EFFECTS OF INQUIRY-BASED SCIENCE TEACHING APPROACH ON LEARNING OUTCOMES OF SECONDARY SCHOOL PHYSICS STUDENTS IN KITUI COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this Thesis is my original work and has not been previously submitted for award of a degree in this university or any other university.

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Recommendation by Supervisors

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ABSTRACT

The present study was inspired by the consistent posting of dismal performance in Physics in the Kenya as depicted in the annual KNEC report on KCSE performance for the duration 2014-2019. The same trend was observed for Kitui County. The study set out to investigate the effect of IBISTA on learning outcomes of secondary school physics students in Kitui County, Kenya. The guiding objectives were: to determine the difference in task competence between Physics students taught using IBSTA and those taught using conventional methods; to assess the variation in self-concept of students taught using IBSTA and those taught using conventional methods; to establish the difference in scientific-creativity of students taught using IBSTA and those taught using conventional methods and to determine the difference in motivation between students taught using IBSTA and those taught using conventional methods. The study was guided by two theories Constructivist and the Self-Determination Theory. It adapted a mixed methodology and a Quasi Experimental Research Design and in particular the Solomon's Four Non-Equivalent Control Group Research Design. The target population was 1600 form four students from 40 Extra-County Secondary Schools in Kitui County. Stratified random sampling was used to select four Extra-County schools. Purposive sampling was used to select 40 Form Four Physics students from each of the four schools and 2 Physics teacher from each of the 4 sampled schools, giving a sample size of 162 respondents. The study employed a Physics Task Competence Test, Students' Questionnaires, and Scientific Creativity Observation Schedule as the research tools. The research instruments were pilot-tested in two Extra-County schools in the neighbouring Machakos County to ascertain their validity and reliability. For reliability, test retest method was used, and computed using Kuder-Richardson formulae and the reliability of both the students' motivation questionnaire, students' self-concept questionnaire and the scientific observation schedule was obtained using Cronbach's Coefficient Alpha. A reliability coefficient average of at least 0.8124 was obtained. Descriptive analysis used frequencies, means, standard deviation and percentage while the inferential analysis used the t-test, Analysis of Variance, Chi-square and the Least Significant Difference (LSD) technique with the aid of Statistical Package for Social Science (SPSS) programme version 24. The hypotheses of the study were tested at α=0.05 level significance. The findings showed a statistically significant difference in the learning outcomes of students exposed to IBSTA compared to those taught by conventional methods. Statistical significance was reported in students' self-concept and out of the four indicators of self-concept, only role performance was not statistically significant. The findings also indicated that achievement goal, as one of the four indicators of motivation was not statistically significant. The study concluded that IBSTA is effective in improving students' learning outcomes. Finally, the study makes recommendations to the various education stakeholders, key among them being the creation of an environment for IBSTA adoption in schools.

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ACRONYMS AND ABBREVIATIONS

ANOVA	-	Analysis of Variance
CBC	-	Competence based Curriculum
EMF:	-	Electromotive Force
IBSTA	-	Inquiry –Based science Teaching Approach
ICT	-	Information and Communication
ISET	-	In-Service Education Training
ISPS	-	Integrated Science Process Skills.
KCSE	-	Kenya Certificate of Secondary Education
KESSP	-	Kenya Education Sector Support Programme
KICD	-	Kenya Institute of Curriculum Development
KIE	-	Kenya Institute of Education
KNEC	-	Kenya National Examination Council
LSD	-	Least Significance Difference
NACOSTI	-	National Commission for Science Technology and Innovation
NSSE	-	National Survey of Students Engagement
OGT	-	Ohio Graduation Test
PCBT	-	Physics Competence Based Test
P. D	-	Potential Difference
QS	-	Questionnaire for Students
SCOS	-	Scientific Creativity Observation Schedule
SI	-	International Standard Units
SMASSE	-	Strengthening of Mathematics and Science in Secondary Education
SPSS	-	Statistical Package for Social Sciences
TTCT	-	Torrance Test of Creativity Thinking
UNESCO	-	United Nations Education, Scientific & Cultural Organization.
USA	-	United State of America

CHAPTER ONE

INTRODUCTION

This chapter sets the background to the study, statement of the problem, purpose of the study, research objectives, hypotheses, and significance of the study, scope of the study, limitations of the study, delimitations of the study, assumptions and concludes with operational definitions of key terms.

1.1. Background to the Study

Physics is a branch of science that involves the study of matter, energy and their interactions. A study conducted in the USA by Kola (2013), argued that concepts learnt in Physics contribute immensely to technological infrastructure needed to make scientific advances, discoveries, health education, economic development, energy and environment. The essence of teaching Physics in education field is to bring about positive change in the behaviour, attitude and thinking of a learner (Tebabal and Kahssay, 2011). IBSTA is positively associated with outcomes when it incorporates teacher guidance, and negatively when it does not (Aditomo and Klieme, 2019). IBISTA gives a learner a problem to discover along with the steps and materials (Bulbul, 2010).

A research study by Kahn and O'Rourke, (2005) on understanding IBL in Secondary School Physics showed that IBL is deeply rooted in learner's activity that enhance their scientific creativity. Another study in the USA by Gormally (2009) found out that there was a great and significant improvement in students' self-concepts and confidence in the use of scientific literacy skills after participation in the Inquiry Based Experiment in the Physics Laboratory. A similar study in Turkey by Zekibayram (2013) confirms that Inquiry-Based activities also promote students' motivation. Inquiry-Based Science Approach teaches concepts, facts or skills that lead learners to formulate their own questions or problems thereby enhancing learning outcomes (Bulbul, 2012).

In another study conducted in South Africa by Baloyi (2015) on the effect of Inquiry Based Science method in teaching practical in Physics, found that learners developed better understanding of science concepts when using this method than when they used traditional methods. Similarly, a research by Ormarod (2008) in Zimbabwe, observed that Inquiry-Based Learning Approach enables students to be actively involved, to be creative in investigating a problem, obtaining data, interpreting, analyzing and getting a conclusion to a problem. Due to the need to put more emphasis on teaching approach Hightower (2010) asserts that the effectiveness of method a teacher applies in teaching physics determines learners output in performance. In a study conducted by Njoroge (2011) it was observed that Physics is an instrument that can help in making Kenya an industrialized country as visualized in Kenya Vision 2030.

A study conducted by Munuve (2010) reported that dismal performance in Science and mathematics, the major contribution is the teaching approaches applied by teachers and instructional instruments used during the instruction. The use of an effective teaching approach enables learners to acquire appropriate scientific skills that can transform a country industrialization and economic development. According to Kaboro & Githae (2015), motivation is always enhancing when inquiry based learning used during teaching Physics practical. Kwena (2007) adds that self-concept of a learner determines the learning outcome in science.

A research study in Kitui by Koki (2015) reported that a teacher has a great role in guiding the learner to have good morale that will make the learner to have internal drive to believe in them and achieve academically. Chelangat (2014) in his study on effects of practical on investigation and scientific creativity amongst secondary school Biology students in Kericho sub-County, Kenya, indicated that the use of practical laboratory investigation approach and integrating it with Inquiry-Based Approach enhances creativity amongst secondary school Biology students. The poor performance in Kitui is due to the conventional instructional methods that teachers use in teaching science, Musembi (2008).

Njoroge, Changeiywo and Ndirangu (2014) observed that students taught using Inquiry-Based Teaching Approach in Physics outshine students taught using the conventional method. IBSTA suggests that the general poor performance in Physics in Kitui County may benefit from a change of teaching methodology. However, Njoroge *et.al. (2014)* did not show evidence that they investigated aspects of creativity, self-concept and task competence. According to the Kenya National Examination Council (KNEC) Physics is clustered with Chemistry and Biology. However, students must select and pursue at least two science subjects at Form three and Four (KNEC Report, 2006). Few of the students opt for a combination of Physics and Chemistry. The performance of Physics in Kitui County has been appalling. A good teaching method enhances good performance in science and mathematics (SMASSE Report, 2014).

The overall performance and achievement of students in the Kenya Certificate of Secondary Education KCSE Physics examination has been poor over the years as stated in table1. The implication is that majority of the candidates fail to meet the expected mastery of the subject matter, which locks them out of careers where Physics is a prerequisite subject (KNEC Report, 2008). The KNEC report also indicated that the topic of current electricity is mostly examined in Practical Paper and in Paper Two and students perform poorly. One of the reasons given for this is methodology used during instruction.

Table 1: Performance in Physics in KCSE Nationally and Kitui County for the Year 2014-2019

Year	Paper	Max. score	Mean-score Nationally (%)	Mean score Kitui County (%)
2014	1	80	24.00	19.00
	2	80	35.75	29.36
	3	40	22.88	20.88
2015	1	80	28.63	25.42
	2	80	23.46	20.46
	3	40	23.85	21.85
2016	1	80	25.32	23.49
	2	80	24.17	20.17
	3	40	23.92	19.36
2017	1	80	26.73	20.49
	2	80	20.77	20.42
	3	40	15.22	15.22
2018	1	80	26.11	26.11
	2	80	21.82	21.82
	3	40	22.37	18.37
2019	1	80	21.64	17.94
	2	80	29.43	23.36
	3	40	22.24	14.42

Source: KNEC Reports (2020)

The data shown in the Table 1 is the National KCSE results in physics and the analysis of Kitui County. The performance of Physics examination from the year 2014 to 2019 in the three Physics papers has been dismal. Physics Paper 3 in particular was poorly performed nationally. In 2014 the average score was 20.88%, 2015 was 23.85%, 2016 was 23.92%, 2017 was 15.22%, in 2018 it was 22.37% and 2019 the score was 22.24%. In Table 1, the record shows that there is a consistent drop of Paper 3 from 2014 to 2019. Table 1 indicates that Physics Paper Three as compared to Physics Paper One and Two as indicated in Table 1. Table 1also indicates that performance of Physics in Kitui County have been poor. There is need to devise the probable solution to improve learning outcome in Physics.

1.2. Statement of the Problem

Persistent poor performance in KCSE Physics National and at Kitui County level has been attributed to factors such as use of conventional instructional method, inadequate facilities, poor mastery of content on the part by the teacher, lack of interactive forums for learners and teacher shortage (KNEC Reports: 2014 to 2019). Several efforts have been put in place to improve learning outcome in Physics. The Government of Kenya in collaboration with the Japanese Government through Japanese International co-operation Agency (JICA) introduced the Strengthening of Mathematics and Science Education (SMASSE) in Secondary Schools. This programme may have put more emphasis on hands-on rather than mind-on approach. Despite such efforts, learners' performance in the national exam in Physics continues to decline. The impact of this trend on self-concept creativity, motivation, and task competence among students has been in adequately investigated. If there will be no attempt to solve the problem this worrying trend will continue. There is limited information on the effects of IBSTA in Physics especially in Kitui County. In an attempt to bridge, this gap the current study investigated effect of IBSTA on learning outcomes of secondary school Physics' students in Kitui County, Kenya.

1.3. Purpose of the Study

The purpose of this study was to investigate effects of Inquiry-Based Science Teaching Approach on learning outcomes of secondary school Physics' students in Kitui County, Kenya.

1.4. Objective of the Study

The current study was guided by the following four objectives to:

i. Determine the difference in task competence between students taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods.
ii. Assess the variation in self-concept between students taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods in Physics.
iii. Establish the difference in scientific-creativity of the student taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods in Physics.
iv. Determine the difference in motivation between students taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods in Physics.

1.5. Hypotheses

To achieve the above objectives, the following hypotheses were tested at $\alpha= 0.05$ level of significance.

H_{01}: There is no statistically significant difference in task competence in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods.

H_{02}: There is no statistically significant difference in self-concept about Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional teaching methods.

H_{03}: There is no statistically significant difference in scientific-creativity in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods.

H_{04}: There is no statistically significant difference in motivation to learn Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods.

1.6. Significance of the Study

The findings of the study may help the Ministry of Education in the reviewing and formulation of policies for implementation of teaching methods that are learner centered. Findings may be helpful to Curriculum developers at Kenya Institute of Curriculum Development (KICD) in their review of secondary school Physics syllabus and instructional objectives in towards Competence Based Education. The information obtained from the study may help the Kenya National Examination Council (KNEC) in the methodology of assessing learning outcomes to make it more comprehensive. The findings of the study may give the head of science department and Physics teachers' insights into preparation of instructional materials for Physics lessons. Physics teachers, who are the implementers of the Physics curriculum, may incorporate and adopt the approach in teaching various topics in Physics and other science subjects. The information obtained from the study may also be essential to a student who takes all the sciences since it may add knowledge and enhance in learning outcome. The study may also help researcher to conduct a study that is similar to the current but to deal with other science subject such as Chemistry and Physics at different levels in high school.

1.7. Scope of the Study

The study investigated the following independent variables; inquiry based science teaching approach and conventional method. The dependent variable was learning outcomes. The study was carried out in Kitui County in Kenya and the target population was 1600 Physics students in all the 40 Extra– County schools. The study involved public secondary schools and Form Four Physics students from four Extra-County schools selected by stratified random sampling from the 40 Extra-County schools in Kitui. The reason for the choice of Extra-County schools is that students are normally admitted to Extra-County schools from different parts of the county. This gives a good representation of students in the whole county. Out of the four schools, selected two were Boys' schools and the other two were Girls' schools. The content covered was current electricity II that was taught over a period of three weeks.

1.8. Limitations of the Study

The researcher encountered various limitations while conducting this study. First, some respondents failed to give correct information due to fear of victimization by the school administration. The researcher overcame this limitation by assuring the respondents that confidentiality would be upheld and ensuring that the respondents gave their responses anonymously where personal identifiers such as the names of the respondents were not disclosed. Secondly, respondents attempted to give socially acceptable answers thereby giving biased data. To mitigate this obstacle, the researcher systematically and clearly explained the purpose of this study and the benefits that would be obtained from study.

The area of study was geographically expansive hence accessing the respondents was a challenge. To deal with this limitation, the researcher contracted two research assistants who assisted in the data collection exercise by ensuring that respondents of the study were contacted in good time. Finally, the results of the study were not generalized to different secondary schools in other areas considering that there might be special dynamics, which have an effect on students' outcome in Physics. To mitigate this limitation, the researcher advocates that further research be carried out on Inquiry-Based Science Teaching Approach in Physics and Chemistry disciplines.

1.9. Assumption of the Study.

This study was guided by five assumptions. The study assumed that the sample drawn from the population was enough to deal with the research problem and the results could be generalized. Another assumption was that Inquiry-Based Science Teaching Approach might differ from conventional methods in its impact on learners' outcome. It further assumed that the respondents provided honest and objective responses to the questions asked besides being cooperative throughout the research process. The study likewise assumed that the Physics teachers conformed to the instructions, which were set for the treatment of the group in order to obtain the relevant information. In addition, the researcher assumed that Physics teachers that were involved in the study had experience and qualified.

1.10. Operational Definition of Terms

The following operational definitions were used in the study.

Achievement: This is the measure of student's ability to recall, apply, comprehend, analyze and synthesis facts and ideas. In the current study, it implies the level of computational skills in getting solutions to questions in the written test.

Conventional Teaching Approach: A traditional mode of instruction in which the teachers use various methods of teaching as learners listen and carry out activity as directed by the teacher. In this study, it is the method used in the control groups.

Critical Thinking: It is purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as an explanation of the evidence. In this study, it refers to a learner being in a position to conclude a problem after an intensive analysis of the concept.

Inquiry-Based Science Teaching Approach: This is a teaching approach driven by the student's own curiosity, interest, or passion to understand an observation or solve a problem when guided by the teacher. In this study, it refers to teaching approach in which the teacher guides the student into seeking information, knowledge through questioning. The learner acquires new information and data and turns it into new knowledge.

Learning outcome: In this study, it refers to the behavioral competences displayed by learners after the learning process that may include; Task competence, self-concept, scientific-creativity, and enhanced motivation.

Motivation: The driving forces stimulate a learner to achieve a certain goal in learning Physics.

Self-concept: It is students' self-perception of their academic accomplishment, academic competence and expectations of their academic success and failure. In the current study, it refers to the internal conviction of a student doing Physics that he or she is capable of performing well in it.

Scientific Creativity: This is the ability to produce an original and unusual idea, or to make something new or imaginative. In the study, it refers to the ability of the learner to approach a Physics practical using the concept learnt theoretically without the teachers' assistance.

Task competence: It refers to the ability, knowledge and skills that enable a student to act effectively in a wide range of situation. In the study it refers to the degree of accuracy in handling any assigned task in Physics practical on Physics pre-test and post -test.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

This chapter deals with literature review to the study with regard to Inquiry Based-Science Teaching Approach, task-competence in Physics, self-concept, scientific creativity and motivation. The chapter further presents the theoretical framework that guided the study and the conceptual framework at the end of the chapter.

2.2. Inquiry- Based Science Teaching Approach

Inquiry-Based Science Teaching Approach is a method that combines the curiosity of students and the scientific method, which enhances the development of scientific creativity while learning, physics (Hesson and Shad, 2007). There are three types of inquiry learning strategy: guided inquiry, free inquiry, and modified inquiry. Ideally, the application of inquiry strategy requires hands-on activities, in which the students actively investigate. The role of the teacher in this method is to instruct through questions, which allow students to make the desired connections (SMASSE report, 2014). Teachers in Kitui County rarely use this method.

Inquiry-Based Science Teaching Approach is important since it motivates learners (Caruso and Woodley, 2008). Self-directed learning gives learners the freedom and autonomy to choose the what, why, how, and where of their learning (Francis, 2017) the method encourages active learning and develops key critical thinking communication and decision making skills. According to Jansen and Merwe (2015) reported that a meaningful learning requires the learning outcomes that also produce graduates who have the critical thinking ability, problem-solving skill, and who will be of service in the future. In addition, Merwe indicated that positive group experiences have been shown to contribute to students' learning, retention and good results.

In a study conducted in U.S.A by Darby (2007) it was found out that inquiry, based learning allows students to debate during class discussion and presentation. As a result, it makes learners responsible and actively involved. Further Darby reported that it provides learners with new experiences since they develop competences in researching current issues; preparing logical argument; actively listening to various perspectives; differentiating between subjective and evidence-based information; asking cogent questions and integrating relevant information. Teachers become partners and mentors providing support and opportunities for students to fully explore subjects (Davis, 2018). Natural science as one of the subjects taught in elementary schools was considered difficult for students (Llewellyn, 2013).

A finding by Nuangchalem and Themmasena (2009) indicated that Inquiry-Based learning activities promote cognitive and analytical thinking. According to this research, which was carried out in Europe, Inquiry-Based Learning brings about learners' satisfaction. Inquiry Teaching Approach provides for deeper and more practical learning opportunities. Learners internalize concepts when they go through a natural progression to understand them (Riandari, Susanti and Suratmi, 2018). According to Chopra and Gupta (2011), Inquiry Teaching Approach allows students to make meaningful real-world connections in the class as they link the relevance between what they learn in the classroom and their potential careers in the future. This causes students to retain knowledge longer when they are active participants in the learning process. In addition, Tasso (2011) found out that science teachers in advanced countries still have problems with understanding and practicing Inquiry-Based Teaching in this 21st century.

Ozel and Luft's (2013) study in Germany indicated that experiences in the classroom did not change the conception and enactment of inquiry among beginner teachers. The researcher recommended that pre-service teachers need many opportunities to build their knowledge and practice about inquiry and they need explicit instructions about the different features of inquiry. Inquiry Based Science Teaching Approach, learners create, integrate and generalize knowledge (Gengle, Abel and Mohammed, 2017. According to Strope and Sommer (2015) when a new teacher incorporates laboratory activity and inquiry learning instruction, it gives a learner a very strong foundation of understanding. Consequently, the learner and the teacher are mutually motivated.

According to a study carried out in Singapore by Sun and Xie (2014), Inquiry-Based Learning improves teachers understanding. Susan and Xie further argued that teachers moved progressively from more teacher-centered thinking about teaching to student-centered thinking. Participating teachers also worked together in designing an interdisciplinary inquiry curriculum providing an effective alternative to traditional rigid standard based curriculum and teacher directed instructions. Alberta Education (2012) outlined a growing body of literature that promotes purposeful inquiry strategies and frameworks that enrich content understanding and promote the appreciation of disciplinary means and processes. The finding also reported that the Inquiry method of teaching improves science teachers' ability to assess students during the lesson and eliminate any misconception of a learner.

In Central India, a study by Madhuri and Goteti (2012) explored how inquiry based learning can be used to promote higher order thinking skills among engineering students taking a chemistry module course in a university in Central India. The findings indicated that students developed critical thinking, problem-solving ability and integration of knowledge at the end of the chemistry module course taught through an inquiry –based approach. Madhuri and Goteti concluded that if the method was effective in chemistry, it could also be effective to physics and Biology.

Adunalo (2011) reported that Teaching and learning constantly endeavor to examine the extent to which different teaching methods enhance growth in student learning. Ayeni (2011) argued that teaching is a continuous process that involves bringing about desirable changes in learners through use of appropriate method. According to Kibirige, Osodo and Mirasi (2013) Discovery Teaching Approach is different from Traditional Teaching Approaches in that learning is active rather than passive, learning is process rather than fact-based, failure is important, feedback is necessary and understanding is deeper. In a research in Rwanda, Mugabo (2015) reported that inquiry based learning influences significantly the performance of a student. Mugabo further reported that inquiry makes a learner to be logical in thinking which enhances understanding.

Inquiry-Based Science Teaching Approach enhanced good performance of students' schools that implemented it in Zambia Mumba (2012). In another study in Zambia by Muzumara (2011), conventional methods have generally proven not to be very effective in the teaching and learning process because they tend to keep learners on the passive side, as learning is not reinforced by practical activities. Muzumara further argued that the use of inquiry teaching Approach promotes achievement since the learner is actively involved physically and mentally.

A study in Tanzania by Athuman (2017) compared Inquiry-Based Teaching with conventional methods in development of student science skills, the finding indicated that learners who were taught using Inquiry-Based Teaching Method in Biology attained higher scores in an achievement test than those who were taught through the conventional lecture method. In line with this study, it is clear that Inquiry-Based learning is effective in ensuring the development of students' scientific skills.

Kibett and Kathuri (2005) reported that students they were taught using inquiry method out performed those who were taught using traditional methods. Further, the report indicated that the instruction method that a teacher adopts determines the learners' performance. In his study on the effect of inquiry learning approach in Biology achievement scores of secondary school students in Machakos, Muraya (2012) found out that the inquiry learning approach resulted in significantly higher mean achievement scores compared to regular teaching method. IBSTA also promoted higher academic achievement of secondary school students in Biology in knowledge, comprehension and application.

Teaching methodologies that teachers apply determine Nduku (2017) reported the performance in Physics as in her study on the influence of the SMASSE projects on the performance of Chemistry in the Kenya Certificate of Secondary Examination in Kitui–Central Sub County, Kitui County Kenya. The literature review indicates that vast information on inquiry has been gathered but there is limited information on scientific creativity, self-concept and motivation in Physics.

2.3. Effects of Inquiry-Based Teaching Approach in Teaching Physics on Student's Task Competence

A study carried out in Mexico by Llewellyn (2013) indicated that Inquiry Based Science Teaching Approach is a scientific process of active exploration that uses critical, logical and creative thinking skills to answer by teacher guidance questions hence learner achievement is obtained. Llewellyn argument was in line with a study conducted by Ural (2016), who observed that through inquiry learning, significant improvement occurs in all aspects of student's motivation and learning outcome. In addition, there was a significant decrease on student anxiety in chemical laboratories, inquiry-based learning activities, the students have fewer misconceptions and understand concepts more meaningfully. The approach a teacher applies in teaching determines the chronological aspect of thinking of a learner.

In a research study in USA by Bittinger (2015) on the impact of an Inquiry-Based Approach on attitude, motivation and learning outcome in a high school Physics laboratory, the findings indicated that inquiry learning in a laboratory setting improves task competence and motivation. Students who are taught through Inquiry Approach put most of their focus on the steps of the procedure and thus enhancing learning outcome (Sesen and Tarhan, 2013).

Students perform better on Inquiry-Based exam questions than non-inquiry based exam questions regardless of how much they struggled to complete the exam (Bryant, 2006). Johnson, Zhang and Kahle (2012), also researched on effects of good physics instruction on student's performance on high stakes test, the Ohio Graduation Test (OGT) the finding reported that good Physics instruction deemed to have student–centered classroom where students were actively involved in problem solving process and the student recorded a high score in the exam. Students become competent in tasks set based on inquiry-based method as opposed to non-inquiry based methods.

Harrison (2014) studied how teaching in Europe adapts to a change in pedagogy as teaching shifts from a deductive to an Inquiry Approach. The finding indicated that Inquiry activities allow teachers to collect more evidence of student performance by observation during the experiment because instead of teaching the instruction, teachers could listen to conversation for misconceptions and perform formative assessment. This was a development from a study done by Zion and Mendelovia (2012) who stated when IBSTA is well introduced to the learner it gives a positive impact on students' task competence in physics. It is essential to introduce learners to IBSTA early in the learning process.

In a study conducted in Europe by Banerjee (2010) on the implication of Inquiry-Based Teaching on student learning in science laboratory, the findings indicated that Inquiry-Based lessons had a positive effect on students and posted a very high score in an achievement test as compared to a class that was taught through traditional approach. Sesen and Tarhan (2013) observed that students who were taught using IBSTA performed better in a chemistry test than those who were taught using traditional methods. Learners' task competence is thus highly determined by the method used in teaching.

Inquiry Teaching Method is more effective as compared to traditional methods of teaching, because it improves different learning domains such as knowledge, ability and task competence that are associated with improve learner outcome (Shafqat, 2015). Additionally, Opara (2011) in his study on inquiry method and student academic achievement in science lesson and policy implications indicated that there is positive significant effect on student achievement. In order for a learner to develop his or her competence, the teacher must apply a learner-centered approach.

In a research done in Turkey by Demirbag and Gunel (2014) on effect of Inquiry-Based Learning on science achievement, writing and argument skills, the findings indicated that the experimental group outperformed the control group in terms of the quality of their arguments and their activity report. Further, it was reported that an Argument-Based Inquiry learning environment was successful in teaching Physics to college students. Another related study by Thoron and Myers (2011) researched on the effects of Inquiry-Based learning on student's ability to learn Agri-Science and found out that the group that used IBSTA outperformed the group that used the traditional approach.

A study in Malaysia by Rakhmawan, Setiabudi and Mudza (2015) indicated that Inquiry-Based Learning makes a student more confident and makes learning more meaningful hence increases learning outcome. Kim and Buckner (2014) also supported that there is a significant difference in student's natural science learning outcome and their motivation to perform in Physics. The learning outcome is proportional to the learners' understanding of a concept.

In Korea, Kong and Song (2014) found out that Inquiry-Based Learning helps learners to develop inquiry skills, which are among the basic skills of the 21st century. The use of inquiry method in teaching Physics raises student's motivation and their problem solving Skills. Their scientific inquiry-based learning environments are also influential in increasing student outcome (Wilke and Straits, 2005). In the 21st Century, a student requires a method that will enable them acquire scientific skills that will build their task competence. The finding concurred with those of a study conducted by Pane, Steiner, Baird, and Hamilton (2018), that learning approaches that emphasize agency and choice, such as problem-based, project-based, and inquiry-based instruction, are associated with improved academic and non-academic outcomes.

A study in South Africa by Athuman (2017) on the comparison of effectiveness of Inquiry-Based Teaching and conventional style of teaching Physics indicated that use of inquiry-based learning develops student's science process skills that enhance good performance in Physics. The use of conventional method limits the learners from gaining science process skills (Adedeji, 2007). A student-centered method helps learners gain science process skills as opposed to conventional method.

In a study conducted in Nigeria by Akinyemi and Afolabi (2009) reported that physics students with low ability level taught using Inquiry-Based Learning techniques performed significantly better than those taught using conventional learning method. In addition, Akinyemi and Afolabi argued that it is the best method to teach physics because it is not biased on gender and performance. The learner task competence does not depend on the gender but the methodology that teacher applies in teaching any concept.

According to a study by Khuzwayo (2005) on history of mathematics education in South Africa, when apartheid ended mathematics was not offered and taken by learners in all schools. It was taught as an abstract, meaningless subject only to be memorized. Students used to fail the mathematics examination but when the inquiry based learning was implemented, Khuzwayo reported that there was a very high significant difference in performance. Around the same time another study was carried out in Lesotho by Ratsatsi (2005) on traditional and alternative views of schools' system mathematics performance, traditional method that were used to instruct students, when teaching played a very big role in low performing students nationally. Conventional methods of teaching hinder the learners' task competence.

Inquiry-Based Learning Approach is a method that arouses learners' creativity in mathematics and science and enhances learner achievement (Abayomi, 2013). The path towards the shift and reforms is the adoption of modern methods of teaching whose focus is on sharpening students' Inquiry-Based ability, as well as their abilities to reason and connect ideas and shift among representations of mathematical concepts or science concepts and ideas (Vandewalle, 2007). The findings echo those of a study conducted in South Africa by Awafala (2013) on effects of Inquiry-Teaching and learner assisted individualism instruction strategy on senior secondary school students. It was found out that teachers play a great role in learners' achievement specifically on the methodology one applies and the way they present to the learner. In addition, it was observed that those teachers who use the Inquiry Based Teaching post a high achievement in their subjects. Therefore, adoption of modern method of teaching helps to sharpen students' abilities, which leads to good learning outcome.

According to a research carried out in Uganda by Ssempala (2017), some of the teachers are conversant with the use of Inquiry-Based Science Approach yet they do not use it in teaching in their stations thus performance is still poor in sciences. It further indicated that those teachers who are well exposed to the Inquiry-Based Teaching Approach do implement it in practical; it is very significant in learners' outcome. Osborne (2014) also argued that science teachers understanding of Inquiry influences their ability to practice Inquiry-Based Instruction thus enhancing good performance.

According to a research by Mwanda (2016), instruction by Inquiry Approach has positive influence on learners' achievement in Biology. He further reported that the method is very effective if it begins from grassroots of secondary school, so that the learner can build confidence and attain Inquiry skills to learn in sciences. This is because it holds many misconceptions since the learner confirms comprehension of raw memorized materials and it is less motivating (Amollo, 2005).

Munene (2015) observed that the main factor that leads to poor performance in learning Physics in Gatundu secondary schools is the use of conventional learning since the approach is teacher-centered. Conventional learning has also been observed to be commonly used in teaching Physics in private and public schools in Kitui County (SMASSE Kitui county Report, 2014) According to KNEC analysis report (2014-2016), for improvement in performance in Physics to be realized, more appropriate teaching methods need to be used.

One of the demands in sciences in the 21st century for the learners of science is the acquisition of scientific skills (KNEC, 2011). The Ministry of Education has tried to enhance the teaching of Physics in most schools by introducing projects such as Strengthening Mathematics and Sciences in Secondary Education in order to improve performance, (SMASSE, 2008). Mutambuki (2014) reported that those schools that implemented the SMASSE project when teaching like using the Inquiry-Based method and cooperative method, their schools recorded improvement in mathematics and sciences as compared to those schools that use conventional methods.

The activities of the SMASSE project are aimed at changing traditional teacher centered teaching methods and equipping teachers with necessary skills for classroom practices that put emphasis on activity-oriented ways of teaching and learning. These include: creating opportunities for learners to take responsibility for their own learning and employing Inquiry-based approach as opposed to recipe-type experiments, encouraging improvisation not only to argument convention equipment, apparatus/materials but also to arouse interest and curiosity among learners, encouraging teachers to draw content and examples from the learners' real life experiences. In order to capture their interest and imagination, foster teachers' ability and appreciation for work planning. After being in-serviced, teachers are expected to use student–centeredness, activity based teaching experiment and research approaches in their teaching in Kitui County (SMASSE, Newsletters, 2016). The literature review indicates that there are number of researches conducted out on impacts of the teaching approaches that the teachers apply in teaching science. Nevertheless, there is limited information on effects of the use of IBSTA and its learning outcome in the area of the study.

2.4. Effects of Inquiry–Based Science Teaching Approach in Teaching Physics on Student's Self-Concept

The quality of a learners' interaction with the environment may strengthen or weaken their self-concept. In a survey in the United States of America by Gliebe (2012), the findings stated that Student's positive conception is helpful in achieving success throughout life. The success in learners' lives depends not only on cognitive ability, but also on emotional skills. It is one's self-perception surmised from attitudes, feelings and knowledge about one's skills, abilities, appearance and social acceptance. Bilge *et al.* (2014) examined burnout and engagement levels in high school students' self-efficacy beliefs, academic success, and study habits.

Participants who reported low self-efficacy were more likely to report higher levels of burnout. Participants who reported better study habits and high self-efficacy were more likely to report higher levels of engagement. Additionally, students who reported poorer study habits and lower levels of self-efficacy similarly reported higher levels of cynicism, which Bilge et al associated with burnout. Green, Nelson, Martin and Marsh (2006) in their report indicated that positive self-concept is an extremely important goal for educational programs to promote and help to link positive outcomes, including higher academic achievement and effort.

Increase in application of Inquiry-Based education develops learners' critical thinking and self-concept because it encompasses multiple activities (Dostal, 2013). The use of Inquiry-Based Learning catalyzes the learner to think critically which makes a learner technologically oriented, satisfies students need and develops learners' self-concept (Kropac, 2009). Inquiry teaching fosters a belief to a learner once involved in active participation that they are able to do things on their own and this builds their self-concept to learn (Costa, 2010). It is therefore important to apply inquiry based learning to enhance learners' critical thinking and self-concept.

According to Gray (2011), IBSTA is a process of learning which builds their self-concept. Ketelhut (2007) reported that inquiry-based curriculum in context–specific setting help to raise the self-concept after the intervention compared to students taught using traditional method of instructions. Armstrong and Hallar (2009), report indicated that students taught using Inquiry method experienced frustration with the process of finding things on their own. These students show more gain in self-concept after the intervention compared to students taught using traditional method of instruction. Self-concept acts as an internal drive to good performance in Physics (Moheeta, 2010). The methodology that a teacher uses in teaching creates a conducive environment of a learner to achieve self- concept (Khan, 2016). In their study in New Jersey, Mason & Kahle (2009) reported that a student who learns through Inquiry-Based-Teaching Approach develops higher self-concept than those who are taught through conventional method.

In a case, study in Europe by Siddiqui and Khan (2016) argued that Physics achievement is correlated positively with the Inquiry-Based Science Teaching Approach and self-concept because it provides a psychologically safe and encouraging environment. The study is in line with the study by Dupe & Oludipe (2013) which reported that achievement Physics is positively correlated with self-concept and methodology used to teaching. Mindset is a major factor influencing intrinsic motivation: believing that intelligence, personality, and abilities are flexible and dynamic, shaped by experience, and changing over the life span. Learners with a growth mindset tend to be more curious, open-minded, and persistent in their learning (Duckworth, 2016). According to Bati (2014), inquiry method stimulates a learner's creativity that results in the learners' internal drive (self-concept). This internal drive improves good learning outcome.

Inquiry method is a key determinant of positive thinking and gain of scientific process skills in science. In his study in Turkey Ceylan (2016) looked at the impact of inquiry based instruction on science process skills and self-efficacy perception of pre-
Service teachers at university level Biology laboratory. Ceylan also noted that IBSTA develops positive perception towards science and thus enhances self-concept. (Morris, 2019). Moreover, a learner's readiness and propensity to engage in self-directed

learning activities varies from person-to-person Learner's knowledge is gradually formed as subjective structure that is in the process of changing and enriching learning.

According to Chang (2008), students who believe in their abilities tend to perform more successfully than those who do not. The findings indicated that students with disability pay a lot of attention and they direct all their energy to learn thus perform better than those without disability. In this way, they build self-concept in learning science. Learners who demonstrate personal responsibility operate with integrity and act in concordance with clear ethical principles (Battelle for Kids, 2019). Personal responsibility emerges from an intrinsic desire to act in ways that benefit oneself, one's local environment, and the greater society.

As investigated in India by Pecina and Zormanova (2009) a learner's participation in the teaching and development of his personal quality is highly emphasized. Pecina and Zormanova further reported that the educational process is the construction of knowledge for learners and teachers, as guarantor of methods, ensuring that every learner can achieve the highest possible level of development. Inquiry-Based Learning as well as most constructivist didactics is based on pre-conceptions of the students as instruments of knowledge (Claro and Loeb, 2019).

A study conducted in Nigeria by Olatunde (2009) reported that individuals with a low academic self-concept have shown low commitment to school. In addition, Dupe and Oludipe (2013) reported that academic self-concept is an important factor to be taken into consideration when using Inquiry-Based Teaching Approach in Physics. IBSTA further indicated that a Physics teacher should help to boost students' personality factor especially academic self-concepts by being warm towards Physics students, using Inquiry-Based Learning Approach. His argument is similar to that of Dambuozo (2005) who indicated that a learner's self-concept and academic achievement is influenced by the methodology that teachers use when teaching Physics. Therefore, students with positive self-concept in any content in Physics, acquire internal drive to put more effort into their academic work.

In his study in Tanzania, Mushi (2012) reported that students had very low self-concept because the school curriculum used was biased towards colonial education system and there was a lot of rote learning which was not beneficial to the learner. Mushi further reported that after independence the Ministry of Education and Vocational Training changed curriculum and implemented the inquiry based learning approach that led to improvement in performance and built self-concept in the learner.

According to Kaboro and Githae (2015), student's self-concept in Physics is enhanced through analogy. Based on the findings, the study concluded that analogy is an effective teaching method, which teacher should apply when teaching. This is because student-centered method which boosts learner's self-concept in Physics. Gethoi (2010) supported this argument by indicating that learning through Inquiry Approach builds' self-concept in Physics.

Teachers, parents and policy makers are linked to the value of culture a learner attain (Mucherah, 2010). Mucherah further indicated that Inquiry-Based Method is student-centered method that boosts learner self-concept. Mutambuki (2014) brings this out in his study carried out in Kitui County. From this literature, review it clear that there is limited information on effects of IBSTA in respect to self-concept in secondary schools in Kitui County hence the purpose of the present study.

2.5. Effects of Inquiry-Based Teaching Approach in Teaching Physics on Student's Scientific Creativity

Marshall, Smart and Horton (2010) argued that Inquiry-Based Learning provides students with opportunities to structure the new knowledge (scientific creativity) and try their thoughts. Students collaborate in order to create new knowledge while, learning how to think critically and creatively, how to make discoveries through inquiry, reflection, exploration, experimentation, trial and error (Alberta Education, 2010). It also ensures that students form evidence-based thoughts and acquire the critical thinking skills.

A case study in USA by Bradley (2009) on tracing the effects of teacher Inquiry on classroom practices indicated that the use of Inquiry teaching leads to creativity of a learner being continuous gain from lower level of thinking to a higher level of thinking. Further Bradley's report indicated that inquiry teaching is an innovative instruction to a learner. Thinking through specific details is critical because the details are where the complexities of teaching reside and where teachers confront the Inquiry instruction choice, which positively influence students' outcome (Chikshi and Fernandez, 2004). Increased creativity of a learner leads to positive learning outcome. In a study conducted by Stafford-Brizard, (2016), resourcefulness, perseverance, and resilience in the face of obstacles and uncertainty, the ability to learn independently; and curiosity, inventiveness, and creativity makes a learner to have a positive outcome.

In Turkey Inquiry Learning is regarded as an approach which is student-centered and which supports the configuration of knowledge (Koseogly and Tumay, 2010). According to Christopher (2014), Discovery Teaching Approach encourages scientific creativity and discourages plain retention of facts. Bereczki and Kárpáti's (2018) systematic review of the literature between 2010 and 2015 reported that teachers generally had high self-efficacy about supporting their students' creativity. However, this does not necessarily translate into teaching practices that promote creativity. That said, this method makes students to be actively involved in learning.

According to Pennington, Heim, Levy, and Larkin (2016), a punitive environment undermines learning by heightening anxiety and stress, placing extra demands on working memory and cognitive resources, which drains energy available to address classroom tasks. Burris and Garton (2007) reported that Inquiry method is exciting to the student and to the teacher as the student builds, connects and shares experiences with others. Creating an identity safe classroom by engaging in culturally responsive pedagogy relies on teachers understanding the views and experiences children bring to school, including, for example, how students communicate in their communities (Lee, 2017).

Wang, Rosé, and Chang (2011) gave brainstorming tasks for 10th graders in their regular geography class. They found that brainstorming supported idea generation and multi-perspective learning. Their study also supported the idea that students were able to be more creative about hypothesizing solutions to problems. They suggested that increased learning during brainstorming was due to exposure to others' perspectives, which enriched the representation of the domain that participating students already, have. A study conducted by Walia (2012) indicated that students taught by the 5E instructional model had higher scores on creative ability in mathematics than students taught using traditional approach.

According to a review by Hong (2013), the real-life problem-solving item describes a problem scenario that could occur in test respondents' lives in a specific domain. It assumes that test respondents have domain knowledge from life experiences. By using their knowledge, test respondents. Depending on class, hours allowed science topics, the level of elaboration and the number and depth of creative-thinking techniques utilized in the development of instructional/learning materials can be flexible (Hong, 12a). This method makes learners to work as a team and the learner gain knowledge since they are highly motivated.

The Inquiry-Based Learning helps students develop skills that enable them to construct vital concepts as teachers instruct. This encourages teachers to move away from the tradition in which knowledge is discrete; hierarchical, sequential and fixed towards an environment in which the learner (Draper, 2007) views knowledge as an individual construction created. Rinita, Prasojo, and Arifai (2018) investigated on improving Senior High School students‟ creativity using discovery-learning model in Sumatra and reported that Discovery Teaching Approach increases students‟ Scientific Creativity abilities. This argument was supported by research findings in Asia by Baker (2008) which showed that Inquiry-Based Learning improves students' problem solving and scientific creativity.

The use of Inquiry teaching skills in teaching science develops and makes a learner to acquire science process skills (Armstrong and Hallar, 2014). In addition, Kong and Song (2014) reported that Inquiry-Based Learning helps learners to develop Inquiry skills that are among the basic skills for 21st century. Abdullah (2015) investigated the effect of guided discovery approach in teaching Creativity in Japan and found out that guided discovery enhances creativity in science. Thus, the teaching approach helps to improve learners' problem solving abilities.

The study by Hong *et al.* (2012) provided a model for problem solvers to evaluate the effectiveness of their thinking behavior when they engage in problem-solving activities in a high-pressure environment. Further study may allow for empirical application of this training. It would also allow future researchers to more accurately assess the effectiveness of training in creative problem solving. Only one short-term empirical study (Hu, Shi, Wang, and Adey, 2010) related to scientific creativity has been conducted in China. This study provided evidence about how the type of instruction affects creative scientific problem finding (CSPF) ability among elementary, middle, and high school students.

The study by Ochu (2006) reported that the quality of education is directly related to the quality of instruction in the classroom. The teacher is considered the most crucial factor in the implementation of all the method of instruction that teachers apply during lesson enhances scientific creativity to the learner during instruction (Darby, 2005). Otobo (2012) found out that inquiry Teaching Approach enhances students" Scientific Creativity to solve day-to-day problems.

In a case study in Zambia by Mumba (2010), reported that the use of inquiry based learning build learner's creativity, motivates and makes them have confidence in learning science. Mumba further argued that if implemented in Zambia schools it would serve great purpose to teachers and enhance good performance. A research in Uganda by Ssempala (2017) indicated that schools whose teachers have been taken for training on teaching using inquiry based learning, have applied, and enhanced creativity among learners. Mumba further reported that learners are actively involved in the lesson that builds their motivation.

A study by Chumo (2014) report indicated that practical investigation laboratory approach enhances scientific creativity among learners. This is got through learners being allowed to apply Inquiry-Based skills to discover the solution of a question in science. The findings also concurred with those reported by Ndeke (2009) that knowledge in science is necessary but not sufficient condition for creativity. Illa and Changeiywo (2010) also reported that there was a positive correlation between learner creativity in Physics and achievement. To add to their findings, a study conducted by

Changeiywo and Itungi (2009) reported that the knowledge function is a pre-requisite to creative production in Physics and scientific creativity has a great relationship with academic achievement.

The goal of SMASSE in Kenya is to enhance performance of Biology, Chemistry, Physics and Mathematics related subjects in the internal and external examinations, positive attitude change and development of learners' creativity during the classroom instruction, (SMASSE, 2008). In a study by Nduku (2017) on impact of SMASSE project on performance and creativity of learners in Kitui County, the finding shows that the skills given to teachers during SMASSE project during a 5 years' period (2011-2016) had an impact on performance in science. In their study in Kenya, Otiende, Abura and Barchok (2013) found that teaching by Inquiry increases students" Scientific Creativity in physics, enabling them to be able to respond to unique problems and situations.

According to a study conducted by Maonga (2015), students who were taught using Inquiry–Based Teaching enhance learners' creativity. In addition, the method of teaching stimulates learners to apply knowledge to solve a problem of map-work with a different approach. It is therefore evident that if the method could be so effective in geography it can also work effectively in science subjects. In schools that use Inquiry-Based Science Teaching Approach, learners are creative and they perform well in Physics practical (Mutambuki, 2014).

2.6. Effects of Inquiry-Based Teaching Approach in Teaching Physics on Student's Motivation

Students using Inquiry-Based Learning are more likely to participate in class activity for challenge, curiosity and mastery over those using traditional methods (Sungur and Tekkaya, 2006). In their research on Inquiry-Based Learning and self- regulated learning with 10^{th} grade Biology students in USA. Inquiry-Based Teaching Approach used with 6^{th} grade math students were effective in making students employ more learning strategies in attitudes to learning, interest and motivation to learn, which were significantly higher than the control group (Kim, 2005). Therefore, it is very clear that inquiry based learning motivates students to learn.

Clerk, Kirschner & Sweller (2012) in their study in America showed that Inquiry Based learning is a useful approach to practice skills and concepts after explicit instruction. Similarly, student autonomy may also have its place in the educational setting. Shared control in which the instructor decides on a set of appropriate task to meet learners' needs and allows the students to choose the task by which to learn had positive effects on motivation and learning in certain domains (Kirschner and Vanmerrienboer, 2013). Alberta Education (2013) suggests that inquiry-based approaches to learning positively influence students' ability to understand core concepts and procedures. Inquiry also motivates a learner and creates a more engaging learning environment.

In a case study in Britain by Saunders, Stewart, Gyles and Shore (2012), study showed that Inquiry approach requires students to discover or construct knowledge through relevant activities and personal investigations. In addition, they found that traditional instruction does not enhance student learning, because students are not engaged, motivated, and perceived on purpose of learning activities. Further Saunders, Stewart, Gyles and Shore, whose findings were emphasizing the study carried out in Germany by Wilhelm (2010) which indicated that lack of motivational for traditional learning activities were because the student did not perceive relevance or purpose for the activity. The Inquiry Approach encourages students' ownership, sense of control, choice and autonomy, explicit purpose for learning, collaboration and personal relevance (Wilhelm, Wilhelm 2010). It is, therefore important for teachers to allow students time to practically carry out activities in the classroom on their own.

A research study in Belgium by Kim (2005) indicated that Inquiry Based Learning is associated with other instructional approaches such as constructivist teaching and Problem-Based learning. Reeve (2012) explained that student motivation represented the driving force that lent strength, goal-directedness, and persistence to student behavior. Considered within the SDT framework, student engagement and viewed as an important outcome of motivation because of its robustness as a predictor of academic performance. In addition, Rotgans and Schmidts (2011) reported that student motivation is a concern for educators because when students do not put forth

the effort to truly understand what they are studying because inquiry learning is designed to pursue students' interest and encourage students to cooperate in self-directed learning, it follows that it would increase students' motivation (Balm, 2009). When students develop interest in a given subject they are likely to learn better.
Motivation is relevant and necessary in learning. In traditional approaches used in teaching Physics, teachers are active while students are passive and not responsible for their learning (Covill, 2011). Covill study further argued that students simply listen and take notes. Students educated in such away are likely to be failed individuals loaded with information based on memorization rather than creative individuals that can question and produce solutions by tackling problems.

Student engagement is highly relevant in education due to benefits from increased motivation and achievement in students (Sinatra, Heddy and Lombardi, 2015). According to a study conducted in Germany by Schaal (2010), the report indicated that motivation is a necessary element for learning. It accounts for between 16% and 38% of learning. Researchers indicated that a central question concerns how to motivate students to value, self- regulate them without external pressure and given that many of the educational activities prescribed in schools are not designed to be intrinsically interesting. Based on the above arguments, it is therefore important to note that motivation is key to students learning outcome.

A case study in Europe by Guthrie, Wigfield and vonsecker (2010) on effects of instructional context on intrinsic motivation of 3^{rd} and 5^{th} grade for integrated reading and Physics instructions, supported the idea that real – world problems arouse attention, interest and sustained effort in science and curiosity for reading thus motivates the learner to know more. Providing feedback focused on effort and process encourages students to adopt a growth mindset, whereas feedback that focuses on depresses student motivation and achievement (Dweck, 2017). In addition, Summerlee and Murray (2010) reported that university students who participated in Inquiry-Based Learning classes during their first year showed an increase in motivation to volunteer in their communities compared to students who did not take inquiry based learning classes. Therefore, teachers should ensure that students are in touch with the real world for them to learn better.

Inquiry-Based activity influences student's motivation through having positive attitudes towards science (physics). This is in line with a research done in Turkey by Zekibayram (2013) on effects of Inquiry-Based Learning methods on student's motivation. The finding indicated that students' extrinsic goal orientation develops after the application of Inquiry-Based activities. The report was supported by the findings obtained in an earlier research study that concluded that Inquiry-Based activities promote student's motivation (Madden, 2011). Cantor *et al*. (2018), children have individual needs and trajectories that require differentiated instruction and supports to enable optimal growth in competence, confidence, and motivation.

In a study case in Indonesia by Napitupulu (2017) on the effect of inquiry based Eco pedagogy model on pre-service Physics teachers' motivation and achievement in environmental physics instruction, the report indicated that motivation is a powerful force in learning and the inquiry based teachings improve motivation and achievement in learning physics. The findings also indicated that inquiry with active participation of students persuades students to particularly focus on given content and use opportunity to maximize achievements due to intrinsic motivation.

In a study conducted by Adedaji and Tella (2007) reported that motivation of a student is a key determinant to good performance in mathematics that motivated students perform better academically than the lowly motivated students. The findings concur with those ZakiBayram (2013) who stressed that successful students have significantly higher motivation for achievement than unsuccessful students do. Good impartation of mathematics knowledge on the part of the teacher; couples with the student's interest in the subject and displays positive attitude which is a good motivating factor which when combined together results in better achievements in Physics (Adeseji, 2007). Thus, the success of a student is determined by the motivation of a student in a subject.

In a study in Zambia by Chola (2015), finding indicated that teaching using Inquiry-Based Approach on topic of acid-base had a positive significant difference than those taught using traditional method. The reason behind the result was that those using the Inquiry-Based learning were highly motivated than those taught using traditional approach. The study concurred with a study finding in South Africa by Shumba

(2012). This indicated that the instructional approach should be modestly demonstrated in order to motivate the learner to learn more and be exposed to new discovery. Students are motivated to learn when demonstration takes place.

Inquiry-Based Teaching enhances high achievement since the students are highly motivated by the method due to being learner-centered method, as argued by Ndirangu 2013. Esokomi (2013) further argued that Inquiry Approach makes students active in participation during class session since the approach is child-centered and motivates them to be involved in any activity. This study was on influence of Inquiry-Based Learning on secondary school students' interest and achievement in Physics in Vihiga County Kenya. In addition to the above, Maonga (2015) reported that Inquiry–Based Teaching approach motivated students who were taught Geography map work. He further reported that there was a high significance in performance in Geography using the teaching approach since the learners are motivated due to interaction with the instructional materials during the lesson. The method that the teachers apply during instruction gives a learner an intrinsic drive in learning.

In a case study by Karambu (2011) on effects of external motivation in students' performance in secondary school in Kitui Central Sub-county, findings indicated that teachers play a very great role in motivating students. It further argued that constructivist learning approach such as IBSTA enhance motivation of a student. From the literature review vast information on the effect of the teaching approaches that are being applied in teaching and how they affect the learners' have been addressed.

2.7. Theoretical Framework

The study was guided by two theories: Constructivist Theory of learning and Self-Determination theory. These theories provide comprehensive but complementary perspectives on Inquiry–Based Science Teaching Approach.

2.7.1. Constructivist Theory

Dewey's (1938) Constructivism Theory guided this study. The constructivism theory of learning upholds that knowledge is actively constructed by organizing subjects not passively received from the environment (Lerman, 2012). Piaget and Bruner who viewed constructivism in slightly different approaches adopted Vygotsky's Theory of Constructivism. Piaget based his examples on philosophy and epistemology while Bruner focused on cognitive structure, which he called mental schema (Culata, 2019).

According to Odundo and Gunga (2013) Constructivism is a cognition theory that stimulates an individual learner to process stimuli from the environment and the resultant cognitive structures that allows the learner to build and produce adaptive behaviour. The social interaction of a student within the environment provides opportunities to become aware of differences in perspective and offer intrinsic motivation to adapt these into schemata (Devries and Kohlbergi, 2010).

According to Lerman (2012), Constructivist theory does not dictate how one should teach; however, it does make it incumbent upon the teacher to deal with each learner as an individual, to value diversity of perspective and to recognize that the learner is a direct reflection of his or her life experiences. A person's education is an element of related involvements, mental structures, and convictions that are utilized to translate articles and occasions (Bredo, 2014).

A study carried out in Kenya by Mwanda (2016) opined that conventional teaching strategies make teaching and learning process boring and less motivating to learners since inadequate planning, unstructured presentation, poor time management and inconsistency in content delivery characterize them. The rationale for using this theory was to support student learning using IBSTA and thus it will motivate the learner. Constructivist model adopted in the study is a social constructivist approach to learning and provides learners with an opportunity to construct knowledge at individual level.

The other rationale of constructivism theory to the study was it guided the researcher to conceptualize that teachers should use teaching approaches that enhance their learners' logical and conceptual growth. Students should be allowed to construct knowledge by being active participants in learning and investigation. IBSTA learning of science may help learners to move away from the rote memorization of facts to meta-cognition and self-evaluation and that teacher's level of training on pedagogical imparts on the teachers' ability to implement inquiry teaching and learning.

IBSTA has a strong theoretical foundation in constructivism. Therefore, constructivism theory provided a theoretical framework for the present study to explore and investigate the issues related to current teaching and learning of physics and the implementation of Inquiry learning by teachers at the secondary school level in Kitui County. It is important to substantiate that; constructivism is not an instructional approach; rather it is a theory about how learners construct knowledge.

2.7.2. Self-Determination Theory

Deci and Ryans' (1985) Self-Determination theory also guided the study. This theory is a macro theory of human motivation and personality that concerns people's inherent growth tendencies and innate psychological needs. Self-determination theory gave a framework to understand student engagement and academic performances among ninth-grade students (Bourgeois and Boberg, 2016)

Researchers have used self-determination theory to understand how the fulfillment of psychological needs such as competence, autonomy, and relatedness can influence academic achievement and engagement (Deci and Ryan, 2006). Deci and Ryan (2006) later expanded on the early work differentiating between intrinsic and extrinsic motivation and proposed three main intrinsic needs involved in self-determination. According to Deci and Ryan, the three psychological needs motivate self- concept and specify nutriments that are essential for psychological and academic being of an individual. These needs are said to be universal, innate and psychological and include the need for competence, autonomy and psychological relatedness. Autonomy: people have a need to feel that they are the masters of their own destiny and that they have at least some control over their lives. Most importantly, people have a need that they are in control of their own behavior. Competence concerns our achievements, knowledge and skills; people have needs to build their competence and develop mastery over tasks that are important to them. Relatedness: people need to have a sense of belonging and connectedness with others. Each of us needs other people to some degree.

According to Ryan, Stiller and Lynch (1994) children internalize school's extrinsic regulations when they feel secure and cared for by the teachers. Self-Determination Theory links personality, human motivation and optimal functioning. It posits that there are two main types of motivation: intrinsic and extrinsic, and that both are powerful forces in shaping who we are academically. The importance of Deci and Ryan theory to this study is that a student learns by doing things on their own, through manipulation of objects in the environment. The theory was applicable in this study because it advocated learning through processes stages. Self-Determination Theory was of great importance because the theory was able to address the learning outcomes as dependent variables.

2.8. Conceptual Framework

A conceptual framework showed the interrelationship between independent variables and dependent variables.

From Figure 1 the direction of the arrows shows the hypothesized direction caused effect relationship in the model

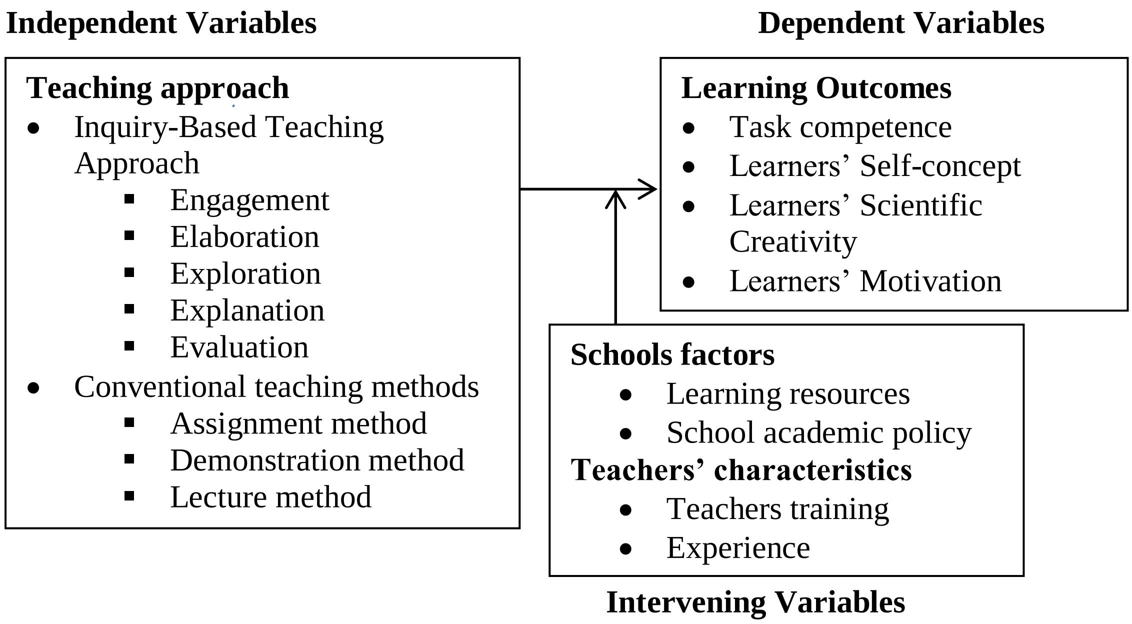

Figure 1: Conceptual Framework on Inquiry-Based Science Teaching Approach (IBSTA)

Source: The Researcher, 2021

The conceptual framework elaborates on the relationship and interplay between the dependent, independent and intervening variables. In the study, dependent variables were Task competence, self-concept, scientific creativity and motivation. Independent variables were IBSTA and Conventional Teaching methods. In an ideal situation, the teaching approach affected the students' learning outcome in Physics. In practical situations, the students' learning outcome in Physics influenced by school factors: learning resources, school academic policy, and teachers' factors such as teachers training and experience as intervening variables as shown in Figure 1.

Intervening variables were controlled. The study involved trained Physics teachers to control the teacher variable because teacher training determines how effectively a teacher enacts the teaching approach. In addition, the study involved teachers teaching the same content from a common syllabus. Form four students who are approximately of the same age were involved in the study. To control for teachers' epistemological views on teaching the involved teachers inducted through a training program and the researcher monitored closely the implementation of the Inquiry-Based Science Teaching Approach (IBSTA) intervention to the treatment groups.

In this study students' task competence in physics was measured using the students score in PCBT. The Physics Competence Based Test (PCBT). PCBT was constructed based on the topic, Current Electricity II, in the secondary school Physics course. This is because the concepts involved are considered too abstract to understand. The concepts, principles and skills involved in the topic are essential in the study of other topics such as, magnetism, mains electricity, cathode rays and cathode ray oscilloscope, x-rays and electronics. These topics are often examined in the KNEC physics paper two and three.

2.9. Gaps in Literature

In Kenya, IBSTA has not been widely investigated in Physics except for some effort in Biology, Chemistry and Geography. The report on the SMASSE project intervention has not greatly affected improvement in performance among students of Physics in Kitui County. In the Kenyan context, no study has simultaneously investigated the effects of the Inquiry –Based Science Teaching Approach on self-concept, scientific creativity, motivation and task competence.

2.10. Summary of Literature

This chapter reviewed both empirical and theoretical literature. The empirical literature has highlighted main parameter of Inquiry-Based Science Teaching

Approach. The empirical literature has also provided the insight of the school in global, regional and local on the positive impact on learning outcome when using any other method of instruction other than conventional methods. The theoretical literature has highlighted the theories that guided the study as well as the conceptual framework that elaborates well the interrelationship between the variables. The theoretical framework for the study highlighted together with the conceptual framework and research gaps.

CHAPTER THREE
RESEARCH METHODOLOGY

3.0. Introduction

This chapter contains research methodology, description of research design, the target population, sampling procedure and sample size, research instruments, validity and reliability of research instruments, ethical considerations, data collection procedures and data analysis.

3.1. Research Methodology

The study used Mixed Methodology that combines quantitative and qualitative research approaches. The fundamental rationale of Mixed Methods study is that the strengths of qualitative and quantitative researches combined while compensating for their weaknesses at the same time (Johnson, Onwuegbuzie and Turner, 2007). According to Creswell (2014), the key2 assumption of this approach is that both qualitative and quantitative data provide different types of information, often detailed views of participants qualitatively and scores on instruments quantitatively and together they yield results that should be the same.

Johnson, Onwuegbuzie and Turner (2007) also argued that mixed methods research design involves the collection of both qualitative (open-ended) and quantitative (closed-ended) data in response to research hypotheses. It includes the analysis of both qualitative and quantitative data. The order for both quantitative and qualitative data collection and analysis was conducted rigorously, that was a good sampling, sources of data and data analysis procedure. The two forms of data were integrated in the design analysis through merging and connecting the data. Quantitative data from was collected using Physics Test and questionnaires while Qualitative data was collected using Creativity observation Schedule.

This methodology was appropriate due to its strength in that, there could be insufficient arguments meaning that neither quantitative nor qualitative analysis could bring about enough evidence since the methods supplement each other. Secondly, the more the evidence, the better the results and thus by combining quantitative and qualitative methods brought better and more reliable results (Schreiber & Asner-Self, 2011).

3.2. Research Design

According to Komar (2005), a research design is a plan, structure and strategy of investigation to obtain answers to research questions or problems. Kothari and Garg (2014) defined Research Design as the blueprint for collection, measurement and analysis of data. The study applied Quasi-experimental research in which the researcher used Solomon's Four, Non-Equivalent Control Group Design. Quasi-experimental designs identified a comparison group that was as similar as possible to the treatment group in terms of characteristics. This was mainly because secondary school classes that were established existed as intact groups and school authorities did not allow such classes to be broken up and be reconstituted for research purposes (Best and Kahn, 2011). It provided adequate control of other variables that may contaminate the validity of the study.

The design helped to access the effect of the experimental treatment relative to control conditions, interaction between pre-test and treatment conditions and to assess the homogeneity of the group before administration of the treatment (Cohen, Manion and Marrison, 2007). Solomon's four-group enables the researcher make a more complex assessment of the cause of the change in the dependent variable and even tell whether changes in the dependent variables are due to the interactions effect between the pre-test and treatment (Randolph, 2008).

Table 2: Solomon's Four Non-equivalent Control Group Design (as Adapted from Shuttle worth, 2009)

Group	Design Group		Pre-test	Treatment	Post-test
I	Experimental	**E1**	**O1**	**X**	**O2**
II	Control	**C1**	**O3**	-	**O4**
III	Experimental	**E2**	-	**X**	**O5**
IV	Control	**C2**	-	-	**O6**

Key: **E1** and **E2** - Experimental group
C1 and **C2** - Control group
O1 and **O3** - Observation at pre-test phase
O2, O4, O5, O6 - Observation at post-test phase
(X) - Indicates treatment
(----) - Indicates the use of non-equivalent group

Table 2 shows that Solomon's Four Non Equivalent Control Group Design. The dotted lines signify that the four groups are non-equivalent. The respondents were randomly organized into four groups (two boys' schools and two girls' schools). Experimental groups as E1 and E2, Control Group as C1 and C2. Experimental groups I (Boys' School) and Experimental Group II (Girls' School) were taught using Inquiry-Based Science Teaching Approach while those in the Control Groups II (Girls' School) and Control Group IV (Boys' School) were taught using conventional teaching method. Prior to treatment, only E1 and C1 were exposed to pre-test (O1 and O3). After two weeks of instruction, all the groups were post-tested (O2, O4, O5 and O6). The post-test O5 and O6 helped the researcher to identify if there was any interaction between pre-testing and treatment. Pre- test and post-test helped to control history and maturation of in respondents with in the research period.

3.3. Location of Study

The Republic of Kenya has forty-seven Counties located in eight Regions namely: Eastern, Western, Coast, Northeastern, Rift valley, Nyanza, Central and Nairobi region. The researcher chose three region randomly that is; western region, Nairobi and Eastern region. Out of the three Regions, the researcher purposely chose Eastern region, which consists of the counties of Embu, Meru, Isiolo, Machakos, Kitui County, Makueni, Marsabit and Tharaka Nithi. According to (KNEC Report 2019), performance in Physics generally in Kenya has been poor. On a comparative of the learners' performance, Kitui County's performance is wanting. That is why the researcher intervened to address the problem and act as a starting point to improve performance in other counties.

The literature reviewed showed that all counties in Eastern Region have Extra-County schools. These schools also take Physics subject. The KNEC reports of 2014 to 2019 indicated that Kitui County was one of the counties that perpetually performed poorly in Physics with a mean not exceeding 3.9 despite the effort that the government has put in place towards the improvement of Physics performance. Due to this gap, the researcher purposely sampled Kitui County for the study. This county has 17 sub-counties; Mwingi Central, Mwingi East, Mwingi West, Kitui West, Kitui Central, Katulani, Nzambani, Mutito North, Mutomo South, Ikutha, Kyuso, Mumoni, Lower Yatta, Matinyani, Tseikuru and Thagicu.

The county has the following number of Extra-County Schools; 14 Boys' schools, 20 Girls' schools and six mixed schools. Using the Solomon's four Design, stratified random sampling was used to obtain one Boys' School and one Girls' School as control groups and one Boys' School and one Girls' School as Experimental groups.

In schools that use Inquiry-Based Teaching, learners are creative and they perform well in Physics practical, as indicated in a case study in Kitui County by Mutambuki (2014). This observation coupled with the fact that there was no evidence of a similar study in Kitui County was the promptitude of this study. These facts give the rationale for the choice of the locale.

3.4. Target Population for the Study

The target population of the study was 1600 Form four students from 40 Extra-County Secondary Schools in Kitui County comprising: 14 boys' schools; 20 girls' schools and six mixed schools as indicated in Table 3. The reason the researcher considered Extra-County schools is that they have comparable level of entry behaviour.

Table 3: Target Population

Category of respondents	No of schools	Total population target
Extra-County Girls Schools	20	800
Extra-County Boys Schools	14	560
Extra-County mixed schools	6	240
Total	**40**	**1600**

Source: The Researcher, 2021

3.5 Sampling Procedure and Sample Size

According to Fraenkel & Wallen (2009), purposive sampling is appropriate where the researcher has previous knowledge of the population and specific purpose of the study, therefore use personal judgment to select a sample. Mugenda and Mugenda (2003), assert that for descriptive study 10%-30% of population is enough as sample size. In view of this, the present study used 10%. The unit of sampling was secondary schools rather than individual students because secondary schools are intact groups (Randoiph, 2008).

Stratified random sampling technique was used to select two Extra-County Boys Schools and two Extra-County Girls Schools out of the 40 Extra-County Schools in Kitui County. Purposive sampling was employed to select Form 4 students taking Physics at KCSE level in each of the selected schools. Simple random sampling was used to assign groups to experimental groups (E1 and E2) each with 40 students and control group (C1 and C2) with 40 students each. Purposive sampling used to select a teacher each from two of the sampled schools. These two teachers taught only the control groups using the conventional methods. Table 4 shows the summary of sampling.

Table 4: Summary of the Sample Size:

Group	Experimental/ Control	Girls	Boys	M	F	Totals
I	Experimental	40	40	-	-	80
II	Control	40	40	-	-	80
	Teachers	-	-	1	1	2
Total		**80**	**80**	**1**	**1**	**162**

Source: The Researcher, 2021

3.6. Research Instruments

The instruments used for this study included: Physics Task Competence Test (P.C.B.T), Questionnaire for students on motivation and self- concept and Scientific Creativity Observation schedule (SCOS). All were designed in line with research objectives.

3.6.1. Physics Competence-Based Test (P.C.B.T.)

Students' learning outcomes and their competence in both experimental and control groups in the study were evaluated using a researcher created Physics Competence-Based Test (P.C.B.T). Two Physics Task Competence Tests: Pre-test and Post-test, were constructed and used. The Pre-test was administered to respondents in the first week of study to assess their pre-treatment Physics academic levels. Pre-tests were administered as formative evaluations to assess students' pre-treatment Physics academic levels (Creswell, 2005).

The pre-test was test that was used to measure students' learning outcomes in learning Current Electricity II in secondary school Physics course. The Physics tests were extracted from K.C.S.E. past papers therefore they were standard. A test consisted of twelve structured questions carrying a maximum of 30 marks. The items tested included knowledge, comprehension and application of content learnt. Tests were scored at different levels along the process of answering statement questions and solving Physics problems relative to respondent's ability. The marking scheme was prepared and moderated to maintain the validity of the test. The researcher assisted by the Physics teachers did examination administration, supervision, marking, scoring and recording. The Researcher analyzed the marks by calculating their mean per group.

3.6.2. Questionnaire for Students (QS)

The purpose for students' questionnaire was to assess the differences in learners' self-concept and the levels of motivation towards the topic of Current Electricity II when taught using the conventional method and the Inquiry-Based Science Teaching Approach. The student questionnaire reflected a five-point Likert scale where they ticked in the choice box the option that matched their response on self-concept and motivation attributes from five given responses which included Strongly Agree (SA), Agree (A), Not Sure (NS), Disagree (D), and Strongly Disagree (SD). The instrument had 12 closed ended questions on self-concept and 15 on motivation adopted from National Foundation for Educational Research of the University of London. The minimum score for each item was S0=1 and the maximum score was S0=5, the results were later labeled and analyzed by the researcher.

3.6.3. Scientific Creativity Observation Schedule (SCOC)

An observation schedule adds crucial information to the collected data using other instruments since this is more than just looking at data from the environment. The brain as well as the eyes and ears are engaged. (Colton and Covert, 2007). The scientific creativity observation schedule (SCOC) was designed to get information about learner behaviour that relates to students' scientific creativity. The researcher adopted a method called Torrance Test of Creative Thinking (TTCT) to assess four aspects of creativity. SCOC consisted of twenty items designed by the researcher to assess and guide in observing during Physics lesson. The researcher observed the learner flexibility in reasoning, ability of the learner to plan, sensitivity of the problem and recognition of relationship between concepts during the Physics lessons. Observations were recorded after every 3 minutes' interval from 3, 6, 9, 12,15,18,21, and 24 up to 39 minutes during the learning session. The tally then calculated per sampling interval in class during learning session at least 2 times per group in order to get detailed information on the learners' symptomatic behaviour.

3.7. Piloting of the Research Instruments

According to Dikko (2016), piloting acts as a good strategy to modify the main study for the researcher. Piloting helps the researcher to get reliable results in a main study. The research instruments were pilot-tested in two Extra County secondary schools in Machakos County. These schools were not included in the sample for the main study.

One Boys' and one Girls' extra-County (one Boys and one Girls) Secondary Schools were purposively sampled. Forty (40) Form Four Physics students and two Physics teachers randomly sampled from each sampled school. This makes 82 participants in the pilot study, representing 10 % of the sample.

The researcher used students' questionnaire and scientific observation schedule during the piloting to ascertain their reliability and Validity. The purpose of conducting the pilot study was to help the researcher to check on the suitability and clarity of the questions on the instruments designed, relevance of the information being sought and the language used to test the reliability of the instruments. It also helped the researcher to familiarize with the administering of the instruments, research plan, logistics of research, school schedules for the study and challenges that he may face during the study.

3.7.1 Validity of the Instruments

To ascertain content validity of PCBT, questions were set from the KCSE past papers of 2014 to 2019. Since KNEC exams are always standardized, the researcher sought the aid of five KNEC trained examiners to moderate the questions. The researcher was guided adequately while developing and revising the research face and construct validity of students' questionnaire and scientific creativity observation schedule through suggestions, relevant comments and discussion by the supervisor and five experts from the School of Education of Machakos University.

3.7.2. Reliability of the Instruments

In quantitative research, reliability refers to the consistence, stability and repeatability of the information provided by a specific respondent, (winter, and 2005). To check for the reliability of the Physics Competence Based Test, the researcher administered the PCBT, to the same group of respondents before and after every two weeks. A test retest method was employed giving two weeks' duration between the tests and using the same participants. This method was preferred since it gave the researcher time to study the responses before administering the test a second time. The two weeks' period also ensured reliable responses as the participants were given adequate time. Reliability coefficient of PCBT for both pre-test and post- test was computed using Kunder-Richardson method, particularly the Formula K.R 21 (Popham, 1999).

The formula was adapted thus $\boldsymbol{r_{tt}} = \left[\frac{K}{K-1}\right]\left[\mathbf{1} - \frac{\sum pq}{s^2}\right]$

Where, r_{tt}= reliability estimate

K = number of items on the test

st^2=Variance of the total test

p = proportion of the respondents getting an item correct.

q = proportion of the respondents getting an item incorrect

Σpq =sum of the product of p and q for each item.

A reliability coefficient of 0.847 and 0.859 of pre-test and post-test respectively were obtained. They were accepted as they were above the recommended reliability coefficient of 0.8 (Mugenda and Mugenda, 2003). The test items were scored as per the marks allocated for each. Reliability of Students Questionnaires and Scientific Creativity Observation Schedule (SCOS) was estimated using the Cronbach's coefficient alpha adopted from Sattler (1988), which was considered appropriate because it determines the reliability of instruments by single administration. The formula was adapted thus:

$$\boldsymbol{r_{tt}} = \left[\frac{\boldsymbol{n}}{\boldsymbol{n-1}}\right]\left[\frac{\boldsymbol{s^2 - \sum pq}}{\boldsymbol{s^2}}\right]$$

n=number of items tested, s_t2=variance of the total test, p=proportion of the respondents getting an item correct, q=proportions of the respondents getting it incorrect, Σ pq=sum of the product of p and q for each item. Where r_{tt}= coefficient alpha reliability estimate. The students' self- concept, scientific observation schedule and motivation questionnaire's was as stated in Table 5. A reliability coefficient average was 0.8124 considered suitable to show the reliability for PCBT. The revised instruments were then administered for the sample respondents in the main study.

Table 5: Reliability Testing

Instruments	No of items	Reliability Coefficient
Pre-Test (PBCT)	12	0.847
Post(PBCT)	12	0.859
Self-concept questionnaire	12	0.776
SCOS	20	0.723
Motivation Questionnaire	12	0.857
Mean		**0.8124**

Source: The Researcher, 2021

3.8. Data Collection Procedure

The researcher sought for an introductory letter from the School of Post Graduate Studies, Machakos University and authorization letter and research permit from National Commission for Science Technology and Innovation (NACOSTI). These documents enabled the researcher to secure an authorization letter from The County Commissioner and County Director of Education, Kitui. These letters introduced the researcher to secondary schools' principals and Physics teachers of the sampled schools seeking consent to carry out research and informing them on the role to play. The subject teachers introduced the researcher to the students and guided them accordingly on how the lesson was to be conducted and its objectives. They also made the students aware that they would work together with the researcher during the lesson. A pretest (Appendix II) was administered to Control Group (**C1**) and Experimental Group (**E1**) but Control Group **(C2)** and Experimental Group **(E2)** were not subjected to the pre-test. The pre-test determined the entry behavior of the students before the use of Inquiry-Based Teaching instruction as assistant researcher helped the researcher in administering the tests.

The researcher taught the experimental groups' students using Inquiry-Based Science Teaching Approach for a period of two weeks (10 lesson, where every week there were 5 lessons to be taught) while the two control groups were taught by their regular teachers using conventional methods for the same period of time. In each of the lessons, the researcher engaged the learners in Inquiry-Based Learning and gave them materials to make engagement, exploration, elaboration, explanation and evaluation. The assistant researcher helped in coordinating the students while the researcher conducted observation on scientific creativity indicators of recognition, sensitivity, flexibility and planning as he filled the creativity observation schedule after every three minutes. After two weeks of instruction, the post-test was administered to all the four groups. The assistant researcher assisted in administering, supervision and marking. After the two-week instructional period, questionnaires for students were also administered to the respondents. To reduce any deviation from the expected teaching approach, the researcher created trust and assured the respondents that the data was for academic purposes only.

3.9. Data Analysis

Both quantitative and qualitative data was generated by the study. Data analysis involved scrutinizing the acquired information and making inferences (Kombo & Tromp, 2006). Both the pre-test and post-test Physics Competence-Based Tests (PCBT), were marked and the marks recorded for each respondent while the data from the questionnaires was sorted, edited and recorded. On qualitative data, the researcher used content analysis approach that emphasized on thematic analysis. This helped in deriving detailed information from views obtained from Creativity Observation Schedule and the Questionnaire. The data were classified into different themes guided by the stated research objectives and links between the analyzed data identified and derived from key patterns that emerged. Thereafter, the researcher presented the data in a narrative form which reinforced by suitable interpretations.

Analysis of quantitative data obtained from the pre-test, post -test and structured questionnaire were divided into two, descriptive analysis and inferential analysis. The descriptive analysis helped the researcher to describe the basic characteristics of the data collected using frequencies, percentages, means and standard deviations. Inferential analysis helped the researcher to determine the association and relationships that existed between IBSTA and learning outcomes. The inferential statistics of Analysis of Variance (ANOVA), LSD, Chi-Squire and t-test were used to list statistical significant differences within and among means in the post-test scores for the groups exposed to IBSTA and those exposed to conventional teaching methods in Table 6. Hypotheses were tested at alpha value $\alpha = 0.05$ level of significance and Statistical Package for Social Sciences (SPSS) Version 24 for Windows used to do the analysis. Information in soft copy was stored in a computer hard drive and a password designed to enhance data security, accessibility and confidentiality.

Table 6: Summary of Quantitative Data Analysis Procedure

Hypothesis	**Independent Variables**	**Dependent Variables**	**descriptive statistics**	**Inferential Statistics**
$H0_1$: There is no statistically significant difference in task competence between students exposed to IBSTA other exposed to conventional teaching method in Kitui County Kenya.	IBSTA teaching Approach Conventional teaching method.	Task competence	Frequency Mean Standard deviation Percentag e	t-test LSD
$H0_2$: There is no statistically significant difference in self-concept towards Physics between student exposed to IBSTA and those exposed to conventional Teaching method in Kitui county Kenya.	IBSTA teaching Approach Convention al teaching method	Learners' self-concept	Frequency Mean Standard deviation percentage	Chi-X^2 ANOVA LSD
$H0_3$: There is no statistically significant difference In scientific creativity in learning Physics between students exposed to IBSTA and those exposed to Conventional teaching methods in Kitui County Kenya.	IBSTA teaching Approach Convention al teaching method.	Students' scientific creativity	Frequency Mean Standard deviation percentage	ANOVA LSD
$H0_4$: There is no statistically significant difference in motivation to learn Physics between students exposed To IBSTA and those exposed to conventional teaching method in Kitui County Kenya.	IBSTA teaching Approach Convention al teaching method.	Learners motivation	Frequency percentage mean standard deviation	Chi-X^2 ANOVA LSD

3.10. Ethical Considerations

Orodho, (2009) observes that ethical considerations in research involves outlining the content of research and what is required of participants, how informed consent was obtained and confidentiality assurance to the respondents that data collected would be handled with integrity. This applies to all types of research as follows:

3.10.1. Research Authorization

The researcher obtained a letter of authority from Machakos University, School of postgraduate studies, research permit from the National Commission of Science, Technology and Innovation (NACOSTI), then authorization letters from the District Commissioner in Kitui for collecting data from sampled respondents in extra–County public Secondary schools in Kitui County. Other codes of ethics bound the researcher in relation to protection of the respondents' identity as well as the researcher as follows:

3.10.2. Informed Consent

The researcher ensured that participants acted voluntarily for they had the freedom and a right to choose whether to participate or not. The researcher was sensitive to human dignity by ensuring protection and provision of proper information to the subjects.

3.10.3. Anonymity

This is realized by protecting the identity of individuals and institutions involved by replacing their real names with pseudonyms (Mwinzi, 2012). The participants were guarded from physical or psychological harm that involves loss of self-esteem, independence and dignity. The researcher ensured that respondent was not in any danger or risk. The researcher also used codes for school, students and teachers for purposes of concealing their identities.

3.10.4. Confidentiality of the Respondent

The researcher assured the respondents that the information they gave would be handled with confidentiality and privacy. They were also assured that the information would be used for no other purpose other than the one stated in the study and that no unauthorized persons would get access to it. To enable the respondents to participate voluntarily, the researcher gave truthful information and urged the respondents to be truthful with the information they gave. The researcher asked the respondents not to write their names, their school or any official tittle. The researcher developed a cipher system that was used to identify the groups.

3.10.5. Data Storage

To ensure anonymity and confidentiality, the information was stored in soft copies such as hard disks and flash discs, kept by the researcher in privacy, and was only used by authorized personnel like the university supervisors. Data saved in the computer was assigned a specific password. The Physics Competence Based Test, Questionnaires, and Creativity Observation schedule were stored under lock and key during and after the data analysis.

3.10.6 Plagiarism

To ensure there was no plagiarism to the document, work was emailed to the authorized Machakos library plagiarism system for plagiarism test. This was done before each defense. The percentage index remained not more than 20 %. This included the references. Whenever the percentage went higher, the thesis was cleaned and then taken back to the programme for plagiarism testing. The final plagiarism index for this thesis was 18% confirmed by the School of education of Machakos University, and placed as appendix XIV. This exercise ensured clean plagiarized work by the researcher.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the findings based on the data collected from the study and their interpretation. The data interpretation report is mainly in tabular mode. The guiding objectives of the study were to;

i. Determine the difference in task competence between students taught by Inquiry-Based Teaching Approach and those taught using conventional methods.
ii. Assess the variation in Self-concept between students taught using Inquiry-Based Science Teaching Approach and those taught using the Conventional methods in Physics.
iii. Establish the difference in Scientific-Creativity of the students taught using Inquiry-Based Science Teaching Approach and those taught using Conventional methods in Physics.
iv. Determine the difference in motivation between students taught using Inquiry-Based Science Teaching approach and those taught using conventional methods in Physics.

The analysis of the data is focused on the four hypotheses of the study in line with the objectives of the study. The first hypothesis was examined using percentage frequencies followed by a t-test then LSD; the second hypothesis was examined by the percentage frequencies, Chi-square technique followed by ANOVA and then LSD; the third hypothesis was examined by the percentage frequencies, followed by ANOVA and then LSD and last hypothesis is examined by the percentage frequencies, Chi-square technique followed by ANOVA and then LSD. The findings of the study were compared with the existing studies to establish whether they agree or disagree with previous studies conducted.

4.1.1. Response Rate

The study had a sample size of 162 respondents. All were to fill questionnaires, take competence-based tests and undergo an observation schedule. A total of 75 respondents (38 control and 37 experimental) were given the pre-test competence-based exam to evaluate the basic understanding of the Physics chapter under study. They were then subjected to the Inquiry–Based Science Teaching Approach for a period of three weeks. The 160 respondents were given the post-test competence-based exam after two weeks' period of teaching. They were also given questionnaires to fill. From the post-test and the questionnaires, the response rate (Table 7).

Table 7: Summary of the Response Rate in Percentage Form

Sample Size		Participants		Non-participants		Response Rate	
F	**%**	**F**	**%**	**F**	**%**	**F**	**%**
160	100	150	93.75	10	6.25	150	93.75

Source: The Researcher, 2021

From Table 7, 150 respondents had filled in the questionnaire and took the competence-based exam. The study had a response rate of 93.75%. According to Best and Khan, (2006) a response rate of 50% is considered adequate, 60% good and above 70% very good. In view of this, the response rate was considered very good and exceeded the threshold postulated.

4.1.2. Demographic Factors

This section presents background information of the study respondents with the aim of gaining some understanding of the sample. Demographic data were categorized into three major areas namely: school category, class level, and students' age.

4.1.3 School Category

The information about the school categories of the respondents was collected. The results are indicated in Table 8.

Table 8: School Category

		Frequency	Percent%	Valid Percent%	Cumulative%
Valid	Extra-county	150	100	100	100
	Total	**150**	**100.0**	**100.0**	

Source: The Researcher, 2021

As shown on Table 8 all the 150 respondents, which was 100%, were from extra-county schools. This then put all the respondents ability at per.

4.1.4 Class Level

The research instruments also elicited information of the respondents' level of education since the variable could influence their ability to give credible information for the study. The findings obtained are shown in Table 9.

Table 9: Class Level

		Frequency	Percent%	Valid Percent%	Cumulative %
Valid	Form 4	150	100	100	100
	Total	**150**	**100.0**	**100.0**	

Source: The Researcher, 2021

From Table 9 the findings show that, 150 respondents, which were 100%, were in form four. This group was found suitable since they carry out many experiments in preparation for K.C.S.E. They therefore, would provide reliable data for the study.

4.1.5 Students' Age

The information about the age of the respondents was collected and the results were as indicated in Table 10.

Table 10: Students' Age

Students' Age		Frequency	%	Cumulative %
Valid	16-17 years	98	65.33	65.33
	18 and above	52	34.67	34.67
	Total	**150**	**100.0**	**100**

Source: The Researcher, 2021

Table 10 shows that 65.33% of the respondents were aged between sixteen and seventeen years. The result shows that 34.67% of the respondents were aged eighteen and above. Therefore, the majority of the respondents were between the ages of sixteen and seventeen years. This is average age of form four students under the 8.4.4 system.

4.2 Effects of Inquiry-Based Science Teaching Approach in Teaching Physics on Students' Task Competence

The first objective of the study sought to determine the difference in task competence between students taught by Inquiry-Based Science Teaching Approach and those taught using conventional methods. Before the treatment started, Experimental Group1 and Control Group1 were given a pre- test exam. The means and standard deviation obtained for the pretest exam for both groups are presented in Table 11.

Table 11: Students Mean Scores for Each Group in the Pre-test

	Category	N	Mean	Std. Deviation	Std. Error Mean
Pre-test score	Control	38	43.34	14.28	2.3173
	Experimental	37	42.75	13.05	2.1457

Source: The Researcher, 2021

Table11 shows the mean scores and standard deviation for all the respondents that undertook the pre-test. E1 had a mean score of 42.75% and standard deviation of 13.05 while C1 had a mean score of 43.34% with a standard deviation of 14.28. The findings show that the mean scores for the two groups were different with the control group C1 having a higher mean score than experimental group E1.

To check whether Control Group1 and Experimental Groups1were statistically significant a t-test was computed. Findings are shown in Table 12.

Table 12: The Independent t-test for Pre-test Mean Score of PCBT1

		F	Sig.	T	df	Mean Dif.	Std. Error Dif.	95% Conf. Intval of the Dif. Lower	Upper
Pre-test score	**Equal var. assumed**	.319	**.574**	.185	73	.585	3.162	-5.717	6.887
	Equal var. not assumed			.185	72.710	.585	3.158	-5.709	6.880

Source: The Researcher, 2021

In Table 12 shows that the t-statistical value was 0.185 with 73 degrees of freedom which yielded a significance level of 0 .574 which is higher than the set value of 0.05. This means that there is no significant difference in the means of the two groups (Control and Experimental) on the pre-test. The findings of this study implies that the experimental and control groups were homogenous in terms of learning outcomes at the start of the study.

4.2.1. Students Learning Outcome on the Post-test

After the learning period, a post-test exam to gauge the effectiveness of each teaching method was administered to all the four groups and their percentage means and standard deviations were computed. Findings obtained are as shown in Table 13.

Table 13: Comparison of Mean Scores and Standard Deviation of Post-test in all the Groups

Sub-category	**Mean**	**N**	**Std. Deviation**
C1	45.42	38	14.63
C2	43.00	39	15.06
E1	59.75	37	10.70
E2	57.95	36	11.52

Source: The Researcher, 2021

Table 13 shows that the Experimental Group E1 had a mean score of 59.75% and E2 had mean score of 57.95%. Control Group C1 posted a mean score of 45.42% and Control Group 2 obtained a mean score of 43.00%. This finding indicates that Experimental Group E1 and E2 posted a higher mean score compared to the Control Groups C1and C2.

Table 14: Post-test Score by Category

Category	Mean	N	Std. Deviation
Control	44.31	70	14.776
Experimental	58.78	80	11.122

Source: The Researcher, 2021

The figures on Table 14 indicate that the average of the Experimental and Control Groups mean scores were 58.78% and 44.31% respectively. This means that the average mean score for the Control Group was lower than that of Experimental Group.

These findings are in line with a study by Banerjee (2010), who argued that Inquiry-Based lesson had a positive effect on students and posted a very high score in an achievement test as compared to a class that was taught through traditional Approach. In addition, Zion and Mendelovia (2012) found out that Inquiry Learning when well introduced the learner has positive impact on students' task competence in Physics.

To understand whether there was a statistically significant difference in task competence depending on the teaching approach used, the following hypothesis was tested:

H_{01}: There is no statistically significant difference in task competence to learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to Conventional teaching methods.

A t-test was used to test this hypothesis. Table 15 presents the findings on the t-test computation of the significant differences between means.

Table 15: Independent t-test for Post-test Examination

		F	**Sig.**	**T**	**df**	**Sig. (2-tailed)**	**Mean Dif.**	**Std. Error Dif.**	**95% Conf. Interval of the Dif. Lower**	**Upper**
Post test score	Equal variances assumed	4.676	.032	-6.826	148	.000	-14.473	2.120	-18.663	-10.283
	Equal variances not assumed			-6.701	127.094	.000	-14.473	2.159	-18.747	-10.199

Source: The Researcher, 2021

From table 15, the Control Group C1 and Experimental Group E2 had 148 degree of freedom yielding a significance level of 0.032, which is, less than the set value of 0.05. This shows that there was statistically significant difference in the means of the control and experimental group.

The findings of this study show that the mean difference between the pre-tests and the post-test scores show that the Inquiry based science teaching approach had a great impact on the performance of students in Physics. This is in line with Osborne (2014), who argued that science teachers' ability to practice Inquiry-Based Instruction enhances good performance.

The present study concurs with a study conducted in Europe by Shafqat (2015) who argued that Inquiry based learning is more effective as compared to traditional methods of teaching, since it improves different learning domains such as knowledge, ability and task competence that improves learner's outcome. The findings are also in line with a study carried out in Malaysia by Rakhmawan, Setiabudi and Mudza (2015) that indicated that Inquiry-Based Learning makes a student more confident and makes learning more meaningful hence increases learning outcomes.

To further understand the different significance levels that exist between the sub-categories (C1, C2, E1 and E2), Least Significant Difference was computed. The findings obtained are shown in Table 16.

Table 16: Results of LSD Post Hoc Comparison of PCBT2 Mean Score

					95% Confidence Interval	
(I) Sub-category	**(J) Sub-category**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**Lower Bound**	**Upper Bound**
C1	C2	2.421	3.118	**.439**	-3.743	8.585
	E1	-14.335	3.0023	**.000**	-20.269	-8.402
	E2	-12.532	2.894	**.000**	-18.252	-6.812
C2	C1	-2.421	3.118	**.439**	-8.585	3.743
	E1	-16.756	3.138	**.000**	-22.958	-10.554
	E2	-14.953	3.034	**.000**	-20.951	-8.955
E1	C1	14.335	3.0023	**.000**	8.402	20.269
	C2	16.756	3.138	**.000**	10.554	22.958
	E2	1.803	2.914	**.537**	-3.957	7.564
E2	C1	12.532	2.894	**.000**	6.812	18.252
	C2	14.953	3.034	**.000**	8.955	20.951
	E1	-1.803	2.914	**.537**	-7.564	3.957

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

Source: The Researcher, 2021

As tabulated in Table 16 the difference between C1 and C2 (0.439), E1, and E2 (0.537) was not statistically significant since P > 0.05. This implies that E1 and E2 groups, C1, and C2 performed relatively the same on Physics task competence test scores. However, the comparison between the mean difference in the groups C1 and E1 (0.000), C1 and E2 (0.000), C2 and E1 (0.000) and E2 (0.000) were statistically significant since P< 0.05. This shows that the experimental groups' mean score was higher than the control groups' mean score in task competence. Therefore, the null hypothesis one, that read *H_{01}: There is no statistically significant difference in task Competence to learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to Conventional methods* was rejected.

These findings concurred with a research conducted by Vandewalle, (2007) who argued that Inquiry Learning when well introduced to the learner has positive impact on students' task competence in physics. This is also in line with a study by Chopra and Gupta (2011) who argued that, inquiry-based teaching approach allows students to make meaningful real-world connections in the class as they link the relevance between what they learn in the classroom and their potential careers. Awafala (2013) observed that those teachers who use the IBSTA posted a high achievement (mean scores) in their subjects.

4.3 Effects of Inquiry-Based Teaching Approach in Teaching Physics on Students' Self-Concept

The second objective of the study was to assess the variation in self-concept between students taught using Inquiry-Based Learning and those taught using the conventional methods in Physics. Self-concept consists of four indicators: self-image, Self-identity, Self-esteem and Role- performance. The researcher treated the data analysis in three levels descriptive, inferential (Chi-square, ANOVA and LSD) statistics and then mixing and interpreting of the data.

4.3.1. Self-Image

Self-image is one of the indicators under self-concept. It deals with how one perceives himself or herself. Generally, people with a high sense of self-image produce better results in their engagements as opposed to those with a low sense of self-image. To test this on the respondents, a questionnaire was given after the three weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the self-image scale:

SI1: Success in the life of student is achieved through positive thinking.

SI2: Inquiry based learning enhances the way I see myself.

SI3: Inquiry based learning provides a good learning environment for me.

Table 17 shows the averages of the control and experimental groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 17: Average Percentage Score on Self–Concept Based on Self Image

	Category					
	Average of C1 and C2 Groups			Average of E1 and E2 Groups		
Array	**D**	**U**	**A**	**D**	**U**	**A**
SI1	28.57%	37.66%	33.77%	17.80%	10.95%	71.24%
SI2	35.06%	45.46%	19.48%	17.81%	26.91%	55.28%
SI3	54.84%	23.38%	21.78%	9.59%	12.32%	78.09%

Key: SI- Self-image Array

Source: The Researcher, 2021

As shown in Table 17, 28.57% of the respondents from the control group (Scale 1: self-image) disagreed that success in the life of a student is achieved through positive thinking, 33.77% agreed while 37.66% were undecided. These findings show that the average score for undecided students was higher (37.66%) than those that agreed and disagreed that success in the life of a student is achieved through positive thinking.

Also shown in Table 17 is that 17.80% of the respondent from the experimental group (Scale 1: self-image) disagreed that success in the life of a student is achieved through positive thinking. The report also shows that 71.24% agreed, and 10.95% were undecided. This implies that the majority of the respondents (70.24%) from experimental groups agreed that success in the life of a student is achieved through positive thinking.

Moving to Scale 2, 35.06% of the respondents in the control group disagreed that the use of inquiry-based learning enhanced the way students see themselves. The results show that 19.48% agreed, while 45.46% were undecided. Therefore, the majority of the respondents (45.45%) were undecided on whether the use of inquiry-based learning enhanced the way students see themselves.

The findings on the experimental groups in Scale 2 show that, 17.81% of the respondents disagreed that the use of inquiry-based learning enhanced the way students see themselves. The results indicate that, 55.28% agreed, and 26.91% were undecided. From the results, most of the respondents (55.28%) agreed that the use of inquiry-based learning enhanced the way students see themselves.

For the Control Group, Scale 3 responses shows that 54.84% of the respondents disagreed that inquiry-based learning provided a good learning environment for a student. The result also indicates that 21.78% agreed and 23.38% were undecided. Therefore, more than half (54.84%) of the respondent disagreed that inquiry-based learning provided a good learning environment for a student.

For the Experimental Group, Scale 3 responses show that 9.59% of the respondents disagreed that inquiry-based learning provided a good learning environment for a student. The results indicate that 78.09% agreed and 12.32% were undecided. Therefore, the majority of the respondents (78.09%) agreed that inquiry-based learning provided a good learning environment for a student.

A comparison between the Control Group and the Experimental one shows that majority of the students (Experimental Group) who were taught using inquiry-based approach believed they were achieving positive thinking in the course of their learning. On the contrary, majority of the students taught using conventional methods (Control Group) were either not sure or disagreed that they were able to achieve positive thinking. The findings of the study showed that the inquiry-based method benefitted the students by enhancing their positive thinking.

Majority of the respondents from the experimental group agreed that inquiry-based learning provided a good learning environment for a student. On the contrary, majority of the respondents from control group disagreed that inquiry-based learning provided a good learning environment for a student. Based on the findings, it was evident that the inquiry-based approach was fruitful as compared to conventional methods.

These findings are in line with a study by Armstrong and Hallar (2009) who argued that students taught using the Inquiry method experienced frustration with the process of finding out things on their own. In addition, Moheeta (2010) indicated that students taught using inquiry based method show more gain in self-concept after the intervention compared to the students taught using traditional method of instruction. Self-concept acts as an internal drive to good performance in Physics and the methodology that a teacher uses in teaching creates a conducive environment for a learner to achieve self- concept (Khan, 2016).

To determine whether the means of responses between the two groups were significantly different on self-image, further analysis was conducted using chi-square. The findings are presented in Table 18.

Table 18: Chi Square for self-concept on learning outcome based on self-image

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	55.841[a]	8	0.000
Likelihood Ratio	68.702	8	0.000
Linear-by-Linear Association	0.763	1	0.382
No. of Valid Cases	**150**		

a. 3 cells (20.0%) have an expected count less than 5. The minimum expected count is 3.30.

Source: The researcher, 2021

At P = 0.000, df=8 and α=0.05 the results in Table 18 show that there was a significant association between self-image and IBSTA. Additionally, the percentage that represents the ratio of the actual count to the expected count was not violated because it was not greater than 20%. The findings concur with Gliebe (2012) who state that Student's positive conception is helpful in achieving success throughout life.

To further understanding the association between self-image and learning outcomes, ANOVA was used to determine the significant differences between these two groups. Table 19 shows the results of ANOVA.

Table 19: The ANOVA of average scores on self-concept based on self-image

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7.338[a]	3	2.446	3.659	.014	.070
Intercept	590.850	1	590.850	883.833	.000	.858
Sub Category	7.338	3	2.446	3.659	.014	.070
Error	97.602	146	.669			
Total	693.000	150				
Corrected Total	104.940	149				

a. R Squared = .070 (Adjusted R Squared = .051)

Source: The researcher, 2021

The results in Table 19 show that, the f-statistic was 3.659, for 3 degree of freedom and a mean difference of 2.446. This yielded a significance level of 0.014 that was less that the set value of **α**=0.05. This indicated that differences between the mean values were statistically significant.

In understanding the differences between the means of LSD was conducted. The findings obtained were presented in table 20.

Table 20: Results of LSD on Self Concept Average Scores of Response Based on Self-Image

(I)Sub-category	(J)Sub-category	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	6.01	.186	**.974**	-.37	.36
	E1	-.48*	.189	**.012**	-.85	-.11
	E2	-.40*	.190	**.036**	-.78	-.03
C2	C1	6.01	.186	**.974**	-.36	.37
	E1	-.47*	.188	**.013**	-.84	-.10
	E2	-.40*	.189	**.037**	-.77	-.02
E1	C1	.48*	.189	**.012**	.11	.85
	C2	.47*	.188	**.013**	.10	.84
	E2	.08	.191	**.690**	-.30	.45
E2	C1	.40*	.190	**.036**	.03	.78
	C2	.40*	.189	**.037**	.02	.77
	E1	-.08	.191	**.690**	-.45	.30

Based on observed means.
The error term is Mean Square (Error) = .669.
*. The mean difference is significant at the .05 level.

Source: The Researcher, 2021

The results in Table 20, show the mean difference between C1 and C2 (p=0.974) and (E1 and E2 (p=0.690) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 performed relatively the same on self-concept based on self-image. However, the comparison between the mean difference in the group C1 and E1 (p=0.012), C1 and E2 (p=0.036), C2 and E1 (0.013) and C2 and E2 (0.037), were statistically significant since P was less that the set value 0.005. The findings therefore mean that the Experimental Groups' mean was higher than the control groups' mean in self-concept based on self-image. The results and findings of this study agree with study by Claro & Loeb, (2019) who stipulated that Inquiry-Based Learning as well as most constructivist didactics is based on pre-conceptions of the students as instruments of knowledge. In addition, the findings are in line with a study by Mason & Kahle (2009), who reported that a student who learns through Inquiry-Based-Teaching Approach develops higher self-concept than those who are taught through conventional method.

4.3. 2 Self-Identity

Self-identity is another indicator under self-concept. It deals with one's ability, traits or physical attributes that help in identifying one self. Generally, people with a high sense of self-identity produce better results in their engagements as opposed to those with a low sense of self-identity. To test this on the respondents, a questionnaire was given after the three weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the self-identity scale:

SI.4 Perform well because I believe in my ability.
SI5. Inquiry based method stimulate my coming up with new ideas which makes me proud of physics.
SI6. The style of thinking and working physics makes me like science.
Table 21 shows the averages of the Control and Experimental scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 21: Results of Self- Concept Average Scores of Response Based on Self-Identity

	Average Control Group (C1&C2)			Average Experimental Group (E1 &E2)		
	D	**U**	**A**	**D**	**U**	**A**
SI4	50.65%	31.17%	18.27%	28.70%	8.22%	63.02%
SI5	45.45%	36.36%	18.19%	27.40%	15.07%	57.54%
SI6	50.65%	33.77%	15.58%	36.98%	15.07%	47.95%

Key: SI- Self-Identity Array
Source: The Researcher, 2021

As shown on Table 21, 50.65% of the respondents from the control group (Scale 4: self-identity) disagreed that a student performs well because they believe in their ability. The results indicate that 18.27% agreed and 31.17% were undecided. These findings show that majority of the respondents (50.65%) disagreed that a student performs well because they believe in their ability.

Also shown in Table 21, 28.70% of the respondents from the experimental group (Scale 4 self-identity) disagreed that a student performs well because they believe in their ability. The findings show that 63.02% agreed and 8.22% were undecided. This implies that majority of the respondents (63.02%) agreed that a student performs well because they believe in their ability.

Moving to Scale 5, 45.45% of the respondents in the Control Group disagreed that IBSTA stimulated students coming up with new ideas that made them proud of Physics. The findings indicated that 18.19% agreed and 36.36% were undecided. Therefore, the majority of the respondents (45.45%) disagreed that inquiry-based teaching methods stimulated students coming up with new ideas that made them proud of Physics.

The findings on the experimental groups in Scale 5 shows that 27.40% of the respondents in the experimental groups disagreed that inquiry-based teaching methods stimulated students coming up with new ideas that made them proud of Physics. The results indicated that 57.54% agreed and 15.07% were undecided. Therefore, the majority of the respondents (57.54%) agreed that inquiry-based teaching methods stimulated students into coming up with new ideas which made them proud of Physics.

The control group, Scale 6 responses show that 50.65% of the respondents disagreed, that the style of thinking and working in Physics makes them like science. The results show that 15.58% agreed and 33.77% were undecided. Therefore, more than half of the respondents 50.65% disagreed that the style of thinking and working in physics makes them like science.

The Experimental group scale 6 responses show that, 36.98% of the respondents disagreed that the style of thinking and working in Physics makes them like science. The results indicated that 47.95% agreed and 15.07% were undecided. The results show that nearly half of the respondents (47.95%) agreed that the style of thinking and working in Physics makes them like science.

Going by the findings from Table 21, the majority of the respondents from the Experimental Group were in favor of the inquiry-based approach due to its advantage of improving their ability. More than half of the respondents from the control disagreed about the students increasing their ability because of the conventional teaching method. The result clear shows that the conventional methods of teaching do not have any positive impact on students' beliefs and abilities.

Most of the respondents in the control group did not find conventional teaching method stimulating them to come up with new ideas while the majority of the respondents from the Experimental Groups were triggered to form new ideas that made them understand Physics in a more enjoyable manner. The majority of respondents from the Experimental Group agreed that the style of thinking and working in Physics makes them like science. On the contrary, majority of the respondents from the Control Group disagreed that the style of thinking and working in Physics makes them like science. These findings are in line with a study by Bati (2014) who reported that Inquiry method stimulates creativity of a learner that gives an internal drive of a learner (self-concept).

In order to identify whether there is a statistically significant difference in the mean scores on self-identity and their learning outcomes a Chi-square was computed and the findings are as presented in Table 22.

Table 22: The Chi square of Average Mean Score of Students Self -Concept Based on Self- Identity

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.160[a]	8	0.030
Likelihood Ratio	34.291	8	0.030
Linear-by-Linear Association	.115	1	0.735
N of Valid Cases	150		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.10.

Source: The Researcher, 2021

At P=0.030, df=8 and α=0.05 the results in Table 22 show that there was a significance association between self-identity and IBSTA because P<0.05. Additionally, the percentage that represents the ratio of the actual count to the expected count was not violated because it was not greater than 20%.

These findings are in line with a study by Green, Nelson, Martin and Marsh (2006), who argued that positive self-concept is an extremely important goal for educational programs to promote and help to link positive outcomes including higher academic achievement and effort.

To further understand the association between self-identity and learning outcomes, ANOVA was used to determine the significant differences between the mean scores of these two groups. The findings were as indicated in Table 23.

Table 23: ANOVA of Average Mean Score of Students' Self-concept Based on Self -Identity

Dependent Variable: Learning outcomes

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	7.230[a]	1	7.230	10.951	.001
Intercept	591.123	1	591.123	895.366	.000
Category	7.230	1	7.230	10.951	.001
Error	97.710	148	0.660		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .069 (Adjusted R Squared = .063)

Source: The Researcher, 2021

The results in Table 23 show that the f-statistic was 10.951, for 1 degree of freedom and a mean difference of 7.230. This yielded a significance level of 0.001 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant.

These findings of the study concurred with those of Dostal (2013) who reported that an increase in the application of inquiry-based education develops learners' critical thinking and self-concept because it encompasses multiple activities.

To understand whether there is a significant difference between the means of the groups LSD was computed. The findings obtained were presented in Table 24.

Table 24: The LSD of the Average Scores on Self-Concept Based on Self-Identity

(I) Sub-category	(J) Sub-category	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.16	.184	**.379**	-.20	.53
	E1	8.31*	.187	**.018**	-.68	.06
	E2	6.33*	.198	**.033**	-.73	.06
C2	C1	-.16	.184	**.379**	-.53	.20
	E1	5.47*	.192	**.015**	-.85	-.09
	E2	7.44*	.203	**.003**	-.90	-.10
E1	C1	8.31*	.187	**.018**	-.06	.68
	C2	5.47*	.192	**.015**	.09	.85
	E2	-.02	.206	**.910**	-.43	.38
E2	C1	6.33*	.198	**.033**	-.06	.73
	C2	7.44*	.203	**.003**	.10	.90
	E1	.02	.206	**.910**	-.38	.43

Based on observed means.

The error term is Mean Square (Error) = .701.

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

Source: The researcher, 2021

The results in Table 24, show that the difference between C1 and C2 (p=0.379) and (E1 and E2) with p=0.910 was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 performed relatively the same on mean in self-concept based on self-identity. However, the comparison between the mean difference in the group C1 and E1 (p=0.018) C1 and E2 (p=0.033), C2 and E1 (p=0.015) and C2 and E2 (p=0.003), was statistically significant since P<0.05. This implies that the experimental groups' mean was higher than the control groups' mean in self-concept based on self-identity.

These findings concurred with those of Kropac, (2009) who found out that the use of Inquiry-Based Learning catalyzes the learner to think critically which makes a learner technologically oriented, satisfies students need, and develops learners' self-concept.

4.3. 3 Self-Esteem

The third indicator of self-concept is self–esteem. It deals with how much one appreciates and values oneself. Generally, people with a high sense of self-esteem produce better results in their engagements as opposed to those with a low sense of self-esteem. To test this on the respondents, a questionnaire was given after the three weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the self-esteem scale:

SE7. Learning occurs when I am actively involved in finding out.
SE8. Liking of Physics is improved by inquiry-based learning which I enjoy the most.
SE9.Practical and discussion-based learning builds my confidence.

Table 25 shows the averages of the control and experimental groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 25: Average percentage Scores on Self -Concept Based on Self- Esteem

	Average of Control Groups (C1&C2)			**Average of Experimental groups(E1&E2)**		
	D	**U**	**A**	**D**	**U**	**A**
SE7	16.88%	35.07%	48.05%	65.76%	20.54%	13.70%
SE8	57.16%	29.85%	12.99%	15.07%	19.18%	65.75%
SE9	55.84%	14.29%	29.87%	11.92%	22.32%	65.76%

Key: SE- Self-Esteem Array

Source: The Researcher, 2021

As shown in Table 25, 16.88% of the respondents from the Control Group (scale7: self-esteem) disagreed that learning occurs when a student is actively involved in finding out. The results indicated that 48.05% agreed and 35.07% of the respondents were undecided. These findings show that less than half of the respondents (48.05%) agreed that learning occurs when a student is actively involved in finding out.

The findings in the Experimental Group in scale7, 65.76% of the respondents disagreed that learning occurs when a student is actively involved in finding out. The results indicate that 13.70% agreed and 20.54% were undecided. From the results, most of the respondents (65.76%) disagreed that learning occurs when a student is actively involved in finding out.

The Control Group, scale 8 responses show that, 57.16% of the respondents disagreed that their liking of physics was improved by the inquiry-based learning. The findings indicated that 12.99% agreed and 29.87% were undecided. Therefore, majority of the respondents (57.16%) disagreed that their liking of physics was improved by the inquiry-based learning.

The findings on the Experimental Groups in Scale 8, 15.07% of the respondents disagreed that their liking of physics was improved by the inquiry-based learning. 65.76% agreed and 19.18% were undecided. The results from the table indicate that majority of the respondents (65.76%) agreed that their liking of physics was improved by the inquiry-based learning.

Moving to Scale 9, 55.85% of the respondents in the control group disagreed that practical and discussion-based learning built their confidence. The findings indicate that 29.85% agreed and 14.29% were undecided. From the results, more than half of the respondents (55.85%) disagreed that practical and discussion-based learning built their confidence.

The experimental group, Scale 9 responses show that 11.92% of the respondents disagreed that practical and discussion-based learning built their confidence. The report indicated that 65.75% agreed and 22.32% were undecided. Therefore, majority of the respondents (65.76%) agreed that practical and discussion-based learning built their confidence.

From the findings of the experimental group, more than half of the respondents agreed that their liking of physics was improved by the inquiry-based learning. On the contrary, majority of the respondents from the control group disagreed that their liking of physics was improved by the IBSTA. The respondents from the control could not have agreed with the inquiry-based approach since they had never been taught using the method. From the Experimental Group, most of the respondents felt that practical and discussion-based learning built their confidence. The control group did not support this statement.

From the findings of the Experimental Group, majority of the respondents agreed that learning occurs when a student is actively involved in finding out. On the contrary, more than half of the respondents disagreed that learning occurs when a student is actively involved in finding out.

In order to show whether there was any association between self-concept and learning outcome in the groups Chi square was computed and findings were as shown in Table 26.

Table 26: The Chi -square of Mean Score on Self-Concept Based on Self- Esteem

	Value	df	Asymptotic Significance(2-sided)
Pearson Chi-Square	30.404[a]	8	.000
Likelihood Ratio	32.091	8	.000
Linear-by-Linear Association	4.125	1	.042
N of Valid Cases	150		

a. 1 cells (6.7%) have expected count less than 5. The minimum expected count is 4.80.

Source: The Researcher, 2021

At P=0.000, df=8 and α=0.05 the results in Table 27 show that there was a significance association between self- esteem and IBSTA since α<0.05. Additionally, the percentage that represents the ratio of the actual count to the expected count was not violated because it was not greater than 20%. These findings concur with those in a study by Ceylan, (2016), which looked at the impact of inquiry-based instruction on science process skills and self-efficacy perception of pre-service teachers at university level in a biology laboratory. He noted that this method develops positive perception towards science and enhances self-concept.

To further understand the association between self-esteem and learning outcomes, ANOVA was used to determine the significant differences between these two groups (Control and Experimental Group). Table 27 shows the results of ANOVA.

Table 27: ANOVA of Average Mean Score of Student s' Self- Concept based on Self–Esteem

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12.667[a]	3	4.222	6.681	.0005
Intercept	597.784	1	597.784	945.856	.0000
Sub Category	12.667	3	4.222	6.681	.0000
Error	92.273	146	.632		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .121 (Adjusted R Squared = .103)

Source: The Researcher, 2021

The results in Table 27 show that, the f-statistic was 3.659, for 3 degree of freedom and a mean difference of 4.222. This yielded a significance level of 0.0005 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant.

These findings agree with the findings by Morris (2019) that a learner's readiness and propensity to engage in self-directed learning activities varies from person-to-person and is influenced by factors such as prior formal and non-formal learning experiences, metacognition, motivation, self-efficacy, and subject area interest.

To understand the differences between the means of experimental and control group LSD was conducted and the findings obtained were presented in Table 28.

Table 28: LSD of scores on student Self-Esteem Based on Self-Esteem.

(I)Sub-category	(J) Sub-category	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
C1	C2	-.09	.176	**.590**	-.44	.25
	E1	6.57*	.178	**.002**	-.92	-.22
	E2	7.68*	.187	**.000**	-1.05	-.31
C2	C1	.09	.176	**.590**	-.25	.44
	E1	8.47*	.182	**.010**	-.83	-.11
	E2	5.59*	.191	**.003**	-.96	-.21
E1	C1	6.57*	.178	**.002**	.22	.92
	C2	8.47*	.182	**.010**	.11	.83
	E2	-.11	.194	**.565**	-.49	.27
E2	C1	7.68*	.187	**.000**	.31	1.05
	C2	5.59*	.191	**.003**	.21	.96
	E1	.11	.194	**.565**	-.27	.49

Based on observed means.
The error term is Mean Square (Error) = .632.
The mean difference is significant at the 0.05 level.

Source: The researcher, 2021

The analysis in Table 28, indicates that the differences between C1 and C2 (p=0.590) and E1 and E2 (p=0.565) was not statistically significant since P> 0.05. This implies that E1 and E2 groups and C1 and C2 groups got relatively the same scores on self-concept based on self-esteem. However, the comparison between the mean difference in the groups C1 and E1 (p=0.002), C1 and E2 (p=0.000), C2 and E1 (0.010) and C2 and E2 (0.003), were all statistically significant since P< 0.05.

These findings show that the experimental groups' mean was higher (64.56%) than the control groups' mean (43.31%) in self-concept based on self-esteem, in line with a study by Khan, (2016) observation that the methodology that a teacher uses in teaching creates a conducive environment for a learner to achieve self- concept. Another study by Mason and Kahle (2009) reported that a student who learns through Inquiry-Based-Teaching Approach develops higher self-concept than those who are taught through conventional method.

4.3.4 Role Performance

The last indicator of self-concept is role-performance. Role performance revolves around how an individual expresses his or her own role. A person with a high level of role performance produces better results in their engagements compared to one with a low level of role performance. To test this on the respondents, a questionnaire was given after the three weeks' period of instruction using inquiry based science-teaching approach. The following variables were under examination in the role performance scale:

RP10.Teacher's response to my questions in class when I am performing a practical activity affects my learning outcome.

RP11. Participation in learning develops knowledge that guarantees me the highest level of development.

RP12. My Physics teacher has played an important role in boosting my performance in physics.

Table 29 shows the averages of the Control and Experimental Groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 29: Analysis of Students Self-Concept Based on Role-Performance.

	Average of Control Groups (C1 & C2)			**Average of Experimental groups(E1 &2)**		
	D	**U**	**A**	**D**	**U**	**A**
RP10	61.04%	20.78%	18.18%	36.99%	16.43%	46.58%
RP11	42.86%	33.77%	23.37%	27.40%	8.21%	64.39%
RP12	68.83%	3.90%	27.27%	33.84%	30.54%	35.62%

Key: RP- Role Performance Array

Source: The Researcher, 2021

As shown in Table 29, 61.04% of the respondents from the Control Group (Scale10: role performance) disagreed that the teacher's response to their questions in class when performing a practical activity affected their achievement. The results indicate that 18.18% agreed and 20.78% were undecided. These findings show that more than half of the respondents (61.04%) disagreed that the teacher’s response to their questions in class when performing a practical activity affect their achievement.

The Experimental Group, Scale 10 responses show 36.99% of the respondents disagreed that the teacher’s response to my question in class when performing a practical activity affects their achievement. The findings show that 46.58% agreed and 16.43% were undecided. Therefore, nearly half of the respondents (46.58%) agreed that the teacher’s response to their questions in class when performing a practical activity affected their achievement.

The Control Group, Scale 11, responses show that 42.86% of the respondents disagreed that participation in learning developed knowledge that guaranteed the highest level of development. The results show that 23.37% agreed while 33.77% were undecided. From these results therefore, most of the respondents (42.86%) disagreed that participation in learning developed knowledge that guaranteed the highest level of development.

The finding on the Experimental Group in Scale 11 shows that 27.40% disagreed that participation in learning developed knowledge that guaranteed the highest level of development. The results show that 64.39% agreed and 8.21% were undecided. As indicated, more than half of the respondent (64.39) agreed that participation in learning developed knowledge, which guaranteed the highest level of development.

Moving to Scale 12, 68.83% of the respondents disagreed that the physics teacher played an important role in boosting their performance in physics. The results indicated that 27.27% agreed and 3.90% were undecided. These findings imply that more than half of the respondents 68.83% disagreed that the Physics teacher played an important role in boosting their performance in Physics.

The Experimental Groups, Scale 12, responses show that 33.84% of the respondents disagreed that the Physics teachers played an important role in boosting their performance in Physics. The results indicate that 35.65% agreed and 30.54% were undecided. Therefore, the less than half of the respondents (35.65%) agreed that the physics teacher played an important role in boosting their performance in physics.

Majority of the respondents from the Control Group disagreed that the teacher's response to their questions in class when performing a practical activity affected their achievement while the majority from the Experimental Group agreed that the teacher's response to their questions in class when performing a practical activity affected their achievement. High percentage of respondents from the control group disagreed that participation in learning developed knowledge that guaranteed the highest level of development whereas a high percentage of the respondents from the experimental group agreed that participation in learning developed knowledge, which guaranteed the highest level of development. Most of the respondents taught using the inquiry-based method agreed that the Physics teacher played an important role in boosting their performance in Physics.

These findings contradict those of a study by Dambuozo (2005), Dupe, and Oludipe (2013) who indicated that a learner's self-concept and academic achievement in Physics is influenced by the methodology that teachers use when teaching Physics.

Table 30: The Chi -Square Average Mean Score on Self-Concept Based on Role-Performance

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	48.582[a]	8	0.481
Likelihood Ratio	59.737	8	0.000
Linear-by-Linear Association	.030	1	0.863
N of Valid Cases	150		

a. 3 cells (20.0%) have expected count less than 5. The minimum expected count is 3.04.

Source: The Researcher, 2021

The results in Table 30 indicate that P=0.481, df=8 and $\alpha=0.05$. This shows that P> 0.05. These findings imply that there is no significance association between role performance and IBSTA. The findings contradict those of a study by Bati (2014) who argued that the inquiry method stimulates creativity of a learner that gives an internal drive of a learner (self-concept), which enhances good learning outcome.

To further understand the association between role performance and learning outcomes, ANOVA was conducted and the significant differences between these two groups (control and experimental group) reported in Table 31.

Table 31: ANOVA of Students' Self-Concept Based on Role Performance

Source	**Type III Sum of Squares**	**Mean Square**	**F**	**Sig.**
Corrected Model	4.727[a]	1.576	2.145	.097
Intercept	572.485	572.485	779.350	.000
Sub Category	4.727	1.576	2.145	.097

a. R Squared = .042 (Adjusted R Squared = .023) df=3

Source: The Researcher, 2021

The results in Table 31 show that the f-statistic was 2.145, for 3 degree of freedom and a mean difference of 1.579. This yielded a significance level of 0.097 that was more that the set value of α=0.05. This indicates that the differences between the mean values were not statistically significant. The findings contradict those of a study by Dupe & Oludipe (2013), which reported that Physics achievement is positively correlated with self-concept and the methodology used in teaching.

To understand the differences between the means on self-concept based on role performance, LSD was conducted. The findings obtained were presented in table 32.

Table 32: LSD of Average Scores on Students' Self-Concept Based on Role Performance

(I)Sub-category	(J) Sub-category	Mean Difference (I-J)	Std. Error	Sig.	95%Confidence Interval Lower Bound	Upper Bound
C1	C2	.15	.185	**0.426**	-.22	.510
	E1	.63*	.188	**0.404**	-.70	.040
	E2	.17*	.209	**0.544**	-.57	.251
C2	C1	-.15	.185	**0.426**	-.51	.224
	E1	.85*	.197	**0.269**	-.86	-.091
	E2	.48*	.217	**0.588**	-.74	.127
E1	C1	.63*	.188	**0.404**	-.04	.702
	C2	.85*	.197	**0.269**	.09	.866
	E2	.17	.219	**0.449**	-.27	.602
E2	C1	.17*	.209	**0.545**	-.25	.570
	C2	.48*	.217	**0.588**	-.12	.741
	E1	-.17	.219	**0.499**	-.60	.273

Based on observed means.
The error term is Mean Square (Error) = .735.
***. The mean difference is significant at the 0.05 level.**

Source: The Researcher, 2021

The analysis on Table 32, indicates that the difference between C1 and C2 (p=0.426) and E1 and E2 with (p=0.449) was not statistically significant since P> 0.05. This implies that E1 and E2 Groups and C1 and C2 obtained relatively the same scores on self -concept based on role performance. However, the comparison between the mean difference in the groups C1 and E1 (p=0.404), C1 and E2 (p=0.545), C2 and E1 (0.269) and C2 and E2 (0.588). The findings show that the difference between the mean was not statistically significant since P> 0.05. This shows that the experimental groups' mean was less than the control groups' mean in self-concept based on role performance. The above findings contradict a study by Siddiqui and Khan (2016) who argued that Physics achievement is positively correlated with the inquiry based Teaching Approach on self-concept.

The average percentages result on students' response on self-concept was determined and the results of the findings were as indicated in Table 33.

Table 33: Overall Percentage Results on Students' Responses on Self –Concept

Average Array	E1	C1	E2	C2
Self-Image	63.51%	39.47%	66.67%	40.17%
Self-Identity	57.64%	42.10%	53.70%	45.45%
Self-Esteem	74.49%	44.74%	54.63%	41.88%
Role Performance	73.48%	47.37%	52.78%	41.03%
Grand Mean	**67.28%**	**43.42%**	**56.95%**	**42.13%**

Source: The Researcher, 2021

Table 33 results indicate that the respondents from the Experimental Group had better outcomes as to compare to the Control Group. The average scores for the experimental group were E1 (67.28%) and E2 (56.95%) while the average scores for the Control Groups were C1 (43.42%) and C2 (42.13%). The average arrays of Experimental Groups were higher than that of the Control Group. This implies that then experimental groups possessed high levels of self-image, self-identity, and self-esteem and role performance than the control groups.

To understand whether there was a statistically significant difference in self-concept and the teaching approach used, the following hypothesis was tested:

H_{02}: There is no statistically significant difference in self-concept toward Physics between students exposed to Inquiry-Based Science teaching Approach and those exposed to Conventional teaching methods.

A chi-square was used to test the hypothesis. Table 34 presents the findings on the t-test computation of the significant differences between mean of responses of indicators of self-concept

Table 34: Overall Results of Chi-square for Self-Concept

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31.969[a]	8	.000
Likelihood Ratio	40.565	8	.000
Linear-by-Linear Association	.239	1	.625
N of Valid Cases	150		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.70.

Source: The researcher, 2021

From the tabulation on Table 34, P=0.0005, df=8 and α=0.000. This shows that there is a significance association between self-concept and IBSTA. Additionally, the percentage that represents the ratio of the actual count to the expected count was not violated because it was not greater than 20%. These results are in line with a study by Kaboro and Githae (2015), which found out those students who were taught, using the conventional method, had a low self-concept while those who were taught using inquiry method had a significantly high self-concept.

In order to determine if there was a significant difference in each of the 4 indicators of self-concept, analysis of variance (ANOVA) was conducted and the findings are as recorded in table 35.

Table 35: Overall Results of Analysis of variance (ANOVA) for Self-Concept

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	110.422	3	36.807	27.605	.0005
Within Groups	194.672	146	1.333		
Total	305.093	149			

Source: The Researcher, 2020

The analysis in Table 35 indicates that, the F-statistic was 27.605, for 3 degree of freedom and a mean difference of 36.807. This yielded a significance level of 0.0005 that was less that the set value of α = 0.05. This implies that there was a statistically significant difference between the means for self- concept of the two groups under study. The implication of this is that the inquiry-based approach positively influenced self-concept that in turn had a positive effect on the learning outcome.

To further understand the statistical difference between the scores obtained, it was essential to find out whether there was any statistically significant difference among the means of the different study groups, LSD was computed and the findings obtained were shown in the Table 36.

Table 36: LSD Overall Results on Self-Concept after Treatment

(I) Sub-category	(J) Sub-category	Mean Diff. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.584*	.263	**.508**	.06	1.10
	E1	8.535*	.267	**.000**	-2.06	-1.01
	E2	11.155*	.269	**.000**	-1.69	-.62
C2	C1	-.584*	.263	**.508**	-1.10	-.06
	E1	8.119*	.265	**.000**	-2.64	-1.60
	E2	8.739*	.267	**.000**	-2.27	-1.21
E1	C1	8.535*	.267	**.000**	1.01	2.06
	C2	8.119*	.265	**.000**	1.60	2.64
	E2	.380	.270	**.162**	-.15	.91
E2	C1	11.155*	.269	**.000**	.62	1.69
	C2	8.739*	.267	**.000**	1.21	2.27
	E1	-.380	.270	**.162**	-.91	.15

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

Source: The Researcher, 2021

The results in Table 36 show that the mean difference between C1 and C2 with (p=0.508) and E1 and E2 (p=0.162) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on self-concept. However, the comparison between the mean difference in the groups C1 and E1 (p=0.000), C1 and E2 (p=0.000), C2 and E1 (0.000) and C2 and E2 (0.000), were statistically significant. Since P< 0.05. This shows that the experimental groups' mean was higher than the control groups' mean on self-concept. Therefore, the null hypothesis two, that stated, H_{02}*: There is no statistically significant difference in self-concept toward Physics between students exposed to Inquiry-Based Learning and those exposed to Conventional teaching methods,* was rejected.

These findings of this study are in line with the findings by Dupe and Oludipe (2013) which reported that physics achievement was positively correlated with self-concept and methodology used in teaching. In addition, Bati (2014) argues that the Inquiry method of instruction stimulates the self-concept of a learner.

4.4. Effects of Inquiry-Based Teaching Approach in Teaching Physics on Students' Scientific Creativity

The third objective of study was to establish the difference in scientific-creativity of the student taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods in Physics. The research employed the Science Torrance Test of Creative Thinking (STTCT) to address the four aspects of Creativity namely: Recognition, Sensitivity, Flexibility and Planning.

4.4.1 Recognition

Recognition refers to the identification of knowledge areas. During each of the lesson in the period of study, the researcher observed to check for existence of recognition as an indicator of scientific creativity. The parameter used to check recognition was:

Ra1: Ability to recall the laws, principles and definition of terms of the topic studied.
Ra2: The student is able to give his/her own opinion about subject matter or about how to solve a problem.
Ra3: The student can give innovative and practical ideas.
Ra4: The student is able to describe the subject matter in various dimensions and skills.
Ra5: The student is able to make summative analysis of what the teacher teaches in the lesson.

The observation made during the lessons in both the Control and Experimental Groups yielded the results as captured and analyzed in Table 37.

Table 37: Scientific Creativity Based on Recognition from the Specific Study Groups

	C1		C2		E1		E2	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Ra1	53.85%	46.15%	61.54%	38.46%	53.85%	46.15%	61.54%	38.46%
Ra2	38.46%	61.54%	38.46%	61.54%	61.54%	38.46%	76.92%	23.08%
Ra3	53.85%	46.15%	46.15%	53.85%	61.54%	38.46%	46.15%	53.85%
Ra4	46.15%	53.85%	53.85%	46.15%	69.23%	30.77%	84.62%	15.38%
Ra5	38.46%	61.54%	38.46%	61.54%	69.23%	30.77%	61.54%	38.46%

Key Ra- Recognition Array

Source: The Researcher, 2021

As shown in Table 37, 53.85% of the respondents from the Control Group C1 (scale 1: Recognition) were able to recall the laws, principles and definition of terms of the topic studied. The results indicate that 46.15% of the same groups were unable. The finding shows that 61.54% of the students from Control Group C2 were able to recall the laws, principles and definition of terms of the topic studied while 38.46% of the respondents from the same group were unable to. The findings show that 53.85% of the respondents from Experimental Groups E1 were able to recall the laws, principles and definition of terms of the topic studied while 46.15% from the same group were unable to. The results indicate that 61.54% of the respondents from E2 were able to define terms of the topic studied. The findings show that 38.46% of respondents of the same group were unable to. This implies that the experimental groups had higher mean scores as compared to the Control Groups meaning. The Experimental Groups were able to define terms better than the control groups.

From Scale 2: recognition, 38.46% of the respondents from C1 were able to give their own opinion about subject matter and about how to solve a problem. The results indicate that 61.54% of the same respondents were not able to. The findings show that 38.46% of the respondents from C2 were able to give their own opinion about subject matter or about how to solve a problem. The results show that 61.54% of the same respondents were unable to. The results indicate that 61.54% of the respondents from E1 were able to give their own opinion about subject matter or about how to solve a problem while 38.46% of the same respondents were unable to. The results show that

76.92% of the students from E2 were able to give their own opinion about the subject matter or about how to solve a problem whereas 23.08% of the same respondents were unable to. This implies that Experimental Groups had higher mean score as compared to the control groups. Therefore, the Experimental Group were able to give their own opinion and solve problem of the content they were taught and define terms better than the control groups.

For Scale 3: Recognition, 53.85% of the respondents from C1 could give innovative and practical ideas. The findings indicate that 46.15% of the respondents from the same group were unable to. The results show that 46.15% of the respondents from C2 could give innovative and practical ideas whereas 53.85% of the respondents from the same group were unable to. The findings show that 61.54% of the respondents from E1 could give innovative and practical ideas whereas 38.46% of the respondents from the same group were unable to. The finding indicates that 46.15% of the respondent from E2 could give innovative and practical ideas. The results indicate that 53.85% of the respondents from the same group could not. These findings show that the Experimental Groups posted a higher mean score as compared to the Control Groups meaning that the Experimental Groups were more innovative and with high practical ideas as compared to the Control Groups.

On Scale 4: Recognition 46.15% of the respondents from C1 was able to discuss the subject matter in various dimensions and skills whereas 53.85% of the respondents of the same group were unable to. The findings show that 53.85% of the respondents from C2 were able to discuss the subject matter in various dimensions and skills. The findings indicate that 46.15% of the respondents from the same group could not. The results indicate that 69.23% of the respondents from E1 were able to discuss the subject matter in various dimensions and skills whereas 30.77% of the respondents of the same group were unable to. The results show that 84.62% of the respondents in E2 were able to discuss the subject matter in various dimensions and skills while 15.38% were unable to. The findings show that Experimental Groups posted higher mean scores as compared to control groups. This implies that Experimental Group was able to describe the subject matter in various dimensions and skills.

Moving on to Scale 5: Recognition, 38.46% of the respondents from C1 were able to make summative analysis of what the teacher taught in the lesson whereas 61.54% of the respondents from same group were unable to. The results show that 38.46% of the respondents from C2 were able to make summative analysis of what the teacher teaches in the lesson. The results show that 61.54% of the respondents of the same group were not in apposition to. The findings show that 69.23% of the respondents from E1 were able to make summative analysis of what the teacher taught in the lesson whereas 30.77% of the respondents of the same group could not. The results indicate that 61.54% of the respondents from E2 were able to make summative analysis of what the teacher teaches in the lesson. The results show that 38.46% of the respondents from the same group were unable to. The findings show that control groups had lower mean scores as compared to Experimental Group. This implies that the Control Groups were not able to make summative analysis of what the teacher taught in the lesson.

In order to further understand recognition as an indicator of scientific creativity, average of responses on Experimental and Control groups were computed. The findings are as in Table 38.

Table 38: Average Percentage Scores of Scientific Creativity Results Based on Recognition

	Average of (C1&C2) groups		**Average of (E1 &E2)Groups**	
	Yes	**No**	**Yes**	**No**
Ra_1	57.69%	42.31%	57.69%	42.31%
Ra_2	38.46%	61.54%	69.23%	30.77%
Ra_3	50.00%	50.00%	53.85%	46.15%
Ra_4	50.00%	50.00%	76.92%	23.08%
Ra_5	38.46%	61.54%	65.38%	34.62%
Ra (Average)	**46.92%**	**53.07%**	**64.61%**	**35.39%**

Key Ra-Recognition Arrays

Source: The Researcher, 2021

Table 38 findings show that 64.61% of the students from the Experimental Group were able to meet the criteria set for recognition. The results show that 46.92% of the respondents from the Control Group were able to meet the criteria for recognition.

This indicates that the percentage mean score of the two groups that is Experimental and Control were different with Experimental Groups posting higher percentages. These findings are in line with a study by Walia (2012) who indicated that students taught using the 5E instructional model had higher scores on creative ability in mathematics than students taught using traditional approach. In addition, Hong (2013), argued that real-life problem solving item describes a problem scenario that could occur in test respondents' lives in a specific domain.

Based on the findings from the observation schedule, it was observed that the Experimental Groups that were taught using IBSTA posted a higher percentage frequencies of positive responses than the control group in; the ability to recall the laws, principles and definition of terms of the topic studied, give their own opinion about subject matter or about how to solve a problem, give innovative and practical ideas, describe subject matter in various dimensions and skills and make summative analysis of what the teacher taught in the lesson.

This finding concurred with a study by Burris and Garton (2007) who reported that Inquiry method is exciting to the student and to the teacher as the student builds, connects and shares experiences with others.

To establish whether the means were significantly different, further analysis was conducted using analysis of variance (ANOVA) and the findings are presented in Table 39.

Table 39: The ANOVA of Average Score on Scientific Creativity Based on Recognition

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.769[a]	3	.923	1.333	**.0275**	**.077**
Intercept	208.000	1	208.000	300.444	**.0000**	**.862**
Sub Category	**2.769**	**3**	**.923**	**1.333**	**.0275**	**.077**
Error	33.231	48	.692			
Total	244.000	52				
Corrected Total	36.000	51				
a. R Squared = .077 (Adjusted R Squared = .019)						

Source: The Researcher, 2021

The results in Table 39 show that the f-statistic was 1.333, for 3 degree of freedom and a mean difference of 2.769. This yielded a significance level of 0.0275 that was less that the set value of **α**=0.05. This indicated that differences between the mean values were statistically significant because P<0.05.

To further understand the statistical difference between the scores obtained, it was essential to find out whether there was any statistical difference between the different study groups. LSD was computed. The findings obtained are shown in Table 40.

Table 40: Results of LSD of Scientific Creativity Average Scores Based on Recognition.

(I)Sub category	(J) Sub category	Mean Dif.(I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	0.00	1.221	**1.000**	-.661	0.661
	E1	-1.46	3.325	**.045**	-2.999	1.532
	E2	-1.46	3.325	**. 045**	-2.999	1.535
C2	C1	0.00	1.221	**1.000**	-661	0.661
	E1	3.45	3.479	**. 000**	7.489	10.987
	E2	2.88	4.248	**. 000**	3.476	6.441
E1	C1	-1.46	3.325	**.045**	-2.99	1.53
	C2	3.45	3.478	**. 000**	7.489	10.987
	E2	0.266	.5899	**.880**	2.447	2.847
E2	C1	-1.46	3.325	**.045**	-2.99	1.53
	C2	2.88	4.247	**.000**	3.476	6.441
	E1	0.266	.5899	**.880**	2.447	2.847

Based on observed means. The error term is Mean Square (Error) = .692.

Source: The Researcher, 2021

From Table 40, it is clear that mean difference between C1 and C2 (p=1.000) and E1 and E2 (p=0.880) was not statistically significant since P> 0.05. This implies that E1 and E2 groups and C1 and C2 groups obtained relatively the same scores on scientific creativity based on recognition. However, the comparison between the mean difference in the groups C1 and E1 (p=0.045), C1 and E2 (p=0.045), C2 and E1 (0.000) and C2 and E2 (0.000), were statistically significant since P<0.05. This affirms that the experimental groups' mean was higher than the control groups' mean in scientific creativity based on recognition. The above findings are in line with a study by Bradley (2010) who argued that the use of Inquiry Teaching leads to creativity of a learner in continuous gain from lower level of thinking to a higher level of thinking.

4.4.2 Sensitivity

Sensitivity is another indicator of scientific creativity. During each of the lesson in the period of study, the researcher observed to check for existence of sensitivity as an indicator of scientific creativity. The parameters used to check sensitivity were:

Sa_1: Identification of errors in the apparatus they are using during the experiment.
Sa_2: While facing a problem or a self-created difficult situation, the student is able to grasp the key elements of the situation.
Sa_3: The student is able to devise and explain a problem clearly and accurately.
Sa_4: Ability to scientifically criticize the results of resistance if they deviate more from one group and way to identify what caused the errors.
Sa_5: The student is able to express key points of a problem and any insufficiency to help find ways to solve the problem.
In order to further understand sensitivity as an indicator of scientific creativity, the average of responses on experimental and control groups were computed. The findings are as in Table 41.

Table 41: Analysis of Students' Sensitivity Average Percentage Frequency after Teaching

	C1		C2		E1		E2	
	Yes	No	Yes	No	Yes	No	Yes	No
Sa1	38.5%	61.5%	53.8%	46.2%	61.5%	38.5%	53.8%	46.2%
Sa2	53.8%	46.2%	38.5%	61.5%	46.2%	53.8%	76.9%	23.1%
Sa3	61.5%	38.5%	53.8%	46.2%	69.2%	30.8%	69.2%	30.8%
Sa4	23.1%	76.9%	30.8%	69.2%	76.9%	23.1%	76.9%	23.1%
Sa5	30.8%	69.2%	30.8%	69.2%	84.6%	15.4%	69.2%	30.8%

Key Sa- Sensitivity arrays

Source: The Researcher, 2021

As shown in Table 41, 38.46% of the respondents from control group C1 (Scale 1: Sensitivity) were able to identify errors in the apparatus they were using during the experiment. The results indicate that 61.54% of the same groups were unable to. The findings show that 53.80% of the respondents from the control group C2 were able to identify errors in the apparatus they were using during the experiment whereas

46.20% of the same groups were unable. The results indicate that 61.54% of the respondents from Experimental Group E1 were able to identify errors in the apparatus they were using during the experiment while 38.46% from the same group were unable 53.80% of the respondents from Experimental Group E2 were able to identify errors in the apparatus they are using during the experiment while 46.20% of the same group were unable.

The findings show that the mean scores for the respondents in the Experimental Group who could identify errors was higher than the mean score for the respondents in Control Group. This implies that more than half of the respondents in the control group were not sensitive to recognizing the errors of the apparatus during the experiment as compared to the experimental group respondents.

From Scale 2: sensitivity, 53.80% of the respondents from Control Groups C1, were able to grasp the key elements of a situation when faced with a problem or a self-created difficult situation, 46.20% of the respondents of same group were unable. 38.46% of the respondents from Control Group C2, were able to grasp the key elements of a situation when faced with a problem or a self-created difficult situation, 46.15% of the respondents from Experimental Group E1 were able to grasp the key element of a situation when faced with a problem or a self-created difficult situation, 53.8 % of the same group were unable. The results indicate that 76.92% of the respondents from Experimental Group E2 were able to grasp the key element of a situation when faced with a problem or a self-created difficult situation, 23.08% of the same group were unable. The results show that the mean scores for experimental groups were higher than the mean score for the control groups. This implies that the students in experimental groups were more sensitive in identifying a challenging situation and how to grasp a key element to solve it as compared to the students in control group.

On Scale 3: Sensitivity, 61.53% of the respondents from Control Group C1 were able to devise and explain a problem clearly and accurately while 38.47% of the respondents from same group were unable. The findings showed that 53.85% of the respondents from control group C2 were able to devise and explain a problem clearly and accurately. The results indicate 46.15% of the respondents from the same group were unable. The findings show that 69.23% of the respondents from Experimental Group E1 were able to devise and explain a problem clearly and accurately while 30.77% of the respondents from same group were unable. The results indicate that 69.2% of the respondents from Experimental Group E2 were able to devise and explain a problem clearly and accurately. The results indicate that 30.8% of the respondents from same group were unable. This finding shows that control groups' mean scores were lower than that of the Experimental Groups. This implies that students in the Experimental Group were able to explain a problem clearly and accurately without making mistakes as compared to respondents in the control group.

From Scale 4: sensitivity, 23.07% of the respondents from C1 were able to scientifically criticize the results of resistance if they deviated from one group to another and identify what caused the errors while 76.93% of the respondents from same group were unable. The finding shows 30.77% of the respondents from Control Group C2 were able to scientifically criticize the results of resistance if they deviated from one group to another and identifies what caused the errors. The results 69.23% of the respondents from the same group were unable. The results show that 76.9% of the respondents from Experimental Group E1 were able to scientifically criticize the results of resistance if they deviated from one group to another and identify what caused the errors while 23.1% of the responds from same group were unable. The results show that 84.6% of the respondents from Experimental Group E2 were able to scientifically criticize the results of resistance if they deviated from one group to another and identify what caused the errors while 15.4% of the respondents from the same group were unable. The findings imply that the Experimental Group was able to criticize the results easily and identify source any error that occurred during the experiment.

Moving on to scale 5: sensitivity, 30.8% of the respondents from control group C1 were able to express key points of a problem and any insufficiency to help find ways to solve the problem whereas 69.2% of the respondents from same group were unable to. The results show that 30.8% of the respondents from the Control Group C2 were able to express key points of a problem and any insufficiency to help find ways to solve the problem. 69.2% of the respondents from the same group were unable to. The results show that 84.62% of the respondents from Experimental Group E1 were able to express key points of a problem and any insufficiency to help find ways to solve the problem whereas 15.38% of the respondents from same group were unable to. The findings indicate that 69.2% of the respondents from Experimental; Group E2 were able to express key points of a problem and any insufficiency to help find ways to solve the problem. The results show that 30.8% of the respondents from same group were unable. The results show that the Experimental Groups posted higher mean scores as compared to the Control Groups. This implies that respondents in the Experimental Group were able to come up with key points that were required to solve any problem during the experiment.

In order to analyze on the mean difference on sensitivity on the Experimental and Control Groups, the average percentages on sensitivity were determined and findings were as recorded in Table 42.

Table 42: Analysis of Students' Sensitivity Average Percentage Frequency after Teaching

	Average Control group		Average Experimental Group	
	Yes	**No**	**Yes**	**No**
Sa1	46.15%	53.85%	57.69%	42.31%
Sa2	46.15%	53.85%	61.54%	38.46%
Sa3	57.69%	42.31%	69.23%	30.77%
Sa4	26.92%	73.08%	76.92%	23.08%
Sa5	30.77%	69.23%	76.92%	23.08%
Grand mean%	**41.54%**	**58.46%**	**68.46%**	**31.54%**

Key: Sa- Sensitivity arrays

Source: The Researcher, 2021

Table 42 results on sensitivity indicate that the percentage means score of the control and the Experimental Group was different. The Experimental Groups posted higher average percentage scores on sensitivity (68.46%) than the control groups (41.54%). This implies that the Experimental Groups were more sensitive than the Control Groups in identifying of errors, grasping key points, scientifically criticizing results and identifying of key points in a problem when conducting an experiment.

In order to establish further whether there was a significant difference between the means of the two groups, ANOVA was computed and the results presented in table 43.

Table 43: ANOVA of Average Mean score of Students' Sensitivity after Treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.332[a]	3	.854	1.878	.025	.083
Intercept	216.000	1	216.000	300.444	.000	.862
Sub category	3.554	3	.854	1.878	.025	.083
Error	30.248	48	.954			
Total	288	52				
Corrected Total	32.000	51				

a. R Squared = .083 (Adjusted R Squared = .0101)

Source: The researcher, 2020

The results in Table 43 show that, the f-statistic was 1.878, for 3 degree of freedom and a mean difference of 0.854. This yielded a significance level of 0.025. That was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant. This implies that the respondents in the Experimental Groups had a higher level of sensitivity, which translated into positive impact on their learning outcomes. These findings are in agreement with Christopher (2014) who asserted that the use of IBSTA presents students with opportunities to ask questions, seek answers, analyze data, discuss ideas and apply their scientific creativity.

In order to determine if there is a statistically significance difference between the means of Experimental Groups and Control Groups on students' sensitivity, LSD was conducted and the findings were as in Table 44.

Table 44: LSD of Average scores on Sensitivity after Treatment on Scientific Creativity.

(I) Sub category	(J) Sub category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.885	.256	**.877**	1.88	2.66
	E1	5.332	.875	**.041**	2.78	8.011
	E2	4.454	.833	**.047**	2.33	7.711
C2	C1	.885	.256	**.877**	1.88	2.741
	E1	3.858	.229	**.000**	3.66	7.201
	E2	4.55	.239	**.003**	4.11	8.66
E1	C1	5.332	.875	**.041**	2.78	8.011
	C2	3.858	.229	**.000**	3.66	7.201
	E2	.205	.112	**.741**	-1.58	-1.22
E2	C1	4.454	.833	**.047**	2.33	7.711
	C2	4.55	.239	**.003**	4.11	8.66
	E1	.205	.112	**.741**	-1.58	-1.22

Based on observed means.
The error term is Mean Square (Error) = .225.

Source: The researcher, 2021

The analysis in Table 44 indicates that the mean difference between C1 and C2 (p=0.877) and E1 and E2 (p=0.741) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on scientific creativity based on sensitivity. However, the comparison between the mean difference in the groups C1 and E1 (p=0.041), C1 and E2 (p=0.045), C2 and E1 (0.047) and C2 and E2 (0.003) were statistically significant since P<0.05. This shows that the experimental groups' mean was higher than the control groups' mean in scientific creativity based on recognition.

These findings are in line with a study by Rinita, Susanti and Suratmi (2018) who argued that learners taught by teachers who do not apply inquiry-based learning in the laboratory, have a great challenge of being scientifically creative, but learners taught by teachers who attend science workshops and apply the IBSTA had very creative and imaginative learners.

4.4.3 Flexibility

Flexibility is also an indicator of scientific creativity. During each of the lessons in the period of study, the researcher observed to check for existence of flexibility of a learner. The parameters used to check flexibility were:

Fa_1: Students were able to discuss and explain subject matters or a single topic from a different angle.
Fa_2: The student is able to show in detail understanding of the subject matter.
Fa_3: Student is able to give constructive opinion and inspire other students.
Fa_4: Student is able to consult other students and the teacher if their apparatus fails when trying to conduct an experiment by themselves.
Fa_5: Student only had general and superficial understanding about subject matter.

In order to further understand flexibility as an indicator of scientific creativity, the averages of responses on experimental and control groups were computed. The findings are as in Table 45**.**

Table 45: Post Observation on Scientific Creativity results Based on Flexibility

	C1		**C2**		**E1**		**E2**	
	Yes	No	Yes	No	Yes	No	Yes	No
Fa1	46.15%	53.85%	46.15%	53.85%	38.46%	61.54%	61.54%	38.46%
Fa2	46.15%	53.85%	38.46%	61.54%	69.23%	30.77%	53.85%	46.15%
Fa3	61.54%	38.46%	61.54%	38.46%	84.62%	15.38%	76.92%	23.08%
Fa4	38.46%	61.54%	38.46%	61.54%	92.31%	7.69%	84.62%	15.38%
Fa5	46.15%	53.85%	46.15%	53.85%	76.92%	23.08%	76.92%	23.08%

Key: Fa- Flexibility Array

Source: The Researcher, 2021

As shown in Table 45. The finding shows that 46.15% of the respondents from control group C1 were able to discuss and explain subject matters or a single topic from a different angle whereas 53.85% of the respondents from same group were unable to. The results indicate that 46.15% of the respondents from Control Group C2 were able to discuss and explain subject matters or a single topic from a different angle while 53.85% of the respondents from same group were unable to. The results indicated that 38.46% of the respondents from Experimental Group E1 were able to discuss and explain subject matters or a single topic from a different angle. The findings show that 61.54% of the respondents from the same group were unable to. The results indicate that 38.46% of the respondents from Experimental Group E2 were unable to discuss and explain subject matters or a single topic from a different angle where as 69.23% of the respondents from the same group were unable to. These findings of the results show that Experimental Group E1 had a lower mean score as compared to E2. This implies that the learner in E1 were less flexible in explaining on discussing of a topic in different angles than group in E2.

Moving on to Scale 2: flexibility, 46.15% of the respondents from Control Group C1 were able to show in-depth and comprehensive understanding of the subject matter. The results show that 53.85% of the respondents from same group were unable to. The results show that 38.46% of the respondents from Control Group C2 were able to show in-depth and comprehensive understanding of the subject matter whereas 61.54% of the respondents from same group were unable to. The results show that 30.77% of the respondents from Experimental Group E1 were unable to show in-depth and comprehensive understanding of the subject matter. While 69.23% of the respondents from same group were able to. The results show that 53.85% of the respondents from Experimental Group E2 were able to show in-depth and comprehensive understanding of the subject matter whereas 46.15% of respondents from same group were unable to. The finding in the study shows that the mean score for the Control Groups were lower than that of the Experimental Groups. This implies that the respondents in control group were less able to show in-depth and comprehensive understanding on subject matter.

On Scale 3: flexibility, 61.54% of the respondents from Control Group C1 were able to give constructive opinion and inspire other students. The results show that 38.46% of the respondents from same group were unable to. The results show that 61.54% of the respondents from Control Group C2 were able to give constructive opinion and inspire other students. The results show that 38.46% of the respondents from same group were unable. The results show that 84.62% of the respondents from Experimental Group E1 were able to give constructive opinion and inspire other students. The results show that 15.38% of the respondents from same group were unable to. The findings indicated that 76.92% of the respondents from Experimental

Group E2 were able to give constructive opinion and inspire other students whereas 23.08% of the respondents from same group were unable to.

These findings show that Experimental Group posted higher mean scores as compared to Control Group. This implies that students in the Experimental Group were better able to give constructive opinion and inspire others as compared to respondents in the control group.

Moving on to Scale 4: flexibility, 38.46% of the respondents from Control group C1 were able to consult other students and the teacher if their apparatus failed when trying to conduct an experiment by themselves. The results show that 61.54% of the respondents from same group were unable to. The findings indicate that 38.46% of the respondents from Control Group C2 were able to consult other students and the teacher if their apparatus failed when trying to conduct an experiment by themselves whereas 61.54% of the respondents from same group were unable to. The findings indicate that 92.31% of the respondents from experimental group E1 were able to consult other students and the teacher if their apparatus failed when trying to conduct an experiment by themselves whereas 7.69% of the respondents from same group were unable to. The findings show that 84.62% of the respondents from experimental group E2 were able to consult other students and the teacher if their apparatus failed when trying to conduct an experiment by themselves while 15.38% of the respondents from same group were unable to.

These findings show that the Experimental Groups had very high mean score as compared to the Control Groups. This implies that in case apparatus failed to work respondents from Experimental Group had had no challenge in consulting the teacher or each other.

On Scale 5: flexibility, 46.15% of the respondents from control group C1 had general and superficial understanding of subject matter while 53.85% of the respondents from same group had not. The results show that 46.15% of the respondents from control group C2 had general and superficial understanding about subject matter. The findings show that 53.85% of the respondents from same group had not. The results indicate that 76.92% of the respondents from Experimental Group E1 had general and superficial understanding about subject matter. The findings show that 23.08% of the respondents from same group had not. The results indicate that 76.92% of the respondents from Experimental Group E2 had general and superficial understanding about subject matter whereas 23.08% of the respondents from same group were had not. These results show that the Experimental Groups posted higher mean scores as compared to the Control Groups.

Table 46: Average Percentage Mean Score on Scientific Creativity Results Based on Flexibility

	Groups Category			
	Average (C1&C2) Groups		Average (E1 & E2) Groups	
	Yes	No	Yes	No
Fa1	46.15%	53.85%	50.00%	50.00%
Fa2	42.31%	57.69%	61.54%	38.46%
Fa3	61.54%	38.46%	80.77%	19.23%
Fa4	38.46%	61.54%	88.46%	11.54%
Fa5	46.15%	53.85%	76.92%	23.08%
Grand mean	**46.92%**	**53.08%**	**71.54%**	**28.46%**

Key: Fa- Flexibility Array

Source: The Researcher, 2021

From Table 46, the results show that 71.54% of the respondents from the experimental groups were able to meet criteria for observation for the flexibility parameter and 46.92% of the respondents from the control group were able to. These findings show that the average scores of the experimental groups were higher than those of the control groups on flexibility array. This implies that respondents in experimental group had high level of flexibility as compared to control group.

These findings are in line with a study by Garton (2007) who argued that the inquiry-based approach is exciting to the students and teachers as the students build connect and share experiences with others. From the experimental results, it was clear that respondents were able to consult teachers and other students, discuss subject matters and freely express their own opinion and views to other students.

In order to establish whether there was a significance difference between the means of the control and the experimental groups, further analysis of the means using ANOVA was computed and the results were as shown in Table 47.

Table 47: The ANOVA of Average Score on Scientific Creativity Based on Flexibility

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.151[a]	3	6.221	3.448	.0005	.67
Intercept	289.000	1	188.000	300.444	.000	.862
Sub-category	3.114	3	6.221	3.448	.000	.67
Error	33.231	48	.692			
Total	188.000	52				
Corrected Total	23.000	51				

a. R Squared = .67 (Adjusted R Squared = .087)

Source: The Researcher, 2021

The results in Table 47 show that, the f-statistic was 3.448, for 3 degree of freedom and a mean difference of 6.221. This yielded a significance level of 0.0005 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant. This implies that there was statistically significant difference between the means of the experimental and the control groups thus the method of inquiry was effective for learners' outcome.

To further understand the statistical difference between the scores obtained, it was essential to find out whether there were any statistical differences between the different study groups. The findings obtained are shown in the Table 4.

Table 48: Analysis of Students' Flexibility in Scientific Creativity after Treatment

(I) Sub category	(J) Sub category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
C1	C2	.554	.354	**.877**	-.66	0.915
	E1	5.665	.441	**.006**	5.512	11.2
	E2	6.214	.377	**.035**	4.122	11.57
C2	C1	.554	.354	**.877**	-.66	.915
	E1	3.11	.298	**.047**	3.14	6.21
	E2	3.89	.311	**.034**	4.66	8.55
E1	C1	5.665	.441	**.006**	5.512	11.2
	C2	3.11	.298	**.047**	3.14	6.21
	E2	.247	.296	**.98**	.12	.455
E2	C1	6.214	.377	**.035**	4.122	11.57
	C2	3.89	.311	**.034**	4.66	8.55
	E1	.247	.296	**.98**	.12	.455

Based on observed means.

The error term is Mean Square (Error) = .445.

Source: The Researcher, 2021

The analysis on Table 48, indicates that the mean difference between C1 and C2 (p=0.877) and E1 and E2 (p=0.980) was not statistically significant since P> 0.05. This implies that E1 and E2 Groups, C1, and C2 obtained relatively the same scores on scientific creativity based on flexibility. However, the comparison between the mean difference in the groups C1 and E1 (p=0.006), C1 and E2 (p=0.035), C2 and E1 (0.047) and C2 and E2 (0.034), were statistically significant since P< 0.05. This shows that the Experimental Groups' mean was higher than the Control Groups' mean in scientific creativity based on flexibility. This led to the rejection of the null hypothesis for the relevant comparisons.

These findings are in line with those in a study by Abdullah (2015) who researched on the impact of the use of inquiry teaching Approach on learners' creative thinking.

In his findings, he indicated that this teaching approach in science stimulates learners' creativity.

4.4.4 Planning

The forth indicator of scientific creativity is Planning. During each of the lessons in the period of the study, the researcher made observations to check for existence of planning as an indicator of scientific creativity. The parameters used to check planning were:

Pa1: Learners were able to plan on how to conduct experiments.
Pa2: Learners were able to setup the apparatus logically.
Pa 3: Learners followed procedures as they conducted experiments.
Pa4: Learners were consistent in filling values in a table as they conduct the experiment.
Pa5: Learners were able to plot their values in a graph.

In order to further understand planning as an indicator of scientific creativity, the average of responses on Experimental and Control Groups were computed and the findings are as in Table 49.

Table 49: Analysis of Students' Planning in Scientific Creativity

	Sub category							
	C1		C2		E1		E2	
Array	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Pa1	38.46%	61.54%	46.15%	53.85%	69.23%	30.77%	61.54%	38.46%
Pa2	30.77%	69.23%	30.77%	69.23%	61.54%	38.46%	53.85%	46.15%
Pa3	53.85%	46.15%	53.85%	46.15%	53.85%	46.15%	69.23%	30.77%
Pa4	46.15%	53.85%	38.46%	61.54%	69.23%	30.77%	76.92%	23.08%
Pa5	53.85%	46.15%	46.15%	53.85%	53.85%	46.15%	46.15%	53.85%

Source: The Researcher, 2021

Key: Pa- Planning Array

As shown in Table 49, 38.46% of the respondents from control group C1 were able to plan on how to conduct experiments while 61.54% of the respondents from same group were unable to. The findings show that 46.15% of the Respondents from control group C2 were able to plan on how to conduct experiments whereas 53.85% of the respondents from same group were unable to. The findings indicated that 69.23% of the respondents from Experimental Group E1 were able to plan on how to conduct experiments while 30.77% of the respondents from same group were unable to. The findings indicated that 61.54% of the respondents from Experimental Group E2 were able to plan on how to conduct experiments. The results show that 38.46% of the respondents from same group were unable to. These findings show that Experimental Groups posted higher mean scores as compared to control groups. This implies that learners in control groups had a big challenge in planning and conducting of practicals while learners in Experimental Groups planned experiment and conducted experiment with a lot of ease.

On Scale 2: Planning, 30.77% of the respondents from Control Group C1 were able to set up the apparatus logically. The findings indicated that 69.23% of the respondents from same group were unable to. The results also indicated that 30.77% of the respondents from Control Group C2 were able to setup the apparatus logically while 69.23% of the respondents from same group were unable to. The results indicate that 61.54% of the respondents from Experimental Group E1 were able to set up the apparatus logically. The findings indicated that 38.46% of the respondents from same group were not able to. The results show that 53.85% of the respondents from Experimental Group E2 were able to set up the apparatus logically. The report shows that 46.15% of the respondents from same group were unable to. These findings show that the mean scores in the experimental group were higher than that of the control group. This implies that the learners in the control group had a big challenge in setting up apparatus logically while the learners in the experimental group were able to arrange apparatus logically without any problem.

Moving on to Scale 3: Planning, 53.85% of the respondents from Control Group C1 followed procedures as they conducted experiments. The results show that 46.15% of the respondents from same group were not able to. The findings indicated that 53.85% of the respondents from Control Group C2 followed procedures as they conducted experiments while 46.15% of the respondents from same group were unable to. The results indicate that 3.85% of the respondents from Experimental Group E1 followed procedures as they conducted experiments whereas 46.15% of the respondents from same group could not. The finding shows that 69.23% of the respondents from experimental group E2 followed procedures as they conducted experiments. In the results, 30.77% of the respondents from same group could not. These findings show that the Experimental Groups posted a higher mean score as compared to the control groups. This implies that respondents in experimental group were able to follow procedures without any teacher's assistance as compared to control group that had a big challenge in following the procedures.

For Scale 4: planning, 46.15% of the respondents from Control Group C1 were consistent in filling values in a table as they conducted the experiment. In the findings, 53.85% of the respondents from same group could not. The results show that 38.46% of the respondents from Control Group C2 were consistent in filling values in a table as they conducted the experiment whereas 61.54% of the respondents from same group could not. The finding shows that 64.21% of the respondents from Experimental Group E1 were consistent in filling values in a table as they conducted the Experiment whereas 35.79% of the respondents from Experimental Group E1 were unable to. The finding shows that 69.23% of the respondents from |Experimental Group E2 were consistent in filling values in a table as they conducted the experiment while 30.77% of the respondents from same group were unable to. The findings of the study show that Experimental Group had posted a higher mean score as compared to control groups. This implies that learners in experimental groups were able fill tables consistently and systematically as they conduct experiment as compared to control groups, which had a big challenge in filling the tables.

On Scale 5: Planning, 53.85% of the respondents from the Control Group C1 were able to plot their values in a graph. The results show that 46.15% of the respondents from same group were unable to. The finding shows that 46.15% of the respondents from the control group C2 were able to plot their values in a graph. The results show that 53.85% of the respondents from same group were unable to. The finding indicates that 76.92% of the students from E2 were able to plot their values in a graph while 23.08% of the respondents from same group were unable to. The results indicated that 53.85% of the respondents from Experimental Group E1 were able to plot their values in a graph. The results show that 46.15% of the respondents from same group were unable to. The results show that 46.15% of respondents from Experimental Group E2 were able to plot their values in a graph while 53.85% of respondents from same group were unable. The findings show that mean scores for the Experimental Groups were higher than those of the Control Groups. This implies that respondents in the experimental groups were able to plot the values they recorded in a table on graph without a big challenge while the respondents in the control groups had a big challenge in recording and plotting values on a graph.

In order to verify if there was any mean difference in experimental group and control group an average percentage mean on responses on planning, was conducted and the results are as indicated in Table 50.

Table 50: Analysis of Students' Planning in Scientific Creativity

	Groups Category			
	Average (C1&C2) Groups		Average (E1 &E2)Groups	
Av. Array	**Yes**	**No**	**Yes**	**No**
Pa1	46.2%	53.8%	58.3%	41.7%
Pa2	30.8%	69.2%	50.0%	50.0%
Pa3	53.8%	46.2%	66.7%	33.3%
Pa4	38.5%	61.5%	75.0%	25.0%
Pa5	46.2%	53.8%	41.7%	58.3%
Grand Mean	**43.10%**	**56.90%**	**58.34%**	**41.66%**

Source: The researcher, 2021

Key: Pa- Planning Array

Table 50 findings indicate that, 58.34% of the respondents from the experimental group met the criteria set for the planning part of creativity while 43.10% of the respondents from the control group met the same criteria. These findings show that the experimental groups posted higher mean scores as compared to the control groups. This implies that respondents in experimental groups had a higher level of planning as compared to respondents in the control groups.

To determine if there was a statistically significant difference between the means of the two groups, Analysis of variance (ANOVA) was carried out and the results presented in Table 51.

Table 51: The ANOVA of Average Score on Scientific Creativity Based on Planning

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.986[a]	1	3.986	1.419	.046	.58
Intercept	96.666	1	96.666	139.180	.000	.858
Sub Category	3.986	1	3.986	1.419	.246	.58
Error	15.974	23	.695			
Total	113.000	25				
Corrected Total	16.960	24				

a. R Squared = .58 (Adjusted R Squared = .17)

Source: The Researcher, 2021

The results in Table 51 show that, the f-statistic was 3.986, for 3 degree of freedom and a mean difference of 3.986. This yielded a significance level of 0.046 that was less that the set value of α=0.05. This indicated that the differences between the mean values were statistically significant. This implies that respondents in the experimental groups had higher outcome due to higher level of planning as compared to the control group.

To further understand the statistically significant difference between the scores obtained, LSD was computed and the results captured in Table 52.

Table 52: LSD of Students' Planning in Scientific Creativity after Treatment

(I) Sub category	(J) Sub category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.841	.322	**.77**	.32	1.23
	E1	4.332	.368	**.004**	2.23	6.67
	E2	4.661	.465	**.003**	2.87	7.51
C2	C1	.841	.322	**.77**	.32	1.23
	E1	5.666	.254	**.000**	3.59	9.18
	E2	6.11	.188	**.000**	4.99	11.08
E1	C1	4.332	.368	**.004**	2.23	6.67
	C2	5.666	.254	**.000**	3.59	9.18
	E2	.014	.211	**.966**	1.55	1.77
E2	C1	4.661	.465	**.003**	2.87	6.67
	C2	6.11	.188	**.000**	4.99	11.08
	E1	.014	.211	**.966**	1.55	1.77

Based on observed means.

The error term is Mean Square (Error) = .296.

Source: The Researcher, 2021

Results in Table 52, show that the mean difference between C1 and C2 (p=0.770) and E1 and E2 (p=0.966) was not statistically significant since P >0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on scientific creativity based on planning. However, the comparison between the mean differences in the groups C1 and E1 (p=0.004), C1 and E2 (p=0.003), C2 and E1 (p=0.003) and C2 and E2 (p=0.000), were statistically significant since P<0.05. This shows that the experimental groups' mean was higher than the control groups' mean in Scientific Creativity based on planning. This implies that the inquiry-based teaching approach enhanced good planning of a learner that lead to high mean score.

These findings are supported by a study by Chumo (2014) who argued that practical activities in Biology enhance inquiry skills that stimulate learners' scientific creativity. Further, his research indicated that Practical Investigation Laboratory Approach enhances scientific creativity among learners. In addition, Maonga (2015) observed that students who were taught using Inquiry–Based Teaching had enhanced creativity. He further argued that this method stimulates learners to apply knowledge to solve a problem of map-work with a different approach.

4.4.5 Average Scientific Creativity

Information in Table 51 shows the mean overall on scientific creativity after exposure to inquiry–based science teaching approach (IBSTA). The average percentage frequency for the four indicators; Recognition, Sensitivity, Flexibility and planning were computed and the findings presented as shown in Table 53.

Table 53: Overall Percentage Frequency Results of Scientific Creativity after Treatment

Average Array	E1	C1	E2	C2
i. Recognition	61.54%	46.15%	66.15%	47.69%
ii. Sensitivity	67.69%	41.54%	69.23%	41.54%
iii. Flexibility	72.31%	47.67%	70.77%	46.15%
iv. Planning	61.54%	44.62%	60.00%	43.07%
Grand Mean	**65.77%**	**45.00%**	**66.04%**	**44.61%**

Source: The researcher, 2021

Table 53 results indicate that the respondents from the Experimental Groups had better outcomes as to compare to the control groups. The average scores for the Experimental Groups were E1 (65.77%) and E2 (66.04%) while the average scores for the Control Groups were C1 (45.00%) and C2 (44.61%). The mean average arrays of Experimental Groups were higher than that of the Control Groups. These findings imply that Experimental Groups possessed high levels of recognition, sensitivity, flexibility, and planning than the control groups.

These findings are in line with a study by Herman and Knobloch (2006) who argued that inquiry based teaching enhances learner's scientific creativity that makes learners to achieve academically in Physics. In addition, Bradley (2009) indicated that the use of inquiry teaching leads to creativity of a learner being continuous gain from lower level of thinking to a higher level of thinking.

To understand whether there was a statistically significant difference in scientific creativity and the method of teaching approach used, the following hypothesis was tested:

***H_{03}**: There is no statistically significant difference in scientific-creativity in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods.*

Analysis of variance (ANOVA) was used to test the hypothesis. Table 54 presents the findings on the ANOVA computation of the significant differences between means of the four indicators of scientific creativity.

Table 54: Overall Results of Analysis of variance (ANOVA) for Scientific Creativity after Treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.117[a]	4	6.147	3.114	0.001	0.87
Intercept	315.000	1	315.000	300.444	0.000	0.862
Sub Category	2.117	3	6.147	3.114	0.001	0.87
Error	33.231	48	.692			
Total	350.000	56				
Corrected Total	35.000	55				

a. R Squared = .87 (Adjusted R Squared = .019)

Source: The Researcher, 2020

The results in Table 54 show that, the f-statistic was 3.114, for 3 degree of freedom and a mean difference of 6.147. This yielded a significance level of 0.001 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant. Mumba (2010), who reported that the use of inquiry based learning builds learner’s creativity, motivates and makes them have confidence in learning science, supports the findings.

To further understand the statistically significant difference between the scores obtained, LSD was computed and the findings obtained were shown in the Table 55.

Table 55: LSD Overall Results of Scientific Creativity after Treatment

(I) Sub category	(J) Sub category	Mean Dif. (I-J)	Std. Error	Sig.	95% Conf. Interval Lower Bound	Upper Bound
C1	C2	.42	.326	**.988**	1.02	1.44
	E1	6.11*	4.352	**.000**	6.22	12.33
	E2	7.55*	5.558	**.001**	7.22	14.77
C2	C1	.42	.326	**.988**	1.02	1.44
	E1	5.69*	2.335	**.005**	4.56	11.14
	E2	7.11*	3.578	**.000**	5.89	13.00
E1	C1	6.11*	4.352	**.000**	6.22	12.33
	C2	5.69*	2.335	**.005**	4.56	11.14
	E2	1.01	1.888	**.907**	3.02	4.03
E2	C1	7.55*	5.558	**.001**	7.22	14.77
	C2	7.11*	3.578	**.000**	5.89	13.00
	E1	1.01	1.888	**.907**	3.02	4.03

Based on observed means.

The error term is Mean Square (Error) = .692.

Source: The Researcher, 2021

The results in Table 55, show that the mean difference between C1 and C2 (p=0.988) and E1 and E2 (p=0.907) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 performed relatively the same scores on scientific creativity. However, the comparison between the mean difference in the groups C1 and E1 (p=0.000), C1 and E2 (p=0.001), C2 and E1 (p=0.005) and C2 and E2 (p=0.000), were statistically significant since P<0.05. This shows that the experimental groups' mean score was higher than the control groups' mean score in scientific creativity. This implies that the experimental groups' mean score was higher than that of the control groups in scientific creativity.

Therefore, the null hypothesis H_{03}: *There is no statistically significant difference in Scientific-Creativity in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods* was rejected.

These findings concur with those in a report by Ssempala (2017) who argued that teaching using inquiry based learning enhanced creativity among the learners. In addition, Dawson (2006) argued that Inquiry teaching gives a learner a positive drive to be scientifically creative, imaginative and have the spirit of readiness to know more.

4.5 Effects of Inquiry-Based Teaching Approach in Teaching Physics on Students' Motivation

The fourth objective of the study focused on determining the difference in motivation between students taught using inquiry-based science teaching approach and those taught using conventional methods in Physics. The data were obtained from both the experimental and control groups. The researcher treated the data analysis at two levels: descriptive and inferential (Chi-square, ANOVA and LSD) statistics and then mixed and interpreted the data. The findings are presented separately and later compared for effectiveness of each teaching approach.

4.5.1. Analysis on the Effect of Inquiry-Based Science Teaching Approach on Motivation

Motivation consists of four measures: Active learning strategy, Physics learning value strong, Performance goals strong and Achievement goals strong. For a detailed descriptive analysis, averages of responses on each array was determined for experimental and control groups as shown in Table 56.

4.5.2 Active Learning Strategies

To test for active learning strategy as an indicator of motivation on the respondents, a questionnaire was given after the two weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the Active learning strategy scale:

ALS1. I find relevant resources that will help me understand any Physics concept
ALS2. I discuss with the teacher or other students any challenging concepts
ALS3. I do not attempt to make connections between the concepts that i learn in physics.

Table 56 shows the averages of the Control and Experimental Groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as

‘Agree’, ‘not sure’ category, and then disagree and strongly disagree grouped as a third category indicated as ‘disagree’.

Table 56: Average Percentage Score on Learner’s Motivation Based on Learning Strategy.

	Control			Experimental		
Array	**D**	**U**	**A**	**D**	**U**	**A**
ALS1	59.74%	22.08%	18.18%	13.70%	15.06%	71.24%
ALS2	54.54%	5.19%	40.27%	80.83%	12.33%	6.84%
ALS3	36.37%	9.09%	54.54%	67.12%	15.07%	17.81%

Key: ALS- Active Learning Strategies

Source: The Researcher, 2021

As shown in Table 56, 59.74% of the respondents from control group (Scale 1: active learning strategy) disagreed that they find relevant sources helpful to understand any Physics concept. The results show that 18.18% of the respondents agreed and 22.08% of the respondents were undecided.

Also shown in Table 56 is that 13.70% of the respondents from Experimental Groups disagreed that they find relevant sources helpful to understand any Physics concept. 71.24% of the respondents agreed while 15.06% of the respondents were undecided. These findings show that majority of the respondents in the Experimental Group agreed that they find relevant sources helpful to understand any Physics concept. This implies that the Experimental Groups posted higher mean scores than the Control Group.

Moving to Scale 2 the control group, 54.54% of the respondents disagreed that they discuss with teachers or other students any challenging physics concept. The results show that 40.26% of the respondents agreed and 5.19% of the respondents were undecided. From the Experimental Group, 80.83% of the respondents disagreed, 6.84% of the respondents agreed and 12.33% of the respondents were undecided. These findings show that Experimental Group posted a lower mean score as compared to control groups. This implies that that majority of the respondents in the experimental disagreed that they discuss with teachers or other students any challenging Physics concept.

The control group, Scale 3 responses show that 54.54% of the respondents agreed that they do not attempt to make connections among the concepts they learn in physics. The results show that 36.37% of the respondent disagreed and 9.09% of the respondents were undecided. From the experimental group, 67.12% of the respondents disagreed that they did not attempt to make connections among the concepts they learn in physics. The results indicate that 17.81% of the respondents agreed and 15.07% of the respondents were undecided. These findings show that mean scores in the control groups were higher than that of the experimental groups. This implies that majority of the respondents in Experimental Groups disagreed that they do not attempt to make connections among the concepts they learn in physics.

To determine whether the means of responses of the two groups had statistically significant difference on Active Learning, Chi-Squire was computed and the findings presented in Table 57.

Table 57: Chi square for Motivation Based on Active Learning Strategy

	Value	**df**	**Asymptotic Significance(2-sided)**
Pearson Chi-Square	39.925[a]	12	.000
Likelihood Ratio	42.101	12	.000
Linear-by-Linear Association	21.808	1	.000
N of Valid Cases	150		

a. 8 cells (14.0%) have expected count less than 5. The minimum expected count is 3.84.

Source: The Researcher, 2021

At P=0.000, df=12 and α=0.05 the results in Table 57 show that there was a significance association between active learning strategy and learning outcome since P<0.05.

This finding concurs with findings of Maonga (2015) who argued that students that were taught using inquiry-based approach in Geography reported that there was high significance in the performance of the subject due to the teaching approach, which motivated the learners due to interaction with the instructional materials during the lesson.

To further understand the association between Active Learning and learning outcomes, ANOVA was used to determine the significant differences between these two groups. Table 58 shows the results of ANOVA.

Table 58: The ANOVA of the Average Scores on Motivation Based on Active Learning Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21.450[a]	4	5.363	9.313	.000
Intercept	568.951	1	568.951	988.119	.000
Active Learning Strategies	21.450	4	5.363	9.313	.000
Error	83.490	145	.576		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .204 (Adjusted R Squared = .182)

Source: The Researcher, 2021

The results in Table 58 show that the f-statistic was 5.363, for 4 degree of freedom and a mean difference of 21.450. This yielded a significance level of 0.000 that was less that the set value of α=0.05. The findings indicated that differences between the mean values were statistically significant.

This implies that there is an association between Physics learning strategy and the inquiry based method. These findings are in line with a study by Alberta Education (2013) which asserted that inquiry-based approaches to learning positively affected students' ability to understand core concepts and procedures.

In understanding further, the differences between the means, LSD was conducted and the findings obtained are presented The Table 59.

Table 59: LSD of the Average Scores on Motivation Based on Active Learning Strategy

(I) Sub-category	(J) Sub-category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.32186	.28853	**.266**	-.248	.8921
	E1	-1.15007*	.29235	**.000**	-1.7279	-.5723
	E2	-1.50292*	.29441	**.000**	-2.0848	-.9211
C2	C1	-.32186	.28853	**.266**	-.8921	.2484
	E1	-1.47193*	.29050	**.000**	-2.0461	-.8978
	E2	-1.82479*	.29256	**.000**	-2.4030	-1.2466
E1	C1	1.15007*	.29235	**.000**	.5723	1.7279
	C2	1.47193*	.29050	**.000**	.8978	2.0461
	E2	-.35285	.29633	**.236**	-.9385	.2328
E2	C1	1.50292*	.29441	**.000**	.9211	2.0848
	C2	1.82479*	.29256	**.000**	1.2466	2.4030
	E1	.35285	.29633	**.236**	-.2328	.9385

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

Source: The Researcher, 2021

From the results in Table 59, the mean difference between C1 and C2 (p=0.266) and E1 and E2 (p=0.236) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on motivation based on active learning strategy. However, the comparison between the mean difference in the groups C1 and E1 (p=0.000), C1 and E2 (p=0.000), C2 and E1 (p=0.003) and C2 and E2 (p=0.000), were statistically significant since P<0.05. This shows that the Experimental Groups' mean was higher than the Control Groups' mean in motivation based on Active learning strategy. This implies that the inquiry based science teaching approach affects active learning strategy of learners

The findings are also echoed by Kim (2005) that when assessed on learning strategies, inquiry based learning approach students employed more learning strategies in attitudes to learning, interest and motivation to learn, which were significantly higher than the control group.

4.5.3 Physics Learning Value Strong

To test for Physics Learning Value Strong as an indicator of motivation on the respondents, a questionnaire was-given after the two weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the Physics Learning Value Strong scale.

PLV1.I enjoy Physics experiments because I use it in my daily life

PLV2.Physics does not stimulate my thinking

PVL3.I likes Physics because it satisfies my own curiosity when learning it

Table 60 shows the averages of the control and experimental groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 60: Percentage Scores of the Average Scores on Motivation Based on Physics Learning Value

	Control			**Experimental**		
	D	**U**	**A**	**D**	**U**	**A**
PLV1	72.73%	6.49%	20.78%	15.07%	21.92%	63.01%
PLV2	24.68%	18.18%	57.14%	47.95%	27.40%	24.65%
PLV3	67.53%	1.30%	31.17%	38.36%	17.80%	43.84%

Key: PL- Physics Learning Value

Source: The Researcher, 2021

As shown in Table 60, 72.73% of the respondents from the control group (Scale1: Physics learning value strong) disagreed that they enjoyed Physics experiments because they used it in their daily lives. The findings show that 20.78% of the respondents and 6.49% of the respondents were undecided. Also in Table 60 is that 63.01% of the respondents from the Experimental Group agreed that they enjoyed Physics experiments because they used it in their daily lives. The results also indicate that 15.07% of the respondents disagreed while 21.92% of the respondents were undecided. These findings show that from the Experimental Groups, majority of the respondents agreed that they enjoyed Physics experiments because they used it in their daily lives while the majority from Control Groups disagreed that they enjoyed physics experiments because they used it in their daily lives. This implies that respondents in the experimental groups enjoyed experiments than the control groups.

Moving to scale S 57.14% of the respondents in Control Group agreed that physics does not stimulate their thinking. The finding also indicates that 24.68% of the respondents disagreed while 18.18% of the respondents were undecided. The experimental group, responses shows that 47.95% of the respondents disagreed that physics does not stimulate their thinking. The result also shows that 24.65% of the respondents from same group agreed and 27.40% undecided. These finding shows that majority of respondents in Experimental Groups disagreed that physics does not stimulate their thinking while in control groups majority agreed that physics does not stimulate their thinking. This implies that learners from control group believe that physics does not stimulate their thinking.

The control group, Scale 3 responses show that 67.53% of the respondents disagreed that they liked Physics because it satisfied their own curiosity when learning it. The findings also show that 31.17% agreed and 1.30% was undecided. From the Experimental Group, 43.8% of the respondents agreed that they liked physics because it satisfies their own curiosity when learning it. The findings also show that 38.36% disagreed and 17.80% were undecided. These findings show that majority of the respondents in Experimental Groups agreed that they liked physics because it satisfied their own curiosity when learning it while majority of the respondents in control groups disagreed that they liked physics because it satisfied their own curiosity when learning it. This implies that learners in control group believe that physics does not satisfy their level of curiosity.

In order to determine whether there is statistically significant difference between the mean Chi square, was computed and the findings are as stated in Table 61.

Table 61: The Chi-squire of Average Mean Score of Students Physics Learning Value Strong Based on Learners' Motivation.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	40.136[a]	8	.000
Likelihood Ratio	48.685	8	.000
Linear-by-Linear Association	4.600	1	.032
N of Valid Cases	150		

a. 2 cells (13.3%) have expected count less than 5. The minimum expected count is 4.20.

Source: The Researcher, 2021

At P=0.000, df=8 and α=0.05 the results in Table 61 show that there was a significance association between Physics learning value and IBSTA. This is because the p value was less that set value of 0.05.

To further understand the association between physics learning and IBSTA, ANOVA was used to determine the significant differences between these two groups. The Table 62 shows the results of ANOVA.

Table 62: ANOVA of Average Mean Score of Students' Motivation Based on Physics Learning Value.

Source	Type III Sum of Squares	DF	Mean Square	F	Sig.
Corrected Model	22.957[a]	4	5.739	10.151	.000
Intercept	463.005	1	463.005	818.899	.000
Physics Learning Value	22.957	4	5.739	10.151	.000
Error	81.983	145	.565		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .219 (Adjusted R Squared = .197)

Source: The Researcher, 2021

The results in Table 62 show that the f-statistic was 10.151, for 4 degree of freedom and a mean difference of 5.739. This yielded a significance level of 0.000 that was less than the set value of α=0.05. This indicated that differences between the mean values were statistically significant.

Sungur and Tekkaya (2006) who reported that students taught using inquiry-based learning were more likely to participate in class activity for challenge, curiosity and mastery over those using traditional methods support these findings.

In understanding further, the differences between the means, LSD was computed. The findings obtained are presented in the Table 63.

Table 63: The LSD of the Average Scores on Motivation Based on Physics Learner Value

(I) Sub-category	(J) Sub-category	Mean Dif.(I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.531	.303	**.082**	-.07	1.13
	E1	2.452*	.307	**.044**	-1.06	.16
	E2	2.595*	.309	**.006**	-1.21	.02
C2	C1	-.531	.303	**.082**	-1.13	.07
	E1	3.983*	.305	**.002**	-1.59	-.38
	E2	1.126*	.307	**.000**	-1.73	-.52
E1	C1	2.452*	.307	**.044**	-.16	1.06
	C2	3.983*	.305	**.002**	.38	1.59
	E2	-.143	.311	**.646**	-.76	.47
E2	C1	2.595*	.309	**.006**	-.02	1.21
	C2	1.126*	.307	**.000**	.52	1.73
	E1	.143	.311	**.646**	-.47	.76

The mean difference is significant at the 0.05 level.

Sources: Researcher 2021

From the results in Table 63, the mean difference between C1 and C2 (p=0.082) E1 and E2 (p=0.646) was not statistically significant since P> 0.05. This implies that E1 and E2 groups and C1 and C2 obtained relatively the same scores on motivation based on physics learning value. However, the comparison between the mean difference in groups C1 and E1 (p=0.044), C1 and E2 (p=0.006), C2 and E1 (p=0.002) and C2 and E2 (p=0.000), were statistically significant since P<0.05 This shows that the experimental groups' mean was higher than the control groups' mean in Motivation based on Physics learner value strong.

The findings concur with study by Wilhelm and Wilhelm (2010) who indicated that the inquiry approach encourages student's ownership, sense of control, choice and autonomy, explicit purpose for learning, collaboration and personal relevance.

4.5.4 Performance Goals Strong

To test for Performance Goals strong as an indicator of motivation on the respondents, a questionnaire was given after the two weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the performance goals strong scale:

PG1. Like doing Physics practical in order to get a good grade.

PG2. Like studying Physics in order to perform better than other students.

PG3. Perform well in Physics because I really love it.

Table 64 shows the averages of the Control and Experimental Groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'

Table 64: Average Percentage Score on Motivation Based on Performance Goal strong

	Control			Experimental		
Array	**D**	**U**	**A**	**D**	**U**	**A**
PG1	66.24%	20.78%	12.98%	21.92%	15.07%	63.01%
PG2	41.56%	23.38%	35.06%	34.25%	19.18%	46.56%
PG3	59.74%	19.48%	20.78%	39.72%	9.59%	50.69%

Key: PG – Performance Goals Array

Source: The Researcher, 2021

As shown on the Table 64, 66.24% of the respondents from control group (scale1: performance goal strong) disagreed that they liked doing Physics practical sessions to get a good grade, 12.98% agreed while 20.78% were undecided. From the experimental group, 63.01% of the respondents agreed that they liked doing physics practical sessions to get a good grade. The result shows that 21.92% disagreed and 15.07% were undecided. These findings show that majority of the respondents in the Experimental Groups agreed that they liked doing Physics practical sessions to get a good grade, while in the control group majority of the respondents disagreed that they liked doing physics practical sessions to get a good grade. This implies that learners in Control Groups reported that there is no relationship between liking doing physics practicals and learning outcome.

The findings on the control group in Scale 2 show that 41.56% of the respondents disagreed that they liked studying Physics in order to perform better than other students did. The findings show that 35.06% agreed and 23.38% were undecided. From the Experimental Groups, 46.56% of the respondents agreed that they liked studying physics in order to perform better than other students did. The results also show that 34.25% disagreed and 19.18% were undecided. The findings show that majority of the respondents in the Experimental Groups agreed that they liked studying physics in order to perform better than other students while in Control Groups majority of the respondents disagreed that they liked studying physics in order to perform better than other students. This implies that learners in the Experimental Groups believed that their good performance depended on how much one liked the subject.

From the control groups' Scale: 3, 59.74% of the respondents disagreed that they perform well in physics because they really loved it. The results show that 20.78% agreed while 19.48% were undecided. From the Experimental Group, 50.69% of the respondents agreed that they perform well in physics because they really loved it. The findings also indicate that 39.72% disagreed and 9.59% were undecided. These findings show that majority of the respondents in experimental group agreed that they perform well in physics because they really loved it. Majority of the respondents in Control Group disagreed that they performed well in physics because they really loved it. This implies that loving the Physics subject has no influence on its performance. These findings are in line with a study by Reeve (2012) who argued that student motivation is a driving forces that strength, goal-directedness, and persistence to student behavior.

In order to understand if there is a statistically significant difference Chi-square was computed and the findings are as stated in Table 65.

Table 65: The Chi square of Average Mean Score on Motivation Based on Performance Goal

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	17.890[a]	8	.022
Likelihood Ratio	21.140	8	.007
Linear-by-Linear Association	1.375	1	.241
N of Valid Cases	150		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.40.

Source: The Researcher, 2021

At P=0.022, df=8 and α=0.05 the results in Table 65 show that there was a significance association between role performance and IBSTA. The p value was less than 0.05. This implies that the mean differences were statistically significant.

To further understand the association between self-image and IBSTA, ANOVA was used. Table 66 shows the results of ANOVA.

Table 66: ANOVA of Average Mean score of Students' Motivation Based on Performance Goal strong.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	42.851[a]	4	10.713	25.018	.000
Intercept	591.990	1	591.990	1382.514	.000
Performance Goals	42.851	4	10.713	25.018	.000
Error	62.089	145	.428		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .408 (Adjusted R Squared = .392)

Source: The Researcher, 2021

The results in Table 66 show that, the f-statistic was 25.018, for 4 degree of freedom and a mean difference of 42.851. This yielded a significance level of 0.000 that was less that the set value of **α**=0.05. This indicated that differences between the mean values were statistically significant. This implies that the mean score of the experimental group was higher than that of the control group. These findings are in line with studies done by Zekibayram (2013) and Madden (2011) who found that students' extrinsic goal orientation develops after the application of inquiry-based activities and promote student's motivation.

In understanding the statistically significant differences between the means, LSD was computed. The findings obtained were presented in the table 67.

Table 67: LSD of Score on Students' Motivation Based on Performance Goal Strong

(I) Sub-category	(J) Sub-category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
C1	C2	.370	.282	**.192**	-.19	.93
	E1	-1.282*	.286	**.000**	-1.85	-.72
	E2	-1.023*	.288	**.001**	-1.59	-.45
C2	C1	-.370	.282	**.192**	-.93	.19
	E1	-1.651*	.284	**.000**	-2.21	-1.09
	E2	-1.393*	.286	**.000**	-1.96	-.83
E1	C1	1.282*	.286	**.000**	.72	1.85
	C2	1.651*	.284	**.000**	1.09	2.21
	E2	.258	.290	**.374**	-.31	.83
E2	C1	1.023*	.288	**.001**	.45	1.59
	C2	1.393*	.286	**.000**	.83	1.96
	E1	-.258	.290	**.374**	-.83	.31

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

Source: The Researcher, 2021

Results in Table 67, show that the mean difference between C1 and C2 (p=0.192), E1 and E2 (p=0.374) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on motivation based on performance goal strong. However, the comparison between the mean difference in the groups C1 and E1 (p=0.000), C1 and E2 (p=0.001), C2 and E1 (p=0.000) and C2 and E2 (p=0.000) were statistically significant. This shows that the Experimental Groups' mean is higher than the control groups' mean in Motivation based on performance goal strong. Therefore, the null hypothesis for the relevant comparisons was rejected.

4.5.5 Achievement Goals Strong

To test for Achievement Goals Strong as an indicator of motivation on the respondents, a questionnaire was given after the two weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the Achievement Goals Strong scale:

AG.1. I feel good when I attain a good score in a physics practical test.
AG2: I would like to be a physicist.
AG3: I would not like to work with people who make scientific discoveries.
Table 68 shows the averages of the control and experimental groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 68: Average Percentage Score on Motivation Based on Achievement Goal

	Control			Experimental		
	D	**U**	**A**	**D**	**U**	**A**
AG1	18.18%	6.49%	75.33%	23.39%	0.00%	76.61%
AG2	46.75%	35.07%	18.18%	28.77%	20.55%	50.68%
AG3	9.08%	12.99%	77.93%	75.34%	6.85%	17.81%

Key: AG- Achievement Goals Strong

Source: The Researcher, 2021

Moving to Scale: 1(Achievement goal) 75.33% of the respondents agreed that they felt good when they attained a good score in a physics practical test. 18.18% disagreed and 6.49% were undecided. From the Experimental Group, 76.61% of the respondents agreed that they felt good when they attained a good score in a physics practical test. The findings show that 23.39% disagreed and 0.00% were undecided. These findings show majority of the respondents from both groups agreed that they felt good when they attain a good score in a physics practical test.

From the findings on the experimental groups in Scale: 2 (Achievement goal strong) 18.18% of the respondents agreed that they would like to be physicists. The results show that 45.75% disagreed and 35.07% were undecided. From the experimental group, 50.68% of the respondents agreed that they would like to be physicists. The results also indicate that 28.77% disagreed and 20.55% were undecided. These findings show that majority of the respondents from experimental group agreed that they would like to be physicists, contrary to the control groups responses. This implies that majority of learners are less decided on the career they would pursue in future.

Moving to Scale 3 (Achievement goal), 77.93% of the respondents agreed that they would not like to work with people who make scientific discoveries. The results also show that 9.08% disagreed and 12.99% were undecided. From the Experimental Group, 17.81% of the respondents agreed that they would not like to work with people who make scientific discoveries. The findings also indicated that 75.34% disagreed and 6.85% were undecided. The findings show that majority of the respondents from the experimental group disagreed that they would not like to work with people who make scientific discoveries. This implies that students have less knowledge on scientific discovery and the Physics content they learn in class is hard to implement in the society. The findings contradict a study by Madden (2011) who argued Inquiry-Based activities promote student's motivation.

In order to understand if there is a statistically significant difference between the means of the groups Chi -square, was computed and the findings are as stated in Table 69.

Table 69: The Chi square of Average Mean Score on Motivation Based Achievement Goal Strong

	Value	**Df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	25.036[a]	8	0.462
Likelihood Ratio	27.708	8	0.001
Linear-by-Linear Association	1.342	1	0.247
N of Valid Cases	150		

a. 6 cells (18.0%) have expected count less than 5. The minimum expected count is 1.50.

Source: The Researcher, 2021

At P=0.462, df=8 and α=0.05 the results in Table 69 show that there was no significance association between self- esteem and IBSTA. This is because the P > 0.05. This shows that there was no significant difference between the mean of the group. These findings contradict a study by Dweck (2017) who argued that providing students with meaningful learning challenges, providing feedback focused on effort and process encourages students to adopt a growth mindset.

To further understand if there was significant difference between the means of the groups, ANOVA was computed. The Table 70 shows the results of the findings.

Table 70: ANOVA of Average Mean Score of Students' Motivation Based on Achievement Goal

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17.856[a]	4	4.464	7.433	0.329
Intercept	559.498	1	559.498	931.595	.000
Achievement Goals	17.856	4	4.464	7.433	0.329
Error	87.084	145	.601		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .170 (Adjusted R Squared = .147)

Source: The Researcher, 2021

The results in table 70 show that, the f-statistic was 4.464, for 4 degree of freedom and a mean difference of 7.433. This yielded a significance level of 0.329 that was more than the set value of **α**=0.05. This indicated that differences between the mean values were not statistically significant. This implies that the teaching approach that the teacher used did not influence leaners achievement.

These findings contradict a study by Saunders, Stewart, Gyles and Shore (2012) who argued that the inquiry approach requires students to discover or construct knowledge through relevant activities and personal investigations, while the traditional instruction does not enhance student learning, because students are not engaged, motivated, and perceived on purpose of learning activities.

In further understanding if there is a statistically significant difference between the means, LSD was computed. The findings obtained are presented in the Table 71.

Table 71: LSD of Score on Students' Motivation Based on Achievement Goal Strong

(I) Sub-category	(J) Sub-category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.175	.321	**.587**	-.46	.81
	E1	-.211	.325	**.517**	-.85	.43
	E2	.177	.328	**.590**	-.47	.82
C2	C1	-.175	.321	**.587**	-.81	.46
	E1	-.386	.323	**.235**	-1.03	.25
	E2	.002	.326	**.995**	-.64	.65
E1	C1	.211	.325	**.517**	-.43	.85
	C2	.386	.323	**.235**	-.25	1.03
	E2	.388	.330	**.241**	-.26	1.04
E2	C1	-.177	.328	**.590**	-.82	.47
	C2	-.002	.326	**.995**	-.65	.64
	E1	-.388	.330	**.241**	-1.04	.26

Source: The researcher, 2021

From the results in Table 71, the mean difference between C1 and C2 (P=0.587) E1 and E2 with (P=0.241) was not statistically significant. In addition, the comparison between the mean difference in the groups C1 and E1 (P=0.517), C1 and E2 (P=0.590), C2 and E1 (P=0.235) and C2 and E2 (P=0.995) were not statistically significant. Since P>0.05. This shows that there was no mean difference between the experimental groups and control groups' in motivation based on achievement goal strong.

These findings contradict the findings by Ndirangu (2013) who argued that inquiry-based teaching enhances high achievement since the students are strongly motivated by the method due to being learner-centered method.

4.5.6 Learning Environment Stimulation

To test for learning environment stimulation as an indicator of motivation on the respondents, a questionnaire was given after the two weeks' period of instruction using the inquiry based science-teaching approach. The following variables were under examination in the learning environment stimulation scale:

LES1.I likes to carry experiments in Physics rather than read about the subject.
LES2.I enjoys discussing Physics problems raised in class with my friends.
LES 3, Doing Physics experiments in the laboratory is fun.
Table 72 shows the averages of the control and experimental groups scores grouped into three categories, that is; agree and strongly agree as one category indicated as 'Agree', 'not sure' category, and then disagree and strongly disagree grouped as a third category indicated as 'disagree'.

Table 72: Average Percentage Score on Motivation Based on Learning Environment Stimulation

	Control			Experimental		
	D	**U**	**A**	**D**	**U**	**A**
LES1	50.65%	16.88%	32.47%	31.51%	8.22%	60.27%
LES2	37.67%	23.38%	38.95%	53.20%	8.44%	38.36%
LES3	66.23%	5.19%	28.58%	26.03%	2.74%	71.24%

Key: LES- Learning Environment Stimulation
Source: The Researcher, 2021

As shown in Table 72, 50.65% of the respondents from the Control Group (Scale1: Learning Environment Stimulation) disagreed that they liked to carry out experiments in physics as compared to reading about them. The findings show that 32.47% agreed and 16.88% were undecided. From the Experimental Group, 60.27% of the respondents agreed that they liked to carry out experiments in physics as compared to reading about them. The finding shows that 31.51% disagreed and 8.22% were undecided. The findings show that majority of the respondents in the experimental group agreed that they liked to carry out experiments in physics as compared to reading about them. From the Control Groups majority of the respondents disagreed that they liked to carry out experiments in physics as compared to reading about them. This implies that learners in Experimental Group preferred experiments to reading Physics, which is a contributing factor for their good learning outcome.

Also shown on table 72 is that 37.67% of respondents from control group (Scale 2: Learning Environment Stimulation) disagreed that they enjoyed discussing physics problems raised in class with their friends. The findings indicate that 38.95% agreed and 23.38% were undecided. From the Experimental Group, 38.36% of the respondents agreed that they enjoyed discussing physics problems raised in class with their friends, 53.20% disagreed and 8.44% were undecided. These findings show that majority of the experimental respondents disagreed that they enjoyed discussing physics problems raised in class with their friends while the majority of the respondents from the Control Group agreed. This implies that the environment of a learner makes the learner to enjoy discussing Physics problems raised in class with their friends.

Moving to Scale 3, 66.23% of the respondents in the control groups disagreed that doing Physics experiments in the laboratory was fun. The results show that 28.58% agreed and 5.19% were undecided. From the experimental group 71.24% agreed that doing experiment in Physics laboratory was fan, 26.03% disagrees and 2.74% were undecided. These findings show that majority of the respondents in Control Group disagreed that doing Physics experiments in the laboratory was fun while majority of respondent in experimental group agree. This implies that learning environment stimulate learners to be comfortable to conduct an experiment.

These findings are in line with a study by Napitupulu, (2017) who argued that motivation is a powerful force in learning and the inquiry based teachings improve motivation and achievement in learning physics in addition Esokomi (2013), argued that Inquiry Approach makes students active in participation during class session since the approach is child-centered and motivates them to be involved in any activity.

In order to identify if there is a statistically significant difference a chi-squire was computed and the findings are as indicated in table 73.

Table 73: The Chi square of Average Mean Score on Motivation Based on Learning Environment Stimulation

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	53.973[a]	8	.000
Likelihood Ratio	61.678	8	.000
Linear-by-Linear Association	8.476	1	.004
N of Valid Cases	150		

a. 3 cells (20.0%) have expected count less than 5. The minimum expected count is 1.80.

Source: The Researcher, 2021

At P=0.000, df=8 and α=0.05 the results in Table 73 show that there was a significance association between learning environment stimulation and IBSTA. This was because the p value was less than α=0.05

To further check if there was, a statistically significant difference between the means of the groups Analysis of Valiance was computed. The findings are shown in Table 74.

Table 74: ANOVA of Average Mean Score on Motivation Based on Learning Environment Stimulation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	16.826[a]	4	4.207	6.922	.000
Intercept	590.563	1	590.563	971.831	.000
Learning Environment Stimulation	16.826	4	4.207	6.922	.000
Error	88.114	145	.608		
Total	693.000	150			
Corrected Total	104.940	149			

a. R Squared = .160 (Adjusted R Squared = .137)

Source: The Researcher, 2020

The results in Table 74 show that, the f-statistic was 6.922, for 4 degree of freedom and a mean difference of 4.207. This yielded a significance level of 0.000 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant. This implies that the learning environment stimulation enhances good learning outcome. The findings are supported by Chola (2015) who that the inquiry based science teaching approach enhanced learners' comprehension and attitude on acid-base concept in chemistry.

In understanding further, the differences between the means of LSD were conducted. The findings obtained were presented in the Table 75.

Table 75: LSD of Average Mean score of Students' Motivation Based on Learning Environment Stimulation

(I) Sub-category	(J) Sub-category	Mean Dif. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.373	.337	**.270**	-.29	1.04
	E1	-1.339*	.341	**.000**	-2.01	-.66
	E2	-.808*	.344	**.020**	-1.49	-.13
C2	C1	-.373	.337	**.270**	-1.04	.29
	E1	-1.712*	.339	**.000**	-2.38	-1.04
	E2	-1.182*	.342	**.001**	-1.86	-.51
E1	C1	1.339*	.341	**.000**	.66	2.01
	C2	1.712*	.339	**.000**	1.04	2.38
	E2	.531	.346	**.127**	-.15	1.21
E2	C1	.808*	.344	**.020**	.13	1.49
	C2	1.182*	.342	**.001**	.51	1.86
	E1	-.531	.346	**.127**	-1.21	.15

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

Source: The Researcher, 2021

From the results in Table 75, the mean difference between C1 and C2 (p=0.270) and E1 and E2 (p=0.127) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on motivation based on learning environment stimulation. However, the comparison between the mean difference in the control groups C1 and E1 (p=0.000), C1 and E2 (p=0.020), C2 and E1 (p=0.000) and C2 and E2 (p=0.001). This implies that the differences between the means were statistically significant since P<0.05. This shows that the Experimental Groups' mean is higher than the control groups' mean in motivation based on learning environment stimulation.

4.5.6 Mean overall on Motivation

The average percentage frequency for the five indicators; active learning strategies, physics learning value strong, performance goals strong, achievement goals strong and learning environment stimulation were computed and the findings presented as shown in Table 76.

Table 76: Average percentage Frequency on Motivation

Average Array of motivation	E1	C1	E2	C2
Active learning strategies	63.96%	48.24%	54.85%	47.86%
Physics learning value strong	66.67%	42.98%	64.82%	41.01%
Performance Goals strong	55.86%	46.49%	74.07%	46.15%
Achievement goals strong	53.16%	42.91%	56.48%	43.59%
Learning environment stimulation	56.76%	41.23%	56.48%	34.19%
Average Score	**59.28%**	**44.37%**	**61.35%**	**42.56%**

Source: The Researcher, 2021

Table 76 results indicate that the respondents from the experimental group had better outcomes as to compare to the control group. The average scores for experimental group were E1 (59.28%) and E2 (61.35%) while the average scores for the control groups were C1 (44.37%) and C2 (42. 56%).The average arrays of experimental groups were higher than that of control group. Experimental Groups possessed high levels of active learning strategies, Physics learning value, Performance Goals, Achievement goals and Learning environment stimulation than the control groups. This implies that the inquiry based teaching approach enhances motivation leading to a good learning outcome.

To understand whether there was a statistically significant difference in motivation and the method of teaching approach used, the following hypothesis was tested:

H_{04}: There is no statistically significant difference in motivation to learn Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to Conventional methods.

A chi-square was used to test the hypothesis. Table 77 presents the findings on the computation of the significant differences between means.

Table 77: The Chi square of overall Average Mean Score on Motivation

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	42.316[a]	8	.000
Likelihood Ratio	46.527	8	.000
Linear-by-Linear Association	1.888	1	.169
N of Valid Cases	150		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.80.

Source: The Researcher, 2021

At P=0.000, df=8 and α=0.05 the results in Table 77 show that there was a significance association between motivation and IBSTA. Additionally, the percentage that represents the ratio of the actual count to the expected count was not violated because it was not greater than 20%. The findings of this study are in line with a study by Esokomi (2013) who argued that inquiry approach makes students active in participation during class session since the approach is child-centered and motivates them to be involved in any activity.

In order to determine if there were significant identifiable differences in each of the 5 indicators on motivation analysis of variance (ANOVA) was computed and the findings are as recorded in Table 78.

Table 78: Overall Results of Analysis of Variance (ANOVA) for Motivation

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.554	3	11.518	6.020	.001
Within Groups	279.339	146	1.913		
Total	313.893	149			

Source: The researcher, 2021

The results in Table 78 show that, the f-statistic was 6.020, for 3 degree of freedom and a mean difference of 11.518. This yielded a significance level of 0.001 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant. The findings are in line with a study by Adedaji and Tella (2007) who reported that motivation of a student is a key determinant to good performance in mathematics.

To further understand the statistical difference between the scores obtained, it was essential to find out whether there were any statistical differences between the different study groups, LSD was computed and the findings obtained are shown in the Table 79.

Table 79: LSD Overall Results of Motivation after Treatment

(I)Sub-category	(J)Sub-category	Mean Diff (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
C1	C2	.32186	.28853	**.266**	-.2484	.8921
	E1	7.15007*	.29235	**.000**	-1.7279	-.5723
	E2	8.50292*	.29441	**.000**	-2.0848	-.9211
C2	C1	-.32186	.28853	**.266**	-.8921	.2484
	E1	6.47193*	.29050	**.000**	-2.0461	-.8978
	E2	9.82479*	.29256	**.000**	-2.4030	-1.2466
E1	C1	7.15007*	.29235	**.000**	.5723	1.7279
	C2	6.47193*	.29050	**.000**	.8978	2.0461
	E2	-.35285	.29633	**.236**	-.9385	.2328
E2	C1	8.50292*	.29441	**.000**	.9211	2.0848
	C2	9.82479*	.29256	**.000**	1.2466	2.4030
	E1	.35285	.29633	**.236**	-.2328	.9385

Source: The Researcher, 2021

From the results in Table 79, the mean difference between C1 and C2 (p=0.266) E1 and E2 (p=0.236) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on motivation. However, comparison between the mean difference in the group C1 and E1 (p=0.000), C1 and E2 (p=0.000), C2 and E1 (p=0.000) and C2 and E2 (p=0.000), were statistically significant since P<0.05. This shows that the Experimental Groups' mean score was higher than the Control Groups' mean score in motivation. Therefore, Hypothesis four that, reads H_{04}: *There is no statistically significant difference in motivation to learn Physics between students exposed to inquiry-based science teaching approach and those exposed to conventional methods,* was rejected.

These findings of this study are in line with study by Napitupulu (2017) who reported that motivation is a powerful force in learning and the inquiry based teaching improves motivation and achievement in learning Physics. In addition, the findings also are in line with a study by Dweck (2017) who argued that providing students with meaningful learning challenges, providing feedback focused on effort and process encourages students to adopt a growth mindset.

CHAPTER FIVE:
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
5.1 Introduction
This chapter summarizes the findings of the study, draws major conclusions from the findings as presented in chapter four and makes relevant recommendations based on the findings of the study.

5.2 Summary of the Findings
The conclusions are presented by objective and the related Hypotheses.

5.2.1 Effects of Inquiry-Based Teaching Approach in Teaching Physics on Students' Task Competence
In this study the findings show that the post-test score for students in the Experimental groups E1 and E2 (M_1=59.76, M_2 =57.95) were higher than those in the control groups C_1 and C_2 (M_1=45.42, M_2=43.00). This indicates that students from the experimental groups outperformed the ones from the control group in the results obtained. The answers and flow of calculation for the Experimental Group was well detailed and clearly elaborated. This showed that IBSTA had a positive effect on whose task competence. The inquiry approach also enabled students to develop process skills and thus enhanced good performance.

There was a significant difference in the post-test (PCBT) on task competence mean scores between students in the Experimental Groups who were taught Physics using IBSTA and those in the control groups taught by conventional methods (F4.676, df=148, P=0.000) since P <0.05.

The results of the study also indicated that the difference between C1 and C2 (0.439) and E1 and E2 (0.537) was not statistically significant since P > 0.05. This implies that E1 and E2 groups, C1, and C2 performed relatively the same on Physics task competence test scores. The comparison between the mean difference in the groups C1 and E1 (0.000), C1 and E2 (0.000), C2 and E1 (0.000) C2and E2 (0.000) were statistically significant since P<0.05. Therefore, the null hypothesis one was rejected.

5.2.2 Effects of Inquiry-Based Teaching Approach in Teaching Physics on Students' Self-Concept

The responses showed that IBSTA enabled students do things on their own which meant that they developed inner confidence in their abilities to learn. They felt that they had what it took to learn and they could do more reading on topics that they did not clearly understand. The inquiry-based science teaching approach cultivated a yearning in the students for the different activities they were engaged in through the inquiry-based approach as they found them engaging and interesting. Such a learning environment encouraged students to think critically, satisfied them and developed their self-concept. The inquiry based science teaching approach further enabled the learners to understand their strengths and weaknesses as well as acquire an internal drive that enhanced good learning outcomes.

The research findings of this study show that inquiry-based science teaching approach changed the perception and conception of students towards Physics. The approach-encompassed methods those were able to engage the students that eventually led to them enjoying and like the subject. The approach focused on skills development, attitude, feelings and cognitive abilities. Students who were taught using the inquiry-based approach had better performance than those taught using conventional methods due to positive self-concept, perceptions, and thoughts that are engaging and intriguing leading to positive thinking.

In this study findings indicate that self-concept mean score for those students in the experimental groups E1 and E2 (M_1=67. 68, $M_2$56.95) were higher than those in the control groups C**1** and C**2** (M_1=43.42, M2=42.13). This means that inquiry based science teaching approach (IBSTA) promoted high mean scores on self-concept.

The findings of this study also show that there was a statistically significant difference in self-concept mean scores between students in experimental groups and those in control groups (F=27.605, df=3, Md=36.609 and P=0.005) which was less than $P<0.05$.

The four indicators of Self- concept: self- image, self- identity and self- esteem were highly correlated with learners' outcome except for role performance which was not statistically significant since (F=2.145, df=3, Md=1.579 and P=0.097).

The findings indicate that the mean difference between C1 and C2 with ($p=0.508$) and E1 and E2 ($p=0.162$) was not statistically significant since $P> 0.05$. E1 and E2 groups, C1, and C2 obtained relatively the same scores on self-concept. The comparison between the mean difference in the averages of self-concept groups C1 and E1 ($p=0.000$), C1 and E2 ($p=0.000$), C2 and E1 (0.000) and C2 and E2 (0.000), were statistically significant. Since $P< 0.05$. *The null hypothesis two was rejected.*

5.2.3. Effects of Inquiry-Based Science Teaching Approach in Teaching Physics on Students' Scientific Creativity.

In this study, findings show that respondents in the experimental group had higher levels of recognition than that of those in the Control Group. The study established that the inquiry-based approach had a more positive impact on learners' level of recognition. The respondents in the Experimental Group were able to recall laws, principles and give their own opinions about the subject matter. In addition, the findings indicate that the respondents in the Experimental Groups were able to make summative analysis as compared to those in the control group who had a challenge in this aspect.

The study also established that students from the Experimental Groups were more sensitive in identifying of errors in apparatus, criticizes, and could give suggestions on how to solve a variety of problems, innovation was high, and their practicality on how to discuss various topics increased. They were able to increase their memory capacity which in turn lead to good learning outcome in the posttest exam they were given and this was not the case with the control group.

It was also found that the Experimental Groups had higher levels of flexibility as an indicator of scientific creativity. They were able to better explain the topic taught from different angles, have in-depth and comprehensive understanding of the taught content, and freely asked for help from their fellow students that was not the case with students from the control groups.

The study revealed that the experimental groups planned their activities before kick starting an experiment. They setup their apparatus properly; they followed procedures, carefully noted down their findings and compared their findings with the expected results from the experiments. The study also established that due to lack of knowledge, students from the Control Groups were very confused on how to conduct experiments. They kept on following what others did.

In this study the findings show that average mean scores for students in groups E1 and E2 (M_1=65.7, M_2=66.04) were higher than those in groups C_1 and C_2 (M_1=45.00, M2=44.61). The experimental groups possessed high levels of recognition, sensitivity, flexibility and planning as compared to the Control Groups. High score on Physics competence based test were attributed to high scores on creativity indicators.

The findings also show that there was a statistically significant difference in scientific- creativity mean scores between those students in experimental groups and taught Physics using IBSTA and those in control groups who were taught by Conventional method (F=3.114, df=3, md=6.147 P=0.001) since $p<0.05$.

The mean difference between C1 and C2 (p=0.988) and E1 and E2 (p=0.907) was not statistically significant since $P> 0.05$. Obtained relatively the same scores on creativity. The comparison between the mean difference in the groups C1 and E1 (p=0.000), C1 and E2 (p=0.001), C2 and E1 (p=0.005) and C2 and E2 (p=0.000), were statistically significant since $P<0.05$. *The null hypothesis three* $\boldsymbol{H_{03}}$*: was rejected.*

5.2.4 Effects of Inquiry-Based Teaching Approach in Teaching Physics on Students' Motivation

The study established that students who were taught using the conventional teaching approach were less motivated to put effort in understanding the concepts taught. The method that was used did not trigger any interest and was not focused on the student. However, most of the students from the Experimental Group showed interest because their teaching approach engaged them in the subject content. Once they completed a task successfully, they would proceed on to the challenging ones that may have required consultation with their teachers.

The inquiry-based approach enabled students develop problem-solving skills, promote active learning and interest. The absence of effort by the Control Group was attributed to lack of motivation and necessity in the physics subject while the attempts by the experimental groups to make connections on the subject content was attributed to interest and curiosity that was instilled by the inquiry teaching method.

In this study findings show that the average mean scores for students in groups E1 and E2 (M_1=59.28, M2=61.35) were higher than those in groups C_1 and C_2 (M_1=44.37, M2=42.56). This implies that Inquiry based science teaching approach-enhanced learners' outcome in Physics and promoted high mean scores on motivation.

The indicators of motivation: active learning strategy; Physics learning value strong, performance goal strong and learning environment stimulation were highly enhanced by inquiry based science teaching approach. However, achievement goal strong was the least enhanced by the inquiry based science approach. The mean difference between C1 and C2 (P=0.587) E1 and E2 with (P=0.241 was not statistically significant. In addition, the comparison between the mean difference in the groups C1 and E1 (P=0.517), C1 and E2 (P=0.590), C2 and E1 (P=0.235) and C2 and E2 (P=0.995), all were not statistically significant. Since P>0.05. This indicated that differences between the mean values were not statistically significant. Therefore, the null hypotheses for the relevant comparisons were accepted.

The study revealed a statistically significant difference in motivation mean scores between students in the Experimental Groups who were taught using IBSTA and those in the control groups taught by Conventional method (F=6.020, df=3, md=11.518 P=0.001) since P<0.05.

The mean difference between C1 and C2 (p=0.266) E1 and E2 (p=0.236) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 obtained relatively the same scores on motivation. However, comparison between the mean difference in the group C1 and E1 (p=0.000), C1 and E2 (p=0.000), C2 and E1 (p=0.000) and C2 and E2 (p=0.000), were statistically significant since P<0.05. *The null hypothesis* $\boldsymbol{H_{04}}$*: was rejected.*

5.3. Conclusions

From the summary of the findings above, the following conclusions were made:

a) That IBSTA is a good method for teaching Physics as it enhances task competence, self-concept, scientific creativity and motivation.

b) That Physics Teachers in Kitui County have relied mainly on the conventional teaching method and should therefore be exposed to the IBSTA to enhance learning outcomes in Physics.

c) That IBSTA requires a conducive or enabling environment that should be created through relevant infrastructure in the context of mentorship and teacher retooling.

d) That there needs to be mentorship of teachers on the integration of face-to-face IBISTA and engagement on use of ICT program of conducting experiments (PHET animation) to adopt a new pedagogy due to the impact covid-19 pandemic.

e) KICD should introduce and develop a programme for the induction and mentorship of teachers on IBISTA to empower them with inquiry teaching skills.

5.4. Recommendations

This section summarizes the major recommendations derived from the findings of the study.

5.4.1. Recommendations for Intervention

Based on the findings and conclusions of this study the following recommendations have been put forward:

1. Physics Teachers should adopt IBSTA since it is an interactive model that ensures students are hooked onto the session and enhances task competence, scientific creativity, self-concept and motivation. (Use of PHET computer programme to conduct online practicals).
2. School administrators should reward Physics teachers who use IBSTA to create a culture that improves students' inquiry skills of engagement, elaboration, exploration, explaining and evaluation consequently improving learning outcomes by making learners competent, with better self-concept, scientific creativity and motivation.

3. KICD should introduce and develop a programme for induction and mentorship of Physics teachers on the implementation of IBSTA to empower them with relevant skills.
4. Since online practicals can be carried out in science subjects, the school management should expand ICT infrastructure, computer hardware and practical integrating software for schools to conduct experiments online based on IBSTA.
5. An appropriate policy should be developed for teacher training institutions to train their teacher trainees with an emphasis on IBSTA as part of their Physics training curriculum.
6. To enhance learning of Physics through IBSTA the researcher came up with a proposed pedagogical model which is an elaboration of Byees model:

5.4.2 A Proposed Pedagogical Model

Building on the findings of this study, and integrating Byee's 5 E model the study proposes a model that shows the interplay between IBISTA and task competence, scientific creativity, motivation and self-concept as depicted in figure 2 below.

(IBSTA MODEL)

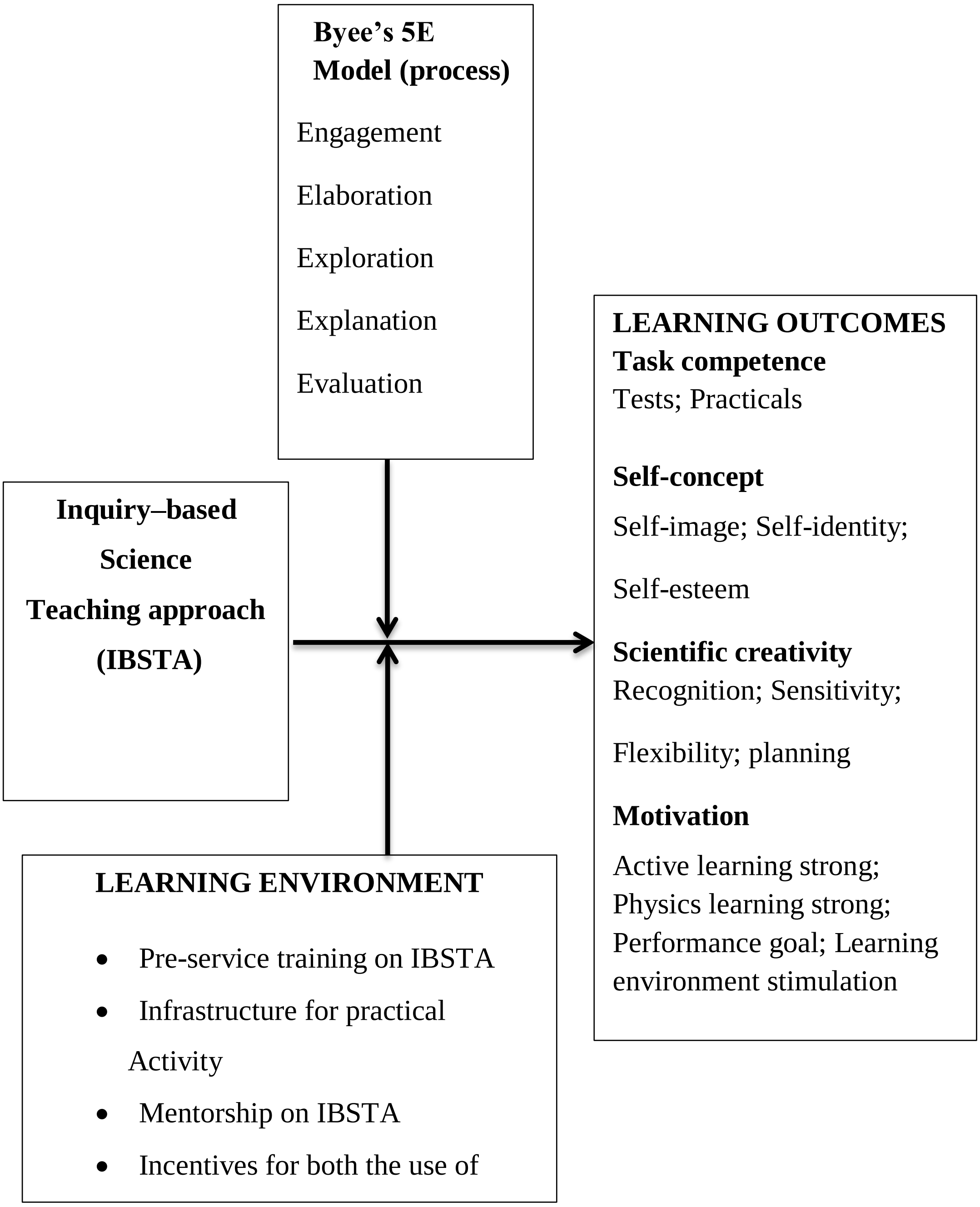

Figure 2: A Proposed Pedagogical Model on Inquiry-Based Science Teaching Approach (IBSTA)

Source: Researcher 2021

In the above model, the institutional requirement includes: Pre-service training and proper evaluation in the use of IBSTA which will make the teachers develops relevant skills and competences; an appropriate infrastructure for practical activities to enable a hands- on approach; mentorship on IBSTA by experienced teachers and consultants as well as the provision of incentives for both the use of IBSTA and good results after using IBSTA

The process component requires that the teacher adopt Byee's 5E model that consist in figure 2.

The implementation process requires systematic exposure of learners to Bee's 5E's:

i. Engagement: where the learners are involved in activities such as measuring and evaluating that they can use to extract the pre-existing information in their minds; to ask interesting questions about the subject; to read a remarkable story; to make a video or an experimental demonstration.

ii. Elaboration: In which the students are provided with opportunity to apply introduced concepts to new experiences and make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes.

iii. Exploration: in this phase, the teacher is a guide who follows the students, provides them with the time and materials needed, and asks the groups' questions for discussions as the students interact with materials and ideas through classroom and small discussion groups.

iv. Explanation: in the explanation phase, the teacher is the most active and students are provided an opportunity to connect their prior experiences with current learning and to make conceptual sense of the main ideas. The phase also provides the opportunity for the introduction of formal language, scientific terms and content information that might make students' prior experiences easier to describe.

v. Evaluation: A phase in which the teacher tries to determine the level of understanding the subject or concept at this stage and at the same time prepares the students to evaluate themselves.

5.4.3. Recommendations for Further Study

The researcher makes the following suggestions for further study:

i. A study should be conducted to establish why **role performance** as a component of self–concept did not strongly correlate with IBSTA.
ii. A study should be conducted to establish why **achievement goal strong** as a component of motivation did not strongly correlate with IBSTA.
iii. A systematic study is carried out to determine whether there are variations on the impact of IBSTA at different class levels from one to four.
iv. A systematic study should to be carried out to determine whether there are variations on the impact of IBSTA in other Science subjects like Chemistry and Biology.
v. Since this study was conducted on extra county schools in Kitui County, more secondary schools of different categories in the county need to be studied for better generalization of the results

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APPENDICES

Appendix. I: Manual for Inquiry-Based Teaching Approach

1. The IBSTA manual has eighteen physics lessons on the topic Current Electricity II. The objectives for each of the lesson were clearly stated. Guidelines on how teachers will introduce the lessons and the students for each lesson are also included. Teachers participating in the inquiry based teaching group are kindly requested to adhere to the instructions in the manual. Sequence of the lessons should be followed as laid in the manual.

The following instructions will serve as a blue print for implementation of Inquiry Based Teaching Approach.

1. As students settle in their group, have them elect group leaders such as; chairperson, secretary, timekeeper and a reporter. These duties should be rational in subsequent groupings.
2. Visit all the groups during exploration and explanation stages, glancing at the students' worksheets and checking on their answers. This will enable you understand each students' current conceptual framework.
3. Let all students be fully engaged and active during the exploration and explanation stages (Hands-on and minds-on activities) and during class presentations.
4. Ask students through provoking questions to enable them reflect on and even change their own conceptual framework.
5. Allow students to discuss within groups & amongst groups in the class. This will create an environment of students to student's interaction both in and out of the class.
6. Continuously ask probing questions like why do you think that way? Can you justify your answer? These kind of questions should be asked throughout the class period to enable the teacher understand current conceptual framework and possible areas of misconception.
7. Allow students to use textbooks and other resources during their group discussion (explanation stage)

Summary

Ensure that your instructional strategies encourage-

1. Student autonomy, student reflection of their work, student-student interaction in and out of classroom, collaborative work.

2. Use methods that help students develop, reflect on, evaluate and modify their own internal conceptual framework.
3. Provide the students with opportunity for interdisciplinary exploration.
4. Develop tasks that demand for higher order thinking skills on learners. That is questions requiring learners to make predictions, interpretation and analysis.
5. Always allow students to participate in activities such as investigation, experiment performing skills, science congress, and projects.

TOPIC CONTENT OF CURRENT ELECTRICITY II

25.1.0 Current electricity II (20lessons)

25.2.1 Scale reading: Ammeter, Voltmeter

25.2.2 Electric circuit: Current, potential difference

25.2.3 Ohms law (experimental treatment required)

25.2.4 Resistance: Type of resistors, measurement of resistance units

25.2.5 Electromotive force (Emf) and internal resistance of a cell (E=V+ Ir)

25.2.6 Resistors in series and in parallel

25.2.7 Galvanometer: Conversion to ammeters and Voltmeters

25.2.9 Problems on ohm's law resistors in series and in parallel

Lesson one and two

Engagement Point (10 min)

Introduce the lesson by presenting to the class the objectives of the topic and objectives of the lesson

Objectives of the Topic (unit) in this topic you will learn about the following.

1. By the end of the topic the learner should be able to
    i. Define potential difference and state SI unit
    ii. Measure potential difference and current circuit
    iii. Connect simple circuit and take measurements using ammeters and voltmeter
    iv. Define resistance and state SI unit
    v. Determine experimentally the voltage current relationship for various conductors.
    vi. Define Emf and explain internal resistance of a cell
    vii. Determine experimentally the Emf and internal assistance of a cell

viii. Derive the formulae for effective resistance of resistors in series parallel and combined.

Lesson objective

By the end of the lesson, the learner should be able to

i. Sketch all the instrument symbols used in the topic of current electricity and how they are connected.

Elaboration Point (30 min)

- Each discussion is given a chance to present report of findings
- Members of the class and the teacher to critique the group presentation immediately after the presentation.
- **Evaluation Point (10 min)**

Members of the group that completes it presenting and have been challenged to make all the necessary corrections.

Lesson Three

Concept of current Electricity II

Engagement Point (10 min)

Lesson objective.

By the end of the lesson, the learner should be able to:

Define;

i. an Electric current

ii. State other sub-units used on electric current and their initials.

Introduction

Review the work of the previous lesson through open-ended questions

Students in class form groups and each group moves to tables that have the apparatus used in current electricity.

Exploration Point (30 min)

- Students to view all the apparatus on the tables of invert electricity
- Identify them on what they measure
- Students to work in groups to identify each apparatus, draw symbols used when drawing a set-up of a complete circuit.
- State their SI units used for each.

Lesson Four and Five

Engagement (20min)

Definition of terms in Current electricity

Objective by the end of the lesson the learner should be able to

i. Define the following terms: current electricity Ampere, Milliampere, Simple circuit, open circuit and closed circuit.
ii. Define potential difference and SI unit.

Exploration and explanation Point (35 min)

Discuss the following questions in your groups. The discussion should be guided by Information gathered from previous lesson.

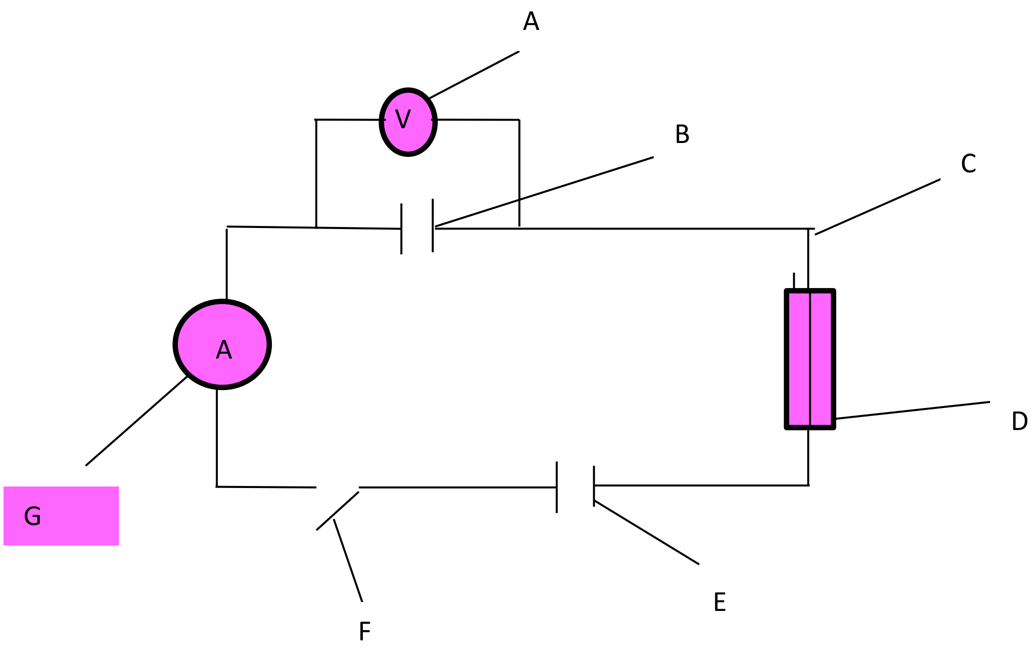
1. A) State the electric device used to measure very small current.
   b) What is the relationship between Milliampere and Ampere?
2. A) How do you differentiate the positive terminal of cell when circuit is open and when it is closed.
3. What is the difference between open circuit and closed circuit?
4. What is the potential difference of a cell?
5. How do you measure the potential difference?

Elaboration Point (20 min)

- Presentation of discussion reports from different groups of the classes
- Teacher and other students critique the group report
- Teacher to harmonize all the definitions of terms to correct scientific meaning to students.

Evaluation Point (5 minutes)

Draw a simple circuit using the simple stand used and tell the student to label them



Lesson Six and Seven

Measure of potential difference & current

Engagement Point (5Min)

By the end of the lesson, the learner should be able to measure potential difference and current in a circuit.

Introduction

- Teacher to ask student to connect a simple circuit of a cell that is a dry cell, bulb wire, switch, and draw a set up on the chalkboard.

Exploration & explanation Point (30 min)

- Explain on how an Ammeter is connected in a circuit and why experiment the connection of circuit and record the reading when using different number of cells and record in a table.
- Discuss on how voltmeter is connected in a circuit and why.
- Experiment the connection of a voltmeter in a circuit and take different reading using different batteries and record in a table.

Elaboration Point (20 min)

Each group presents its findings for class discussion. The discussion includes harmonization of the group findings by the teacher.

Groups are allowed to present their work in a chart on board and make comparison of values got.

Evaluation Point (10 min)

Teacher gives assignment

Lesson Eight

Ohms Law

Engagement Point (5 min)

Objective: By the end of the lesson, the learner should be able to

i. Derive and verify ohms' law

ii. State ohms' law.

Teacher introduces the lesson by asking student to:

i. State two cases that are always noted when components are connected in a series in an electric circuit

ii. State two cases observed always when components are connected in parallel in an electric circuit.

Teacher presents the learning task for the lesson.

Explanation and elaboration Point (20 min)

- Learners to conduct an experiment to verify ohms' law.
- Each group to prepare a table of values of current and potential difference
- Set apparatus as shown in a set up and record the values on the table given.
- Group to draw graph of voltage against current
- Analyze the graph and make their conclusions.

Elaboration Point (10 min)

- Group reports are presented inform of tables and graphs on a chart or manila.
- Teacher to harmonize the definition of the Ohms law
- Stating of law scientifically
- Determining scope of a graph of voltage against current and how it is related with law.

Evaluation Point (5 min)

- Teacher to give assignment of calculation questions involving Ohms law

Lesson Nine and Ten

Engagement (10 min)

Experiment to verify resistance of wire using voltmeter and ammeters.

Objective: By the end of the lesson, the learner should be able to:

i) Define resistance

ii) Carry out experiment to determine the resistance between voltage and current

Introduction

Teacher to introduce lesson through asking student to:

i. State Ohms law
ii. Define Ohms law on the chalkboard
iii. State formula that is used to calculate current

Explanation and exploration point (40 min)

a. Expound on:

I. Ohms law and find the slope of the graph.
II. What do the slopes of graph represent?
III. State SI unit of the slope got
IV. Using the SI unit of the slope got
V. using the SI unit of the slope define the term resistance
VI. Briefly describe how you can experiment to measure resistance of materials.

b. A current of 4 ma flows through a conductor of resistance 4kΩ. Calculate the voltage across the conductor

c. Differentiate resistance in series and in parallel

d. Differentiate between Ohmic and non-Ohmic conductors

e. State three factors that affect the resistance of a metallic conductor

Elaboration point (20min)

- Students in each group to demonstrate to other members in class on how to verify the relationship between voltage and current.
- Teacher to harmonize the formula to calculate resistance – R=V/I
- Teacher to sketch different graphs of voltage against current when you use different resistors like metal, semi-conductors, thermionic diode, thermistor, torch bulb etc.

Evaluation Point (10min)

- Teacher to assign students with questions from Kcse past papers physics paper 1 year 2016 to attempt Question 12 and 13

Lesson eleven and twelve

Measurement of resistance.

Engagement (10 min)

Objective: By the end of the lesson, the learner should be able to:

- Describe experiment to measure resistance using;
  - i. Voltmeter method
  - ii. The wheat stone bridge
  - iii. The meter bridge

Introduction

Teacher will introduce the lesson through asking students to briefly describe how to measure

- ✓ resistance using voltmeter method
- ✓ the formula used to determine resistance

Teacher to present learning task for the lesson

Exploration and explanation point (40min)

Students go to their respective groups

Students will discuss the following questions in groups:

- ❖ Teacher to provide a set-up of experiment to measure resistance
- ❖ Groups to prepare the table below with 5 different values

Voltage (V)	Current (Amperes)	V/T
3.0		
2.5		
2.0.		
1.5		
1.0		
0.5		

- ❖ Compare the values
- ❖ Plot a graph of V against T

ii. Repeat the experiment of resistance but instead use 4 resistors, led, galvanometer to measure the resistance (wheat stone bridge (drawn setup)

iii. Repeat the same experiment of resistance but instead use (Resistor, Galvanometer, meter rule, nichrome wire mounted on mm scale and record the relationship the meter bridge (drawn setup)

Elaboration point (20 min)

Every group to make a report briefly on the method they used in finding the resistance.

Evaluation point (10 min)

Teacher to give a worked out experiment in KLB BK 3 physics pg. 196 and the students to draw the graph and answer all the application questions related to the graph

Lesson thirteen and fourteen

Resistors network

Engagement (10 min)

By the end of the lesson the learner should be able to connect resistors in series, parallel and combined system

Introduction

Teacher to ask students question

i. What is a resistor?
ii. Name types of resistors
iii. Name three methods used to connect resistors (resistor network)
iv. State SI unit for resistance of a resistor

Teacher to present the activity for the lesson.

Exploration & Explanation (40 min)

- → Students in their group connect the apparatus as indicated on the drawn set up and record voltages in each resistor in a table
- → Repeat the same experiment but instead connect the resistors in series and record current and voltage in each resistor.
- → Repeat the same experiment but instead use both series and parallel to come up with a combined circuit and record the values of current and voltage.

  Elaboration point (30min)

  - Each group presents its result for class discussion.
  - Students from a chosen group to demonstrate on connection of resistor in series parallel and combined system.

Evaluation point (10min)

Teacher to evaluate the work presented by the groups

Teacher assigns the groups to draw resistor network on manila papers.

Lesson fifteen and sixteen

Effective resistance for resistors in series, parallel and combined system

Engagement point (10min)

i. Objectives: by the end of the lesson the learners should be able to derive effective resistance of resistors in parallel series
ii. Solve numerical problem of resistors network

Introduction:

Teacher introduce the lesson through asking questions

i. Name two types of fixed resistors
ii. Name two types of variable resistors
iii. Why do voltmeter connect in parallel in a circuit
iv. Why do ammeter connect in series in a circuit

Exploration and explanation point (30min)

Students in each group to discuss on how to derive effective resistance of resistors when connected in:

a. Series
b. Parallel
c. Combined system

Groups to apply the derived formula to calculate the effective resistance of the resistor network drawn in their KLB Form 3 Physics textbook.

Elaboration point 25 min

Group presents their results for whole class discussion. The class discussion must involve critiques of the results

Teacher to harmonize the derived formula for:

i. parallel network
ii. series network

Evaluation point:

- Teacher to evaluate as each group give its presentation and rank them per group
- Teacher assigns work from KLB Physics pg. 195 Nos. (3&4)

Lesson Seventeen and Eighteen

E.m.f. and interval resistance

(E=V+Ir)

Engagement point (10min)

- Objectives: By the end of the lesson, the learner should be able to determine E.m.f. and explain the internal resistance.
- Students move to their group desk for the practical activity

Explanation and elaboration point 30min

- ✓ Student to conduct an experiment to verify Emf and internal resistance of a cell.
- ✓ Groups to follow the list of the procedure and set up given by the teacher
- ✓ Group to draw the graph of voltage against current
- ✓ Group to determine the slope of the graph
- ✓ Group to determine the Emf and internal resistance of a cell using the graph they have drawn.

Elaboration point (25min)

Group to give a brief report while other students to critique and make clarification.

Teacher to make an input on relationship of internal resistance Emf and p.d and relate with the formulae.

Evaluation point (10min)

Teacher to evaluate the presentation by the learners.

Teacher gives an assignment during the library lesson to conduct an experiment to determine emf and internal resistance and teacher to give out a handout with setup & procedure.

Appendix. II: Physics Competence-Based test

NAME: ………………………………… SCHOOL……………. DATE……
CANDIDATE'S CLASS…
TIME: 1 HOUR.
PHYSICS COMPETENCE- BASED TEST 2020 (PRE –TEST)
INSTRUCTIONS TO CANDIDATES.

a) Write your **NAME, SCHOOL** and **INDEX NUMBER** in the spaces provided above.

b) Sign and write the date of examination in the spaces provided above.

c) Answer **all** the questions in the spaces provided in the question paper.

d) Non-programmable Silent Electronic calculators and mathematical tables may be used.

PHSYSICS ACHIEVEMENT TEST (30 MARKS)

1. Define the term resistivity (1 mk)

   ………………………………………………………………………………………

   ………………………………………………………………………………………

2. Differentiate between ohmic-conductor and non-ohmic conductor. (2 mks)

   ………………………………………………………………………………………

   ………………………………………………………………………………………

3. Name two types of variable resistors. (2 mks)

   ………………………………………………………………………………………

   ………………………………………………………………………………………

4. A current of four mA flows through a conductor of resistance 24Ω. Calculate the voltage across the conductor. (2 mks)

   ………………………………………………………………………………………

   ………………………………………………………………………………………

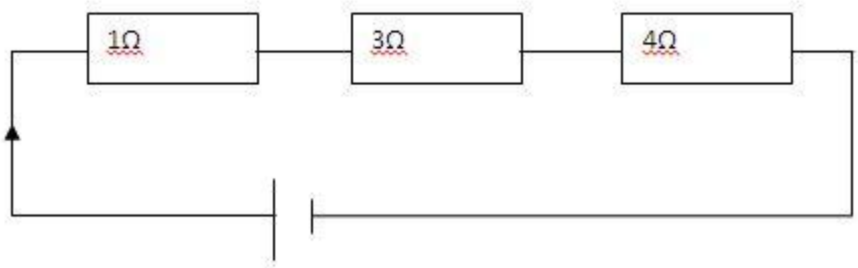
5. State three factors that affect the resistance of a metallic conductor. (3 mks)

   ………………………………………………………………………………………

   ………………………………………………………………………………………

   ………………………………………………………………………………………

6. The figure below shows three resistors in series connected to a power source. A current of 2 A flows through the circuit.



Calculate:

a) The effective resistance in the Circuit (2 mks)

……………………………………………………………………………………….

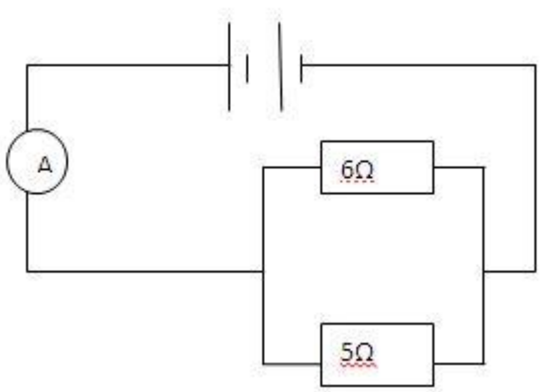
b) The voltage in the circuit. (1 mk)

…………………………………………………………………………………………
…………………………………………………………………………………………

7. A battery consists of four cells in series, each of E.m.f. 2.0v and internal resistance 0.5Ω resistor. Calculate the current through the battery. (3 mks)
………………………………………………………………………………………..
……………………………………………………………………………………….

8. In a circuit diagram shown in figure below each cell has an E.m.f. of 1.5V and internal E.m.f. of 0.5Ω when the switch is closed. Determine the ammeter reading.

(3mks)



…………………………………………………………………………………………
…………………………………………………………………………………………
………………………………………………………………………………………..

9. State ohms' law. (1 mk) ……………………………………………………….

……………………………………………………………………………………

……………………………………………………………………………………

10. Explain the reasons as to why voltmeter in a circuit is always connected parallel to the circuit. (2 mks)

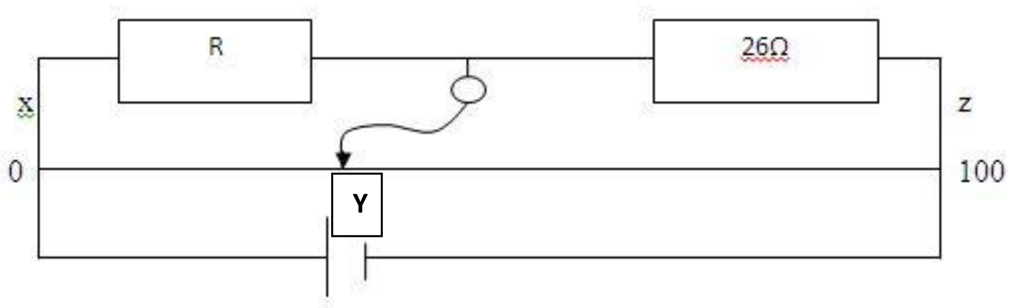
……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

11. In an experiment to determine the resistance of a nichrome wire using the meter bridge the balance point was found to be 48cm mark. If the value of the resistance in the right hand gap needed to balance the bridge was 26Ω, calculate the value of the unknown resistor. (3 mks)

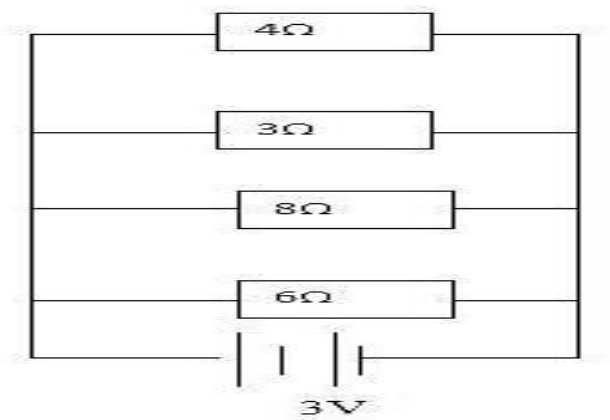


……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

12. The circuit diagram in figure below shows four resistors in parallel connected across a 3V supply.



Calculate: -

a) The effective resistance. (2 mks)

…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

b) The current is whole circuit. (2 mks)

…………………………………………………………………………………
…………………………………………………………………………………
……………………………………………………………………………….

c) The current through the 8Ω resistor. (1 mk)

…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

Appendix. III: Physics Competence-Based Test 2

NAME: ………………………………… SCHOOL……………. DATE: …

CANDIDATE'S CLASS…

TIME: 1 HOUR. (Post-test) (30mks)

PHYSICS COMPETENCE- BASED TEST 2020

INSTRUCTIONS TO CANDIDATES.

e) Write your **NAME, SCHOOL** and **INDEX NUMBER** in the spaces provided above.

f) Sign and write the date of examination in the spaces provided above.

g) Answer **all** the questions in the spaces provided in the question paper.

h) Non-programmable Silent Electronic calculators and mathematical tables may be used.

PHSYSICS ACHIEVEMENT TEST (40 MARKS)

1. State Ohm's Law……………………………………………….....................................

………………………………………………………………………………………. …….

(2mks)

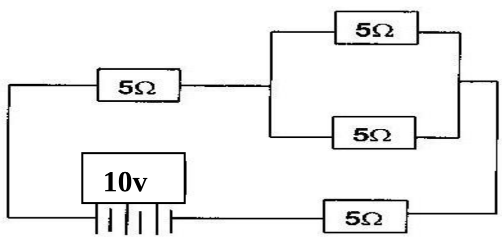
2. Explain why moving coil meters are unstable for the use of alternating voltages. (1mks)

……………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………..

3. Four 5Ω resistors are connected to a 10V d. c. supply as shown in the diagram below.



Calculate; -

i) The effective resistance in the circuit…………………………………………

……………………………………………………………………………..

…………………………………………………………………………………

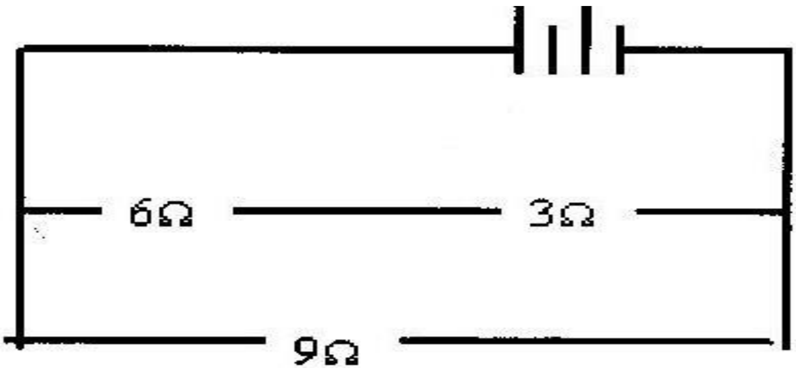
………………………………………………………………………… (2mks)

ii) The current I following in the circuit………………………………………..

……………………………………..……………………………………………

………………………………………………………………………… (1mks)

3. Study the circuit diagram. Determine the potential drop across the 3 resistor. If the EMF of the cells is 12V(3mks)



5. State two conditions that are necessary for a conductor to obey Ohm's law.

………………………………………………………………………………………

……………………………………………………………………………………….

…………………………………………………………………………………….. (2mk

6. A current of 0.08A passes in circuit for 2.5 minutes. How much charge passes through a point in the circuit? ....

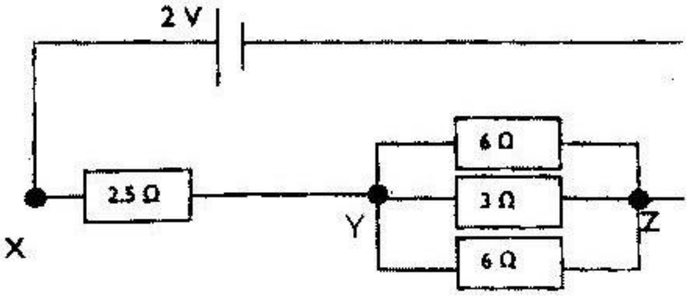
……………………………………………………………………………… (1mk)

7. An ammeter, a- voltmeter and a bulb are connected in a circuit so as to measure the current flowing and the potential difference across both. Sketch a suitable circuit diagram for the arrangement. (2mks)

………………………………………………………………………………………

………………………………………………………………………………………

8. a) In the circuit diagram shown, calculate the effective resistance between Y and Z.



b) Determine the current through the 3Ω resistor…………………. (3mks)

………………………………………………………………………………………

……………………………………………………………………………………..

c) Name two factors that affect the resistance of a resistor (2mks)

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

9. An electric bulb with a filament of resistance 480Ω is connected to a 240V mains supply. Determine the energy dissipated in 2 minutes. (2mks)

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

10. In the circuit diagram shown in figure 7, the ammeter has negligible resistance. When the switch S is closed, the ammeter reads 0.13A.

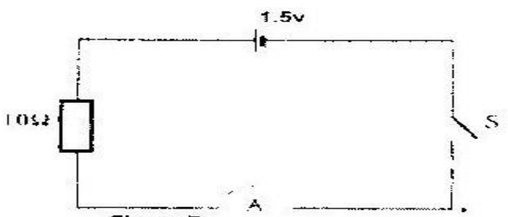


Figure 7

a). Determine the internal resistance of the cell. (3mks)

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

b) The graph in figure 9 shows the current voltage characteristics of a device, X.

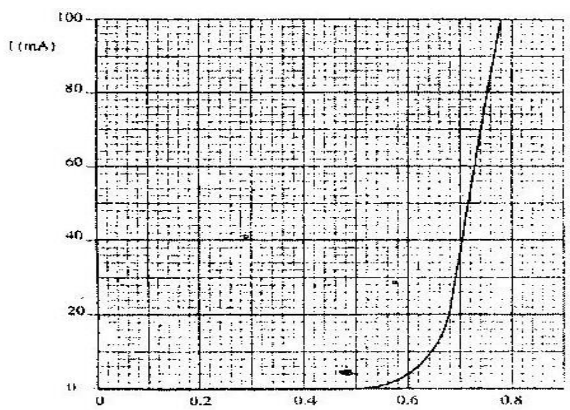


Figure 9

i) State with a reason whether the device obeys Ohm's laws. (2mks)

………………………………………………………………………………………

…………………………………………………………………………..

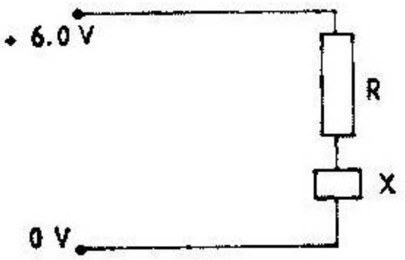
ii) Determine the resistance of the device, X, when the current through it is 60m A. (2mks)

…………………………………………………………………………..

…………………………………………………………………………

………………………………………………………………………….

11. When the device, X, is connected in the circuit below, the voltage across it is 0.70V.



Calculate the value of the resistance R. (3mks)

……………………………………………………………………………….

…………………………………………………………………………………

…………………………………………………………………………………

13. The cell in figure 10 has an Emf of 2.1V and negligible

14. The internal resistance.

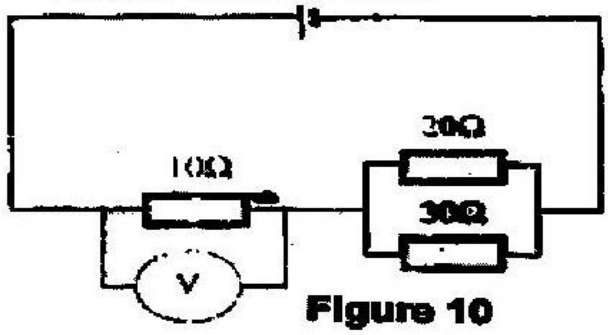


Figure 10

Determine the

i) Total resistance in the circuit. (3mks)

Appendix. IV: Marking Scheme for Physics Achievement Test

Marking scheme

1. It is the measure of resistance of a given size of a specified material to an electrical conduction. √ 1

2. ***Ohmic*** – conductors: Is conductor that obeys ohm's law. √ 1

Non – Ohmic conductors are conductor that does not obey ohm's law. √ 1

3. Rheostats √ ***1***

Potentiometer/ potential divider. √ 1

4. V = 1R √ 1

$= 4 \times 10^{-3} \times 24$

$= 96 \times 10^{-3}$ √ 1

9.6×10^{-2}

5. Temperature √ 1

Length of the conductor √ 1

Cross-section area √ 1

6. $RE = R_1 + R_2 + R_3$ √ 1

$= 1 + 3 + 4$

$= \mathbf{8\Omega}$ √ **1**

b) V = 1R

= 2 X 8 √ 1

= 16V

7. Total Voltage = 2 x 2 x 2 x 2 = 4V

Total r = 0.5 x 4 = 2.0Ω √ 1

Effective resistance = r + R

= 2.0 + 0.5

= **2.5Ω**

$V = 1R$

$I = {}^{V}/_{R}$

$= {}^{4}/_{2.5}$ √ 1

$= \mathbf{1.6A}$

8. $R_E = \frac{R_1 \; R_2}{R_1 \; R_2}$

$= \frac{6 \times 5}{6+5}$ √ 1

$= \frac{30}{11} + 1$

$= \mathbf{3.7273\Omega}$

Total voltage 1.5 x 2

3.0V √ 1

$I = {}^{V}/_{R}$

$= \frac{3.0}{3.7273}$

$= \mathbf{0.805A}$ √ 1

9. The current flowing through a conductor is directly proportional to the potential difference across if provided the temperature and other physical conditions are kept constant √ 1

10. Voltmeter has very high resistance and once connected in series √ 1 with circuit it will consume a lot of current leading to over-heating that causes the voltage drop. √

11. ${}^{xy}/_{yz} = {}^{R_1}/_{R_2}$ √ 1

$\frac{48}{52} = \frac{R}{26}$

$\frac{48 \times 26}{52} = R$ √ 1

$R = \mathbf{24\Omega}$ √ **1**

12. $a)$ $\frac{1}{R_E} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$ √ 1

$= \frac{1}{4} + \frac{1}{3} + \frac{1}{8} + \frac{1}{6}$

$\frac{6+8+3+4}{24}$ $\frac{21}{24}$ $R_E = \frac{24}{21}$

$= \mathbf{1.143\Omega}$ √ **1**

b) Effective voltage = 3V

Current in whole circuit

$I = \frac{V}{R_E}$ √ 1

$= \frac{1}{1.143}$ √ 1

$= 2.625\ A$ √ 1

c) Through 8Ω = $\frac{3}{8}$ $V/R = I$ √ 1Δ

$= \mathbf{0.375A}$ √ **1**

Appendix. V: Marking Scheme for Physics Competence-Based Test

Marking scheme

1. The current flowing through a resistor is directly proportional to the p.d. applied as long as the physical factors remain constant

2. Every time the current is reversed the direction of key pointer also reversed. This would give an average of zero.

3. For the two 3Ω resistors in parallel their total = product/sum=1.5 Ω for series connection i.e. 3.3 and 1.5Ω, total 7.5 Ω

$\therefore RT = 7.5\ \Omega$

(ii) $I = \frac{E}{RT} = \frac{10v}{7.5} = 1.33A$

RT = product/ sum = 9x18= 4.5 Ω

I = 12/4.5 = 8/3 Amps

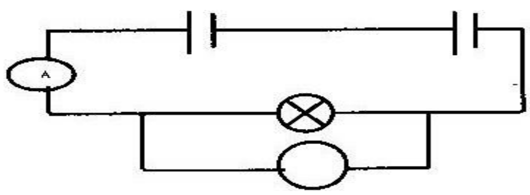
I through the 3 Ω is equal to I through the Ω since total resistance in each route are equal = $^{8}/_{3}A \times \frac{1}{2}$

p.d = $^{4}/_{3} \times 3 = 4V$

4. Constant temperature, magnetic field, tension, compression, kinks etc.

5. The current flowing through a resistor is directly proportional to the p.d applied as long as the physical constants are held constant.

6. Q= It = 0.08 x 2.5 x 60 = 12C

7. 

8. (a) $\frac{1}{R_T} = \frac{1}{6} + \frac{1}{3} + \frac{1}{6} = \frac{4}{6} = \frac{2}{3}$ $\therefore RT = 1.5\ \Omega$

(b) For the whole circuit $R_t = 1.5 + 2.5 = 4\ \Omega$

Main current $= \frac{E}{RT} = \frac{2}{4} = 0.5A$

P.d across YZ = IR = 0.5 x 1.5 = 0.75V

P.d across any of the resistors in parallel

3 x 1 = 0.75A

$I = 0.25$ A

9. E= Pt = $\frac{V2}{R}$ x 2 x 60 = $\frac{240 \times 240 \times 120}{480}$

= 14400J

= 14.4KJ

10. E=Ir+V

1.5=0.13r+0.13

0.2=0.13r

R=0.2/0.13

R=1.538 Ω

11. (a) (i) It does not obey Ohm's law; because the current – voltage graph is not linear throughout

b. From the graph current flowing when p.d is 0.70 is 60mA

P.d across R= 6.0 – 0.7 = 5.3V

R= $\frac{5.3V}{60mA}$

= 88.3 Ω

c. From the graph current flowing when p.d is 0.70 is 60mA

P.d across R = 6.0 – 0.7 = 5.3V

R= $\frac{5.3V}{60mA}$

= 88.3 Ω

12. (i) Parallel circuit $\frac{1}{30} + \frac{1}{30} = \frac{2}{30}$

R = 15 Ω

Total resistance = 10 + 15

= 25 Ω

Appendix. VI: Physics Students' Questionnaire on Self-Concept and Motivation

Introduction

This is not a test and there are no correct or wrong answers. It is important that you give your honest view. Read the items with care in order to understand before making your choice. Please tick (✓) against the box provided against the statement, you agree most with.

SECTION A: General information

1. State the category of your school.

   County Girls School ( )   X- County School ( )

   County Boys School ( )
2. Name of your school………………………….
3. You are in which class …………….
4. How old are you

13 – 14 yrs. ( ) 16 – 17 yrs. ( ) 18 years and above ( )

SECTION B: LEARNERS' SELF CONCEPT

What is your opinion on the given statements on self-concept when learning physics in your school? Put a tick (✓) in the box provided against the statement

Key: (S A) – Strongly agree (A) – Agree, (NS) – Not sure (D) – Disagree, (Ds) - Strongly disagree .please put one tick (✓) as appropriate.

	STATEMENTS OF SELF CONCEPT	SA	A	NS	D	SD
	Scale 1:Self –Image					
1	Success in the life of a student is achieved through positive thinking.					
2	The use of inquiry-based learning enhances the way I see myself.					
3	The use of inquiry-based learning provides a good learning environment for me.					
	Scale 2:Self-Identity					
4	I perform well because I believe in my ability.					
5	Inquiry based method stimulates my coming up with new ideas which makes me proud of physics.					
6	The style of thinking and working in physics makes me like science.					
	Scale 3:Self Esteem					
7	Learning occurs when I am actively involved in finding out.					
8	My liking of physics is improved by inquiry-based learning which I enjoy most.					
9	Practical and discussion based learning builds my confidence.					
	Scale 4:Role Performance					
10	The teachers' response to my question in class when am performing a practical activity affects my achievement.					
11	I believe that participation in learning develops knowledge that guarantees me the highest level of development.					
12	My physics teacher has played an important role in boosting my performance in physics.					

SECTION C: LEARNERS' MOTIVATION

To what extent do you agree with the following statement on level of motivation when learning in physics? Please put a tick (✓) in the box provided against the statement. **Key: (S A) – Strongly agree (A) – Agree, (NS) – Not sure (D) – Disagree, (Ds) - Strongly disagree please put one tick ( ) as appropriate.**

Scale 1:Active learning strategies	SA	A	NS	D	SD
1. I find relevant resources helpful to me understand any physics concept					
2. I do not discuss with the teacher or other students any challenging physics concept					
3. I do not attempt to make connections between the concepts that I learn in physics.					
Scale 2: physics Learning Value Strong					
4. I enjoy physics experiments because i use it					

in my daily life.					
5. Physics does not stimulate my thinking.					
6. I like physics because it satisfies my own curiosity when learning it.					
Scale 3:Performance Goal Strong					
7. I like doing physics practical in order to get a good grade					
8. I like reading physics books in order to perform better than other students.					
9. I perform well in physics because I really love it.					
Scale 4 :Achievement Goal Strong					
10. I feel good when I attain a good score in a physics practical test.					
11. I would like to be a physicist					
12. I would not like to work with people who makes discoveries in physics					
Scale 5 :Learning Environment Stimulation					
13. I like to carry out experiments in physics than read about them					
14. I enjoy discussing physics problems raised in class with my friends					
15. Doing Physics experiments in the laboratory is fun.					

Appendix. VII: Scientific Creativity Observation Schedule (SCOS).

School: …………………… Class: ………… Group: ……………

The researcher will observe learner's psychological behavioral reactions reflecting the aspects of scientific creativity abilities.

When the Teacher invites comments/Questions, they will be answered by:

- Recalling laws/ principles/theorems
- Applying formulas/ principles/ laws
- Making hypothesis/ speculations and generalization.

	Students' activities/responses	**Tally/Frequencies**													
	Recognition	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**33**	**36**	**39**
R(i)	Able to recall the laws, principles, and definitions of terms of the topic studied.														
R(ii)	The student is able to give his or her own opinion about subject matter or about how to solve a problem														
R(iii)	The student can give innovative and practical ideas.														
R(iv)	The student is able to describe subject matter in various dimensions and skills														
R(v)	Able to make summative analysis of what the teacher teaches in the lesson.														
	Sensitivity														
S(i)	Identifies errors in the apparatus they are using during experiment														

S(ii)	While facing a problem or self - created difficult situation, the student is able to grasp the key elements of the situation														
(iii)	The student is able to devise and explain a problem clearly and accurately.														
S(iv)	Criticize scientifically the results of resistance if they deviate more from one group and way to identify what caused the errors														
S(v)	The student is able to express the key points of a problem and any insufficiency to help find ways to solve the problem														
	Flexibility														
F(i)	The students is able to discuss and explain subjects matters, or a single topic from different angle														
F(ii)	The student is able to show in-depth and comprehensive understanding about subject matter														
F(iii)	The student is able to give constructive opinion and inspire other														

	students..														
F(iv)	Consults other students, teachers when the apparatus fail to work when carrying out experiment by themselves.														
F(v)	The student only has general and superficial understanding about subject matter														
	Planning														
P(i)	Do the learners plan on how to conduct experiments?														
P(ii)	How does the learner set up the apparatus logically?														
P(iii)	Do the learners follow procedures as they conduct the experiment?														
p(iv)	Are the learners consistent in filling values in a table as they conduct experiment?														
P(v)	Are the learners able to plot all the values in the table on a graph?														

Appendix. VIII: a Summary Model Adopted from Research Design

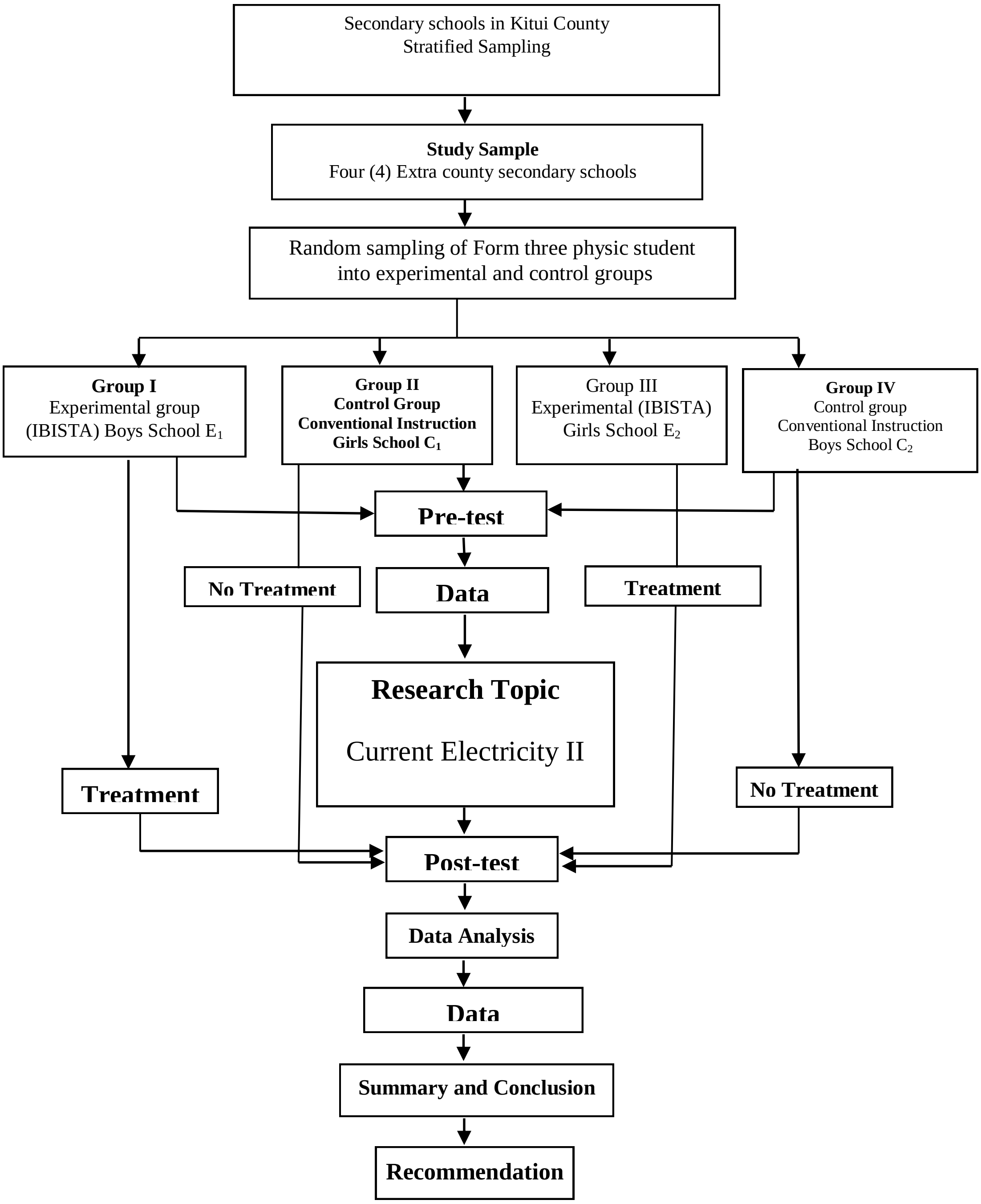


Figure: 3

Summary model of a Research Design

Source: Researcher 2021

Appendix. IX: parent/guardian permission form (parent/guardian consent form)

Title of the Study: The Effects of Inquiry-Based Science Teaching Approach on Learning Outcomes of Secondary School Physics Students in Kitui County, Kenya

Researcher: **Kunga Gathage John**

Your permission is being sought to have your child participate in this study. Please read the following information carefully before you decide whether to give your permission.

Purpose of the research:

To determine effects of IBSTA on learning outcomes of secondary school physics students in Kitui County, Kenya

Procedure to be followed:

During research study, researcher with consent will teach your child from school administration, their subject teacher and all other relevant authorities. They will be given attest before start of topic to determine their prior knowledge. During teaching, they will be observed their scientific creativity using a creativity observation schedule. After the end of research, they will be given a post-test to assess their outcome and fill a student questionnaire with help of the subject teacher

Discomforts/risks:

The risks in this study are minimal There are no foreseeable discomforts or dangers to either you or your child in this study. (i.e., no greater than those ordinarily encountered in daily life or the performance of routine physical or psychological examinations or tests).

Benefits for participation:

There are is direct benefits to your child, for participating in this research. The research will be to find out if the method of instruction will be effective for the topic of current electricity II, a topic in Form three syllabuses and is a topic that is highly tested in KCSE exam. This topic student performs very poorly in the Country as report show from KNEC report. The researcher chose Kitui as an area to be sampled out of all 47 counties to conduct the research.

Time duration of participation:

Participation in the study will be done during their Physics lesson so it will not interrupt the school system. This will be in line with syllabus and content that is supposed to be taught in Form three.

Statement of confidentiality:

All records will be kept confidential and will be available only to professional researchers and staff. If the results of this study are published, the data will be presented in-group form and individual children will not be identified.

Voluntary participation:

Your child's participation is voluntary. If you feel your child has in any way been coerced into participation, please inform the school administration through subject teacher. We also ask that you read this form to your child and inform your child that participation is voluntary. At the time of the study, the subject teacher and the researcher will once again remind your child of this.

Termination of participation:

If at any point during the study you or your child wishes to terminate the session, we will do so. Questions regarding the research should be directed to:

Subject teacher: Mr.…………………… or

Researcher: Mr. John Kunga

This research has been reviewed and approved by the **Departmen**t of education communication and technology, school of education **Machakos University**. If at any time before, during or after the experiment your child experiences any physical or emotional discomfort that is a result of his/her participation, or if you have any questions about the study or its outcomes, please feel free to contact them.

SIGNING THE FORM BELOW WILL ALLOW YOUR CHILD TO PARTICIPATE IN THE STUDY DURING SCHOOL HOURS WITHOUT YOUR PRESENCE.

Please return by end of One week after receiving it if you do not sign and return this form, the researchers will understand that you do not wish to allow your child to participate.

Parent Signature Box Student Signature Box

I, the parent or guardian of ________________________________, a minor ______ years of age, **permit** his/her participation in a program of research named above and being conducted by Kunga Gathage John

__________________________________ _____________

Signature of Parent or Guardian Date

____

Please write your name here.

Student Signature Box

I, ________________________________, agree to participate in the program of research named above and understand that my participation is voluntary

__________________________________ _____________

Signature of Parent or Guardian Date

Please write your name here.

Appendix. X: University Letter of Introduction

MACHAKOS UNIVERSITY

OFFICE OF THE DEAN GRADUATE SCHOOL

Telephone: 254-(0)735 247939, (0)723805929
Email: graduateschool@machakosuniversity.ac.ke
Website:www.machakosuniversity.ac.ke

P.O.Box 136-90100
Machakos
KENYA

REF.MksU/GS/SS/011/VOL.1

15th June, 2020

The Director,
National Commission for Science, Technology and Innovation
P. O Box 30623,
NAIROBI

Dear Sir

RE: KUNGA GATHAGE JOHN- E83/2700/2018

The above named is a PhD student in the second year of study and has cleared his course work. The university has cleared him to conduct a research entitled **"The effects of inquiry- based science teaching approach on learning outcomes of secondary school physics students in Kitui County, Kenya"**

Kindly assist him with a Research Permit in order to undertake the research

Thank you.

DR.KIMITI RICHARD PETER
AG.DEAN GRADUATE SCHOOL AND CHAIRMAN BOARD OF GRADUATE STUDIES
KRP/anm

ISO 9001:2008 Certified ....Soaring Heights in Transforming Industry and Economy

Appendix: XI: Research Authorization

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **920378**

Date of Issue: **26/June/2020**

RESEARCH LICENSE

This is to Certify that Mr.. KUNGA GATHAGE JOHN of Machakos University, has been licensed to conduct research in Kitui on the topic: THE EFFECTS OF INQUIRY-BASED SCIENCE TEACHING APPROACH ON LEARNING OUTCOMES OF SECONDARY SCHOOL PHYSICS STUDENTS IN KITUI COUNTY, KENYA for the period ending : 26/June/2021.

License No: **NACOSTI/P/20/5365**

920378

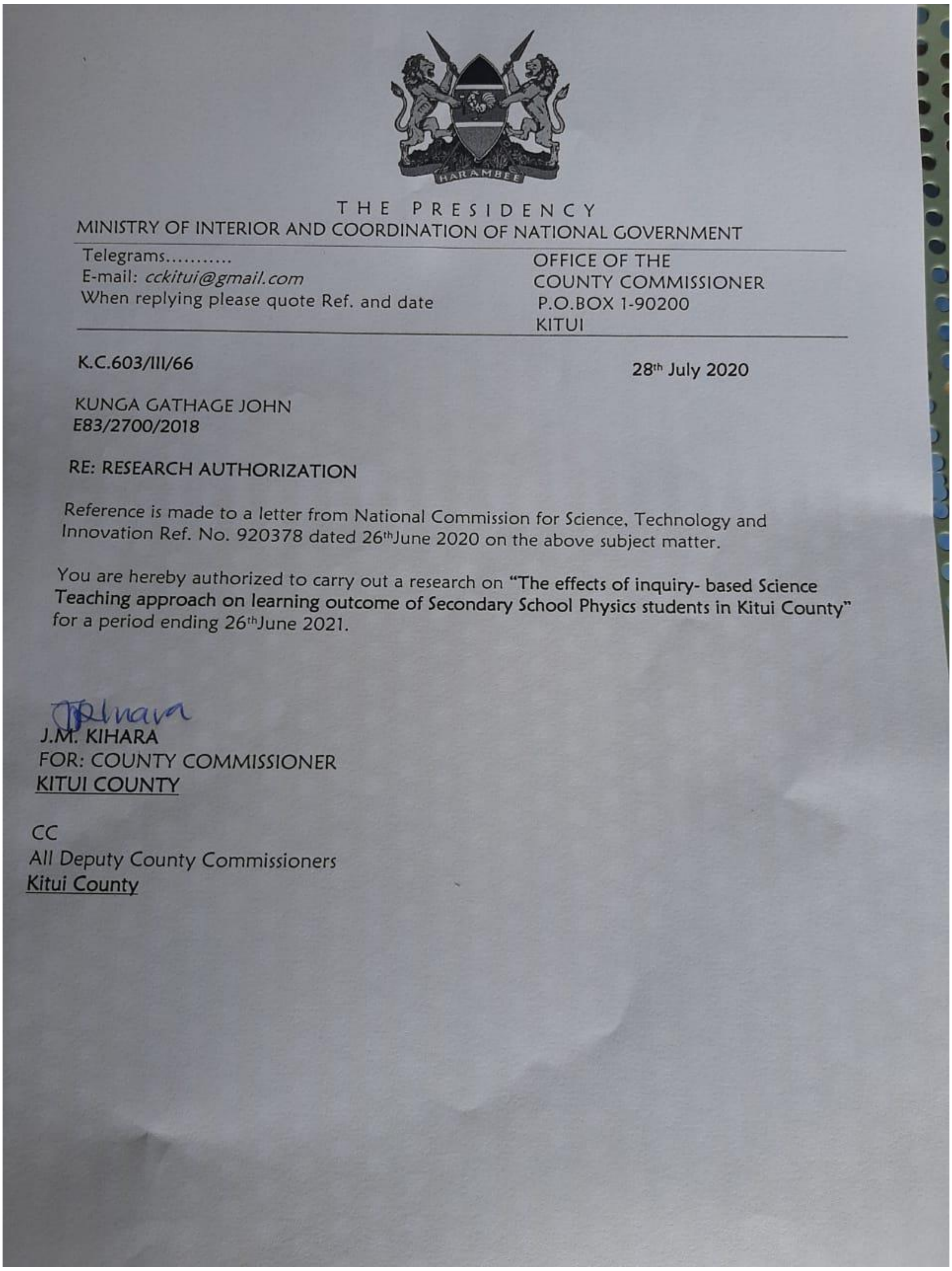
Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Appendix: XII: Letter from County commissioner



HARAMBEE

THE PRESIDENCY
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telegrams..........
E-mail: *cckitui@gmail.com*
When replying please quote Ref. and date

OFFICE OF THE
COUNTY COMMISSIONER
P.O.BOX 1-90200
KITUI

K.C.603/III/66

28th July 2020

KUNGA GATHAGE JOHN
E83/2700/2018

RE: RESEARCH AUTHORIZATION

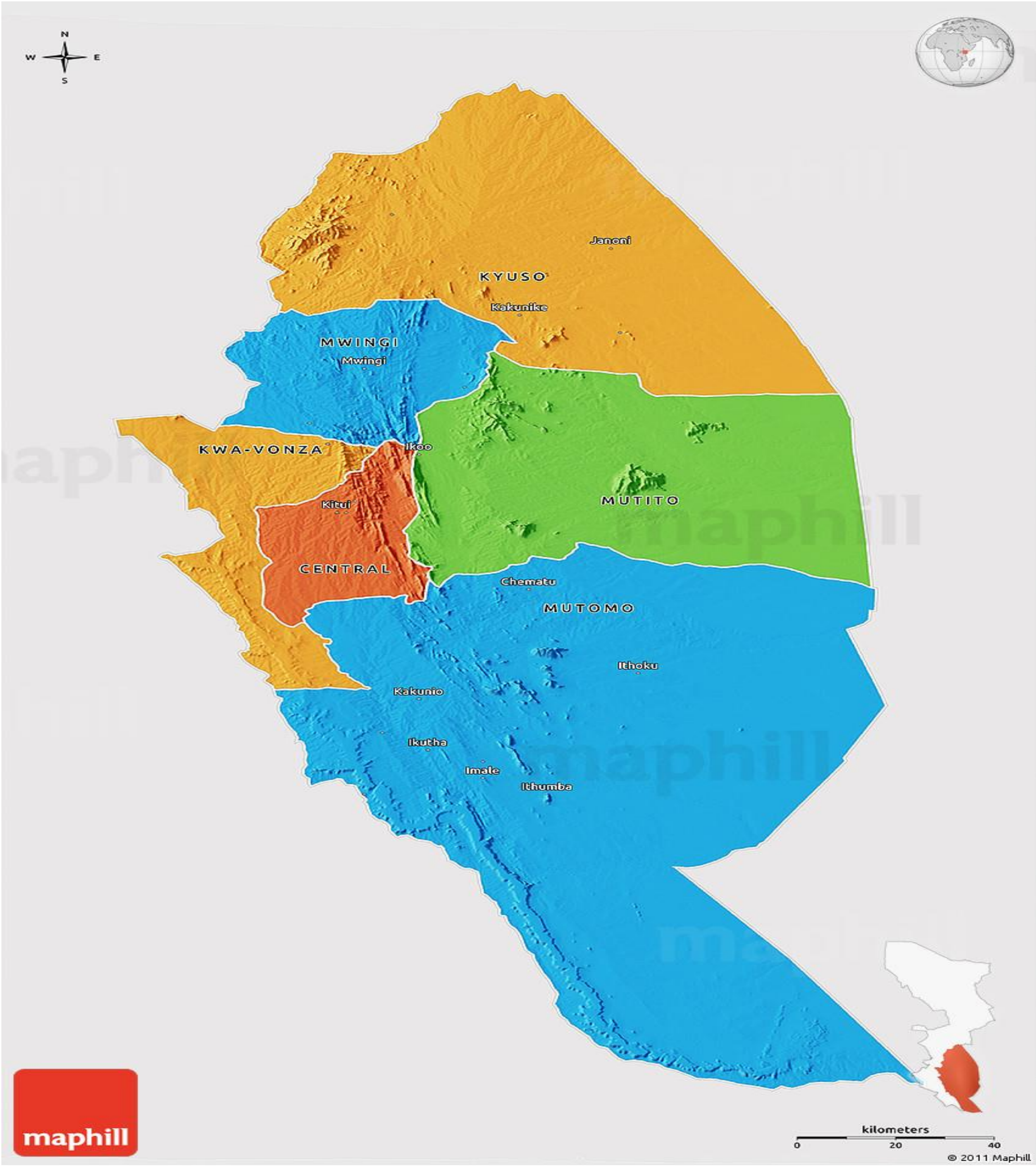
Reference is made to a letter from National Commission for Science, Technology and Innovation Ref. No. 920378 dated 26th June 2020 on the above subject matter.

You are hereby authorized to carry out a research on **"The effects of inquiry- based Science Teaching approach on learning outcome of Secondary School Physics students in Kitui County"** for a period ending 26th June 2021.

J.M. KIHARA
FOR: COUNTY COMMISSIONER
<u>KITUI COUNTY</u>

CC
All Deputy County Commissioners
<u>Kitui County</u>

Appendix. XIII: Location of the Study



Source: Self: Key: The coloured map is showing the different sub-county of Kitui county, which the researcher intends to carry out the research the sub-county, includes Kyuso, Mutomo, Mutito, Kitui Central, Mwingi, and Kwa-vonza.

Appendix. XIV: Similarity Index

EFFECTS OF INQUIRY-BASED SCIENCE TEACHING APPROACH ON LEARNING OUTCOMES OF SECONDARY SCHOOL PHYSICS STUDENTS IN KITUI COUNTY, KENYA

ORIGINALITY REPORT

18%	18%	0%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	iprjb.org Internet Source	11%
2	iosrjournals.org Internet Source	7%

Exclude quotes On

Exclude bibliography On

Exclude matches < 2%