-based learning method in enhancing student comprehension and knowledge retention.

Furthermore, the benefits of inquiry-based learning extend beyond mere academic performance. Engaging students in this dynamic and experiential learning process fosters high-level thinking, scientific process skills, and cognitive abilities. This pedagogical approach capitalises on active mental engagement, encouraging students to explore, question, and experiment. Through this active participation, students not only enhance their scientific process skills but also develop creativity, reflection, analytical and critical thinking abilities.

Moreover, inquiry-based learning nurtures a variety of skills that have enduring value in students' lives. These skills not only contribute to academic success but also empower individuals to navigate complex challenges in various contexts (Ozturk, et al., 2022). As students engage in hands-on experiments, collaborative investigations, and problem-solving activities, they not only enhance their academic prowess but also acquire essential life skills.

An important aspect of this learning method lies in its ability to enhance self-esteem and motivation in students. When students experience academic success, especially through methods that encourage active participation and critical thinking, their confidence in their abilities is bolstered. This newfound confidence not only fuels their motivation in the classroom but also translates into improved self-efficacy, empowering them to tackle future academic challenges with enthusiasm and resilience.

In conclusion, the comprehensive analysis of pre-intervention and post-intervention test scores presented in Table 3, coupled with the statistical rigor of the t-test, underscores the transformative potential of inquiry-based learning in the realm of physics education. The significant improvements observed in student performance, coupled with the development of critical cognitive skills and enhanced self-esteem, highlight the multifaceted benefits of this pedagogical approach.

Educators, armed with these insights, are encouraged to embrace inquiry-based learning methodologies, recognizing their capacity not only to impart knowledge effectively but also to nurture the intellectual and personal growth of their students. As education continues to evolve, inquiry-based learning stands as a beacon, illuminating a path towards a more engaging, effective, and empowering educational experience for learners worldwide.

Research Question 2: What is the differential effect of inquiry-based learning on the academic performance of male and female students in electricity and magnetism concepts?

This question was also posed, mainly to determine how the inquire-based learning has helped female and male students differently.

Table 4 shows the results of the effect of inquiry-based learning on the academic performance of male and female students in electricity and magnetism concepts.

Table 4: Differential Effect of Inquiry-based Learning on the Academic Performance of Male and Female Students in Electricity and Magnetism Concepts

Sample	**Number of students**	**Mean (Max=20)**	**Mean Difference**	**Standard deviation**	**P-Value**	**Remarks**
Male	34	11.53	0.97	3.096	0.1811521	Not significant
Female	18	10.56		3.85		

P > 0.05 = Not Significant, P< 0.05 = Significant

In contemporary educational research, the question of whether teaching methodologies have a differential effect on male and female students' academic performance is of paramount importance. Table 4, presented in this study, meticulously analyses the post-intervention test scores of male and female students who were exposed to an inquiry-based teaching approach. The male students exhibited a mean score of 11.53, while their female counterparts achieved a slightly lower mean score of 10.56. This resulted in a mean difference of 0.97 between the two groups. These statistics set the stage for a rigorous analysis aimed at understanding the significance of these differences and their implications for educational practices.

The study employed a t-test, a statistical method commonly used to ascertain significant differences between two groups. In this case, the t-test was utilized to determine the significance of the disparity between the post-intervention scores of male and female students. The calculated p-value, 0.1811521, was compared with the conventional threshold of significance, often denoted as alpha (α), which is typically set at 0.05. A p-value exceeding this threshold implies that the observed differences are not statistically significant.

The outcome of the t-test, in this scenario, leads to the acceptance of the null hypothesis ($H0_2$). This means that there is no substantial statistical difference between the mean post-intervention test scores of male and female students taught using inquiry-based learning. Therefore, the study does not provide evidence to support the claim that gender plays a significant role in the effectiveness of inquiry-based learning in the context of Electricity and Magnetism.

Interestingly, these findings diverge from the results reported by Issaka (2018), whose research suggested a slight gender disparity in achievement and retention capacities favouring male students when taught using integrated science with inquiry-based methods. This discrepancy highlights the nuanced nature of educational research and the necessity of considering diverse factors that might influence the outcomes. Factors such as teaching styles, classroom environment, and even cultural differences could contribute to variations in results across different studies.

A crucial aspect of this study lies in the determination of standard deviations within the male and female groups. The standard deviation, representing the dispersion of scores within a group, was 3.096 for male students and 3.85 for female students. These values shed light on the distribution of scores within each gender group. A narrower standard deviation indicates that the scores are clustered closely around the mean, suggesting a more consistent performance within the group. Conversely, a wider standard deviation implies greater variability in scores.

The comparable standard deviations in this study indicate that both male and female students exhibited similar levels of variability in their post-intervention test scores. This suggests that the inquiry-based teaching approach had a consistent impact on students, regardless of gender. Such uniformity in the dispersion of scores further strengthens the argument against gender-based disparities in the effectiveness of this teaching methodology.

In the broader context of educational research, these findings underscore the importance of evidence-based teaching methodologies that are equitable and inclusive. The study advocates for the continued exploration and implementation of inquiry-based learning approaches, emphasizing their ability to provide equal opportunities for both male and female students to excel academically.

Moreover, these results have implications for pedagogical practices and curriculum development. Educators and curriculum designers can draw valuable insights from this study to create teaching strategies that cater to diverse learning styles and abilities, irrespective of gender. By embracing methods that have been demonstrated to be effective for all students, educators can contribute to fostering a more inclusive educational environment.

In conclusion, the comprehensive analysis presented in Table 4, coupled with the meticulous application of statistical methods, illuminates the nuanced relationship between teaching methodologies, gender, and academic performance. The study's findings provide valuable evidence suggesting that, in the specific context of inquiry-based learning in Electricity and Magnetism, there is no significant difference in the outcomes between male and female students. This conclusion not only adds depth to the existing body of knowledge but also underscores the need for continued research to unravel the complexities of gender disparities in education. Through such rigorous investigations, educators and policymakers can make informed decisions to create an educational landscape that is truly equitable, providing every student with an equal opportunity to succeed.

Research Question 3: What is the perception of students towards the use of inquiry-based approach in the teaching and learning of electricity and magnetism concepts?

This question was crafted to determine how students percieved the use of inquiry based learning method aside the traditional method of learning(lecture method).

The students' responses to items on their perception of the use of inquiry-based approach in teaching Electricity and Magnetism are shown in Table 5, their perceptions are in percentages.

Table 5: Perception of students towards the use of inquiry-based approach in the teaching and learning of electricity and magnetism concepts

Statement	SD (F%)	D (F%)	N (F%)	A (F%)	SA (F%)
1. The inquiry-based learning approach helped me better understand electricity and magnetism concepts.	2 (3.9)	5 (9.6)	8 (15.4)	20 (38.5)	17 (32.7)
2. I found the inquiry-based learning activities engaging and interesting.	1 (1.9)	4 (7.7)	10 (19.2)	22 (42.3)	15 (28.9)
3. Inquiry-based learning improved my critical thinking skills when dealing with electricity and magnetism topics.	3 (5.8)	7 (13.5)	6 (11.5)	18 (34.6)	18 (34.6)
4. I felt more motivated to learn about electricity and magnetism through inquiry-based methods.	2 (3.9)	6 (11.5)	9 (17.3)	19 (36.5)	16 (30.8)
5. The inquiry-based approach made it easier for me to connect theoretical concepts with real-life applications in electricity and magnetism.	1 (1.9)	4 (7.7)	11 (21.2)	21 (40.4)	15 (28.9)
6. I believe that inquiry-based learning is an effective method for grasping complex electricity and magnetism principles.	2 (3.9)	5 (9.6)	7 (13.5)	17 (32.7)	21 (40.4)
7. The inquiry-based approach enhanced my problem-solving abilities related to electricity and magnetism.	3 (5.8)	5 (9.6)	8 (15.4)	15 (28.9)	21 (40.4)
8. I felt actively involved in my learning process when using inquiry-based methods for electricity and magnetism.	1 (1.9)	5 (9.6)	8 (15.4)	17 (32.7)	21 (40.4)
9. I think that inquiry-based learning should be used more often in teaching electricity and magnetism.	2 (3.9)	6 (11.5)	7 (13.5)	19 (36.5)	18 (34.6)
10. My overall learning experience with electricity and magnetism was positively influenced by the inquiry-based approach.	1 (1.9)	4 (7.7)	9 (17.3)	22 (42.3)	16 (30.8)

Key: SD= Strongly Disagree, D= Disagree, N= Neutral, A= Agree, SA= Strongly Agree

The results from Table 5 reflect a comprehensive view of the students‘ perceptions towards the inquiry-based learning approach in understanding electricity and magnetism concepts. Across all questions, students were given the choice to respond on a scale from strongly disagree (1) to strongly agree (5).

While a majority of the students (71.2%) agreed or strongly agreed that the inquiry-based learning approach helped them understand electricity and magnetism concepts, it's noteworthy that 13.5% of participants disagreed or strongly disagreed. This indicates that while most found the method effective, there were still a few who did not find it as beneficial in enhancing their understanding of these complex topics. Additionally, 15.4% of participants remained neutral, suggesting a lack of strong opinion in this group. Inquiry-based approaches which are student-centered were also recommended to enhance students‘ knowledge of electricity and magnetism (Afra et al, 2009). As students are involved in the process from a variety of angles, inquiry-based learning can contribute to their academic success. The inquiry-based learning approach promotes the use of reasoning and questioning on different issues, enabling students to do scientific research and reach scientific solutions. This method helps students acquire more sustainable and meaningful knowledge and become more successful academically

According to Blyth (2010), inquiry-based learning is an approach in which students learn by discovery; hence facilitates a deep understanding of concepts and enables students to engage actively in the learning process.

Similar patterns emerged concerning engagement. A substantial 42.3% agreed, but 9.6% disagreed, and 19.2% were neutral about finding the inquiry-based learning activities engaging and interesting. This indicates a more varied response, with a significant portion enjoying the activities, but some participants not feeling as engaged, possibly due to differences in learning preferences or teaching styles. In inquiry-based learning, students are encouraged to actively participate and discover new information (de Jong & Van-Joolingen, 1998)

Regarding critical thinking skills, while 69.2% agreed or strongly agreed that the inquiry-based approach improved their critical thinking abilities, 19.2% disagreed or strongly disagreed, suggesting a divergence in opinions. Furthermore, 11.5% were neutral, indicating a lack of strong consensus among this group about the impact on their critical thinking skills. These findings support Slavin (2006)‘ study which revealed that inquiry-based learning arouses students' curiosity and motivates students to continue to seek until they find answers which improves their critical thinking skills

In terms of motivation, 36.5% agreed, 11.5% disagreed, and 34.6% remained neutral. This mix of responses suggests that while a considerable portion felt motivated, some participants didn't experience a significant boost in motivation, possibly due to individual differences in learning preferences and intrinsic motivation levels. This finding supports findings obtained in earlier research studies concluding that inquiry-based learning promotes students‘ motivation (Crawford, 2000; Holbrook & Kolodner, 2000)

Connecting theoretical concepts with real-life applications was perceived differently by participants. While 69.2% agreed or strongly agreed that the inquiry-based approach facilitated this connection, 9.6% disagreed or strongly disagreed, and 21.2% were neutral. This indicates a split opinion, with some participants finding the connection effective, but others not seeing a strong correlation between theory and practical applications. Through inquiry-based learning, students relate concepts of a specific issue with real-life problems, and they are then able to propose solutions to these problems (Sasmaz-Oren et al., 2010).

Despite the majority (72.1%) believing in the effectiveness of inquiry-based learning, 9.6% disagreed or strongly disagreed, and 7.7% were neutral. This suggests that while a significant portion had confidence in the method, there were still participants who remained unconvinced about its efficacy in teaching complex scientific principles.

Regarding problem-solving abilities, 69.2% agreed or strongly agreed that the inquiry-based approach enhanced their skills. However, 15.4% disagreed or strongly disagreed, and 15.4% were neutral. This indicates a diverse range of experiences, with some participants feeling empowered in problem-solving, while others didn't perceive a significant improvement.

Active involvement in the learning process was reported positively by 72.1% of participants. However, 11.5% disagreed or strongly disagreed, and 15.4% were neutral. This indicates that while many participants felt actively engaged, a significant portion did not share the same sentiment, possibly due to differences in teaching methods or individual learning preferences.

While 71.2% of participants advocated for the future use of inquiry-based learning, 15.4% disagreed or strongly disagreed, and 13.5% were neutral. This highlights a substantial level of support for the method, but also a notable portion of participants who were not convinced of its suitability for future implementation.

In conclusion, the results demonstrate a varied response to the inquiry-based learning approach. While a significant portion of participants found the method effective, engaging, and motivating, there were also participants who disagreed or remained neutral, indicating a need for a nuanced approach to accommodate diverse learning preferences and experiences.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter contains a summary of findings, conclusions, recommendations and suggestions offered to improve upon the teaching and learning Electricity and Magnetism concepts.

5.1 Summary of Major Findings

This research aimed at investigating students' perceptions towards the use of inquiry-based approach in the teaching and learning of electricity and magnetism concepts, assess the effect of inquiry-based learning on students' academic performance in electricity and magnetism concepts and assess the differential effect with respect to gender of inquiry-based learning on student academic performance in electricity and magnetism concepts.

The findings of this study are summarised as follows:

1. A majority agreed, but a notable percentage disagreed on the effectiveness of inquiry-based learning in understanding electricity and magnetism.
2. A significant portion found inquiry-based learning to be engaging, but a minority disagreed, indicating diverse responses.
3. A majority agreed that inquiry-based learning enhanced critical thinking, but a notable minority disagreed.
4. Responses were mixed; a portion agreed while another portion disagreed, demonstrating varied motivation levels with the use of inquiry-based learning.
5. Opinions were divided; while a majority agreed, a minority disagreed on the ability of inquiry-based learning to connect theory with real-life applications.

6. A considerable increase in test scores was observed, demonstrating the effectiveness of inquiry-based learning in teaching Electricity and Magnetism.
7. There was no significant difference found in post-intervention test scores between male and female students in inquiry-based learning for Electricity and Magnetism, challenging the notion of gender-based disparities.
8. Uniform standard deviations were observed, indicating consistent performance variability across genders, suggesting that the inquiry-based teaching method affects both genders similarly.

5.2 Conclusion

The study revealed a mixed but generally positive response to inquiry-based learning in teaching electricity and magnetism. While most students agreed on its effectiveness and engagement, there were dissenting voices and concerns about specific aspects such as critical thinking enhancement and real-life application integration. The significant improvement in test scores showcased the method's efficacy in enhancing students‘ performance in the concepts learnt, and the study debunked gender-based disparities, indicating equal performance between male and female students. To maximize its benefits, addressing the concerns raised by a minority of students is essential.

5.3 Recommendations

Based on the findings of the study, the following recommendations were made:

1. Physics teachers of Shama SHS should tailor inquiry-based activities to cater to diverse learning preferences.
2. Physics teachers of Shama SHS should design tasks that explicitly nurture critical thinking skills within the inquiry-based framework.

3. Physics teachers of Shama SHS should develop modules that vividly connect theoretical concepts with practical, real-life applications.
4. Physics teachers of Shama SHS should research and address factors influencing student motivation within inquiry-based learning environments.
5. Management of Shama Senior High School should provide ongoing professional development to ensure educators are proficient in implementing inquiry-based methods.
6. Physics teachers of Shama SHS should encourage collaborative projects and peer-to-peer learning to enhance engagement and deepen understanding.

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APPENDICES

APPENDIX A

PRE-INTERVENTION TESTS

Answer all questions

1. Which of the following is an example of a non-magnetic material?

A) Iron

B) Nickel

C) Copper

D) Cobalt

2. What is a magnetic field?

A) The area around a magnet where its effects can be detected

B) The point on a magnet where the magnetic force is strongest

C) The direction in which a magnet's north pole is pointing

D) The process of magnetization and demagnetization

3. How is a magnet formed through magnetization?

A) By heating a material to a high temperature

B) By rubbing two materials together

C) By passing an electric current through a material

D) By exposing a material to sunlight

4. Which of the following factors affects the strength of a magnet produced by electrical method?

A) Temperature

B) Color of the material

C) Shape of the magnet

D) Sound vibrations

5. What are magnetic domains?

A) Small particles found within non-magnetic materials

B) Regions within a material where the magnetic alignment is uniform

C) Magnets made from a combination of different materials

D) Electric fields generated by magnets

6. What is hysteresis?
   A) The ability of a material to be easily magnetized
   B) The loss of magnetism in a material over time
   C) The resistance of a material to magnetization
   D) The phenomenon where a magnet attracts a non-magnetic material
7. Give an example of practical use of magnets.
   A) Playing music
   B) Storing digital data
   C) Cooking food
   D) Painting walls
8. What is an electromagnetic field?
   A) The area around a magnet where its effects can be detected
   B) A force exerted on a charged particle in motion
   C) A combination of electric and magnetic fields
   D) The process of switching on a motor or fan
9. Which of the following factors affects the magnetic force on a current-carrying conductor in a uniform magnetic field?
   A) Length of the conductor
   B) Resistance of the conductor
   C) Voltage applied to the conductor
   D) Thickness of the conductor
10. What forces are set up between parallel current-carrying conductors in a uniform magnetic field?
    A) Repulsive forces
    B) Attractive forces
    C) No forces
    D) Gravitational forces
11. What is the torque produced by a current-carrying rectangular coil in a uniform magnetic field?
    A) The twisting force on the coil
    B) The push or pull on the coil
    C) The rotation of the coil
    D) The bending of the coil

12. How is the force exerted on a charged particle moving in electric and magnetic fields?

A) By increasing the temperature of the particle

B) By changing the colour of the particle

C) By changing the shape of the particle

D) By changing the velocity of the particle

13. What is the application of a relay?

A) Generating electricity

B) Switching on a motor or fan

C) Creating a magnetic field

D) Demagnetizing a material

14. Which of the following devices can be switched on using a relay?

A) Radio

B) Telephone

C) Television

D) All of the above

15. What is the purpose of using a relay to switch on a motor, fan, or light?

A) To increase the voltage

B) To reduce the resistance

C) To control the flow of current

D) To generate heat

16. Which of the following materials is considered non-magnetic?

A) Aluminum

B) Nickel

C) Cobalt

D) Steel

17. What is the purpose of magnetization?

A) To make an object attractive

B) To increase the size of a magnet

C) To align the magnetic domains in a material

D) To generate electricity

18. What happens during demagnetization?

A) The magnetic field strength increases

B) The material becomes non-magnetic

C) The material becomes permanently magnetized

D) The magnetic domains become disordered

19. How does temperature affect the strength of a magnet?

A) Higher temperature increases the strength

B) Lower temperature increases the strength

C) Temperature does not affect the strength

D) The strength is directly proportional to the temperature

20. What is the relationship between electricity and magnetism?

A) They are unrelated phenomena

B) They are the same thing

C) Electricity can generate a magnetic field

D) Magnetism can generate an electric field

APPENDIX B

ANSWERS FOR PRE-INTERVENTION TESTS

Each answer carries 2 marks

1. C) Copper

2. A) The area around a magnet where its effects can be detected

3. C) By passing an electric current through a material

4. A) Temperature

5. B) Regions within a material where the magnetic alignment is uniform

6. B) The loss of magnetism in a material over time

7. B) Storing digital data

8. C) A combination of electric and magnetic fields

9. A) Length of the conductor

10. B) Attractive forces

11. A) The twisting force on the coil

12. B) By changing the velocity of the particle

13. B) Switching on a motor or fan

14. D) All of the above

15. C) To control the flow of current

16. A) Aluminum

17. C) To align the magnetic domains in a material

18. D) The magnetic domains become disordered

19. C) Temperature has no effect on the strength

20. C) Electricity can generate a magnetic field

APPENDIX C

POST-INTERVENTION TESTS

Answer all questions

1. Which of the following materials is commonly used to make permanent magnets?

A) Aluminum

B) Plastic

C) Neodymium

D) Glass

2. What is the process of magnetizing a material by aligning its domains in the same direction called?

A) Magnetization

B) Demagnetization

C) Polarization

D) Remagnetisation

3. Which of the following factors does NOT affect the strength of an electromagnet?

A) Number of turns in the coil

B) Current flowing through the coil

C) Length of the coil

D) Temperature of the surroundings

4. What is the unit of measurement for magnetic field strength?

A) Tesla

B) Volt

C) Ampere

D) Watt

5. Which of the following devices uses the principle of electromagnetic induction?

A) Microphone

B) Speaker

C) Battery

D) Resistor

6. What happens to the magnetic field strength when the distance from a magnet increases?

A) It increases

B) It decreases

C) It remains constant

D) It becomes zero

7. Which of the following is an example of a naturally occurring permanent magnet?

A) Bar magnet

B) Electromagnet

C) Hard disk drive

D) Soft iron core

8. What is the primary purpose of a magnetic compass?

A) To measure electric current

B) To detect magnetic materials

C) To determine geographical directions

D) To generate electricity

9. Which of the following materials is commonly used as a core in transformers?

A) Aluminum

B) Plastic

C) Copper

D) Iron

10. What is the phenomenon called when a magnet induces a magnetic field in a nearby non-magnetic material?

A) Magnetic repulsion

B) Magnetic induction

C) Magnetic permeability

D) Magnetic hysteresis

11. What is the relationship between the magnetic field strength and the magnetic flux density?

A) They are directly proportional

B) They are inversely proportional

C) They have no relationship

D) It depends on the material being magnetized

12. What type of magnetism is exhibited by a material that becomes magnetized only when placed in an external magnetic field?

A) Ferromagnetism

B) Diamagnetism

C) Paramagnetism

D) Antiferromagnetism

13. Which of the following devices converts electrical energy into mechanical energy using the principle of electromagnetism?

A) Generator

B) Transistor

C) Capacitor

D) Diode

14. What is the purpose of a magnetic shield?

A) To block the flow of electric current

B) To increase the strength of a magnet

C) To redirect magnetic fields

D) To create an electromagnetic field

15. Which of the following factors affects the direction of the force experienced by a current-carrying conductor in a magnetic field?

A) Length of the conductor

B) Width of the conductor

C) Orientation of the conductor

D) Color of the conductor

16. What is the process of removing magnetism from a material called?

A) Magnetization

B) Remagnetization

C) Demagnetization

D) Polarization

17. Which of the following materials is commonly used in magnetic resonance imaging (MRI) machines?

A) Aluminum

B) Plastic

C) Copper

D) Superconducting magnets

18. What is the purpose of a magnetic levitation (maglev) train system?

A) To reduce air pollution

B) To increase transportation speed

C) To generate renewable energy

D) To measure magnetic fields

19. What is the phenomenon called when a material retains some magnetism even after the external magnetic field is removed?

A) Magnetic remanence

B) Magnetic susceptibility

C) Magnetic coherence

D) Magnetic anisotropy

20. Which of the following materials is NOT attracted to a magnet?

A) Iron

B) Nickel

C) Cobalt

D) Aluminum

APPENDIX D

ANSWERS POST INTERVENTION TESTS

Each answer carries 2 marks

1. C) Neodymium

2. A) Magnetization

3. D) Temperature of the surroundings

4. A) Tesla

5. A) Microphone

6. B) It decreases

7. A) Bar magnet

8. C) To determine geographical directions

9. D) Iron

10. B) Magnetic induction

11. A) They are directly proportional

12. C) Paramagnetism

13. A) Generator

14. C) To redirect magnetic fields

15. C) Orientation of the conductor

16. C) Demagnetization

17. D) Superconducting magnets

18. B) To increase transportation speed

19. A) Magnetic remanence

20. D) Aluminum

APPENDIX E

STUDENTS QUESTIONNAIRE

Introduction

Dear Participant, thank you for taking the time to provide your valuable feedback. This survey aims to assess your perception of the effectiveness of Inquiry-based Learning (IBL) in the teaching and learning of electricity and magnetism concepts. Your responses will greatly contribute to understanding the impact of this approach on your learning experience. Please indicate your level of agreement with each statement by ticking [✔ □] the appropriate response.

Scale: Students' Perception of Inquiry-Based Learning in Teaching and Learning of Electricity and Magnetism Concepts

1. The inquiry-based learning approach helped me better understand electricity and magnetism concepts.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

2. I found the inquiry-based learning activities engaging and interesting.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

3. Inquiry-based learning improved my critical thinking skills when dealing with electricity and magnetism topics.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

4. I felt more motivated to learn about electricity and magnetism through inquiry-based methods.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

5. The inquiry-based approach made it easier for me to connect theoretical concepts with real-life applications in electricity and magnetism.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

6. I believe that inquiry-based learning is an effective method for grasping complex electricity and magnetism principles.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

7. The inquiry-based approach enhanced my problem-solving abilities related to electricity and magnetism.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

8. I felt actively involved in my learning process when using inquiry-based methods for electricity and magnetism.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

9. I think that inquiry-based learning should be used more often in teaching electricity and magnetism.

Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

10. My overall learning experience with electricity and magnetism was positively influenced by the inquiry-based approach.

Strongly Disagree □ Disagree □ Neutral □ Agree□ Strongly Agree □

APPENDIX F

TIMETABLE

DAY/TIME	8:00 am - 10:00am		10:30am-12:30pm		1:00 pm – 3: 00 pm
MONDAY	**G. SCIENCE B (E. Physics)**	BREAK		BREAK	
TUESDAY					**GENERAL ARTS 2 (Core Physics)**
WEDNESDAY			**AGRIC SCIENCE (E. Physics)**		
THURSDAY					
FRIDAY					**GENERAL ARTS 1 Core Physics**