RELATIONSHIP BETWEEN SCIENCE PROCESS SKILLS TEACHING APPROACH AND LEARNING OUTCOMES IN BIOLOGY IN SECONDARY SCHOOLS IN MAKUENI COUNTY, KENYA

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DECLARATION AND APPROVAL

This thesis is my original work, not presented for an award of a degree in any other university or any other award.

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DEDICATION

This work is dedicated to my wife Mercy Wanjira, my son Brian Ndolo, my daughter Michelle Wanjiku and Mr. Kituku my colleague teacher.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAAS	American Association for the Advancement of Science
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BAT	Biology Assessment Test
CBC	Competency-Based Curriculum
CEMASTEA	Centre for Mathematics Science and Technology Education in Africa
CLT	Constructivism Learning Theory
CXC	Caribbean Examinations Council
ECOL	Examinations Council of Lesotho
ELT	Experiential Learning Theory
IEP	Individual Education Program
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KIE	Kenya Institute of Education
KNEC	Kenya National Examinations Council
KR-20-Kuder	Kuder-Richardson's coefficient
MoEST	Ministry of Education, Science, and Technology
NACOSTI	National Commission of Science, Technology, and Innovations
NTI	National Teachers Institute
PBL	Problem-Based Learning
SECGPE	Secondary Education Certificate General Proficiency Examinations
SEQIP	Secondary Education, Quality Improvement Project

SMASE	Strengthening of Mathematics and Science Education
SPS	Science Process Skills
SPSTA	Science Process Skills Teaching Approach
SPSS	Statistical Package of Social Sciences
TSC	Teachers Service Commission
UNESCO	United Nations Educational, Science, and Cultural Organization
WAEC	West African Examinations Council

ABSTRACT

Biology makes students aware of the nature of their daily life, and the care and protection of the environment. This study looked at the relationship between Science Process Skills Teaching Approach and learning outcomes in biology in secondary schools in Makueni County, Kenya. The persistently low level of students' learning outcomes in biology, observed for a long time prompted this research. The teaching of the abstract nature of biological concepts had remained teacher-centered with the learner being a passive participant with minimum learning resource interaction. The objectives of the study were: To determine the difference in learners' self-efficacy in biology among students taught by Science Process Skills Teaching Approach and those taught using Conventional Teaching Methods; To establish the difference in learners' creativity in biology of students taught using Science Process Skills Teaching Approach and Conventional Teaching Methods; To establish the difference in the level of critical thinking for students exposed to Science Process Skills Teaching Approach and Conventional Teaching Methods; To determine the difference in learners' academic performance in biology among students exposed to Science Process Skills Teaching Approach and Conventional Teaching Methods. The constructivism and experiential learning theories guided the study. It adopted a mixed research methodology that had both qualitative and quantitative and a Quasi-Experimental Research Design that involves Solomon's Four Non-Equivalent Control Group Design. The accessible population was Form Two Biology students within Makueni County. The study used a stratified random sampling technique to assign the four public co-educational secondary schools from the randomly sampled four Sub-Counties in which only one school per the sampled Sub-County was to participate in the study. The research selected a sample size of 204 Form Two students from the county. SPSTA was the intervention for the two experimental groups and Conventional Teaching Methods were for the control groups. A five-point Likert scale questionnaire measured the students' achievement in self-efficacy in biology while Biology Assessment Test (BAT) measured the students' learning outcomes in creativity, critical thinking, and academic performance. Research experts from the department of educational communication and technology of Machakos University and two experienced biology teachers did content and construct validation of the instruments. The reliability test used the split-half reliability through the KR-20 formula for the BAT, resulting to a coefficient of $\alpha = 0.860$, and the five-point Likert scale questionnaire used Cronbach's alpha which gave a coefficient of $\alpha=0.870$. The study used Statistical Package of Social Sciences (SPSS) version 21.0 to analyze the collected data. The expression of the students' self-efficacy levels was in terms of percentage of their confidence levels. Data analysis used descriptive and inferential statistics. Descriptive statistics calculated mean scores, and standard deviations while inferential calculated t-test, One-Way ANOVA, ANCOVA, Least Significant Difference (LSD) Post-Hoc Scheffe Multiple Comparisons, and Chi-Square Tests to test the hypothesis at α 0.05 level of confidence. The findings of the study demonstrated that SPSTA enhances learning outcomes in students' self-efficacy in biology, creativity, critical thinking, and academic performance. The results of the study will provide useful information to biology teachers, curriculum developers, Quality Assurance and standards officers (QASO), and teacher-trainers.

CHAPTER ONE

INTRODUCTION

1.0. Introduction

This chapter consists of the background information to the study, statement of the problem, the purpose of the study, objectives of the study, research hypothesis, and rationale of the study, the significance of the study, the scope of the study, limitation, delimitations and assumptions of the study. The chapter finally looks at the operational definitions of terms used in the study.

1.1 Background to the study

Globally, there has been an emphasis on the development of Science Process Skills and scientific knowledge among the learners as the major objective of science education (Adeyemi, 2008). One of the most important and pervasive goals of schooling is to teach students to think and have confidence of the thought made. Cimer (2012) argues that the perspective of teaching biology is to make learning relevant by extending students' views of the world and connecting school biological topics with daily life experiences. This would play a great role of the students developing the abilities of solving problems encountered in daily life.

According to (Reiss & Winterbottom, 2021) the principles of teaching biology in secondary schools are to help the learners to build excellent understanding of the subject, enhance their interest in the subject and learn how to connect ideas from separate topics of the subject. Science, biology included has unique skills which emphasis on hypothesizing, creativity, critical thinking, and logical reasoning from data which students need to develop when they are been taught. These skills are referred to as Science Process Skills because they have their orientation in sciences.

Science Process Skills are the abilities used by scientists during their work, and the competencies displayed in solving scientific problems or testing ideas with evidence through scientific methods (Ongowo &Indoshi, 2013). When Science Process Skills are used during the teaching-learning process students develop scientific knowledge and learn the nature of science by doing and experiencing it directly as they solve the problems. Ongowo & Indoshi (2013) have clarified that the Science Process Skills make individual learners to actively participate and address important issues and problems around them.

Based on the above, there is need to prepare biology educators effectively to deliver the secondary school biology curriculum in a way that enables the students to develop scientific knowledge, creative and critical thinking skills. Scholars such as (Mustaq & Khan, 2012) have argued that good teaching of science improves performance and perception of concepts by learners. Mustaq and Khan further indicate that this plays an important role in producing great leaders and work force for socio-economic development improvement in sciences industrial revolution and good management of resources.

Sciences comprise of chemistry, biology, and physics that have been poorly performed (KNEC, 2020). The subjects work interchangeably towards producing reliable science literacy students. Panoy (2013) highlights the goal of science as the acquisition of skills and scientific knowledge for application in the daily life of the student as well as the management and conservation of the environment. This means that with scientific knowledge, students become scientifically oriented and stable to shape the world of science. LI and Klahr (2006) suggested that the main aim of science education is to teach students about the accumulated knowledge of the natural world and mechanisms of discovering and constructing scientific knowledge through the application of the Science Process Skills Teaching Approach.

Opulencia (2011) considers science education to help the students to think like scientists when addressing scientific literacy challenges and the benefits from the learned knowledge. In this vies the students have the ability to identify a problem on their own and look for solutions so that they develop a sense of self-innovativeness that displays creativity. On the other hand, (Miller, 2017) argues that science education helps teachers to shape the students' behavior and motivation towards the learning of science without which they would face unprepared challenges. Science allows the student to develop experimental skills to prove the phenomenon at hand. Through the teaching of biology, the students would understand the role and value of biology in society and the interaction between biology and society.

Students learning biology through active participation are engaged, test their ideas, and build their understanding fast than when they learn by hearing or reading (Ewers, 2001). Therefore, it may be difficult to imagine learning biology without hands-on, minds-on, and hearts-on activities, which provides the students with the ability to discover and transform information, and check new information against old. Studies by scholars such as (Cigrik & Ozkan, 2015) explain that hands-on activity greatly contribute to increased students' Science Process Skills. Some of the hands-on activities include measuring, manipulating, drawing, making charts, recording data, and finding answers to problems. These skills are scientifically oriented hence referred to as Science Process Skills.

Science Process Skills helps students to develop higher mental processes which include problem solving, creativity, critical thinking, and decision-making (Tan, & Termiz 2003; Koray, Koksal, Ozdermir & Presley, 2007). The Science Process Skills Teaching Approach has activities that blend hands-on, minds-on, and hearts-on activities to bring awareness about the secondary school biological concepts (McNeill, 2009). Dogan and Kunt (2017) define Science Process Skills as the skills that facilitate the learning of science, provide active learning, and allow the students to develop a sense of responsibility for the learning process. The use of Science Process Skills increases the learner's permanency of knowledge especially when the learning is hands-on, minds-on, and hearts-on activity based which makes the learner an active participant in the learning process. Hands-on, minds-on, and hearts-on activity learning technology enable the information learned through doing to be stored in the long-term memory that allows faster logical retrieval of the concepts.

Ornstein (2006) supports the idea of Dogan & Kunt (2017) that, hands-on-activities in cooperating Science Process Skills are essential for the development of students' competencies and abilities. This supports the ideas that; "Tell me, I forget, teach me, and I remember, involve me, and I will learn" (Matis, 2017). With reference to Science Process Skills, (LI &Klahr, 2006), argues that students accumulate knowledge of the natural world through discovery and construction of scientific knowledge. Therefore, students taught using Science Process Skills Teaching Approach are likely to be scientifically knowledgeable on the subject content and with a lot of confidence.

Studies that focused on the performance of students in science tests showed poor results from the tests which Prudente (2011) associated with the approaches used by teachers in the teaching and learning process in the classroom situations. This indicates that teaching approaches have effects on the general learning achievements of the students at any given time. Poor performance in biology has an effect of lowering the international roles of making students aware of the present, the effect of nature in their daily lives, the responsibility for the care and protection of the environment and the earth in general.

The problem of poor performance in science subjects especially biology is global as indicated by UNESCO (2012) in Canada, Australia and India. Fonseca and Conboy (2006) also show poor performance in Portugal due to poor quality and quantity of instructions and psychosocial environment of the classroom. Mullis, Martin, Foy, and Arora (2011), compared the science performance between USA learners and that of both Singapore and Chinese Taipei with results indicating that the USA learners were significantly below. USA biology students experienced severe difficulties in understanding many of the biological concepts, which were because of the poor teaching methods and minimal exposure to teaching-learning resources.

Program for International Student Assessment-PISA (2012), reports that more than 20 percent of young European students were not able to attain basic Science Process Skills in all science subjects. A related report attributed the poor performance in sciences in Australian science students to a lack of learner's interest and poor teacher preparedness especially in the teaching methods (TIMSS, 2003). From the Caribbean examinations council (CXC) (2002), only 18.7% of 3,779 Jamaican students in grades I, II, and III passed in their SECGPE (Secondary Education Certificate General Proficiency Examinations) the rest failed. The failure was associated to lack of understanding of many of the biological concepts like adaptations of mammalian lungs to functions and the structural change in plants' respiratory surfaces that affects the rate of gaseous exchange in plants among others (CXC, 2002).

In Nigeria, biology is a very important subject in the senior secondary, prioritized because it enables the students to understand their immediate environment; acquire biological knowledge that is applicable in many fields like Medicine, Biochemistry, Pharmacy, Microbiology, and Agriculture among others. However, with such key importance, the teaching of biology in Nigerian secondary schools has been facing many challenges.

West African Examinations Council (WAEC) (2012; 2013 & 2014), revealed that only 49%, 38.5%, and 35.66% respectively got quality scores in the biology examinations, the rest got low scores. The poor performance was because of the nature of teaching methods used, availability of laboratories, and other teaching facilities in their right number as per the number of students taking biology. The students' learning outcomes in biology in the Senior Secondary Certificate Examination (SSCE) in Nigeria has been unsatisfactory for many years.

Dinah (2013) indicated the reasons that contributed to the unsatisfactory results to include unavailability of textbooks; laboratory apparatus as well as other related teaching/learning resources, and the teaching methods. Mamalanga and Awelani (2014), gave similar possible factors leading to the poor performance of biology in Nigeria and added lack of enough support from stakeholders coupled with ill-equipped libraries as other factors. The researchers found out that science teachers have less innovative skills in blending teaching methods to improve understanding of biological concepts.

The poor performance in biology compared to the other science subjects experienced in Nigeria is a replica of what Lesotho has been experiencing. The reports from the

Examinations Council of Lesotho (ECOL, 2012), indicated that more than 50% of biology students in their high school examination performed below average except within the years 2008-2012 when the performance slightly improved.

A study by Akiri and Nkechi, (2009) linked the poor performance and low achievements in biology in Lesotho to ineffective teacher interaction in the classroom; poor teachers' performance in terms of accomplishing the teaching tasks; the negative attitude of the teachers towards teaching; and the poor teaching habits. The poor performance noted in biology was linked to the pedagogy used that was non-innovative and non-student centered. The poor performance and low achievements in biology are common in almost all African countries Kenya included.

In Kenya, the goal of education is to promote economic, technological, and industrial development for the national good (Gacheri & Dege 2014). This means that biology, as a science is significant, relevant to life and society, and equips students with useful concepts, principles, and theories for the growth of the nation. Learners need to be empowered with knowledge that can increase the required standards for the projected economic growth. Industrial and technological developments in Kenya depends on skills, knowledge, and expertise in science hence appropriate teaching of sciences is necessary (KIE, 2006) as envisaged in vision 2030. Biological knowledge helps to develop high-yielding, disease-resistant, and fast-maturing food crops and animals to meet the food requirements for the nation.

According to KICD (2003) the objectives of the Kenyan learners to learn biology for the four years includes the following: the learners to be able to communicate biological information precisely, clearly, and logically; apply knowledge learned in school to improve and maintain the individual, family and community health; to develop a positive attitude towards biology and relevant practical skills. Biology helps to develop an awareness of the value of cooperation in solving problems and getting knowledge, skills, and attitudes for further education and training. Despite biology being a key subject in Kenyan secondary schools' education, the Kenya National Examinations Council indicates poor learning outcomes in the Kenya Certificate Secondary Education (K.C.S.E) than any other subject (KNEC, 2020), as in table 1.1.

Table 1.1
Summary of Biology KCSE Candidates' Overall Performance in Kenya from 2016-2020

Subject	Biology		Physics		Chemistry	
Year	Mean Score	SD	Mean score	SD	Mean Score	SD
2016	58.37	35.16	79.53	42.40	47.42	32.47
2017	37.85	23.45	70.09	39.59	48.09	32.80
2018	51.38	23.26	68.54	35.31	53.76	33.45
2019	51.38	23.26	65.18	33.96	52.17	32.71
2020	53.03	29.50	71.03	35.03	45.01	30.19

Source: KNEC, (2020).

The mean scores for biology and chemistry tend to be too low and biology in 2017 showed the poorest performance (KNEC, 2020). This is an indication that the mastery of biological concepts faced many challenges. Thematic learning-rich with varied group activities, discussions, and active learning about the biological concepts linked itself to creative exploration, critical thinking, and the ability to explain biological concepts. Therefore, teachers need to adopt relevant pedagogical practices that help the learners to answer questions that approach the curriculum topics from varying angles and perspectives (KNEC, 2020).

Students' underachievement in biology from different angles as observed and viewed by Owino, Ahmad, and Yungungu (2014) was associated with the teaching methods, and teaching-learning resources. The learners are less involved in the learning process and the teacher has the authority of the knowledge. This indicates that matching teaching methods and resources appropriately leads to unexpected great improvement in the learners' achievement levels in the subject.

Teacher-centered learning approaches where the teacher only lectures and students complete assignments out of class and later take examinations dominates most of the teaching-learning process in Kenyan secondary school level of education (Kolawole, 2008). The teacher less manipulates the learning activities to cater for the learning outcomes in biology.

This study looked into the extent to which the Science Process Skills Teaching Approach converts teacher-centered lessons to learner-centered to make the learners active to learn how to learn but not what to learn. Learner-centered teaching and learning approaches actively engage the learners in the learning process for effective mastery of the subjects' content to foster understanding, creativity, critical thinking, and automate performance (Ministry of Education Science and Technology (MoEST), 2001). Some of the learner-centered approaches include constructivism learning, inquiry-based learning, Science Process Skills Teaching Approach, project, experimentation, cooperative learning among others.

Makueni County secondary schools must have produced a lower number of students as qualifiers to biology-related courses for the years ranging from 2016 to 2020 because of the Low achievement noted in Table 1.2.

Table 1.2
Mean Scores for Biology, Physics, and Chemistry for Makueni County Secondary Schools from 2016-2020.

Year	Biology mean scores	Physics mean scores	Chemistry mean scores
2016	2.340	3.820	2.280
2017	2.015	3.384	2.045
2018	3.070	4.020	3.100
2019	2.926	3.559	2.597
2020	2.610	3.256	2.341

Source: Makueni County Educational Office KCSE KNEC, (2020).

There has been minimal research on how Science Process Skills Teaching Approach influences the learner's outcomes in biology to increase the possibility of getting more students joining Biology-related careers Hayati, Bintari, & Sukaesih, (2018). The study investigated how the use of the Science Process Skills Teaching Approach improves the learning outcomes in biology in secondary schools in Makueni County.

Wilke, (2003) found that students who use non-student-centered methods have low student's Self-efficacy. Students have low creativity when taught Biology using their textbooks and lecture methods without allowing them room to think on their own as in Liang (2002). This has also been major challenge in the teaching and learning of Biology in Kenya (CEMSTEA, 2016). It implies that teacher-centered learning has negative effects on the students' learning outcomes.

1.2 Statement of the Problem

Despite the government of Kenya's commitment to improve the quality of the learners' achievement in biology, there have been persistent low learning outcomes in the subject at the National, County, and Sub-County levels in the secondary schools. The students have displayed low attainment of self-efficacy; poor creativity; low levels of critical thinking, and poor academic performance. Attempts by researchers and interventions through workshops, seminars, and in-service training on how to counter the low learning achievements in biology have not recorded any significant improvement. This has been attributed the non-innovative and teacher-centered teaching approaches, which have significantly placed little emphasis on the fundamental Science Process Skills. This in turn has had a greater threat to biology-related careers. It is a further signal that the low learning outcomes may continue to middle colleges and universities with serious consequences. From the contention of this study, the trend might be reversed by an intervention that focuses on Science Process Skills Teaching Approach.

Minimal studies on the use of the Science Process Skills Teaching Approach and its contributions towards learners' self-efficacy in biology, creativity, critical thinking levels, and students' academic performance has been done. Therefore, this study investigated the relationship between Science Process Skills Teaching Approach and the learning outcomes in biology in secondary schools in Makueni County, Kenya.

1.3 Purpose of the Study

The purpose of the study was to investigate the relationship between the Science Process Skills Teaching Approach and learning outcomes in biology in secondary schools in Makueni County, Kenya.

1.4 Objectives of the Study

The general objective of this study was to determine the level of learning outcomes in biology after the students were exposed to Science Process Skills Teaching Approach as compared to those exposed to conventional teaching methods.

The following specific objectives guided this study:

1. To determine the difference in learners' self-efficacy in biology among students taught using Science Process Skills Teaching Approach and Conventional Teaching Methods.
2. To establish the difference in learners' level of creativity for biology students taught using Science Process Skills Teaching Approach and Conventional Teaching Methods.
3. To examine the difference in the level of critical thinking for students exposed to the Science Process Skills Teaching Approach and Conventional Teaching Methods.
4. To determine the difference in academic performance in biology among students exposed to Science Process Skills Teaching Approach and Conventional Teaching Methods.

1.5 Research Hypotheses

The following hypotheses assisted in achieving the research objectives.

1. **H_O**: There is no statistically significant difference in learner's self-efficacy in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County.

2. **H$_O$**: There is no statistically significant difference in biology students' level of creativity between those exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County.

3. **H$_O$**: There is no statistically significant difference in biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County.

4. **H$_O$**: There is no statistically significant difference in learner's academic performance in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County.

1.6 The Rationale of the Study

Science Process Skills are a set of intellectual skills that use scientific activities that the students learn and develop during the learning process. Hodson (2005) suggests that students' performance improves when hands-on, minds-on and hearts-on activities that involve the Science Process Skills Teaching Approach capture their interests. The study focused on Science Process Skills Teaching Approach because it allows students to be actively involved in the learning process.

Through active participation, the learners build self-efficacy levels, become creative and critical thinkers hence improve in their academic performance. The Science Process Skills Teaching Approach improves the learners' attention, learning skills, and retention of biological concepts. Further, Science Process Skills Teaching Approach plays a key role in assisting to make the abstract nature of biology concepts easy to explain, understand, and conceptualize.

KNEC (2020) explains low learning outcomes in biology to have resulted from the rare and poor use of the Science Process Skills Teaching Approach by most of the biology teachers. Most of the teaching-learning processes were rote learning where the teacher was the authority of the knowledge and most of the students tended to memorize the biological concepts. A similar encounter of low learning outcomes in biology and the reasons for such an encounter was in a report obtained from Makueni County Educational Office (2019) and therefore it was necessary to carry out this study.

The study used Quasi-Experimental Research Design to avoid randomizing the schools because most of the Kenyan secondary schools are intact groups of classes in nature. The principals of these schools did not wish to break their classes down for a study and therefore the research had to adopt the design. The design assisted to find out the effects of the Science Process Skills Teaching Approach interventions on the treatment groups compared to the control groups exposed to the Conventional Teaching Methods. It also controlled the major threats to internal validity during the study. Finally, the design controlled any interaction between the sampled schools for the study.

KNEC (2019-2020) gives limited information on the relationship between the Science Process Skills Teaching Approach and the learning outcomes in biology in secondary schools in Kenya Makueni County included. It is against this background that the study investigated the relationship between the Science Process Skills Teaching Approach and learners' learning outcomes in biology in secondary schools in Makueni County, Kenya.

1.7 Significance of the Study

The study has added to the body of knowledge on the relationship between the Science Process Skills Teaching Approach and the learning outcomes in biology in secondary schools, which was to add to the existing body of knowledge of the various researchers about learning how to learn but not what to learn. Curriculum developers will gain a lot of information on how to arrange the biology content in line with the relevant Science Process Skills Teaching Approach activities that are learner-centered to improve the learning outcomes.

Ministry of education was expected to gain knowledge on how Science Process Skills Teaching Approach promotes the quality of biology whose most concepts are abstract hence the low learning outcomes persistently noted. The ministry would also get to know the best ways of infusing the Science Process Skills Teaching Approach and its activities for effective and systematic teaching of the biology concepts. The various science and related disciplines organized workshops like SMASE, CBC, and SEQIP, which targets improvement in learning outcomes learned how effective the Science Process Skills Teaching Approach employs the student-centered learning process in the teaching of biology.

Teacher training institutions, which include the colleges, universities, and even the practicing teachers, would also benefit from the use of the Science Process Skills Teaching Approach to improve the learners' learning outcomes in biology. This would change the teachers’ approach from the use of the Conventional Teaching Methods, which makes the learners learn what to learn, to an approach that enables the learners to learn how to learn learner-centered teaching methods used during the study period. When the learners learned at a student-centered level, there was a great improvement in their self-efficacy in biology, students' creativity, critical thinking, and academic performance in biology.

To the students, the study opened them towards activity-based learning that raises critical thinking, creativity, logical thinking, decision-making abilities, problem-solving skills, learning curiosity, imaginative skills, and increased interest levels in the learning of biological concepts. Through the acquisition of the Science Process Skills gained from the use of Science Process Skill Teaching Approach the students would become innovative, constructive, focused enough, and in their best position to use the skills to solve community-based problems and conserve the environment.

1.8 Scope of the Study

The study targeted the public secondary schools in Makueni County- Kenya because public schools were many and they had reliable Teachers Service Commission (TSC) trained biology teachers who could teach accurately and timely for the appropriate data and relevant findings required to answer the research objectives. The research used Form Two Biology Students because by the time of the study, they had become familiar with secondary education, biology at this level was compulsory, and lastly, they were preparing to select it as one of their examinable subjects by the end of the four years' course.

Form Ones were not suitable because by the time of the study, they were still acclimatizing with secondary education and Forms Three and Four had already chosen their electives and therefore not all students were to be involved. It only considered the relationship between the Science Process Skills Teaching Approach and the learners' learning outcomes in biology in secondary schools where science teachers frequently use Conventional Teaching Methods.

The study used the topic of exchange of gaseous in both plants and animals found in the Form Two syllabus to obtain the data because students have faced challenges in answering KCSE questions from the topic. Gaseous exchange also stands out as the pillar for the topics of respiration, and excretion and homeostasis hence the need to use it in the study.

Using the Science Process Skills Teaching Approach and the Conventional Teaching Methods the data was collected from where the interpretations and conclusions of the findings were made to provide a clear generalization of the level of the students' learning outcomes in biology. The data from these two approaches provided an opportunity to compare well for effective conclusions to be drawn hence the need why the two were considered in the study.

Mixed research method that had both qualitative and quantitative methods was adopted where the qualitative method was for collecting the qualitative data and the quantitative for the quantitative data that was limited to descriptive and inferential statistics. The qualitative data collected using a qualitative method was converted to quantitative data for easy analysis and interpretation.

Constructivism Learning Theory (CLT) and Experiential Learning Theory (ELT) that allows the learner to be an active participant in the learning process were used. Stratified random sampling was done to provide the four public co-educational secondary schools and a five-point Likert scale questionnaire on the learners' self-efficacy in biology provided the qualitative data. The BAT provided the quantitative data about the students' creativity and critical thinking that were summed-up to give the academic performance results in biology.

1.9 Limitations of the Study

The research experienced the following limitations during the period of study

i. The researcher was required to comply with the daily routine and customs of the sampled public co-educational secondary schools but not to alter it.
ii. The study was to follow the year's term two curriculum calendar of the Form Two syllabus and therefore it was the responsibility of the researcher to consider how best to fit in the term dates provided by the Ministry of Education and the regular teacher's scheming level for the class.
iii. The study was limited to the specific Science Process Skills but did not examine the unconsciously used process skills by the biology teachers from the sampled co-educational public secondary schools in Makueni County.
iv. The research limited to qualitative and quantitative research methods.

1.10 Delimitation of the Study

This study was delimited to:

i. Form Two Students from the public secondary schools because who were taking biology as a compulsory subject.
ii. The study concentrated on a segment of biology content based on gaseous exchange because it is a fundamental pillar for respiration, and excretion and homeostasis topics. It makes understanding of these other two topics easy.
iii. It confined itself on the relationship between Science Process Skills Teaching Approach in the teaching of biological concepts and the students' learning outcomes in biology.

iv. This study narrowed the collection of data to the sampled public co-educational secondary schools.

1.11 Assumptions of the Study

The study had the following assumptions:

i. Teachers of the treatment groups were to follow the Science Process Skills Teaching Approach guidelines to the latter and use the resources supplied effectively.
ii. The respondents from the chosen co-educational public secondary schools were at the same level of content coverage in biology.
iii. Teachers of the control groups were not in positions of unconsciously using the selected Science Process Skills that could have almost given the same impact as the intervention given to the treatment groups.
iv. The students had a narrow gap of perception and attitude towards the topic of gaseous exchange.

1.12 Operational Definition of Terms

Biological concept is an idea, thought, principle, or understanding of biology knowledge

Causative Process Skills: are skills indicating why or how learning achievements are through the nature of the teaching-learning method.

Conventional method: is a strategy in which the teacher has the authority of the knowledge and the learner is only passive during the learning process.

Creativity: is recognizing gaps, formulating a hypothesis, forming ideas, and testing the ideas against the hypothesis for communication of the data collected.

Critical thinking: is an organized active mental process that helps in understanding events, situations, and thoughts.

Intervention: Is a special direction for students given an individualized educational program. (I.E.P).

Learner-centered learning: is an approach where the learner is at the center of the learning process with the teacher being a facilitator of the process.

Learning Science: is a process of predicting a problem and solving it through the construction and reconstruction of explainable knowledge.

Processes: are rational steps a learner uses when applying skills like drawing, predicting, observing, formulating hypotheses, and experimenting.

Quality scores: refer to the numerical values in a Biology test of a learner who attains at least 60% and above

Science: is the pursuit and application of knowledge of the natural and social world following a systematic methodology based on evidence.

Science Process Skills: are procedural skills, and activities used by the learners to construct knowledge to solve a problem and formulate results.

Scientific creativity: is a way of comprehending, formulating, and experimenting with new scientific ideas and concepts to add them to the existing field of knowledge.

Self-efficacy: is the belief in one's capabilities to organize and execute the courses of action to produce given achievements.

Skills: Are specific abilities a learner displays in a learning process like observing, measuring, calculating, recording, and others.

Student Achievement: Is the degree or measure of the amount of academic content a student learns in a determined amount of time.

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

This chapter reviews related literature on teaching and learning of biology, difficulties in learning biology, teaching strategies in biology, concept formation in biology, learning outcomes, Science Process Skills, Science Process Skills Teaching Approach and learners' self-efficacy in biology, Science Process Skills Teaching Approach on creativity, critical thinking skills and academic performance in biology. The chapter also considers the constructivism and the experiential learning theories that support the study, theoretical and conceptual framework, and the various research gaps in the literature.

The literature reviewed on the teaching methods used by biology teachers with observations of how they influence learners' learning outcomes. Previous studies had been done on how science students are supposed to be made active learners and how through learning on their own, they become creative, critical, and develop Self-efficacy but by the time of this study no good improvement had been noted.

2.1.1. Teaching and Learning Biology

The purpose of teaching at any level is to bring out fundamental changes in the learners like the acquisition of intellectual skills, ability to solve problems, and inculcation of values, knowledge, and attitudes. Yustina and Vebrianto (2009) in their study found out that biology teachers in Indonesia were more inclined to explanation and provision of information regarding the phenomenon and concepts in biology verbally and not through real-life observations. Teachers only explained topics, provided sample questions, and gave exercises. The teachers did not allow the students to identify the problem, observe, look for possible solutions, and solve the biological problem on their own.

The students in these schools responded in form of revision with the teachers being subject matter-oriented with a focus on discussion of the content without considering the students' interests and abilities in the learning process (Depdikbud, 2005; Suryawati, Osman & Meerah, 2010; Yustina, Osman & Meerah, 2011). From the above the learning process focuses on the teacher as the key role player without allowing time for the student's science skills and attitude to develop. Just like in Indonesia, the teaching of biology in Kenya has an orientation of a teacher-centered approach with little students' involvement.

Howard (2009) argues that a successful teacher must use a variety of teaching strategies and methods suitable to the students' learning styles. In addition, Danmole and Femi-Adeoye (2004), agree that no single method is best for the teaching of biology at all times. Teaching strategies used must permit students' active participation and acquisition of knowledge and skills that are applicable in real-life situations to solve problems.

Teachers need to adapt to different approaches when teaching students how to acquire knowledge, skills, and experiences (Pacia, 2014). Teachers should use learner-centered approaches to ensure active learner participation in the learning process. In an active learning process, the students have an active impact on the learning process and it allows them to focus on creating knowledge using skills such as analytical thinking, critical thinking, creativity, and problem solving among others. Learning biology is a process that allows the construction and reconstruction of previous knowledge.

Martin (2009) explains learning of science in general as a way of redefining the existing knowledge, constructing concepts, explaining concepts, and predictions as a basis for future knowledge. Therefore, the learner predicts a problem, interact with prior experiences when solving the problem to construct new explainable biological knowledge.

Effandi and Zanaton (2007) notes that biology teachers should know how students learn biology and how best they should teach them. Efforts should be made to direct the presentation of biology lessons from the Conventional Teaching Methods to more student-centered approaches where they actively participate. This drives the character of learning how to learn but not what to learn in a more advanced way that can promote students' self-efficacy, automate academic performance, creativity, critical thinking about biological concepts among the learners.

Wambugu and Changeiywo (2008) further noted that the teaching approaches adopted by biology teachers could affect students' learning outcomes in biology. Learning outcomes are a product of how the teacher presents the lesson in a logical way for the concepts to be logically stored in their memories.

According to McDowell (2001), learning no longer supports the transmissive style of lecturing where memorization and reproduction of knowledge dominate but rather a learner involvement approach where the learner should be the central key player. The emphasis is that the teacher's role is not to lecture only but to act as a facilitator to encourage active participation, dialogue, and interaction of the student with the course materials and with each other.

Allen and Tanner (2005), points out that active learning is seeking new information, organizing it meaningful, and having the chance to explain it to others. It emphasizes on interactions of learners with peers, instructors, and cycles of activities, which gives the students consistent opportunities to apply their learning in the classroom.

When students are placed at the center of instruction, the focus is shifted from teaching to learning and promotes a learning environment to metacognitive development necessary to make the students independent and critical thinkers (Bransford, Brown & Cocking, 2000). In the learner-centered classroom, the learner is empowered and is an active agent to his or her learning (Weimer, 2013). The learner can make decisions, influence aspects of learning a topic, and demonstrate knowledge or skills attained. They are the agents of the learning process with the teacher only facilitating the learning process.

Students learn by interacting with and transforming the received information to own it through becoming creative and having critical thinking. Active learning involves the learners in the structuring of the knowledge, making their approach to the learning, reflecting on their own, and controlling the learning process (Virtanen, Niemi, & Nevgi, 2017). Active learning includes physical activities, interactions, collaborations among students, deep processing of information, elaborations by the individual learner, and learner explorations. By doing so, knowledge becomes more meaningful, useful, and powerful to understand.

Science Process Skills like observing, measuring, recording, interpretations, hypothesizing among others that involve students actively in the learning process can facilitate learning. Student-centered teaching-learning approach is more likely to be effective because the students play a provocative role in the learning process (PISA, 2012). A student identifies the problem that arouses the desire to find solutions on his or her own through various learning activities.

Science Process Skills Teaching Approach allows students to be able to describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate the new ideas to others (Opara, 2011). Therefore, it is necessary that during the teaching and learning process the students experience hands-on, minds-on, and hearts-on engagements with science materials as they try to solve problems using diverse practical activities.

Process-based activities emphasized in biology lessons are doubtless because it is evident in the objectives and instructional programs in biology at secondary schools' syllabus. Practical work that has hands-on, minds-on, and hearts-on activities in biology facilitates the necessary learning environment like active participation and integration to life and meaningful learning (Karamustafaoglu, 2011). However, the teaching and learning of biology in secondary schools in Kenya have mostly used the Conventional Teaching Methods with little on Science Process Skills Teaching Approach and therefore, the need for this study.

2.1.2. Difficulties in Learning Biology

Biology is a unique branch of natural sciences concerned with the understanding of natural phenomena and events of life. Mayr (2004), points out the two major fields in biology as functional and historical biology in which the functional processes of biology deal with physiological processes of living organism that are explained by the natural laws of physical sciences and it can be explained while the historical biology provides explanations of the processes.

Research from Tekkaya, Ozkan, & Sungur (2001) and Cimer, (2004) found out that students face difficulties in learning biology especially in some concepts and topics like protein synthesis, respiration, gaseous exchange, photosynthesis, cell division, hormonal regulation, oxygen transport, nervous system, and genetic manipulation among others. These difficulties have great harm to the biology students' learning outcomes.

According to Mayr (2004), students present the following reasons for the difficulties they experience when learning biology: abstract from the biological materials, concepts and the use of textbooks during the learning process by the teachers that makes it hard for them to understand the concepts. Further, classroom management that does not make the students enjoy learning process, the methodologies used by the teachers that are too much on memorization and lectures are other difficulties students experience during the learning process.

Further studies by Kidman (2008) gives students' difficulties as; biological events and life processes that cannot be seen directly with the naked human eye; abstract biological concepts; presences of Latin names that the students have difficulties in memorizing; materials used in learning that are not related to everyday life; teaching style of the teachers which are not student-oriented.

The difference between reality and materials delivered in the classroom makes students study harder to understand the concept in the topic of biology because relating the two to form a biological concept is difficult and requires time (Kidman, 2008). Lack of reality in experiences is a contributing factor to the poor understanding of the biological concepts by the students, which the Science Process Skills Teaching Approach tends to improve through the various hands-on, minds-on, and hearts-on activities.

Lastly, Cimer (2012) noted other difficulties experienced by students when learning biology in secondary schools as; limitations of learning facilities, infrastructure, and limited learning time which leads to the teaching-learning process been more of theories with fewer practical activities and experiments to strengthen the concept of the topics requiring practicals presented by the teacher. Other difficulties include; Students experience boredom hence loses interest in the learning process; quick and incomplete delivery of the concepts by the teachers such that the students lack enough times to internalize the concepts to their fullest.

Science Process Skills Teaching Approach has skills and activities that maintain the students' active participation to increase their interest to learn.

These difficulties are inimitable by finding effective learning methods like the Science Process Skills Teaching Approach that have activities that arouse the interests and perceptions of the learners. The learners had low learning outcomes towards biology and low confidence levels to most of the biological concepts as evidenced in the pre-test results.

2.1.3. Teaching Strategies in Biology

Successful teaching and learning of biology is achieved effectively when maximum participation of the learners in the teaching and learning process is given attention (Rwanda Education Board, 2015). Most biology use strategies that are teacher-centered allowing passive participation of the learner. Quite a significant number of teachers use lecture-based strategies known as Traditional Instructional Methods (TIM), which include lectures, note writing, assignments, and tutorials, which this study refers them as Conventional Teaching Methods of Teaching (CMT), where the teacher is an authority of the subject content.

Conventional Teaching Methods of teaching are wholly teacher-centered, with the students expected to recite and/or memorize specified content available in written or typed lecture notes. Conventional Teaching Methods has relatively little student activity and involvement with much of knowledge being passively derived from the teacher to the student (Ajaja, 2009; Bennett, 2003; Borich, 2004; Trowbridge, Bybee, & Powell, 2000). The role of teachers during the teaching-learning process is to stand at the front to deliver the knowledge through a lecture without putting into consideration the rate and level of reception of the biological concept being taught with the role of the student been a listener and copying of notes of the abstract biological concepts.

Teaching strategies in biology have experienced a significant shift with efforts to meet the individual student's needs due to the changes in teaching aids and learning objectives, (Helikar, Cutucache, Dahlquist, Herek, Larson, & Rogers, 2015). They have become more interactive and activity-based with the learning been through collaborative techniques which allow active participation and engagement of learners that are components of the Science Process Skills Teaching Approach.

Strategies are expected to attempt to fulfill the objectives of the learning process by shifting them from teacher-centered to learner-centered teaching strategies where the learner is directly involved in the learning process. Recently, the teaching of biology demands strategies that allow the students contribute to the growth of their biological knowledge through formulating and solving their biological problems (Fred & Arend, 2010). Through Student-centered activities like those found in the Science Process Skills Teaching Approach students greatly improve their academic performance and provide high level of engagement in the learning process.

When student-centered teaching strategies that vary from moderate to extensively student-centered approaches are used by biology teachers, the students score significantly higher and their view about biology and learning of biology improves (Connell, Donovan, and Chambers 2016). The strategies reform the Conventional Teaching Methods characterized by teacher-centered knowledge and passive participation of students in the teaching-learning process to Student-centered learning strategies that require and involve students in some of the key components of Science Process Skills Teaching Approach such as planning process, implementation, and assessments of their learning process. Students have ownership and empowerment opportunities in the learning process with their teachers differentiating the instructions to suit the nature of the learners.

According to Thomas (2003) Student-centered strategies have the following characteristics: engagement of the students to work harder than their teachers; students know how to think, solve problems, evaluate evidence, analyze arguments, and generate hypotheses but under the guidance of the teacher without assuming that they will pick these skills on their own. Further, the strategy is characterized by the ability of the students to reflect on what they are learning and how they are learning it with the teacher talking less but only challenging the assumptions of the students to prepare them on critical thinking and increase their self-efficacy levels about the concept they are learning.

Teachers include assignment components to open up the students so that they can reflect, analyze, and comment on what they are learning and how they are learning it. The goal of this method is to make the students aware of themselves as learners and then develop learning skills within themselves as a strong characteristic of the learner-centered strategy. The strategy motivates the students by giving them control over the learning processes with the role of the teachers limited towards searching ways of how to share the power of the knowledge with students; Learner-centered has a lot of collaboration and promotes shared commitments to learning. All these characteristics are displayable when the learning involves the Science Process Skills Teaching Approach activities where the learners have the opportunity of constructing their knowledge.

2.1.4. Concept Formation in Biology

Carey (2000) defines concepts as mental representations that are expressed by a single word, such as plant or animal, alive or dead. Complex concepts can describe a whole idea, for example the process of gaseous exchange, the theory of natural selection among others. Concepts can therefore act like building blocks of more complex or even abstract ideas. Concept formation helps to interrelate different topics for easy understanding.

Biology concepts are mental organizations about life and components based on similarities among objects or events interacting with life. When forming concepts, different ideas have aspects that are similar (Sternberg & Ben-Zeev (2001). These similar aspects form the basis for grouping the ideas together into concepts. Concept acquisition, formation, and development have no end because at any time a new concept can be acquired as the learner interacts with the learning environment (Sternberg et al 2001).

Sternberg et al, (2001) suggested that teachers should present to the learners the definition of the different types of concepts according to how they will see them as most or least in class; provide examples of important part of the concepts either directly from their textbooks, class syllabi, or course outlines; help students to develop a firm sense of the critical attributes that define individual concepts make clear them concept

Zirbel (2001) contends that learning leading to concept formation depends on perception, awareness, and on how new ideas get integrated into the old knowledge database through reasoning before getting reorganized into creation of new ones. New information is the first part of learning and so the whole leaning process involves the integration, re-organization, and creation of new mental structures. This implies that, whenever one refers to an object that is not present or an activity that is not going on the impression of these must be created in the mind of the person as new knowledge. Teachers should therefore, have strategies that would adequately open the learner's mind allowing good creativity of the idea that is well thought.

According to Zirbel, (2001) deep thinking involves the construction of new concepts based on what is already known by the student and prior experiences about the knowledge. The new concept becomes facts, attributes, or steps in a process of what expected of learning to be through an active participation. The teacher helps students to form a concept by allowing them time to find out the critical characteristics across the different examples of the concept and then summarize those characteristics into a definition that they can write. This therefore implies that the learners should be guided by the teachers towards the formation of the concepts, which most biology teachers rarely do. Key elements of concept formation are the processes of grouping information into larger units and differentiation of it to provide more meaning.

Human mind dynamically is expected to store Knowledge, which constantly updates itself from the previous information to build on a new one through some kind of reasoning (Dahl & Voll, 2004). The reasoning opens the learners to perceive the different ideas in order to form the concept expected by the teacher through activity-based learning. The process of Concept formation assists in the construction of new pieces of knowledge from previously known ones using Science Process Skills. It comprises of two main steps aggregation and characterization, which assists the learners to form ideas.

During the process of concept-formation, the learner follows three important phases: perception where experiential learning forms the starting point of concept-formation (Blaisdell & Cook (2005). The experiences provide opportunities for the mental images about the objects or events from where the ideas are developed. The abstraction phase that allows the mind to analyze the already perceived images and synthesis what is common in them; lastly, the generalization where the learners are to form a general idea about the common characteristics of the objects or events hence forming the concept expected.

Prasasti and Listiani (2018) further supports that activity-based learning improves students' Science Process Skills, which determine concept formation through systematic activities such as formulating problems, making hypotheses, designing experiments, implementing designs made in the laboratory, and trying to be able to communicate the results of research offer a solution to the problem found. Learners become key role players in the concept formation as they form the concepts biology.

When teaching targeting concept formation, the teachers uses inductive or deductive instructional strategies. Inductive teaching gives the learners the chance to derive the rule of concepts from what has been provided to them. Learners need to notice a concept, a structure, or a rule so that they can hold it in their short- or long-term memory (Bilash, 2009). Concepts are expected to emphasize individual students' explorations and independent thoughts. Inductive strategies are highly recommended in sciences because they make the learners actively engaged in process of concept formation as they classify the categories of the examples of the objects or events into their similarities and differences. Teachers in secondary schools use examinations to evaluate the level of concept formation among the learners but this study used the five-point Likert scale questionnaire and BAT to evaluate the level of concept formation after teaching the students using the Science Process Skills Teaching Approach. Science Process Skills Teaching Approach has skills that assist in concept formation in biology and therefore it led to the fast formation of biological concepts during the study.

2.1.5. Learning Outcomes

Bell-Gredler cited in Winataputra (2008) defines learning outcomes as consisting of two words, learning, and outcomes where learning is a process that human beings use to gain a variety of competencies, skills, and attitudes. Learners acquire these abilities through proper interactions and experiences as they learn in the classroom. An outcome is the realization of proficiency, potential skills, and capacities of an individual (Sukmadinata, 2014). Through learning, the students can rank their learning successes in the subject.

Therefore, learning outcomes are the learning, innovative skills learners acquire in a learning process and the academic performance of the learners in any subject like biology (Trilling & Fadel, 2009). These learning and innovative skills include critical thinking skills, creativity, problem-solving skills, and communication skills. They depict students' learning outcomes using standardized measurement tools such as performance tests, skill tests, and analytical thinking tests (Uwaleke & Offiah, 2013). A common such standardized test is prepared to meet all the levels of testing.

Agboola and Oyemide (2007) further describe learning outcomes to be the gain of knowledge by students through a learning program. This implies that learning outcomes is a result-oriented construct that indicates the extent of performance of the desired task. Individual learners achieve them to reveal the knowledge and skills developed during the lesson indicated by scores of a test given by the teachers. The scoring test crafted reveals that the maximum learning outcomes from the subject taught should be either formative or summative. From the test, the learners' high or low grades measure the learning outcomes after the learning process.

Learning outcomes from a learning process measured by test scores or grades the learner gets from the test evaluates how successful the learner masters, acquires knowledge, and develop skills from the subject been taught during the lesson (Tu'u, 2004). Conventional Teaching Methods do not promote much of the learning outcomes in biology since they do not immerse the students into problem-solving situations thereby, leading to low learning outcomes in biology. The learning outcomes should reflect the learner's self-driven abilities.

When students lead discussions and activities in any learning situation, their learning outcome levels are increased and their interest in the subject and task promoted (Ahmad & Aziz, 2009). Teaching approaches based on hands-on, minds-on, and hearts-on activities that facilitate the learning processes to make the learner more active are influential on learners' learning outcomes in the subject.

The leading factors which are the causes of poor performance in biology are instructional methods used by the teachers (KNEC report, 2015; Akanmu, & Fajemidagha. (2013). Mostly teachers in biology use the teacher-centered methods where they only talk about the biology with the students reading it. Knowledge is useful in students when learned through seeking and individual learner discoveries but not memorization (Braund, Bennet, Hamden-Thompson. (2013); Akiyemi & Folashade, 2010). The teacher should therefore allow the learner to explore the knowledge through use of teaching methods that are learner-centered like the Science Process Skills Teaching Approach.

KNEC (2020) attributes low learning outcomes in biology in KCSE to be a result of inappropriate teaching techniques and unprepared teachers who hurry and give haphazard lesson presentations to complete the syllabus. Prepared teachers are less likely to pass on misconceptions to learners, are more confident, and present a variety of examples and analogies that help the learner to learn and understand the concepts in the topic.

Howard (2009) asserts that, creatively, analytically, and practically taught students perform better than those taught merely by Conventional Teaching Methods. The knowledge possessed by teachers and the style used in teaching it helps the learners to determine their learning outcomes (Purwanto, 2004). In learning activities, the teacher acts as a mentor to allow room for active learning that leads to high attainment of learning outcomes in the subject. This calls for a need to change the teaching approaches to be learner-centered like the use of Science Process Skill s Approach.

Turan and Demire (2011) talk of the implementation of learner-centered approaches in a learning process to be a source of learners to attain life-long learning skills. This makes the learners accept the knowledge conveyed by the teachers at that time of interaction hence improving the learning outcomes. Interactions using appropriate teaching approaches like Science Process Skills Teaching Approach should focus on how they affect learning outcomes.

Rennie, Dieking, and Falk (2013) talk of students' active participation in the learning process to enhance learning outcomes since participation encourages and provides students with the opportunities to utilize the knowledge learned in different situations and not just at the examination. During the active learning process, the learners need to be able to establish goals, persevere challenges, monitor the learning process, and adjust the learning strategies that can assist them to overcome the learning difficulties to increase learning outcomes.

Most of the teaching of the abstract concepts of biology has been through memorization and rote teaching which KNEC (2020) associates to be the cause of the low outcomes in Biology. This nature of teaching does not promote much learning outcomes in biology since it does not immerse the students into problem-solving situations.

Ezeani (2004) pointed out that Conventional Teaching Methods focus mainly on the sense of hearing that encourages rote learning and regurgitation of information without allowing learners time to construct their meaningful knowledge that is consistent with their prior ones. Therefore, there is a need for the transformation of the teaching approaches to make the learners active key players if high learning outcomes in biology are paramount.

The Science Process Skills Teaching Approach that has many skills and activities that make the learners more active hence ultimately increasing the learning outcomes was necessary and therefore the need for the study on the relationship between Science Process Skills Teaching Approach and learning outcomes in biology to prove the formulated hypotheses.

2.1.6. Science Process Skills

LI and Klahr (2006) observe that the main aims of teaching science are to teach students about accumulative knowledge of the natural world, to discover and construct scientific knowledge through the application of Science Process Skills. In process skills, rational activities involving the application of a range of skills like drawing, predicting, interpreting, and inferring, hypothesizing, and others are key in teaching-learning process. The specific activities that a learner trains to do for example observing, measuring, recording, and drawing are the skills likely to be missing in biology teaching-learning process to improve the low learning outcomes.

Behera and Satyaprakasha, (2014) refer to process skills as the process strategies organized stepwise to assist a learner to solve a problem. They help the learners to identify a problem, look for solutions on their own, and communicate the knowledge gained to others. Karsli and Alipasa (2014) define Science Process Skills as the adoption of skills used to compose knowledge, identify a problem, think about it, look for solutions, and make conclusions. From this definition, the learner becomes the key player towards the use of the skills as he or she looks for the solutions of the existing problem.

Science Process Skills are skills used in carrying out scientific operations, generating useful information, and solving problems (Aktamış & Ergin, 2008). They are fundamental to the teaching of biology concepts that are abstract because they allow the learners to attain some levels of meaningful conclusions when performing the active learning process. Science Process Skills are central to the teaching of science in secondary schools. They are skills devised to enhance meaningful learning of science concepts and theories especially in biology where concepts are abstract (Adeyemi 2008; Ige, 2000).

Acquisition of the Science Process Skills is a key primary vehicle for promoting formal reasoning skills and students' understanding, thereby enhancing the desired learning outcomes in students. These skills are achieved through hands-on, minds-on, and hearts-on activity-based learning processes which makes the learner to be more self-driven (Ibrahim, 2015). Teachers should prepare and guide the learners towards the use of these activities to improve their learning outcomes in biology.

Teachers should also help the learners to develop abilities like predicting, hypothesis, classifying, questioning, investigating, experimenting, discussing, evaluating, inferring, recording, and interpreting information on their own if they will have to appropriately teach sciences in secondary schools (Wolfinger, 2000; Aydogdu, 2010; & Ozgelen, 2012). Science Process Skills Teaching Approach has these stated abilities inculcated in it, which highly promote the learning process.

Abdullah (2007) pointed that the inclusion of Science Process Skills in teaching encourages learners to refine the old and new ideas, and discard inferior ideas to solve novel problems. Further, Akinoglu and Tandogan (2007) state that problem-solving abilities resulting in improved coordination of previous experiences, knowledge, and intuition to determine outcomes of a situation require integration of Science Process Skills in the classroom learning.

Karamustafaoglu (2011) explains Science Process Skills as the key player for the thinking skills required to get scientific information. They are necessary tools for producing and using scientific information to carry out research and solve existing problems. They facilitate the learning of science, active participation by students, a sense of responsibility in their learning, increase permanency in learning, and acquisition of research skills and methods. The learner uses them to solve problems and obtain knowledge and ideas processed in the minds of the learner for better creativity, critical thinking skills, and general performance.

Myers, (2006) and Ozgelen, (2012) tend to agree that, the scientific approach promotes students' ability to seek for knowledge, solve problems, and conduct experiments on their own. They combine learners' psychomotor skills (hands-on), cognitive skills (minds-on), and affective skills (hearts-on) activities during the learning process.

Sevilay (2011) observes Science Process Skills (SPS) as the terminal skills that the learner uses when solving problems or doing scientific experiments that allow the students to develop a sense of responsibility on their own. Science Process Skills emphasizes a learning process that would allow the learner to gain creative skills, engagement abilities, critical thinking, and the value of knowledge. There is a hypothetical-deductive reasoning that most learners rarely play a key role towards the Science Process Skills during learning process.

Mei, Kaling, Xinyi, Sing, and Khoon (2007) classify Science Process Skills into two categories: Basic and Advanced Science Process Skills. All Science Process Skills are complementary to each other and provide the students with the opportunity to reach meaningful learning goals. Blending one with the other makes the learner more focused on how best it is to form a biological concept and become useful for the application.

The basic Science Process Skills include observations, classifying, measuring, calculation, using space or time relationships, communicating, inferring, and predicting (Dahsah, Seetee, & Lamainil, 2017). Martin, Sexton, Franklin, Gerlovich, and McElroy, (2005) and Ngoh (2009), outlines advanced Science Process Skills to comprise of: formulation of hypotheses, the definition of operational variables, identification of variables, control of variables, experimentations, interpretation of data, and the making of inferences.

The Science Process Skills Teaching Approach has some key advantages as it develops learners’ skills useful in solving everyday problems; is activity-oriented, learner-centered and encourages maximum student participation; is motivating and increases students’ interest; allows the development of scientific thinking among learners; facilitates the formation of concepts from primary experiences; and encourages the development of skills in students.

However, it has disadvantages as other non-science disciplines do not seem to benefit much from this approach since it is scientifically oriented; the planning of the activities to facilitate the development of skills among students could be time-consuming and expensive in terms of material resources required. The use of the science education strategies by teachers enables learners to use Science Process Skills to identify and define a problem, generalize, hypothesize experiment, observe, analyze, make inferences, and apply the knowledge obtained.

Studies done in Indonesia showed remarkably low attainment of Science Process Skills hence the different levels of students' achievement having a mixture of low and high achievers (Deta, Suparmi, & Widha 2013; Prabowo, 2015; Rusmiyati & Yulianto 2009; Ambarsari, Santosa & Maridi, 2013). The American Association for the Advancement of Science (AAAS, 2001) attributes the high level of performance in boys in science lessons to the incorporation of basic and advanced Science Process Skills in the learning process. They awaken and stir student-reasoning abilities toward problem solving and improve their perception and understanding of concepts during learning experiences (Ozgelen, 2012). Good reasoning based on a combination of creativity and a high level of critical thinking that most students are poor in promotes learning outcomes in students.

Orhan, (2008); Mei, *et al*. (2007); Lumbantobing, (2005); Tifi, Natale & Lombardi (2006) Notes Science Process Skills to likely make students get used to logical and systematical thinking as they solve problems in their daily lives. Logical minds that students require to apply scientific knowledge in their own lives are useful when learners are logically solving problems.

Sukarno (2013) notes that poor use of Science Process Skills by science teachers leads to poor inclusion of teaching-learning activities hence the learner is partially active. It implies that when using Science Process Skills, the learner becomes the central focus on how the activities drive the attainment of the learning outcomes. KNEC (2020) attributes the low achievement in biology to poor use of Science Process Skills during the learning process. Despite these observations, the report does not specify the skills that need greater consideration.

An investigation by Nyakan (2008) showed that students who learned through the Science Process Skills Teaching Approach attained higher scores in Physics than those exposed to conventional instructional approaches. Blending of the Science Process Skills Teaching Approach with the other teaching methods showed greater improvement towards students' achievement in chemistry and biology (Abungu, 2014; Chebii, 2008 & Myers, 2004). Scientific processes emphasize decision-making and problem-solving skills as significant in any learning process (Anderson, 2002: Reeve, 2016). They have a key role in the learning process.

From the findings above there was a need to investigate whether if a similar approach, when used in biology teaching, was to produce similar results. This study focused on the integration of both basic and advanced Science Process Skills in teaching biology, for the improvement of learning outcomes. The study considered selected Science Process Skills that students acquire and use in the learning process to improve their learning outcomes in biology.

2.1.7. Science Process Skills Teaching Approach and Learners' Self-Efficacy levels in Biology

Self-efficacy is a part of the non–cognitive factors that lead to good learning outcomes because it adds to the perseverance of an individual when encountering difficulties in a learning task (Stankov & Lee, 2017). It is usually indicated by the confidence the learners have towards concepts or problem being solved during a teaching-learning process.

Teaching of all sciences need to be done in a way that it allows the students to investigate, ask questions, find a problem, and collaborate with their peers to seek for solutions to a problem in a confidence way. Confidence is the certainty of a learner to handle an activity (Stajkovic, 2006). Confidence helps to measure the learners' Self-efficacy levels in whatever concept they are been taught. Self-efficacy refers to students' beliefs that assist when organizing, mastering new skills, ideas, and tasks, and regulating actions that result in specific learning outcomes (Nasiriyan, Azar, Noruzy & Dalvand, 2011).

Self-efficacy is key to learners' learning outcomes and influences their memory indirectly (Bandura, 2006). It determines the individual learner's choices, efforts, and the persistence of the efforts in case of difficulties. Most students believe that good self-efficacy leads to success in science tasks, and courses. (Britner & Pajares, 2001; Zeldin & Pajares, 2000).

Secondary school science students mostly depend on their self-efficacy to achieve the expected learning targets inside and outside the classroom (Kupermintz, 2002; Lau & Roeser, 2002). Self-efficacy for self-regulatory learning reflects on individual students' beliefs and capabilities to use a variety of learning strategies like mastery experiences, vicarious experiences, verbal persuasions, and psychological and emotional states (Klassen, Krawchuk, & Rajani, 2008).

A good and well-organized learning process must be able to improve the learner's Self-efficacy levels if at all they have to benefit and get motivated to put more efforts into education. It is concerned with people's beliefs in their capabilities to produce given attainments (Bandura, 2006). Students' level of Self-efficacy can be affected by the effort they spend on an activity, persistence to confront learning obstacles, resilience in adverse learning situations, level of academic outcomes, and choice of environment.

Bartimote-Aufflick, Bridgeman, Walker, Sharma, and Smith (2015) identify some strategies of promoting students' Self-efficacy as facilitating opportunities to work with their peers, helping learners to identify their misconceptions, using technology in the learning process, providing resources and activities for the challenging biological concepts, and encouraging learners to share their personal experiences. Well-designed strategies accompanied by adequately good learning interventions enhance the students' Self-efficacy in biology.

Bandura (2006) gives three dimensions of Self-efficacy as magnitude (level), strength, and generality. Magnitude refers to how difficult a person can adapt to a specific behavior, strength refers to how certain an individual is in performing a specific task, and generality is the degree to which Self-efficacy beliefs positively relate to behavior.

Self-efficacy in the academic field affects students' efforts, perseverance, and emotional reactions to certain tasks in a school. Chemers, Hu, and Garcia (2001) look at academic Self-efficacy as the learner's ability and confidence to master academic subjects and make greater use of effective cognitive strategies in learning. Whorton (2009) maintains academic Self-efficacy as the level of confidence a learner possesses to perform a particular academic task successfully. The success in the academic task varies according to the learner's confidence levels.

Students with academic Self-efficacy skills actively take part in a learning process and have self-regulated activities (Bandura, 2006). The characteristics of Learners with academic Self-efficacy are management of time and learning environment, monitor and regulation of learning efforts. Chemers, et.al (2001), asserts that higher Self-efficacy results leads to increased academic performance. Brickman (2004) relates high academic learning outcomes with increased confidence, and responsibility to complete learning tasks. Learners with high levels of academic Self-efficacy can achieve higher grades and persist in academic challenges than those with lower academic Self-efficacy.

Frey and Determan, (2004) reports that students with high Self-efficacy and less anxiety possess superior abilities and better learning outcomes than those with low. Some of these abilities include identification and solving of problems, innovation, invention, construction of new knowledge among others. Self-efficacy skills can predict academic performance, personal academic goals, and pleasant learning-related emotions (Putwain, sander, & Larkin, 2013). Learners become successful in their studies and persevere academic challenges effectively when they meet their confidence through active role-plays learning. The Science Process Skills Teaching Approach opens the chances for active role-play by the learners that in turn increases their Self-efficacy in biology.

Biology Students having a positive Self-efficacy become successful in their learning outcomes because they can attempt challenging tasks more often, persist longer as they solve the challenges, and exert more effort as they overcome them (Britner & Pajares, 2001; Zeldin & Pajares, 2000). Inefficacious learners shy away from difficult biology tasks, have slackened efforts, give up easily, and are unable to remove barriers in learning process (Ormrod, 2000). Researchers have paid less attention to how classroom teaching of biology contributes to the development of students' Self-efficacy in biology. This provoked the study to focus on how effective the use of the Science Process Skills Teaching Approach improves learners' Self-efficacy in biology.

2.1.8. Science Process Skills Teaching Approach and Creative Skills

Science Process Skills Teaching Approach has skills gained through certain science educational activities that every scientifically literate individual uses to comprehend the nature of science to increase the quality and standards of life (Huppert, Lomask &, Lazarorcitz 2002). Creativity is a mental activity made to produce new extraordinary and unique ideas and concepts (Beghetto & Kaufman, 2010). A human beings innate characteristic can be increased or lowered depending on the environment to which the individual is exposed.

A creative person has; problem-solving skills, the capability of self-evaluation, self-assessment, logical thinking, and a high rate of visualization (Starko, 2013; Ward & Kolomyts, 2010). Gardner (2006) states five activities done by a creative individual that include; problem-solving, production of concepts or theories, achievement styles together with their learning outcomes. Such individuals are in a position to generate new ideas, make an inference, relate, predict, make a hypothesis, recognize problems, interpret the problems, and apply the existing knowledge to solve the problems. Learners become creative in their ideas and products from the learning process that are unique and new and the teachers should encourage them to think laterally and associate different ideas.

Some of the educational activities that emphasize students' creativity in any given science classes include; finding problems in open-ended tasks (Uziaks & Kommula, 2019), students establishing their hypotheses (Cheng, 2010), and testing these hypotheses using designed experiments (Aktamış & Ergin, 2008). Finding multiple solutions to the specific problems already found, discussing and sharing the new ideas, and making links so that they solve real-life problems (Hong, Peng, O'Neil, & Wu, 2013; McCune, 2009; Tam, Heng, & Jiang, 2009; Yager & Akcay, 2008; Yager, Choi, Yager, & Akcay, 2009). Therefore, creative teaching in sciences encourages and inspires students to take risks, make scientific discoveries, and build solid scientific comprehension skills.

In this innovative age, students need to thoroughly comprehend scientific concepts and generate innovative ideas and products that can solve the existing problems within their life situations through the utilization of concepts creatively (Sawyer, 2010). Students need full support in terms of the right resources like teachers with innovative teaching methods and tools to achieve their full creative potentials.

Students view creativity as the ability to create new ideas to challenge the existing ones and get solutions in many different ways (Bjørner, Kofoed, & Bruun-Pedersen, 2012). Educational activities involving Science Process Skills allow students to undertake scientific research that promotes their research skills. Students become creative as they use their Science Process Skills to look for solutions to the problem they have identified.

The abilities of a creative learner include the use of comparisons to express ideas and solve problems (Metaphoric thinking); solve problems; self-evaluation and self-assessment; logical thinking; and have a higher rate of visualization (Starko, 2013; Ward & Kolomyts, 2010). The learners with creativity are normally able to generate ideas, make inferences, relate and predict, give an analogy, and then synthesize the ideas. Learners who learn how to think creatively and develop new ideas from scientific learning usually have high abilities to apply the skills in their working areas (Meador, 2003). These learners are usually sensitive to problems and motivated to find useful, unique, and new solutions to the problems. It is through creativity that the learners build confidence in any acquired information since it is from within their initiatives.

Scientists use creativity in every stage of scientific research to construct knowledge (Abd-el Khalick & Lederman, 2000). Many of the scientific processes have steps designed to allow for the use of some creativity to come up with a new unique idea. Creativity helps learners to recognize gaps in a problem or information, create new unique ideas or hypotheses, test the hypotheses, and then transmit the data through communication as cited by Torrance, in Dass, (2004). Creative learners are creative in performance, easily recognize a problem, think creatively and differently, and find solutions to the problem.

Moravcsik, (2006) explains how learners' scientific creativity are displayed through explanation of science presenting the natural laws, formulation, and comprehension of new ideas, the invention of new experiments coupled with the discovery of new regulatory properties of the scientific research, and giving scientific activity plans and project originality. Students who use creativity are likely to make their science functional and produce a valuable product instead of amassing information.

Science Process Skills Teaching Approach components like Finding problems and formulating hypotheses are important in improving scientific creativity among students. Scientific creativity from a learner who learns through Science Process Skills Teaching Approach is better than for the one using the Conventional Teaching Methods (Meador, 2003; Liang, 2002; Hu & Adey, 2002; Cheng, 2004). Lee and Lee, (2002) notes that creative skills in learners increase when they attain them using Science Process Skills creative activities. Creativity is used especially when introducing a problem, hypothesizing to show how to eliminate the problem, and designing experiments for testing the hypothesis that are all skills of the Science Process Skills Teaching Approach. Learners normally predict a problem based on natural laws and life situations, and possible solutions are given. Studies by psychologists on creativity have shown little concern about scientific creativity gained through Science Process Skills Teaching Approach and that the scientific knowledge and theories are directly taught to the students as they appear in their textbooks without allowing them room to think on their own as cited by Mansfield and Busse in Liang (2002). The teachers teach the lesson in the classroom and demonstrate or give out the procedures of the experiments without allowing the students some time to have their own discoveries and formulations. The learners' scientific creativity in this research was viewed as an educable skill rather than a comprehension endowment or extraordinary skills. This study looked into the extent to which the use of the Science Process Skills Teaching Approach improves the students' creativity levels in biology especially the fluency, originality, flexibility, and elaboration of the biological concepts.

2.1.9. Science Process Skills Teaching Approach and Critical Thinking

The National Council for Excellence in Critical thinking (NCECT, 2014) defines critical thinking as the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication. Developing critical thinking skills in students involves learning the art of suspending judgment and therefore one should adopt a perspective rather than a judgmental orientation.

Critical thinking is concerned with concepts and principles, but not with hard and fast rules. The concepts involved in critical thinking are; identification of a problem, rational inquiry, conceptual analysis, logical reasoning, nature of the argument, and conclusion, while the principles for critical thinking include acquisition of knowledge through thinking; reasoning and questioning based on facts; learning what to think through how to think; and judgment of the effectiveness of argumentations. It employs both logical and broad intellectual criteria of clarity, credibility, accuracy, precision, relevance, depth, breadth, and significance.

According to (Foundation for critical thinking, 2009), Critical thinking has two components which are the skills to generate and process information, and beliefs and habits to use skills to guide behavior based on intellectual commitment. It is self-guided, self-disciplined, self-directed, self-monitored, and self-corrective thinking, which attempts to reason at the highest level of quality in a fair-minded way. Individuals who think critically live rationally and reasonably.

Asyari, Mudhar, Susilo, and Ibrohim, (2015) give the criteria of critical thinking skills in the following order: students to propose a solution, explain an argument or state a problem in an assignment and provide a wrong answer. Step two students propose a solution, explain an argument, or state the problem in an assignment but they are not in a position to make a connection between the reviewed information well and their work improperly presented. In step three, they are in a position of providing the information in step two in a systematic language that is not clear. At step four, the students can provide more solutions or ideas with several examples and their work presented in a clear language. Step five the students have more relevant answers or ideas in acquaintance with the received problems and several facts to provide a sufficient explanation and interpretation in a comprehensive, coherence and concise language.

Critical thinking is highly significant in the learning process. Therefore, critical thinkers should be active learners with skills that make them participate and generate deeply thought information on their own. Dobozy, Bryer, and Smith (2012) view critical thinking as the ability of the learner to tell facts from opinions, to see holes in an argument, to spot illogic, to evaluate evidence, and to tell about the established causes and effects. The student needs to challenge and evaluate their integrity and authenticity of existing ideas and knowledge by use of critical thinking.

Ozden (2011) perceives critical thinking as an active and organized mental process that targets understanding of events, situations, and thoughts in our surrounding world and the persons we interact with by considering our thoughts and the thoughts of other persons. Kim (2009) looks at critical thinking to be able to help in the acquisition of information through active learning, problem solving, decision-making, and utilization of the information. Critical thinking has a strong linkage to Philosophy, Psychology, Pedagogy, and Social Sciences.

Betina and Mike (2014) point out those learners requiring critical thinking to utilize and form reasonable concepts that the brain can process stepwise through the information-processing model. Critical thinking is commonly used in several scientific teaching methods like observation, exploration, construction of reliable knowledge (constructivism), experimentation, and project (Demir, 2015). These methods need students with open minds that can reduce content-centered teaching approaches that result in students' memorization of concepts and the rote learning that limits critical thinking emphasized by learner-centered approaches.

According to Osborne (2014), critical thinking is among the higher-order cognitive process of evaluation, critique, and synthesis that are distinguishable from the lower orders like recall and applications that are the key demands of cognitive levels. Developed critical and reflective thinking skills that limit rote learning and narrow minds towards concepts increases the students' ability to see, think, comment, question, research, and resolve events scientifically.

Demir, (2015) notes that the development of critical thinking during formal education goes through different perspectives and the actively practiced Science Process Skills that apply suitable teaching techniques. Students need guidance on how to become active independent learners by developing skills that have logical and critical thoughts. Some of the active practices embedded in the Science Process Skills Teaching Approach include problems solving techniques, Inquiring–Based Learning, project, experiential learning, Problem-Based-Learning (PBL).

Osborne (2014) outlines three ways of fostering critical thinking among learners in a classroom situation as opportunities to engage learners in critique argumentation and questioning for them to develop the ability to reason and understand science. Secondly, driving learners to criticize or challenge the already formed knowledge; lastly, critical comparison between the shreds of evidence within the learners' predictions and what they observe to maintain the objectivity of science.

Further, Abrami et al. (2015) argue out that it is most effective to foster students' critical thinking skills through provision of practices that allows them a dialogue and exposure to the authentic problems. These practices seem typical for the stimulation of the learners' critical thinking skills, which are against the traditional teacher-focused ones that in most times teachers have used to transmit information to students.

Pedrosa-de-Jesus, Moreira, Lopes, and Watts, (2012) states that a provoking and questioning learning context fosters the critical thinking levels of students. Critical thinking-centered questions accompanied by Science Process Skills Teaching Approach activities allow the students to develop a positive attitude towards the concepts taught.

Abrami, Bernard, Borokhovski, Wade, Surkes, Tamim, and Zhang, (2008); Genc, (2008) states that learners' critical thinking skills are promoted when there are creation and sustenance of a learning environment that encourages students to express their ideas, explore, take risks to share successes and failures, and questions to each other. Critical thinking also requires students to be given time to think, experiment for themselves, stimulate discussions, and reflect on action through provoking questions and approaches (Rui Marques, Celina, & Isabel, 2011). An idea well thought, explored, discussed, and experimented with makes learners critically look at an existing problem in any situation and give solutions to it.

Active learning tends to promote higher-order critical thinking skills such as analysis, evaluation, inductive and deductive reasoning, and hence effective learning (Hooey & Bailey, 2005; Bedford, 2010). Critical thinking plays a key role in the effective and sufficient acquisition of knowledge among learners when exposed to provocative activities that involve active learner participation. This study targeted on how to make students active in the learning process for the effective development of critical thinking skills in biological concepts using the Science Process Skills Teaching Approach.

2.1.10. Science Process Skills Teaching Approach and Students' Academic Performance in Biology

Academic performance forms the major detector for performance in schools in both regular and alternative basic education. Academic performance is the measure of the student-learning outcome at the end of the teaching-learning process. Academic performance results from learning that have teaching activities displayed by both the teacher and the student, whose product is reflected by the learner when expressing it in terms of grades or score after doing the examination (Martinez, 2007). The grades express either passing or failing of examinations or assessments done by the students in certain tests, subjects, or courses. Measurement of any success of an educational institution is usually based on the academic performance and the students' ability to apply learned knowledge but not on the test and examination results obtained by students (Yusuf, 2012).

Narad and Abdullah (2016) define academic performance as the knowledge gained by students assessed through use of marks scored by the teachers or educational goals achieved by students during a learning process. Academic performance involves factors like intellectual levels, personality, motivation, skills, interests, study habits, Self-efficacy and Self-esteem, and the teacher-student relationship.

It possesses an amorphous nature since it broadly incorporates various factors ranging from becoming a professional to the development of students' abilities and skills (York, Gibson & Rankin, 2015). In academic performance completion of courses, gaining knowledge and skills are good measures of the levels of academic performance among students. Sound academic performance is a prerequisite that enables the learners to secure good jobs, better careers, and subsequently a quality life.

According to Narad and Abdullah (2016), the success or failure of any academic institution depends largely upon the academic performance of its students from a test scored over a given period of the learning process. Students' academic performance is mostly the result of learning prompted by the teaching activities by the teacher and produced by the student during the learning process.

Afe, (2001) argues out that the effectiveness of a teacher has a great influence on the students' academic performance because the teacher is a facilitator in the teaching and learning process. In an active learning approach like Science Process Skills Teaching Approach, teachers facilitate activities that permit students to be responsible in the learning process and provide them with the opportunities to encounter the concepts hence an improvement in the academic performance. The students should actively build knowledge and be aware of their ways of learning to increase the chances of them getting better grades. This involves giving them control of their learning, preparing questions to promote discussions, and planning activities that require the students' active participation.

Caballero, Abello, and Palacio, (2007) argues out that academic performance is all about the learners meeting their goals, achievements, and objectives set in their course of the learning process. Grades that are as a result of an assessment or examination express the extent to which the students have passed or failed the tests on the subjects and helps to value whether the academic performance is poor or better.

Barca, Peralbo, Brenlla, Seijas, and Santamaría (2003) point out the key determinants of academic performance to be the learning approaches used by teachers during a learning process. Good teaching approaches lead to high grades in a test as a measure of academic performance. Academic performance provides a point of reference to how much the learner has successfully acquired the expected knowledge from the learning process.

2.2: Theoretical Framework

Constructivism and Experiential-learning theories where the Constructivism Learning Theory (CLT) views the learner as a constructor of new knowledge while in the Experiential Learning Theory (ELT) the learner builds new knowledge from experiences.

2.2.1. Constructivism Learning Theory

The theory has its historical roots in the work of Dewey as cited in Gutek, (2014); Vygotsky as cited in Moyer, Hackett, & Everett, (2007); and Piaget as cited in Mascolo & Fischer, (2005). Piaget as cited in Mascolo & Fischer, (2005) views the learner to be in position of gaining knowledge through the process of reflection and active construction in the mind. They believed that the context in which teachers teach an idea as well as the students' beliefs and attitudes towards the idea, affects the students' learning process.

Constructivism is an approach that holds the view that learners should actively construct and make their knowledge by determining reality through their active encounters (Elliott, Kratochwill, Cook, & Travers, 2000). The learners actively construct and understand concepts when derived from meaningful connections between the prior knowledge and experiences with the new through the learning processes that forms the central idea of the constructivism learning theory.

The teacher provides opportunities for the learner to construct their own knowledge through engaging in self-directed inquiry, problem-solving, critical thinking, and reflections in the real-world context. Teacher ought to provide environment where the students can construct the new knowledge from pre-existing knowledge.

Loyens, Rikers, and Schmith (2009) outline four characteristics of the constructivism learning theory as knowledge construction, cooperative learning, metacognition, and authentic learning. According to the theory, knowledge construction is done from pre-existing knowledge and from inside the learners but not an external phenomenon (Schunk, 2012). A learner should be creative, critical, and with an open mind if effective construction of new knowledge ought to be achieved.

The theory encourages students to use active participation approaches that involve hands-on, minds-on, and hearts-on activities like experimentations, projects among others to create more knowledge, reflect on the knowledge, and communicate their understanding of the new knowledge (Oliver, 2000). Students need to be actively innovative, creative, and critical as they construct the new knowledge which to some extend improves their self-efficacy.

Yilmac (2011) advances the presentation of the Piagetian perception on the existence of knowledge in the mind of the learner to be in schema forms constructed based on pre-existing knowledge. They are supposed to bring their own unique experiences into their classroom in every day's lesson if they have to construct new schemata of the knowledge and become creative.

Learners remain active throughout and they apply current understanding, note new relevant learning experiences, and the consistency of prior and emerging knowledge to promote the modified knowledge (Phillip, 2009). Constructivism Theory has key benefits that include:

i. The learners learn and enjoy more when they are actively involved rather than being passive.

ii. It concentrates on the learners' thinking and understanding rather than memorization and rote learning.
iii. Allows for transfer of principles from the learners to other learning settings to make the application of knowledge possible.
iv. It gives the students ownership of the learned concept because the learning is through questioning, explorations, and discussions. Students' creativity instincts allow the development of the abilities to express knowledge and retain more.
v. They engage students more because the learning activities are on the real-world context.
vi. Promotes learners' social and communication skills when they emphasize collaborative learning, team learning, self-regulatory learning, and exchange of ideas.

Teachers in most of the schools teach biology such that students need to memorize most of the abstract concepts and gain less of the real-life applicable skills. This study used the constructivism theory to show how the construction of new knowledge from pre-existing ones through the active involvement of the learners improves the learning outcomes in biology. Learners apply knowledge effectively in real-life situations as long as the opportunities to construct it within themselves are at their disposal.

2.2.2. Experiential Learning Theory

Experiential learning theory (ELT) drawn from the work of Dewey as cited in Gutek (2014), Kolb, and Kolb, (2017), and Lewin cited in Smith (2001). Dewey views experiences to be the basis of the learning process. From this theory, the learners are expected to strive to make sense of what they are learning by relating it to their prior knowledge and discussing it with others. A learner's intelligence is not only an inborn characteristic but also a result of interactions of the learner with the environment (Yoon, 2000). Lewin emphasizes that the learner has to be active in the learning process. Generally, the theorists base learning on experiences, active participation, and appropriate interaction of the learner with the resources, content, and other learners.

The focus of this theory is the experience, which serves as the driving force in the learning process of the students. Kolb (2014) found out experience as the source of learning and lesson development among learners in any learning environment. Baker, Jensen, and Kolb, (2002) supports that knowledge constructed through the transformative reflection on the learner's experiences forms the basis for the new experiences linked to the learner's prior experiences. Transformative reflection enables the learners to interpret and reinterpret concepts to shift their view of the idea into new more updated one.

Kolb, and Kolb, (2017) talks of learning as the process that helps in the assimilation of new experiences into the existing concepts and body of knowledge; learning is the process of creating knowledge where creation and recreation of social knowledge in the learner takes place. Therefore, the ELT indicates that through the transformation of experience, learners in a learning situation create knowledge. The transformation of experiences has their basis on facts, developed observations, and created theories usable in solving problems and allowing the learner to make decisions.

Experiential Learning Theory defines learning as a process involving four phases: concrete experiences (apprehension), reflective observations (intentions), abstract conceptualization (comprehension), and active experimentation (extensions) (Bahar & Bilgin, 2003). At the concrete experiential phase, the learners should have concrete experiences based on facts of the topic related to daily life situations and activities accompanied by examples. Analysis and role-play activities by the learner should be appropriate to the learning method used, which is rarely the case for most biology teachers. Learners gain high self-efficacy levels and creative skills when they are involved in role-play activities.

Reflective observations phase allows the learner to develop various perceptions of thinking about what has been learned and observed (Kolb & Kolb, 2006). Learner's thoughts and opinions are reflected and questioned giving room for critical thoughts and decision-making to dominate. The nature of the teaching-learning method used usually determines the level of reflective observations the learner is bound to make.

Abstract conceptualization focuses on theoretical knowledge about the thoughts and concepts of a topic that can explain the observations of the learner. A teacher summarizes and explains the concepts appropriately for the learners to base their experiences as they learn new knowledge (Healey & Jenkins, 2000). During the study, the learners were able to comprehend the logical structure of what they had learned through their experiences and interaction with the biological concepts.

Active experimentation phase is where the learners implements what they have learned through active participation instead of the common approaches of sitting to observe and listen. Students prefer implementing what they have learned on their own because they prove the knowledge useful to them (Hein & Bundy, 2000, Kılıç, 2002). Implementation through active participation gives the learner a chance to be creative and modify the learned knowledge to the life situations, solve problems, and ultimately build high levels of self-efficacy. Using Science Process Skills within the experiential learning cycle helps the learners to develop basic skills, experimental process skills, and causative process skills.

Experiential learning involves activities such as setting goals, thinking, planning, experimentation, reflection, and observations, which form some of the key Science Process Skills activities.

It enables the learners to develop metacognitive skills and increases the abilities of self-learning on their own (Kolb & Kolb, 2006). When the learners are engaged in activities, the construction of new meaningful concepts in a unique way is possible, because they incorporate cognitive, emotional, and physical aspects of learning into the learning process. Examples of experiential learning are cooperative education, service learning, problem-based learning, conversational learning, active learning, student-centered learning, and e-learning which all have the Science Process Skills embedded in them.

Experiential Learning Theory builds itself on six proponents: learning is a process but not an outcome, which is improved if the primary focus is on the engagement of the students in the process. Education is continuous reconstructions of experiences build one after the other. Learning is a relearning process from prior knowledge which is facilitated by a process that draws out the students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with the new and more refined ideas learned. Learning requires resolution of conflicts about a concept and therefore the process is a conflict driven with differences, and disagreements about the concept. Learning is a holistic process that involves the integration of the total human thinking, feelings, perceptions, and behavior. Lastly, learning is because of the transactions between the learner and the environment they are exposed (Dewey as cited in Gutek 2014).

Through Science Process Skills activities, learners relate their prior experiences with the new experiences to form new knowledge that with time improves the learning outcomes in biology, unlike the Conventional Teaching Methods that are passive to the learners. This study used the Experiential Learning Theory to point out how the existing experiences used by the learners form new experiences that form new knowledge to improve the learning outcomes in biology. Learning that applies the six proponents of the experiential learning theory is said to improve learning outcomes in biology among learners.

2.3. Integrated Theoretical Framework

Constructivism's central idea is on learning as an active process where the learner is the key role player with activities that promote formation of knowledge. The teacher is required to act as a facilitator to help the learner to be an active participant in the learning process. The learner through active participation makes meaningful connections between the prior knowledge, new knowledge, and the process involved in the learning (Phillip, 2009). Reconstitution of varieties of hands-on, minds-on, hearts-on activities is for ensuring that the learners are more active and effective in acquiring knowledge.

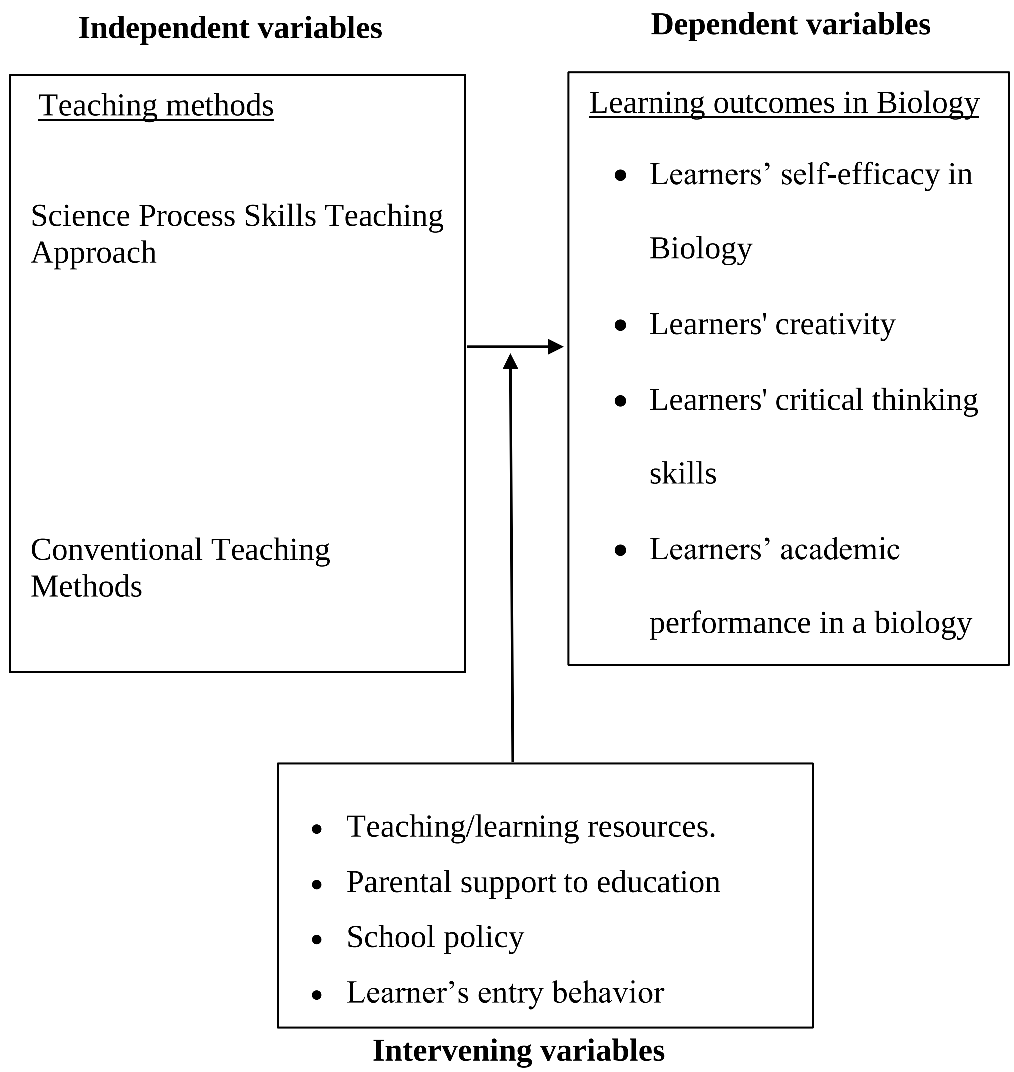
The role of the teachers is to design learning situations and make appropriate rules for the construction of new knowledge (Moustafa, Assaraf & Eshach, 2012). The teacher ensures the following; the learners understand the pre-existing knowledge, guide the activities and the use of the learning resources, encourage the learners' interactions, engage the learners in the learning experiences, and provide time for the construction of the knowledge for better learning outcomes in biology.

The theory was related to the research by the fact that the students used the Science Process Skills Teaching Approach to construct new knowledge as the teachers played the role of a facilitator during the study. Learners developed creativity and critical thinking skills as they constructed knowledge using the Science Process Skills Teaching Approach in their learning process.

Experiential Learning Theory as per Baker, Jensen, and Kolb (2012) has its main driving force on knowledge construction through the transformative reflection of one's experiences. Experiences gained through the learning cycle comprises of concrete experiences, critical reflections, abstract conceptualizations, and active experimentations. The research borrowed the learning cycle of the Experiential Learning Theory to relate the Science Process Skills to the construction of new knowledge.

During the study, learners encountered new experiences, interpreted the existing experiences at their disposal, formed new ideas, modified those that were existing, compared gained experiences with their understanding levels, and then applied the new and the modified experiences that resulted to improve the learning outcomes in Biology. The learners used Science Process Skills embedded in the learning cycle of the learning experience theory to construct knowledge from their prior experiences (Kolb & Kolb, 2006). The two theories collectively help in the formation of new knowledge through showing how the learners are the key players in construction of ideas from within their own and from related prior experiences.

2.4 Conceptual Framework on the Relationship between the Science Process Skills Teaching Approach and Learning outcomes in Biology.



Source: Researcher's Formulation.

Figure 1:
Conceptual Framework on the Relationship between the Science Process Skills Teaching Approach and Learning outcomes in Biology.

In the conceptual framework labeled Figure 1 the Science Process Skills Teaching Approach and Conventional Teaching Methods are the independent variables. Science Process Skills Teaching Approach has Basic skills, which include observations, recording, predictions, and measurements, and advanced skills, which are the formulation of hypotheses, experiments accompanied by interpretation and inferences.

Conventional Teaching Methods include lectures, content drilling, and copying notes among others. The research adopted the integration of several Science Process Skills of the Science Process Skills Teaching Approach as independent variables to find out their relationship with the learners' learning outcomes, which are the dependent variables. The study categorized the dependent variables into; students' Self-efficacy in biology, creativity, critical thinking skills, and academic performance in biology.

The intervening variables that influenced the independent variables in explaining the outcome of the study were Teaching/learning resources; Parental support to education; School policies, and Learner's entry behavior. The Co-educational public secondary schools chosen within Makueni County had the same characteristics to ensure a good comparison of the outcomes from the study between the interventions of the Science Process Skills Teaching Approach and the Conventional Teaching Methods towards students' learning outcomes in biology.

Teaching and learning of sciences require more blended learner-centered approaches that can improve the experienced low learning outcomes in Biology in the Kenyan secondary schools. Improvement of the learners' skills and abilities using the Science Process Skills Teaching Approach in this study proved that it is easy to construct new knowledge from the existing body of knowledge.

2.5 Research Gaps

Demir (2015) outlined the useful activities in teaching learning as experimentations, projects, explorations, interpretations, observations, measurements, calculations, demonstrations, drawing, and construction of knowledge, among others which are examples of the Science Process Skills. Teaching methods, which the biology teachers have being using, have had less activities but Science Process Skills Teaching Approach can have more, which can allow learner-centered teaching. Therefore, this study looked into whether the paradise shift to the use of Science Process Skills Teaching Approach by biology teachers would promotes minimal learning outcomes in biology.

Kinnear, Boyce, and Bennett (2004) support that the Science Process Skills Teaching Approach allows for better development of skills, knowledge, and attitudes that are in line with the content taught and learned compared to the learners taught using the Conventional Teaching Methods due to the activities in it. Low learning outcomes noted by KNEC (2015-2020) in KCSE has been associated with less participation of the learners in the learning-process due the nature of the teaching methods used. KNEC reports have been giving minimal information on the relationship between Science Process Skills Teaching Approach activities and learners' learning outcomes in biology in Kenya Makueni County included hence this study was necessary.

A study done by Nyakan (2008) on the effectiveness of the Science Process Skills Teaching Approach for Form Two physics students, showed that the students exposed to Science Process Skills Teaching Approach had high learning outcomes in their creativity levels, Self-efficacy, and critical thinking than those exposed to Conventional Teaching Methods. The attainment of these skills in biology have been too low leading to the low academic performance in national examinations (KNEC, 2020) hence the need for this study to find out whether similar results as seen in physics by Nyakan (2008) could come out when Science Process Skills Teaching Approach was used in teaching biology.

CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

3.0. Introduction

This chapter looks into research methodology, research design, location of the study, target population, sampling procedure, and sample size, the instruments used to collect data, piloting of the instruments, validity and reliability testing of the instruments, data collection methods, and procedures, data analysis techniques and procedures, and lastly the ethical considerations.

3.1 Research Methodology

This research adopted a mixed research methods approach that uses both qualitative and quantitative research methods and relied purely on the primary data to effectively address the key research objectives. Qualitative method provided qualitative data from a five-point Likert scale questionnaire that was converted to quantitative data for effective data analysis and interpretation. The quantitative method provided numerical data from the standardized Biology Assessment Test organized into tables for easy analysis and interpretation.

3.2 Research Design

The study used a Quasi-experimental research design involving the Solomon Four Non-Equivalent Control Group Design as studied by Borg and Gall cited by Githua and Nyabwa (2008). Quasi-Experimental research design evaluated the effect of the teaching interventions of the Science Process Skills Teaching Approach against the Conventional Teaching Methods.

Classes in schools within the research region were intact and their students randomized for the purpose of the study. Non-Equivalent Control Group design in this study refers to the control and experimental groups participants' characteristics, which were unbalanced within the participants because they were from different Sub-Counties in Makueni County. Solomon Four Non-Equivalent Control Group Designs symbols were adopted as proposed by Wiersmal (2000) where C1 and C2, E1 and E2, represent Control and Experimental groups respectively.

Group	Pre-test	Intervention	Post-test
Group 1 (E1)	T1	RX	P1
Group 2(C1)	T2	-	P2
Group 3(E2)		RX	P3
Group 4(C2)		-	P4

(Source: Best and Khan, 2003).

Figure 2:
Solomon Four Non- Equivalent Control Group Design

The adoption of the design was because secondary schools' authorities do not normally allow their classes to be dismantled and reconstituted for purposes of a study which if done could be unethical and outside the school's traditions and customs (Shadish, Cook & Campell, 2002). Therefore, the classes were maintained in their intactness during the study period

Co-educational Sub-County public secondary schools in Makueni County were used from which, E1 and E2 were randomly assigned to the experimental groups that received the interventions of Science Process Skills Teaching Approach in teaching while C1 and C2 were the control groups that were exposed to the Conventional Teaching Methods. A pre-test examination labeled T1 and T2 was administered to E1 and C1 groups respectively while a post-test examination labeled P1, P2, P3, and P4 was administered to all groups after the interventions as shown in Figure 2. Both the pre-test and post-test comprised of Biology Achievement Test (BAT) and the five-point Likert scale questionnaire items constructed by the researcher. Rx represented the intervention or treatment by use of the Science Process Skills Teaching Approach made for the E1 and E2. The denotation (-) implies no intervention to C1 and C2 (Mugenda & Mugenda, 2003).

The dotted lines between E1, C1, E2, and C2 indicated that the groups used in the study were intact. The co-educational public secondary schools were allocated their respective groups for the study using random sampling technique.

3.3 Location of the Study

Conduction of the study was in co-educational Sub-County public secondary schools in Makueni County, Kenya which lies between Latitude 1° 35' and 2° 59' South and Longitude 37° 10' and 38° 30' East. It borders Machakos to the North, Kitui to the East, Taita Taveta to the South and Kajiado to the West and covers an area of approximately 8,008.9 km^2.

Generally, Makueni County has irregular rains in most of the Sub-Counties which seriously affect the key economic activities of agriculture relied on by the parents for the payments of boarding and lunch money to maintain their students in school throughout. It has accessible weather and tarmacked roads with Mombasa-Nairobi highway traversing through the County.

Majority of the schools in the county had opportunities of exposing both genders to the study without comparing them. Students of these schools were of low to average abilities with a few who had joined having high abilities after they had dropped their national and extra-county admissions due to financial constraints from their parents or guardians, and some of the parents or guardians feared the long traveling distance between these schools and their homes.

Purposive selection of the county was because of the consistent posting of poor biology results in Kenya Certificate Secondary Education (KCSE) within several years consecutively. The highest mean score posted by the secondary schools in Makueni County within the last five years from 2020 has been 4.203 which is below the average mean score as in Table 2 (Makueni County Educational Office KNEC-KCSE report, 2020) and hence the need for the choice for the location of study.

Makueni County had a large number of public secondary schools that increased the probability to purposively sample the public co-educational secondary schools and provide better findings on the relationship between the Science Process Skills Teaching Approach and learners' learning outcomes in biology hence it was necessary to choose the County for this study.

3.4 Target Population

According to Ogula (2005), any group of institutions, or people, or objects, or subjects that have common characteristics makes a population, which can be used by researchers to carry out research in a particular aspect. Individuals of a population are exposed to the research interventions in accordance to the research objectives from where conclusions are drawn. Target population provides a study data required for making inferences (Cox, 2013). Borg and Gall (2003) perceived the target population as the one that provides a solid foundation of information and the first step upon which validity and reliability of the study are embodied. The target population had common characteristics that provided information that formed the basis in which the study embedded its data to test the research hypotheses. Target population for this study was 119,225 secondary school biology students in Makueni County with the accessible population as the Form Two Biology students in the public Sub-County co-educational secondary schools which had trained biology teachers who were relied on for the accurate teaching of the topic on gaseous exchange during the research period. The information about the 390 public secondary schools and the 25 private secondary schools that gave 415 schools in the county was from Makueni County educational office.

Majority of the students within and outside Makueni County are absorbed in the public secondary schools with a few joining the private schools (Makueni County Educational Offices, 2020). Therefore, the study was based in the public secondary schools to increase the chances of getting better findings of the relationship between Science Process Skills Teaching Approach and learners' learning outcomes in biology. The following categories of public secondary schools exist in the County; National single-sex, single-sex extra-county, Single Sex County, Co-educational County, Single-sex Sub-County, and co-educational Sub-County.

The study purposively focused on 322 co-educational public Sub-County secondary schools because of the mixed-gender characteristics in them to avoid biasness. Approximately 119,225 students were the total population of the students in the County out of which 31, 574 were Form Two Biology Students with a population of boys as 15,503 and girls 16,071 (Makueni County Education Offices KNEC-KCSE report, 2020). Table 3.1 shows the total number of Form Two Students, in Makueni County.

Table 3.1:
Total Secondary Schools' Form Two Biology Student Population in Makueni County.

Gender	Population	Percentage
Boys	15,503	49.10
Girls	16,071	50.90
Total	31,574	100%

Source: Ministry of Education Science and Technology (2020). February Staff Returns. Makueni County Educational Offices, Kenya.

Form Two Students were sampled for this study because of the following reasons: the one year's exposure to secondary schools' science curriculum; they had already adjusted to the secondary schools' education, and had attained a stage at which students develop interests in biology.

The results of the study were made to establish how learners' skills are boosted to enhance their interests in biology and increase the number of students taking biology up to form four through the use of the Science Process Skills Teaching Approach. Biology for all Forms One and Two students in the public secondary schools of the County is compulsory just as it is in any other Kenyan secondary school and hence the main reason why the choice of the Form Two Biology students as the accessible population was necessary.

3.5 Sampling Procedure and Sample Size

The research randomly sampled the four Sub-Counties based on their common characteristics and the distance from one another. This minimized the incidences of contamination of the groups to be used in the study since they were far from one another. The randomly sampled Sub-Counties formed 44.4% of the total Sub-Counties in Makueni County, which was a good representation for effective collection of data. This sampling met the requirements for the Quasi-experiment research design that allows only four groups to participate in any study.

Purposive sampling was used to select the Sub-County co-educational public secondary schools because the county comprises of both single sex and mixed schools with the mixed public schools forming the highest percentage of 77.60% compared to the unisex with 16.40%. Co-educational schools were chosen purposely because their populations were well spread and were many to give accurate data. Purposive sampling is appropriate where the researcher has previous knowledge about the population and has a specific purpose and targeted personal judgment in selecting the sample (Fraenkel & Wallen 2006). Selection of the co-educational schools was made to ensure the study was not biased on specific sex. Sampling focuses on selecting information-rich participants who when used appropriately can answer the questions under study (Patton, 2009). From the target population of 119,225 students in Makueni County 26.50% Form Two Biology Students formed the accessible population. These students were mature and conditioned to secondary school education hence suitable to provide data for this study.

This study adopted stratified random sampling to select the four co-educational Sub-County public secondary schools from the 322 schools one from each Sub-County with comparable characteristics from Makueni County. Stratified random sampling considered getting unit from the secondary schools' classes but not an individual student because the nature of the learners' classes occurs as intact groups (Gall, Gall, & Borg 2003). These intact classes have students taught as a class and therefore any intervention would affect all. The schools sampled had the standard class size according to ministry of education but not below.

The research was in each of the co-educational public secondary schools of the randomly selected Sub-Counties whose classes had a class size above 40 students with smallest class as 45 and the highest 54. Table 3.2 gives the total number of public secondary schools and the co-educational schools that provided the sample schools per Sub-County in Makueni County.

Table 3.2:
Distribution of public Secondary Schools per Sub-County in Makueni County

S/No.	Sub-County	Total number of schools	Total number of co-educational schools
1.	Makueni	45	37
2.	Kathonzweni	38	31
3.	Makindu	28	22
4.	Kibwezi	68	56
5.	Mbooni East	48	43
6.	Mbooni West	41	35
7.	Kilungu	24	19
8.	Nzaui	56	44
9.	Mukaa	42	35
	Total	390	322

Source: Makueni County Educational Office (Staff Returns Feb 2020).

Stratified random sampling technique used to select the four public co-educational secondary schools ensured that they are quite apart to avoid interactions during the study. It ensured that the randomly sampled school had the following characteristics; is a Sub-County co-educational secondary school because they are the ones that admit the majority of the students; students' enrolment was within the Ministry of Education, Science and Technology (MoEST) class population; adequacy of teaching and learning resources supplied by the ministry to the public schools; and the choice of the topic was "Gaseous exchange" which is taught in Form Two because learners poorly achieve in it in KCSE questions (KNEC, 2020).

Gaseous exchange was chosen because it is fundamental to the next two topics of respiration, and excretion and homeostasis in the Form Two Biology syllabus. All these criteria were acquired from the Sub-County educational office in which each of the randomly sampled co-educational schools was found except the availability of teaching and learning resources and the accurate enrolment in Form Two which were obtained from the respective selected school.

Expert judgments based on prior experience concerning the desired information were used to select the public secondary schools as per (Mugenda & Mugenda, 2003). Four out of the 322 Sub-County co-educational public secondary schools were randomly sampled as per Quasi-Experimental Solomon Four Non- Equivalent Control Group Design, which requires four groups to be involved in any study.

Two hundred and four Form Two Biology Students were involved in the study from an accessible population of 31,574 with a student population per group as E1=53, E2= 52, C1= 54, and C2=45 respectively with age of fifteen years on average. This formed the sample size for the study. Two of the schools were assigned to be the experimental groups that received the interventions of the Science Process Skills Teaching Approach while the other two were exposed to the Conventional Teaching Methods that served as the control groups for the study.

Two of the randomly sampled schools one being an experimental group and the other a control group had two streams and therefore the biology teachers of the experimental group exposed all their two streams to the Science Process Skills Teaching Approach for ethical considerations. The control group was taught using the Conventional Teaching Methods.

In the control group that had two streams, still the teachers exposed the students to the Conventional Teaching Methods. The sampled schools that had two streams, the study randomly sampled one stream from the class to consider its data for analysis in accordance with the research objectives and the respective research instruments.

3.6 Data Collection Instruments

A research instrument collects information (data) to answer the research questions for any study (Fraenkel & Wallen, 2000). The research used both qualitative and quantitative approaches that provided the qualitative data from the five-point Likert scale questionnaire and quantitative data from the Biology Assessment Test. Assessment of learning using a variety of tools and techniques like tests and questionnaires provides feedback on the learning and teaching processes (Parker, 2005). The assessment of the learning outcomes and measurement of the confidence level in biology in this study provided qualitative and quantitative data for analysis.

The most popularly used tools in assessing learning outcomes have been standardized achievement tests, (Haladyna, Downing, & Rodriguez, 2002). A five-point Likert scale questionnaires tested the learner's Self-efficacy in biology while Biology Assessment Test (BAT) tested learners' creativity, critical thinking, and academic performance.

3.6.1 A Five-Point Likert Scale Questionnaire for Testing Student's Self-Efficacy in Biology

Towards the end of the study, a five-point Likert scale questionnaire provided qualitative data about learners' Self-efficacy in biology from the students of the randomly sampled co-educational public secondary schools. Likert scale measures the respondents' feelings, opinions, attitudes, investigative motives, and mastery of content (Weng & Cheng, 2000). It describes the set of items comprising of equal number of favorable and unfavorable statements about opinions, attitudes, and feelings of the respondents (Saunders, Lewis, & Tornhill, 2009). The statements have values that rate respondents' levels of the feelings, and opinions.

The use of the scale was easy and quick because the respondents understood it very well before administration. It measured feelings, mastery of content, opinions, perceptions, among others according to the degree of confidence about concepts the respondents had learned using the range of statements by providing responses.

According to McLeod, (2008) data from a Likert scale assumes the measurement of the strength or the intensity of the respondents' opinions to be on a linear scale. The respondents had a choice with a neutral point hence that was the reason why it was in ordered categories. Therefore, the treatment of the Likert scale data was as the ordinal level of measurement but not nominal measurement because it had specific ordered categories (Jamieson, 2004). The questionnaire had ten-ordered item covering different aspects of the learners' confidence that was subjected to all the groups involved in the study.

Likert scales normally arrange or rank data in a way that gives equal intervals between points on the scale but with no natural zero point (Brown, 2011). The determination of the individual students' confidence level was through calculating the average from the rating of the questions in the questionnaire.

Likert scale has Likert items combined into a single composite score or variable for easy data analysis (Boone & Boone, 2012; Joshi, Kale, Chandel, & Pal, 2015). The scale rating that described not at all confident and slightly confident were combined to become below confidence while the ones on quite and extremely confident formed above confident category with those who displayed confidence remaining as a category of its own for easy data analysis and interpretation of the effects of the interventions.

The items in the Likert scale had common ideas, interrelated, logically sequential, and coherent hence rated to give the opinions and perceptions of the respondents in the specific constructs of the research objective. Visual display of the scale on a paper in form of a questionnaire is made for easy and quick administration since the scale only needs an explanation to the respondents and they give their responses from where the data is compiled (Murray, 2013).

The design of the five-point categorized type of response scale is from a series of questions with measuring scales alongside each of the questions (Boone& Boone, 2012). The statements were rated at the end with values that the learners could understand to enable them give accurate data.

The reason for using the Likert scale in educational and psychological research is to collect data from a phenomenon measured by nominal or ordinal scales (Jakobson, 2004). Joshi et al. (2015) provides the logical arrangement of characteristics of items that helps to guide in preparing a Likert scale. They include, the arrangement of the items in a logical sequence, close interrelating of the items to provide some independent information, sorting out the elements that are cohesive so that they can be able to measure a distinct element of an issue. These characteristics make the Likert scale to be at a point of measuring specific elements at its own perceptive.

Measurement of the students' Self-efficacy levels was based on the magnitude, strength, and generality of their confidence levels. It was rated in the levels of the learners' degree of confidence ranging from 1-5 where 1 represented not at all confident, 2 slightly confident, 3 confident, 4 quite confident, and 5 extremely confident. The rating of the questionnaire assisted in the conversion of the qualitative data to quantitative data for quick and easy analysis and interpretations.

Confidence provides individuals with the certainty to handle an activity or process an idea. (Stajkovic, 2006). The Likert scale in this study combined the items to provide the qualitative measure of the learners' Self-efficacy based on their confidence levels on the concepts they learned on gaseous exchange. The computed mean scores from the Form Two Biology learners' responses measured their levels of Self-efficacy in the chapter of gaseous exchange as either: highest, high, low, or lowest.

The researcher supplied the questionnaires to the biology teachers of the respective randomly sampled co-educational public secondary schools, which the researcher collected later. The treatment of results from the Likert scale questionnaire was with a lot of confidentiality and anonymity.

3.6.2 Biology Assessment Test (BAT)

This study used the Biology Assessment Test (BAT) that had test items made to provide quantitative data from the students. It provided quantitative data about the learners' creativity, critical thinking, and academic performance. BAT comprised of questions ranging from the high to the low order level as per the revised Bloom's taxonomy (Seaman, 2011). The revised bloom's taxonomy was used to guide and assist the researcher in preparing valid and standardized BTA to ensure the questions, conditions for administering, scoring procedures, and interpretations are consistent and suitable for the students (Anderson et al., 2001). Standardization of a test makes the scores reliable to indicate the measured abilities or skills from the learners.

The Biology Assessment Test objectively tested the learners' levels of, creativity, critical thinking, and academic performance. It had a short answer items' format as modeled in section A of KCSE biology paper two examinations. It had 70 marks well distributed following the revised Bloom's taxonomy allowing independent score of 35 for creativity and the other 35 for critical thinking that were later summed up and converted to 100% to measure the students' academic performance levels. The administration and scoring of the questions of the test were in a predetermined and standard manner.

Biology Assessment Test had section A that tested the learners' creativity on originality, fluency, and flexibility of ideas (Rababah, & Methem, 2015). These scholars described originality as the ability of a learner to produce distinct and personal ideas, and provide solutions to problems, fluency as the ability to produce novel ideas, and flexibility as the ability to produce various ideas.

A Torrance Test of Creative Thinking (TTCT) accompanied by descriptive and inferential statistics determines the students' creativity levels. Test on creativity levels in section A of the Biology Assessment Test, adopted the revised Bloom's taxonomy according to Krathwohl, (2002), which places creativity above evaluation hence is a higher-order skill.

The total marks for section A on creativity ranged from Zero (0) to 35 taking care of the three components of creativity measured giving a maximum score of 35 for the student who scored all the items correctly. Computation of the learners' mean scores in the section measured the creativity levels of the learners which were valued as either; highly, moderately, or less. Learners with a mean of 0-10 were valued as less creative, 11-20 moderately creative, and 21 and above as highly creative.

Section B in the Biology Assessment Test on critical thinking had marks ranging from zero (0) to 35 determining the learners' levels of critical thinking skills. The Biology Assessment Test section on critical thinking assessed the students' ability to analyze, evaluate, and reason inductively and deductively in their answers. The mean score values rated critical thinking as poor, good, better, or best were 0-8 measured critical thinking as poor, 9-16 good, 17-24 better, and 25 and above best.

The academic performance of the learners from the Biology Assessment Test was measured as either below expectations, approaching expectations, meeting expectations, or exceeding expectations. A minimum of zero (0) score was awarded to the learners who scored all the items wrong while 100% was awarded to those who managed to score all the items correctly. The mean scores were valued as follows; from zero (0) to 31% which covered E, D-, D were said to be below expectations, 32-52% measuring grades D+, C-, C were those approaching expectations, 53-73% graded as C+, B-, B, and B+ were meeting expectation, and 74-100% with grades A-, and A exceeding expectations. The grading system used the Kenya National Examination Council format (KNEC, 2020).

Administration of the BAT's pre and post-test items supplied by the researcher during the scheduled date was within two hours under the supervision of the biology teacher of the sampled co-educational Sub-County public secondary schools. All schools involved in this study were supplied the test in the same day to minimize rigging out in order to ensure the data to be obtained was accurate.

Administration of the standard test was as a pre-test to two groups, one been the experimental group one (E1), and other as the control group one (C1) before the exposure of the interventions with the Science Process Skills Teaching Approach to the treatment groups by the beginning of the study. Towards the end of the research intervention, there was administration of the Biology Assessment Test as a post-test to all the four groups under the supervision of the biology teachers of the respective sampled co-educational secondary schools.

3.7. Piloting of the Research Instruments

Piloting was done before the main study to pre-test or a try-out of a particular research instrument, which was important (Polit, Beck, & Hungler, 2001). The advantage of conducting a pilot study about any research instrument is to give a warning about where the main research project would fail, and whether the proposed research instruments are inappropriate or complicated to give the true data to answer the research hypotheses so as to make corrections with improvements before the main study. Piloting study further helps to clarify the research protocols that need adjustments before the full study.

Pilot testing for this study was in one of the Sub-County co-educational public secondary schools of Makindu Sub-County. Makindu Sub-County has a total of 28 secondary schools with 6 private, 2 Extra-County public, 4 County public, and 21 Sub-County co-educational public secondary schools with almost similar characteristics to the randomly sampled sub-counties in Makueni County used in the study.

The co-educational public secondary school used in piloting had a total population of 47 Form Two Biology students. This was within the normal class population according to the ministry of education government's policy of 45 students per class. A Degree holder biology teacher who had 5 years of teaching experience taught in accordance to what the actual study required which ensured quality during the normal study. The researcher piloted the research instruments before the full study by administering, monitoring them in person and prove reading to minimize interference hence it was easy to make the necessary revision and improvements of the instruments.

Piloting identified spelling mistakes, language misinterpretation, and some little ambiguity in a few of the items of the Biology Assessment Test and others from the five-point Likert scale questionnaire statements as the potential practical problems in the research instruments. Kimberlin and Winsterstein. (2008) point out that, an unreliable instrument needs some revision and improvements to make it reliable for effective collection of data. Once an instrument becomes reliable, it also gains a high degree of accuracy and gives reliable data that provides good inferences.

All spellings mistakes were corrected and the misconceived language was made simple for the students to read and understand the items of the Biology Assessment Test and the statements of the five-point Likert scale questionnaire. Reconstruction of the test items by changing the sentence structure, and wording was done to make the questions achievable by the learners.

During the piloting period, piloting of the Biology Assessment Test and the five-point Likert scale questionnaire proved effective for collecting the quantitative and qualitative data from the real respondents of the study. The students responded well to the questionnaires and the BAT giving enough data that on analysis assisted to make all the necessary corrections and improvements.

3.8. Instrument Validity and Reliability

Validity explains how well the collected data covers the actual area of investigation (Ghauri, & Gronhaug, 2005). It helps to ensure all essential items are included and the undesirable ones eliminated to avoid their effects in the study. Reliability measures the consistency of results or their repeatability.

3.8.1. Validity

Validity gave the degree to which the research instrument measured the expected phenomenon of the study. According to Roberta and Alison (2015), validity measures concepts of the phenomenon or the problem in an accurate manner to answer the research objectives.

Mugenda and Mugenda (2003) values validity to be able to give the inferences of research results accurately and meaningful. Results of the data when analyzed represent the variables of the study accurately. Fraenkel and Wallen, (2014) talks of validity as a provider of correct inferences based on the results from the research instrument, the instrumentation process, and the characteristics of the group studied.

In validity, Interpretations of the test scores were to find the relationship between the Science Process Skills Teaching Approach learners' learning outcomes in biology in Makueni County. It is of great importance to note that, the test items must match with the learning outcomes that the test is measuring, and the instruction given should match with the learning outcomes and the item presented for assessment. Validity in this study determined what test questions and questionnaire statements to use to ensure the two research instruments truly measure the issues of importance the research objectives intended to achieve.

The research instruments were validated in terms of their content, and construct. Content validation measured the degree to which the questions or the test items covered the specific areas of gaseous exchange and the objectives of each of the lessons taught during the period of the study. The BAT content measured the learners' learning outcomes in their creativity levels, critical thinking skills, and the academic performance. The research instruments were also approved by the supervisors of the thesis after fellow students as peers had given feedback as well.

The content validation of the five-point Likert scale questionnaire looked into the measurements of the learners' fluency, flexibility, and originality. The construct validation of the five-point Likert-scale questionnaire used indicators and values about the levels of confidence which included, not at all confident; slightly confident; confident; quite confident, and extremely confident. Construct validation assessed all that the research objectives were targeting for effective testing of the hypothesis. Construct validation of the BAT had indicators and measurements that matched with the learning outcomes in biology on creativity and critical thinking.

Maaike, (2013) argues that the use of relevant experts like educationists, teaching material developers, researchers, and experienced implementers of the curriculum like teachers are some of the key research instrument validators due to their specialization and experience. He recommends at least two experts for validation to deal with subjectivity. The research experts from the Department of Educational Communication and Technology, and Early

Childhood Education of Machakos University in the School of Education did the content and construct validation for the research instruments.

Two biology-trained teachers who had more than ten years of teaching experience and more than five years of marking experience as Kenya National Examinations Council (KNEC) biology examiners did construct validation for the research instruments. The experience of the trained teachers guaranteed good encounters of the teaching experience, variety of teaching methods for good learning outcomes, testing formats, presentation of answers by learners, and then the skills the learners develop as per the ministry of education in Kenya. This is what made the entire research instrument accurately collect the data analyzed in chapter four during the main study**.**

3.8.2 Reliability

Reliability measured the consistency, dependability, and stability of the test. A research instrument can consistently measure the characteristics of interest over time. Mugenda and Mugenda, (2003) define reliability as the measure of the degree to which a research instrument yields consistent results or data after repeated trials during a study. Reliability simply addresses the overall consistency of a research instrument. It ensures that the research instrument produces similar results and lessens the chances that the obtained scores are due to randomly occurring factors (Marczyk, Dematteo, & Festinger, 2005). Consistency of the results testing reliability are a true reflection of how the instrument can be relied on.

Scientific research requires accurate measurement especially of the physical attributes that have values assigned to them. The values show the degree of dependability of the research instrument during the research process. Reliability of the five-point Likert scale questionnaire achieved during piloting used Cronbach's alpha test which gave a coefficient of the questionnaire as α=0.870. This highly reliable coefficient showed high internal consistency of the questionnaire.

Split-half technique tested the reliability of the Biology Assessment Test before the collection of the actual data. Split-half Reliability estimates the reliability of a teacher-made test (Amedahe & Gyimah 2002). During the piloting stage, the research divided the Biology Assessment Test items into two halves, as one comprising of odd numbers while the other was made of the even numbers and each half-scored independently so as to determine the split-half reliability. The technique used gave high internal consistency with a coefficient of α=0.86 hence the BAT instrument was reliable for collection of data.

Split-half technique provided some elements of misconceptions and ambiguity in some of the questions of the Biology Assessment Test due to poor construction of the items. Reframing of the items ensured that they met the standards of the revised Bloom's taxonomy. KR-20 (Kuder-Richardson formula 20) formula was the best statistical method to use to calculate the reliability;

$$\boldsymbol{r_{kr20}} = \left(\frac{\boldsymbol{k}}{\boldsymbol{k-1}}\right)\left(\boldsymbol{1} - \frac{\boldsymbol{\sum pq}}{\boldsymbol{\delta^2}}\right)$$

Where,

r_{kr20} The Kuder-Richardson formula 20

K The total number of test items

$\sum$ indicates, the summation of 'p' and 'q'

δ^2 the variance of the entire test

p the proportion of the test takers who answered the test items in the BAT

Correctly divided by the total number of the test takers.

q the proportion of test-takers who wrongly answered the test items in the BAT divided by the total number of the test takers.

r Reliability coefficient of the test

When $k = 47,\ k - 1 = 46, p = 3.6169, q = 3.3937,\ \delta = 76.90, \sum pq = 12.2747.$

Therefore $r = 0.860$

The coefficient of $r = 0.860$ was good and therefore found to have high consistency of the test. This meant that all the parts of the test contributed equally to the measurement of the learning outcomes in biology about students' creativity, critical thinking skills, and academic performance, which the BAT was measuring.

3.9 Data Collection Methods and Procedures

Antonius (2003) talks of data as information collected systematically, organized, and recorded for analysis to enable readers to interpret it correctly. During data collection, information on variables of interest is gathered and measured in an established systematic fashion that enables one to answer the stated research objectives, test the hypotheses, and evaluate the learning outcomes.

Data collected should be from the responses of the research instruments used to answer the research objectives systematically but not in a haphazard way. The goal for data collection is to capture quality evidence that allows the building of a convincing and credible answer to the study research objectives. Accurate data collection helps to maintain the integrity of research.

The researcher visited Makueni County Commissioner's office, educational County office, Governor's office, and even the selected four co-educational public secondary schools before beginning the study. Pre-visit determined the workability of the scheduled research activities, allowed time for the researcher to familiarize with the customs and traditions of the selected co-educational public secondary schools, obtained information about the coverage of the Form Two Biology syllabus, and the allocations of the lessons in the master timetable.

The pre-visit also provided more information on each of the sampled school's calendars of events within the period of the study, which assisted in rescheduling the research appropriately. During the pre-visit, the researcher became conversant with the biology teachers of the respective co-educational secondary schools and established their academic and professional experiences.

Science Process Skills Teaching Approach manual in this study considered the five stages learning cycle of Science Process Skills, which included observation, manipulation, generalization, verification, and application (Wenning, 2011). To train these teachers the research adopted modified online manual about the Science Process Skills from Wenning, (2011) to make them conversant with the use of the Science Process Skills Teaching Approach.

The researcher taught one of the experimental schools despite the teachers in the school were trained on how to use Science Process Skills Teaching Approach to teach. Training of the teachers who were not used to teach in one of the experimental groups targeted them to become conversant with the interventions been used for personal future use. The Science Process Skills adopted by the teachers were basic and advanced skills but integrated as the teacher taught the lessons.

Basic skills used in this study included observations, identification and creation of themes, classifying, measuring, calculation, communicating, inferring, and predicting. The advanced Science Process Skills were formulation of hypotheses, the definition of operational variables, identification of variables, control of variables, experimentations, interpretation of data, and the making of inferences.

Two from the randomly sampled co-educational public secondary schools one experimental (E1), and the other a control group (C1) were exposed to a pre-test before the interventions which the researcher had notified the concerned selected schools during the pre-visit exercise. The results of the data were analyzed to measure the students' entry behavior before the treatment and was also made to establish the effects of the pre-test to the post-test.

Teachers of the four selected co-educational public schools were aware of a Biology Assessment Test post-test to be done and post-test filling of the five-point Likert scale questionnaire by the students at the end of the interventions. The post-tests came after exposure of the experimental groups E1 and E2 to the Science Process Skills Teaching Approach method and the control groups C1 and C2 to the Conventional Teaching Methods. To control the differences that may occur between the groups Solomon Four Non-equivalent control group design was used. This randomized the groups and limited interactions that may have otherwise interfered with results of the study.

Teachers were made aware of the results of the Biology Assessment Test that provided quantitative data and that of the five-point Likert scale questionnaire that provided qualitative which were to be treated with a lot of confidentially and anonymity they deserved. Analysis of the data of the pre-test, post-test of both the questionnaire and the BAT used the Statistical Package for the Social Sciences (SPSS) vision. Biology Assessment Test sections scored independently and the total of all the sections provided data for rating the learners' academic performance as either below, approaching, meeting, or exceeding expectations with each rating having the KCSE grades associated to it.

Teachers of the respective sampled schools issued out the five-point Likert scale questionnaire to each of the learners, and with their consent, the learners filled the rated questionnaires to provide the qualitative data. The means from the responses of the questionnaire targeted the magnitude, strength, and generality to measure the levels of the students' Self-efficacy in biology in terms of either below confident, confident or above confident.

BAT was issued under the supervision of the biology teacher, and then the answered test was collected and sealed for marking. The researcher marked the paper of the students from each of the sampled schools involved in the study for purposes of confidentiality and anonymity of the respondents. The results from the marked students' work provided the quantitative data on creativity, critical thinking, and academic performance.

3.10 Data Analysis Techniques and Procedures

Data analysis structures, bring order, and then calculates, and provide meaning to a mass of data collected during a research period (Marshall & Rossman, 2011). Analysis and interpretation of data represents the application of deductive and inductive logic (Best & Khan, 2006). Both qualitative and quantitative data analysis methods were adopted by the study.

Data analysis was with the aid of the Statistical Package for Social Sciences (SPSS) version 21. Both descriptive and inferential statistics summarized the quantitative and qualitative data. The analysis of the qualitative data was systematic and sequential because it provided the senses about the research participants' views and opinions of situations, corresponding patterns, themes, categories, and regular similarities (Cohen, Manion, & Morrison, 2013). Quantitative data was represented in tables from where the analysis was done in accordance to the research objectives.

The BAT tested on numerical scores that provided quantitative data, while the questionnaire's qualitative data was converted to quantitative which were both exposed to statistical analysis and computed based on the principles of mathematics (Denscombe, 2010). The research used descriptive and inferential data analysis techniques for easy and accurate interpretation of the results answering the research objectives.

Mean scores from each section of the Biology Assessment Test measured specific research objectives and the overall mean score from the totals of the two BAT's sections measured the biology learners' academic performance as either below, approaching, meeting, or exceeding expectations, which was an integration of the CBC assessment format with the grading of KCSE in this research.

The computed mean scores for the responses from the questionnaire measured the magnitude, strength, and generality of the learners' Self-efficacy in biology. The data analysis procedurally followed the relevant research objectives using the Statistical Package for Social Sciences (SPSS) version 21.0 that has inclusions, which the study required such as descriptive and bivariate statistics.

Descriptive statistics looked into mean scores and standard deviation while inferential statistics used t-test, One-Way ANOVA, ANCOVA, Least Significant Difference (LSD), and Chi-squire test to analysis the data and test the research hypothesis. Descriptive statistics helped in understanding whether the produced outputs from the analysis are meaningless or useful. Inferential statistics were to find out the statistically significant difference between the groups used in the study.

A t-test was to determine and understand the mean difference between each of the experimental and the control groups. Borg and Gall, (2007) states that a t-test is a quality test because it helps in detecting differences between means of two groups. One-Way ANOVA (Analysis of Variance) and ANCOVA (Analysis of Covariance) were used to analyze the differences in the means of C1, C2, E1, and E2 post-test scores to determine whether their differences were statistically significant and if the pre-test had any effect on post-test results. One-Way Analysis of variance (ANOVA) facilitates the comparison of means of more than two groups (Fraenkel & Wallen, 2000).

In this study, One-Way ANOVA determined the BAT's mean learning outcomes for the post-test scores within the four groups to find out the variations between the groups. ANCOVA is the inclusion of continuous variables in addition to the independent and dependent variables as means for control (Tabachnick & Fidell, 2013). It confirms the results of the pre-test scores as the covariate and also adjusts the post-test means for the differences that normally occur in intact groups like the co-educational public secondary schools used in the study among the groups of the pre-test (Dimitrov & Rumrills, 2003).

ANCOVA confirmed the results of the pre-test scores as the covariate and also adjusted the post-test mean scores of co-educational public secondary schools used in the study among the groups of the pre-test. The hypothesis was tested at $\propto$=0.05 level of significance. Least Significant Difference (LSD) Post hoc Scheffe Multiple Comparisons was used to compare each of the experimental groups with each of the control groups to find out whether there was any statistically significant difference at α= 0.05 level.

Chi-Square Test was to confirm if any statistically significant difference could have been because of the Science Process Skills Teaching Approach interventions. If the *p*-value of the Chi-Square is less than the alpha level of 0.05 or the Chi-Square value calculated from the observed and expected frequencies is above the critical value at a given degree of freedom and alpha level then statistically significant differences between the groups are usually noted hence the need to reject the null hypothesis. Table 3.3 summarizes the statistical analysis.

Table 3.3:
Summary of Statistical Analysis

Hypothesis	Independent Variables	Dependent Variables	Statistical Test
H_O1: There is no statistically significant difference in student's self-efficacy in Biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County.	-Science Process Skills Teaching Approach -Conventional Teaching Methods	Students' self-efficacy achievement in Biology	-One-Way ANOVA, -ANCOVA, -Least significant Difference (LSD). t-test
H_{OXYGEN}: There is no statistically significant difference in Biology students' level of creativity between those exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching methods in Makueni County.	-Science Process Skills Teaching Approach -Conventional Teaching Methods	Students' creativity	One-Way-ANOVA, -ANCOVA, -Least Significant Difference (LSD). -Chi-Square test, -t-test
H_O3: There is no statistically significant difference in Biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching methods in Makueni County.	-Science Process Skills Teaching Approach -Conventional Teaching Methods	students' critical thinking	-One-Way ANOVA, -ANCOVA, - Least Significant Difference (LSD). -Chi-Square test, -t-test
H_O4: There is no statistically significant difference in student's academic performance in Biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching methods in Makueni County.	-Science Process Skills Teaching Approach -Conventional Teaching Methods	student's academic performance	-One-Way ANOVA, -ANCOVA, - Least Significant Difference (LSD). -Chi-Square test, -t-test

The summary above relates each hypothesis to respective skill to be developed, and data analysis tool to find out the statistically significant difference between the control and the experimental groups by the end of the study. Interventions were by use of the Science

Process Skills Teaching Approach but with the control groups exposed to Conventional Teaching Methods.

3.11. Ethical Considerations

The researcher sought permission from the National Commission of Science, Technology, and Innovations (NACOSTI) through the post-graduate school of Machakos University to carry out the research. The county and sub-county commissioners provided permission, which guaranteed enough security during the research period as the researcher visited the sampled public co-educational secondary schools. For effective visiting of the selected public co-educational secondary schools, the county and sub-county educational offices in Makueni County provided the required permission to the researcher.

The researcher familiarized himself with the teachers involved to teach in the study after obtaining permission from the principals of the respective randomly sampled public co-educational secondary schools. Through the principals of these schools, the researcher trained the biology teachers of the two experimental schools that were to receive the Science Process Skills Teaching Approach interventions using the standardized online manual on Science Process Skills Teaching Approach. During this time, the researcher confirmed to maintain the levels of anonymity, confidentiality, and that the purpose of the data collected from these schools was for research and not for sharing elsewhere for any unintended purpose.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSIONS

4.1. Introduction

This chapter presents the demographic information for the study; results of the findings of the research that were guided by the research objectives which determined the relationship between Science Process Skills Teaching Approach and Learner's Self-Efficacy, creativity, critical thinking and academic performance in Biology in Secondary Schools in Makueni County. Analysis and interpretation of the data in line with the research objectives was done from where conclusions and discussions of the analyzed data were made. The Chapter focused on the data from the respondents who were the biology students of the Sub-County co-educational public secondary schools in Makueni County.

Analysis and interpretation of the data was carried out based on the five-point Likert scale questionnaire that gave qualitative data on biology learners' Self-efficacy and the Biology Assessment Test which gave quantitative data from three of the research objectives which pointed out students' creativity, critical thinking, and academic performance respectively.

Quasi-experimental research design was used where four schools were randomly sampled with two being randomly assigned the experimental groups and the other two the control groups. The experimental groups received the interventions of the Science Process Skills Teaching Approach while the control groups received the Conventional Teaching Methods during the period of study.

A pre-test was subjected to one experimental and one control group with the aim of finding out the homogeneity of the learners before the intervention. The four groups were later subjected to a post-test after the intervention was exposed to the experimental groups. Data collected from the respondents who were Form Two Biology students was presented in tables for analysis.

4.2 Demographic characteristics

This study was concerned about the relationship between the Science Process Skills Teaching Approach and learning outcomes among biology students in Kenyan secondary schools. The respondents were the Form Two Biology students of the public sub-county co-educational secondary schools in Makueni County. The distribution of the respondents' population per each randomly sampled co-educational school was as in Table 4.1.

Table 4.1:
Showing the Distribution of the Number of Respondents School-wise and Gender-wise

Students	C1	E1	C2	E2	Total	percentage
Female	28	33	26	29	116	56 %
Male	26	20	19	23	88	44%
Total	54	53	45	52	204	100%

The data clearly indicates that the population of students in a class per each school was almost the same and within the expected class size according to the ministry of education in Kenya. Most of the students in the study were at the average age of between 16-18 years and all taking biology as a compulsory subject. They were of average academic performance from their Kenya Certificate of Primary Education (KCPE) results with most of them within 200-350 out of 500 marks. There were a few with high marks of above 350 and another small percentage below 200 marks.

All the schools involved in the study had almost similar geographical, climatic, and external learning environments. From the four selected co-educational public secondary schools, two received the intervention of the Science Process Skills Teaching Approach and the other two were exposed to Conventional Teaching Methods to find out the strength of the intervention in the learning outcomes of the biology students in Kenyan secondary schools. They were all at the same level of syllabus coverage in the chapter on gaseous exchange in plants and animals hence convenient for the study during this time of the academic year.

4.3 Analysis of Pre-test

Analysis of Pre-test for the two instruments, the five-point Likert scale questionnaire and the Biology Assessment Test, was to enable the research to check the respondents' entry behavior and to determine whether the groups were similar before the commencement of the study in the biology topic on gaseous exchange. The experimental group (E1) and control group (C1) sat for the Biology Assessment Test pre-test and the analyzed results done as per each of the research objective. The two groups still filled the five-point Likert scale questionnaire, and their pre-test results coded and analyzed.

4.4 Testing the Hypothesis H_O1 to determine the Effects Science Process Skills Teaching Approach to Learner's Self-Efficacy in biology in secondary schools

To establish the relationship between the Science Process Skills Teaching Approach and the learners' self-efficacy in the topic of gaseous exchange in biology in Makueni County. Pre and post-test scores from the five-point Likert scale questionnaire were analyzed to determine the confidence levels of the respondents. The findings regarding the students' self-efficacy level from the data were first expressed in terms of percentage of their confidence levels in three categories as below confidence or confidence or above confidence. Descriptive and inferential statistics was to find out the statistically significant difference between the control and the experimental groups.

Below confidence combined those respondents who were rated in the scale of not at all confidence and the slightly confidence ones, while above confidence combined those rated as quiet and extremely confidence for easy analysis. The analyzed Pre-test scores were made to find out the homogeneity of C1 and E1 before the beginning of the study.

The post-test results were analyzed to determine whether H_O1 that there is no statistically significant difference in learners' Self-efficacy in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods could be rejected or not. The participants of control group 1 (C1) and experimental l (E1) were subjected to a five-point Likert scale questionnaire Pre-test to find out whether their entry behavior before treatment and subsequent post-test were the same.

Table 4.2:
A Five-Point Likert Scale Questionnaire Pre-test showing percentage confident levels of control group 1 (C1) students

Serial Number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	96.30	3.70	0.00	100
2	How confident are you that you can complete a biology assignment in time?	98.15	1.85	0.00	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	100.00	0.00	0.00	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	100.00	0.00	0.00	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	96.30	3.70	0.00	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	96.30	3.70	0.00	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	92.60	7.40	0.00	100
8	With a lot of confidence, can you perform all practical's covered in gaseous exchange?	98.15	1.85	0.00	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	100.00	0.00	0.00	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	96.30	3.70	0.00	100

Most of the students in control group 1 were below the confidence levels accounting for more than 97.40% on average in every question in the questionnaire with a few of less than 2.60% on average showing some confidence before the intervention using the Science Process Skills Teaching Approach. The experimental group 1 gave similar results to the pre-test Five-Point Likert Scale Questionnaire after exposure to the pre-test as in Table 4.3.

Table 4.3:
A Five-Point Likert Scale Questionnaire Pre-test showing percentage confident levels of experimental group E1

Serial Number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	100.00	0.00	0.00	100
2	How confident are you that you can complete a biology assignment in time?	98.11	1.89	0.00	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	92.45	7.55	0.00	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	92.45	7.55	0.00	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	98.11	1.89	0.00	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	98.11	0.00	1.89	100
7	Are you confident that you can link gaseous exchange with other related Biology topics?	98.11	1.89	0.00	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	100.00	0.00	0.00	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	100.00	0.00	0.00	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	94.34	5.66	0.00	100

The five-point Likert scale questionnaire pre-test results for both the experimental group 1 (E1) and control group (C1) showed that most of the students were below the confidence level towards the concepts in the topic of gaseous exchange before the intervention of the Science Process Skills Teaching Approach. To find out whether the percentage confidential levels changed due to the interventions, a post-test of the five-point Likert scale questionnaire was performed to each of the groups used in the study.

Table 4.4:
A Five-Point Likert Scale Questionnaire Post-test showing percentage confident levels of control group C1

Serial number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	40.74	51.85	7.41	100
2	How confident are you that you can complete a biology assignment in time?	66.67	33.33	0.00	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	44.44	50.00	5.56	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	51.85	44.44	3.71	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	70.37	27.78	1.85	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	57.41	40.74	1.85	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	66.67	33.33	0.00	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	77.78	18.52	3.70	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	75.93	20.37	3.70	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	72.22	16.67	11.11	100

From Table 4.4 there was improvement in the students' percentage confidence levels from the pre-test results in the control group 1 (C1) but most of the students showed below confidence levels with an average of 62.40%. A small percentage of 3.90% on average displayed above confidence level in most of the questions in the questionnaire as opposed to the pre-test outcomes. On average 33.70% were confident after the intervention.

Table 4.5:
A Five-Point Likert Scale Questionnaire Post-test showing percentage confident levels of Experimental group E1

Serial number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	5.66	66.04	28.30	100
2	How confident are you that you can complete a biology assignment in time?	20.75	58.50	20.75	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	28.30	52.83	18.87	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	26.42	52.83	20.75	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	13.21	69.81	16.98	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	28.30	54.72	16.98	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	24.53	66.04	9.43	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	18.87	60.38	20.75	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	28.31	62.26	9.43	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	28.30	60.38	11.32	100

A higher percentage of Experimental group 1 students who had done their pre-test before the intervention ended up becoming confident in the topic of gaseous exchange with also a higher percentage of 60.40% on average above the 33.70% from their counterpart control group 1 who had also done the pre-test. An average of 17.40% was above the confidence levels been higher from that of the control group 1. There was a higher improvement because the students become more confident than it was in their pre-test results that were associated with the interventions of the Science Process Skills Teaching Approach but not the pre-test.

These findings agree with those of (Dinsmore & Parkinson, 2013; Stankov, 2013; Stankov, Kleitman, & Jackson, 2015; Stankov, Morony, & Lee, 2013) who found out a strong relationship existing between students' confidence levels and academic success after exposure to activity-based interventions. According to this study increased learners' activities increases students' confidence levels because they assist to prepare them to receive and familiarize with the concepts.

Therefore, the increased confidence levels for experimental group 1 (E1) were from the interventions but not from the influence of the pre-test because a similar encounter should have been reflected by the control group 1. This implied that the Science Process Skills Teaching Approach had a greater influence towards the students automate confidence levels. These results are in line with those of Sihotang, Setiawan, and Saragi, (2017) who viewed learning strategies that involve active learner participation to affect the students' confidence levels.

Table 4.6 shows the confidence levels of the students of control group 2 not exposed to pre-test after using the Conventional Teaching Methods of teaching during the study period.

Table 4.6:
A Five-Point Likert Scale Questionnaire Post-test showing percentage confident levels of Control group C2

Serial number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	28.89	11.11	60.00	100
2	How confident are you that you can complete a biology assignment in time?	48.89	51.11	0.00	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	80.00	20.00	0.00	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	73.33	26.67	0.00	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	73.33	26.67	0.00	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	80.00	20.00	0.00	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	62.22	35.56	2.22	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	82.22	17.78	0.00	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	75.56	22.22	2.22	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	80.00	20.00	0.00	100

Table 4.6 shows most of the students on responding to the five-point questionnaire to have been below confidence levels towards the biological concept taught during the period of study with an average of 68.40%. An average of 6.50% of the students proved to be above the confidence levels with about 25.10% accountable to the confidence level lower

compared to those below the confidence levels. This concurs with study by Mahyuddin, Elias, Cheong, Muhamad, Noordin, and Abdullah. (2006) where students not exposed to active learning showed low confidence levels towards learning of concepts.

Table 4.7:
A Five-Point Likert Scale Questionnaire Post-test showing percentage confident levels of Experimental group E2

Serial number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	0.00	90.38	9.62	100
2	How confident are you that you can complete a biology assignment in time?	0.00	96.15	3.85	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	0.00	92.31	7.69	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	0.00	92.31	7.69	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	0.00	88.46	11.54	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	0.00	92.31	7.69	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	0.00	94.23	5.77	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	0.00	96.15	3.85	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	0.00	94.23	5.77	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	0.00	94.23	5.77	100

After the intervention, the students of the experimental group 2 showed high percentage of confidence levels in most of the questions of the five-point questionnaire of 93.10% with 6.90% above the confidence levels and none of the students were below confidence levels. The confidence level for E2 was higher than for E1 after the interventions but for above confidence level E1 had a higher percentage than E2. Despite the two groups were exposed to the same interventions, these differences could have been due to local factors within the schools which this study did not explore like different abilities, perceptions among others. This therefore was a clear indication that, the Science Process Skills Teaching Approach had a great impact towards the experimental group 2 than the Conventional Teaching Methods exposed to the control group 2 hence the interventions proved more superior to the Conventional Teaching Methods. The findings agree with those of Karimi and Saadatmand, (2014) in which students raised their confidence levels when exposed to learning strategies that promotes positive feedback, motivation, and problem-solving skills.

Table 4.8:

A Five-Point Likert Scale Questionnaire Post-test showing percentage confident levels of the control groups

Serial Number	Question	Below confidence %	confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	35.71	31.66	32.63	100
2	How confident are you that you can complete a biology assignment in time?	59.18	40.82	0	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	61.22	36.73	2.05	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	62.04	33.73	4.23	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	72.45	26.53	1.02	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	66.29	31.63	2.08	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	65.31	34.69	1.02	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	80.55	16.81	2.64	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	76.53	20.41	3.06	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	76.53	17.35	6.12	100

Table 4.8 shows that on average 65.50% of the students were below confidence levels after using the Conventional Teaching Methods and 29.00% were confidence about the biological concept taught during the study. Only 5.50% proved to be above the confidence levels hence an indication that most students ended up with low self-efficacy in biology. The percentage imply that most students were below confidence level in the biology concepts taught.

Table 4.9:
A Five-Point Likert Scale Questionnaire Post-test showing percentage confident levels of the Experimental groups

Serial Number	Question	Below confidence %	Confidence %	Above confidence %	
1	Are you confident that you have learned gaseous exchange to your expectations?	3.04	77.98	18.98	100
2	How confident are you that you can complete a biology assignment in time?	11.32	76.42	12.26	100
3	How confident are you that you understood the complicated concepts in gaseous exchange presented to you?	14.15	72.64	13.21	100
4	Are you confident you can in the future answer all questions of different levels in gaseous exchange?	13.64	71.98	14.38	100
5	With confidence, can you actively demonstrate the various activities explaining gaseous exchange?	8.6	78.3	13.1	100
6	Can you confidently remember what you have learned in gaseous exchange after one year?	14.15	72.64	13.21	100
7	Are you confident that you can link gaseous exchange with other related biology topics?	12.96	79.21	7.83	100
8	With a lot of confidence, can you perform all practicals covered in gaseous exchange?	13.21	77.36	9.43	100
9	Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?	14.53	77.35	8.12	100
10	Can you confidently perform well in gaseous exchange even when ideas are hard?	15.22	77.45	7.33	100

From Table 4.9, 11.79% on average of students in the experimental groups 1 and 2 were above the confidence levels after using the Science Process Skills Teaching Approach, which was above 5.5% of the students of the control groups 1 and 2 taught using the Conventional Teaching Methods. 76.13% were confidence about the various biological concepts on gaseous exchange which was similarly above the 29.00% encountered in the control groups 1 and 2, 12.08% were the students who were below the confidence levels compared to the high percentage of 65.50% from the control groups.

Therefore, the findings of this study showed that majority of the experimental groups' students were confident in the concepts of gaseous exchange as opposed to the control groups. The findings reveal that the Science Process Skills Teaching Approach which is activity based is effective in assisting the students to gain high levels of self-efficacy in biology.

These findings are similar to the findings of Mahyuddin et al. (2006) where very high percentage of the students exposed to active learning were confidence after a learning process and a very lower percentage showed low confidence. These differences in percentage confidence levels showed no statistically significant differences between the groups hence, there was need for further analysis using the differential and inferential statistics. Differential and inferential statistics were necessary to establish whether the differences noted were statistically significant at α 0.05 level, which were determined using mean scores, standard deviations, t-test determined the differences between groups E1 and C1.

ANOVA was to find out whether there existed differences between the experimental and the control groups, while the Least Significant Difference (LSD) Post hoc Scheffe Multiple

Comparisons determined the statistically significant difference between one group and the other.

Table 4.10:
Mean Scores of the Five-Point Likert Scale Questionnaire Pre-test Results for Groups C1 and E1

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Pre-test	C1	54	1.2907	.40154	.05464
	E1	53	1.2943	.39779	.05464

Pre-test analysis was to determine if the starting points of C1 and E1 were the same for each of the two groups. There was no statistically significant difference between mean scores for pre-test Self-efficacy scores of the two groups. The mean scores for the two groups C1 and E1 who did the pre-test were almost the same at 1.2907 and 1.2943 respectively.

This means that with the two groups showing no statistically significant difference in their mean scores in the pre-test for the five-point Likert scale questionnaire they were similar and at par in the topic gaseous exchange by the beginning of the study period. A t-test for the pre-test questionnaire results was calculated to determine whether the differences in their mean scores were statistically significant or not at the level of α=0.05 as in Table 4.11.

Table 4.11:
Independent Sample t-test for Groups E1 and C1 Pre-test Scores on Self-Efficacy

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	p-value
BAT	C1	54	1.2907	.40154	105	-.047	1.98	0. .963
	E1	53	1.2943	.39779				

*Not significant at p>0.05 level

*Critical values (df= 120, t=1.98, p>0.05) Calculated values (df=105, t=-0.047, p=0. 963)

t- Computed < t-critical

Not significant at α= 0.05 level

From Table 4.11 there is no statistically significant difference between C1 and E1 because the t-critical value of 1.98 is greater than the t-computed value of -0.047. Therefore, groups

E1 and C1 had no statistically significant difference between them because the $p= 0.963> \alpha$ 0.05 significant level, indicating that the two groups had the same characteristics that were equally distributed throughout the respondents for the study hence homogenous and comparable. The objective of this study was to find out the relationship between the Science Process Skills Teaching Approach and the learning outcomes in biology in secondary schools and therefore post-test results analysis on students' level of self-efficacy were necessary as presented in Table 4.12.

Table 4.12:
The Five Point Likert Scale Questionnaire Post-test Mean Score and Standard Deviation for the Four Groups after Intervention.

Groups	Mean	N	Std. Deviation
E1	2.9491	53	.16008
C1	2.3519	54	.25971
E2	3.0635	52	.16807
C2	2.2578	45	.46976
Total	2.6676	204	.45131

C1 = Control Group 1 E1 = Experimental Group 1
C2 = Control Group 2 E2 = Experimental Group 2

From Table 4.12, groups E1 and E2 attained mean scores of 2.9491 and 3.0635 respectively while C1 and C2 had 2.3519 and 2.2578 respectively in their post-test results. When the post-test mean score results from E1 and C1 were compared with their pre-test mean score results, each showed a gain of E1 =1.6548 and C1= 1.0612 which indicates that the post-test was scored better than the pre-test and that the experimental group 1 (E1) mean score was above that of the control group 1. The gain observed in the experimental group 1 in the post-test mean score was attributed to the interventions of the Science Process Skills Teaching Approach used while the gain experienced in the control group 1 was from the Conventional Teaching Methods.

The significantly observed mean scores of the two experimental groups E1 and E2 were better to those of the control groups C1 and C2 exposed to the Conventional Teaching Methods. This proves that Science Process Skills Teaching Approach (SPSTA) resulted in a significant improvement of the individual students' Self-efficacy in biology to the experimental groups. To determine whether these differences were statistically significant, one-way ANOVA test for the post-test results was necessary.

Table 4.13:
One-Way ANOVA Test for Post-test scores on students' Self-Efficacy in Biology

	Sum of Squares	Df	Mean Square	F-computed	t-critical	*P*-value
Between Groups	25.289	3	8.430	104.992	2.6519	0.000
Within Groups	16.058	200	.080			
Total	41.346	203				

*Significant at p≤ 0.05 level
*Critical values (df= (3, 200), F=2.6519, p<0.05) Calculated values (df= (3,203) F=104.992, p=0.000)
F- Computed> t-Critical,
Significant

Table 4.13 indicates that a statistically significant difference exists between the mean scores of the groups, F (3, 200) =2.6519, P<0.05. The F-computed is greater than the t-critical hence showing the difference between the groups is statistically significant. The results of the data analysis were according to those of Ceylan (2016), where the experimental classes exposed to interventions had better results on Self-efficacy than the control classes.

The interventions had influential effects on the experimental groups than the control groups. Therefore, it was necessary to reject the null hypothesis but the findings could not indicate clearly, where the difference between these groups was arising. It was necessary to carry out, Least Significant Difference (LSD) Post-Hoc Scheffe Multiple Comparisons, to identify which of these groups were significantly different by statistics.

Table 4.14:
Least Significant Difference Post hoc Scheffe Multiple Comparisons of SPSTA Post-test Self-Efficacy Means for Four Groups

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	.59720*	.05479	.000
	E2	-.11440	.05531	.236
	C2	.69128*	.05744	.000
C1	E1	-.59720*	.05479	.000
	E2	-.71161*	.05505	.000
	C2	.09407	.05719	.441
E2	E1	.11440	.05531	.236
	C1	.71161*	.05505	.000
	C2	.80568*	.05769	.000
C2	E1	-.69128*	.05744	.000
	C1	-.09407	.05719	.441
	E2	-.80568*	.05769	.000

Table 4.14 shows the results of the Least Significant Difference Compared the difference between two means in which each group's mean is compared with the other. The mean scores of groups E1 vs C1, E1 vs C2, E2 vs C1, E2 vs C2 all had statistically significant difference at α=0.000 which were below 0.05 α level. The Post-Hoc results showed that the difference was more significant between the students exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods.

However, from the data analysis, there was no statistically significant difference in the means between groups E1 vs E2 and C1 vs C2 showing that E1 and E2 were the same after they encountered the intervention while C1 and C2 were the same due to the exposure to the Conventional Teaching Methods. From this, the students given the Science Process Skills Teaching Approach interventions outperformed those in the control groups exposed to the Conventional Teaching Methods.

The results of the study suggested that students exposed to Conventional Teaching Methods had low levels of individual students' Self-efficacy. The implication is that students with higher Self-efficacy levels had strong beliefs of performing better in classroom activities than those with low levels.

The study concluded that Science Process Skills Teaching Approach used by the experimental groups (E1 and E2) led the students to acquire relatively higher self-efficacy levels in biology compared to those exposed to the Conventional Teaching Method. This study corroborates other studies such as Wilke, (2003) who found that student-centered pedagogy techniques raised the student's Self-efficacy than the non-student-centered conventional methods.

The conclusions of this study indicate that any exposure of students to Science Process Skills Teaching Approach interventions increases the student's self-efficacy toward biology. From the analysis of the hypothesis the study showed that there was no statistically significant difference in learner's Self-efficacy in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected.

The results of this study echo Goodrich, Gabry, Ali, and Brilleman, (2020) study on the effects of interventions on students' Self-efficacy, which enhanced significantly after the exposure of the learners to interventions during their study period. The Science Process Skills Teaching Approach assisted in making the students more active in participating hence increasing their Self-efficacy in the learning process that made them strong enough to deal with the challenges and became resilient to overcome the difficult concepts in the topic.

4.5: Testing the Hypothesis H_O2 to find out the Relationship between Science Process Skills Teaching Approach and Biology students' level of creativity

Analysis of Hypothesis H_O2 on the relationship between the Science Process Skills Teaching Approach and students' level of creativity using the post-test scores for the four groups was to test whether there was any statistically significant difference between the groups. The hypothesis (H_O2) testing determined whether there is no statistically significant difference in biology students' level of creativity between those exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods.

Table 4.15:
Pre-Test Mean Score on Creativity

Pre-Test	Groups	N	Mean	Std. Deviation	Std. Error Mean
Creativity	E1	53	6.85	5.146	.707
	C1	54	7.04	4.157	.566

Pre-test Analysis determination on creativity among the students gave the two groups C1 and E1 to be at the same starting point by the beginning of the study. There was no statistically significant difference between their pre-test mean scores on creativity. The two groups C1 and E1 had mean scores of 7.04 and 6.85 respectively in their Biology Assessment Test pre-test results analysis, which were too close giving a very narrow difference between them. The mean scores showed that the students of both the experimental and control groups were less creative before the interventions because the mean scores were within the range between 0-10. This was an indication that the two groups had no significant difference in their mean scores in their Biology Assessment Test pre-test results hence were similar and at par in the gaseous exchange topic by the beginning of the study period. This difference noted through calculation of the mean scores was not enough hence the need to determine whether the differences were statistically significant or not at the level of α=0.05 using the t-test as in Table 4.16.

Table 4.16:
Independent sample t-test for groups E1 and C1 pre-test scores on creativity

Test	Group	N	Mean	SD	Df	t-computed	t-critical	*p*-value
BAT	C1	54	7.04	4.157	105	0.836	1.98	0.101
	E1	53	6.85	5.146				

*Not significant at p>0.05 level
*Critical values (df= 120, t=1.98, *p*>0.05) Calculated values (df=105, t=0. .836, *p*=0.101)
t- Computed< t-critical
Not significant at α=0.05 level

Results in Table 4.16 shows that the experimental groups E1 and C1 achieved close mean scores of 6.85 and 7.04 with t-computed at 0.836 which is lower than the t-critical value of 1.98. The *p*-value of *p*=0.101 is greater than the significant level of α=0.05 hence the two groups were similar and at par by the start of the study. This meant that the respondents who were the Form Two Biology students had similar characteristics in their creativity levels by the beginning of the research period.

To determine whether there was any relationship between the Science Process Skills Teaching Approach and students' creativity levels in biology, there was need for an analysis of the students' post-test Biology Assessment Test mean scores. This hypothesis sought to find out whether there was any statistically significant difference in students' creativity levels between those exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods as in Table 4.17 where the post-test mean scores were obtained from two of the groups that had received pre-test.

Table 4.17:
Creativity Post-test Means and Standard deviation on BAT for E1 and C1

	groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test E1 vs C1	E1	53	13.36	6.070	.834
	C1	54	9.93	4.770	.649

E1 and C1 gained 13.36 and 9.93 respectively in their post-test mean scores against their pre-test mean scores with the experimental group E1 outperforming the control group C1. E1 had a mean gain of 6.51, which almost doubled after exposure of the group to the Science Process Skills Teaching Approach. The experimental group 1 students become moderately creative after the intervention of the Science Process Skills Teaching Approach. Control group 1 students improved but their mean scores remained within the BAT's mean range description of the less creative students. This implies Science Process Skills Teaching Approach could have contributed to the improved learners' creativity levels beyond how the Conventional Teaching Methods had done to the control groups.

Therefore, in terms of creativity levels Science Process Skills Teaching Approach appears more superior to the Conventional Teaching Methods. Table 4.18 shows the statistical difference between the four groups used in the study in their post-test mean score and standard deviation to find out whether there was any statistically significant difference between the experimental using the Science Process Skills Teaching Approach and the control groups using the Conventional Teaching Method after the intervention.

Table 4.18:
Creativity Post-test Mean Score and Standard Deviation for the Four Groups after Intervention.

Groups	Mean	N	Std. Deviation
E1	13.36	53	6.070
C1	9.93	54	4.770
E2	13.44	52	4.522
C2	9.40	45	5.006
Total	11.60	204	5.426

From the analyzed results in Table 4.18, the experimental groups E1 and E2 achieved higher mean scores of 13.36 and 13.44 respectively than the control groups C1 that had

9.93 and C2 9.40. This is an indication that the Science Process Skills Teaching Approach exposed to the experimental groups contributed the difference between the experimental groups and the control groups. The results further showed that Science Process Skills Teaching Approach (SPSTA) significantly improved individual students' creativity in biology and hence the entire class.

Experimental groups in this study displayed moderately creative skills towards formation of biology concepts in the chapter on gaseous exchange because their mean scores were within 11-20 BAT described mean score while the control groups were less creative within 0-10 range. The findings are in line with the results of (Okere, 2002) who viewed that, the experimental groups after interventions always attain better mean scores in the subject tested than the control groups exposed to the Conventional Teaching Methods.

One- Way ANOVA was carried out to establish whether the four groups' mean scores after using Science Process Skills Teaching Approach and the Conventional Teaching Methods to the control groups had a statistically significant difference between them at α=0.05 significant level.

Table 4.19:
One-Way ANOVA of the Post-test Scores on the creativity

	Sum of Squares	Df	Mean Square	F-computed	t-critical	*P*-value
Between Groups	709.520	3	236.507	8.980	2.6519	0.000
Within Groups	5267.519	200	26.338			
Total	5977.039	203				

*Significant at $p \leq 0.05$ level
*Critical values (df= (3, 200), t=2.6519, $p<0.05$) Calculated values (df= (3,203) F=8.980, $p=0.000$),
F- Computed> t-Critical,
Significant at $p \leq 0.05\alpha$ level.

Table 4.19 indicates that a statistically significant difference existed between mean scores of the groups, F (3,200) =8.980, $P<0.05$ α level is less than 0.05. This led to the rejection of the null hypothesis, which stated there is no statistically significant difference in biology students' level of creativity between those exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods.

These findings did not indicate which groups were similar, which were different to each other, and therefore, it was necessary to carry out Least Significant Difference (LSD) Post-hoc Scheffe Multiple Comparisons on creativity to know which groups had statistically significant different as in Table 4.20.

Table 4.20:
Post-Hoc Scheffe Multiple Comparisons of SPSTA Creativity Post-test Means for Four Groups

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	3.433*	.992	.009
	E2	-.084	1.002	1.000
	C2	3.958*	1.040	.003
C1	E1	-3.433*	.992	.009
	E2	-3.516*	.997	.007
	C2	.526	1.036	.968
E2	E1	.084	1.002	1.000
	C1	3.516*	.997	.007
	C2	-4.042*	1.045	.002
C2	E1	-3.958*	1.040	.003
	C1	-.526	1.036	.968
	E2	4.042*	1.045	.002

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

The result in Table 4.20 indicates that there was a statistically significant difference between each of the experimental groups to the control groups. From these analyses, the statistically significant differences were noted as follows. E1 Verses C1 was significant at 0.009α level, E1 Verses C2 at .003α level, C1 versus E2 was at .007 α level, and E2 versus

C2 were at 0.002 α levels, which were all below 0.05α levels. This suggests that the differences were due to the Science Process Skills Teaching Approach interventions that had superior effects on students' creativity levels as compared to those exposed to the Conventional Teaching Methods.

There was no statistically significant difference at 0.05α level between E1 versus E2 and between C1 and C2. This is an indication that E1 versus E2 had similar exposures hence were at par after even the intervention despite the slight mean difference and C1 versus C2 mean scores appeared the same at the end of the study but after they were exposed to the Conventional Teaching Methods. Since the study involved a Solomon four non-equivalent control group design, there was a need to confirm their results by performing an analysis of covariance (ANCOVA) using pre-test mean scores as covariate.

According to Dimitrov and Rumrill (2003), pre-test scores are covariates in ANCOVA with a pretest-posttest design to reduce the error variance and eliminate systematic bias. Wilcox (2015) talks of ANCOVA to be able to reduce the effects of initial group differences statistically by making compensating adjustments to the post-test means of the groups used in the study. Similarly, according to Borg and Gall, (2007), Wachanga, (2002), Analysis of Covariance reduces the initial statistical group differences effects through making compensating adjustments to the post-test mean scores obtained by the groups involved during a study. Pre-test results from this study were the covariates used in the ANCOVA test.

Table 4.21:
Analysis of Covariance (ANCOVA) of the Creativity Post-test Scores of SPSTA with Pre-test as the Covariate

Source	SS	Df	MS	F	*P*
adjusted means	322.37	1	322.37	11.1	0.001196
adjusted error	3019.29	104	29.03		
adjusted total	3341.65	105			

*Significant at $p < 0.05\alpha$ significant level,
*Critical values (df= (1, 105), F=3.936, $p<0.05$) Calculated values (df= (1,104), F=11.1, $p=0.001196$), F- Computed > F-Critical

The results in Table 4.21 showed a significant difference between the mean scores of Experimental Group 1 and Control Group 1, F (1,105) = 29.03, $p<0.05\alpha$ significant level which was $p=0.001196$. Since Experimental Group 1 used Science Process Skills Teaching Approach, it is reasonable to infer that the students exposed to Science Process Skills Teaching Approach performed better in biology than those exposed to Conventional Teaching Methods, and therefore, this led to the rejection of the null hypothesis.

The pre-test had no significant contribution to the post-test scores of Experimental Group 1. It was necessary to confirm on whether the difference was because of the use of the Science Process Skills Teaching Approach through the Chi-square test that looked into any statistically significant difference between the observed and the expected as in Table 4.21. Chi-square helps to detect the relationship between categorical variables.

Table 4.22:
Chi-Square Test on Creativity between the Observed and the Expected

O	E	O-E	$(O\text{-}E)^2$	$\frac{(O-E)^2}{E}$
64	50.44	13.56	183.8736	3.65
41	54.56	13.56	183.8736	3.37
34	47.56	13.56	183.8736	3.87
65	51.44	13.56	183.8736	3.57
				$X^2 = 14.46$

* Computed Chi-Square test value is Significant at $p < 0.05$ level,

*Critical value of 3.841, Computed Chi-Square Test value $X^2 = 14.46$, df = 1, $\alpha = 0.05$,

In Table 4.22 the Chi-square test computed value of X^2=14.46 is quite above the critical value of 3.84 at a degree of freedom of 1 and α= 0.05. This means that the distribution between the observed and the expected frequencies is significantly different with equal distribution in all categories. The statistically significant difference could have been due to the interventions of the Science Process Skills Teaching Approach.

Therefore, based on the computed chi-square test value, the null hypothesis there is no statistically significant difference in students' creativity levels between the groups exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods was rejected. The rejection of the null hypothesis was evident from the significant difference between the groups exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods.

The findings of this study point out that, the students of the experimental groups E1 and E2 exposed to the intervention of Science Process Skills Teaching Approach improved more in their creative abilities than the control groups C1 and C2 in post-test. There was a statistically significant difference between the experimental groups E1 and E2 exposed to the Science Process Skills Teaching Approach and the control groups C1 and C2 exposed to the Conventional Teaching Methods as in Tables 4.19, 4.20, and 4.21. These findings are in agreement with those of Aktamış and Ergin (2008) where acquisition of creative abilities increased when the students used the Science Process Skills in the teaching-learning process than those exposed to the Conventional Teaching Methods.

There was an increase in biology creativity in the two experimental groups which was quite contrary to the control group as in the chi-square where the computed value was greater than the critical value at degree freedom of 1 at p=0.05α. This is because Science Process Skills Teaching Approach has activities that promoted students' creativity levels and enabled them to develop fundamental scientific understanding portrayed by the higher scores noted from the experimental groups compared to the control groups that used the Conventional Teaching Methods.

The findings of this study are in line with those of Lin, and Li, (2003) who found out that the Science Process Skills Teaching Approach directed activities increased scientific creativity especially in Biology. Teena (2014) in India still found out that the use of Science Process Skills in the teaching-learning process enhanced students' creativity level in secondary schools.

The results from this study imply that the Proficiency of using the Science Process Skills Teaching Approach strengthens inductive reasoning which is a basis of creativity amongst secondary school students. Clear evidence was from the comparison of creativity scores between the experimental groups and the control groups where the experimental groups scored higher than the control groups showing high levels of creativity.

The results further indicated that the findings concurred with the following studies which showed involvement of Science Process Skills in teaching increases students' creativity; Lee (2002) students having Science Process Skills possess simple and creative activities that improve creativity; and Arokoyu and Nna, (2012), supports these findings through their study where they found out that the use of Science Process Skills in the teaching-learning process by Nigerian teachers greatly improved students' creativity. Lastly, these findings are consistent with the findings of Chebii (2011) on the effects of Science Process

Skills Mastery Learning Approach on secondary school chemistry students' achievement in which when it was used there was an improvement in the learners' creativity resilience.

4.6 Testing the Hypothesis H_O3 to Determine the Effect Science Process Skills Teaching Approach on Secondary School Biology Students' Critical Thinking Skills.

The relationship between the Science Process Skills Teaching Approach and the students' critical thinking was determined from the analysis of the post-test scores of the hypothesis H_O3 for all the groups involved in the study. The H_O3 sought to determine whether there is any statistically significant difference in biology students' critical thinking skills between the students exposed to Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods. Data analysis started by looking at the similarity in characteristics between the two groups E1 and C1 before the interventions were given to the experimental groups during the study.

Table 4.23:
Critical Thinking Pre-Test Mean Score

	Group	N	Mean	Std. Deviation	Std. Error Mean
Critical Thinking	E1	53	4.92	4.459	.612
	C1	54	5.67	4.991	.679

Pre-test analysis showed that the starting point for C1 and E1 was the same for the two groups whose mean scores were close with a difference of 0.75 although the mean score for C1 was higher at 5.67. There was no difference between the mean scores for pre-test critical thinking Biology Assessment Test results for the two groups. This meant that the two groups were similar and at par in the topic gaseous exchange by the beginning of the study because there was no significant difference in their Biology Assessment Test pre-test means scores. A t-test for the Biology Assessment Test pre-test results determined whether the differences in their mean scores were statistically significant or not at the level of α 0.05 as in Table 4.24.

Table 4.24:
Independent Sample t-test for Groups E1 and C1 Critical Thinking Pre-test Scores

Variable	Group	N	Mean	SD	df	t-computed	t-critical	*p*-value
BAT	C1	54	5.67	4.991	105	-0.811	1.98	0. 243
	E1	53	4.92	4.459				

*Not significant at $p>0.05$ level
*Critical values (df= 120, t=1.98, $p>0.05$) Calculated values (df=105, t=-0.811, $p=0.243$)
t- Computed < t-critical
Not significant at $\alpha=0.05$ level

Results in Table 4.24 show that groups E1 and C1 achieved 5.67 and 4.92 mean scores respectively with t-computed at -0.811 lower than the t-critical value of 1.98. The *p*-value was at $p=0.243$ which was above the significant level of $\alpha=0.05$ hence the two groups were similar and at par by the start of the study. This meant that the respondents who were the Form Two Biology students had similar critical thinking skills characteristics by the beginning of the research period.

To determine whether the relationship between the Science Process Skills Teaching Approach and students' critical thinking skills in biology was there and statistically significant, an analysis of the students' post-test Biology Assessment Test mean scores was necessary. This proved the hypothesis stating there is no statistically significant difference in students' critical thinking skills between those exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods.

Table 4.25:
Critical Thinking Post-test Means and Standard Deviation on BAT for E1 and C1

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Critical Thinking	E1	53	10.53	7.298	1.002
	C1	54	7.96	4.322	.588

The resulting post-test scores from the students in the control group were 7.96 and those of the experimental group were 10.53 with a difference of 2.57. This therefore, meant that the Mean values were significantly different for groups E1 and C1. Experimental group 1 developed good critical thinking skills after the interventions of the Science Process Skills Teaching Approach compared to the students of control group 1 who remained poor. This implies Science Process Skills Teaching Approach contributed to the improved learners' critical thinking skills in biology than what the Conventional Teaching Methods did to the control group 1 (C1).

Table 4.26 gives statistical analysis to find out if there was a statistically significant difference between the four groups used. The analysis was based on the four groups' critical thinking skills post-test mean scores and standard deviation to find out whether there was any significant difference between the experimental groups using the Science Process Skills Teaching Approach and the control groups using the Conventional Teaching Methods.

Table 4.26:
The Critical Thinking Levels Post-test Mean Scores Obtained by the Four Groups

Groups	Mean	N	Std. Deviation
E1	10.53	53	7.298
C1	7.96	54	4.322
E2	11.88	52	5.983
C2	7.93	45	4.098
Total	9.62	204	5.834

Table 4.26 indicates that experimental groups E1 and E2 achieved higher post-test mean scores of 10.53 and 11.88 respectively than control groups C1 and C2, which scored a mean of 7.96 and 7.93 respectively. E1 and C1 post-test mean score gain against pre-test were 5.61 and 2.29 respectively with the experimental group having a higher mean score gain.

Experimental groups outperformed the control groups with their means being higher depicting that the students developed good critical thinking skills during the study. This implies that there were increased critical thinking skills among students under the interventions than those exposed to the Conventional Teaching Methods.

This shows that Science Process Skills Teaching Approach had a substantial improvement in the students' critical thinking skills compared to the Conventional Teaching Methods. The results from a study done by Burbach, Matkin, and Fritz, (2004), support this study through their conclusion that any student-centered instructional strategy interventions improve critical thinking skills. To determine whether the difference was statistically significant, One-Way ANOVA of post-test mean scores was performed as in Table 4.27.

Table 4.27:
One-Way ANOVA of the Post-test Scores on the Critical Thinking

	Sum of Squares	df	Mean Square	F-computed	t-critical	*P*-value
Between Groups	370.381	3	123.460	3.563	2.6519	.015
Within Groups	6930.574	200	34.653			
Total	7300.956	203				

*Significant at $p \leq 0.05$ level
*Critical values (df= (3, 100), F=2.6519, $p<0.05$) Calculated values (df= (3,202) F=3.563, $p=0.015$),
F- Computed> t-Critical,
Significant

The One-Way ANOVA indicated that the difference between the control and the experimental groups' mean scores were statistically significant at F (3,200), $p<0.05\alpha$ significant level where the *p*-value was at $\alpha=.015$ with the F-computed at 3.563 been greater than the t-critical value of 2.6519. The differences were from the treatment by the Science Process Skills Teaching Approach that was activity-based the experimental groups underwent. Therefore, the null hypothesis stating that no statistically significant difference in biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected.

Since these findings did not indicate which groups are similar and which are different, it was therefore, necessary to carry out Least Significant Difference (LSD) Post-Hoc Scheffe Multiple Comparisons on critical thinking skills to know which groups had a statistically significant difference once compared one to each other as in Table 4.28.

Table 4.28:
Least Significant Difference (LSD) Post-Hoc Scheffe Multiple Comparisons of SPSTA Critical Thinking Post-test Means for Four Groups

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	2.565	1.087	.138
	E2	-1.356	1.098	.676
	C2	2.595	1.140	.163
C1	E1	-2.565	1.087	.138
	E2	-3.922*	1.092	.006
	C2	.030	1.135	1.000
E2	E1	1.356	1.098	.676
	C1	3.922*	1.092	.006
	C2	3.951*	1.145	.009
C2	E1	-2.595	1.140	.163
	C1	-.030	1.135	1.000
	E2	-3.951*	1.145	.009

*. The mean difference is significant at the 0.05 level

Table 4.28 shows results of the Post-hoc Scheffe Multiple comparisons test of the statistically significant difference between any two means done for all the four groups. The Biology Assessment Test post-test mean scores for groups E2 vs C1, and E2 vs C2 had a statistically significant difference at α 0.006, and α 0.009 respectively that were below α 0.05 level. These results indicated that the students of the experimental group E2 outperformed their counterparts in the control groups C1 and C2 exposed to the Conventional Teaching Methods. Therefore, the conclusions were that, the Science Process Skills Teaching Approach used by the experimental group E2 was responsible for the relatively increased critical thinking skills shown by the higher mean scores.

However, there was no statistically significant difference in the mean scores between groups E1 and E2 who were both exposed to the Science Process Skills Teaching Approach, and groups C1 and C2 exposed to the Conventional Teaching Methods meaning that each of the exposures had equal effects on each of the categories of the groups. There was also no statistically clear significant difference between groups E1 vs C1, and E1 vs C2 in their Post-hoc Scheffe Multiple Comparisons results hence there was a need to perform Chi-square test to check whether the difference was due to SPSTA and then a t-test to fin d out the statistically significant difference in two of the groups being compared. Before then analysis of covariance (ANCOVA) using the pre-test as the covariate was necessary to find out the statistically significant difference between the groups as in Table 4.29.

Table 4.29:
Analysis of Covariance (ANCOVA) on Critical Thinking Post-test Scores of SPSTA with Pre-test as the Covariate

Source	SS	Df	MS	F	*P*
adjusted means	207.75	1	207.75	6.12	.014984
adjusted error	3532.45	104	33.97		
adjusted total	3740.2	105			

*Significant at $p < 0.05$ level
*Critical values (df= (1, 100), F=3.936, $p<0.05$), Calculated values (df= (1,104) F= 6.12, $p=0.014984$), F- Computed > t-Critical

Table 4.29 shows ANCOVA results based on the adjusted means of the four groups. The findings of the ANCOVA test showed that there was a statistically significant difference between the mean scores of the experimental groups and the control groups where, F (1, 105) =33.97, with a *p*-value of 0.014984 which is less than α0.05 significant level. There was a statistically significant difference in the post-test BAT mean scores between the experimental groups and the control groups.

This indicates that the interventions of the Science Process Skills Teaching Approach played a great role in the students' critical thinking levels in the experimental groups than in the control groups. Therefore, the null hypothesis there is no statistically significant difference in biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected. Chi-square test at df=2 and significant level of α 0.05 was done to check on the statistically significant difference between groups E1, C1, and C2 which did not appear clearly in the ANOVA, ANCOVA, and the Post-hoc Scheffe Multiple Comparisons as in Table 4.30.

Table 4.30:
Cross-tabulation for Groups E1, C1, and C2. Critical Thinking.

		Higher and Lower than E1 mean		Total
		High	Low	
Groups	C1	16	38	54
	C2	10	35	45
	E1	26	27	53
Total		52	100	152

Table 4.30, shows the population of the students who were below and above the mean scores of each of the three groups from where the chi-square test was analyzed to find out whether there was any statistically significant difference between the groups at α= 0.05 as in Table 4.31.

Table 4.31:
Chi-Square Test on Critical Thinking between Groups E1, C1, and C2

	Value	Df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided) Sig.	95% Confidence Interval Lower Bound	Upper Bound
Pearson Chi-Square	8.567[a]	2	.014	.013[b]	.000	.031
Likelihood Ratio	8.537	2	.014	.013[b]	.000	.031
Fisher's Exact Test	8.336			.013[b]	.000	.031
N of Valid Cases	152					

a. 0 cells (0.0%) have an expected count less than 5. The minimum expected count is 15.39.

b. Based on 152 sampled tables with starting seed 2000000.

Chi-square test on critical thinking skills gave a statistically significant difference at α= .014 and df =2 which was below *p*= 0.05α significant level for each of the two control groups (C1 and C2) against the experimental group 1 (E1). This statistically significant difference was from the Science Process Skills Teaching Approach exposed to the experimental groups meaning that the interventions improved the students' critical thinking skills, which was not the case for the control groups exposed to the Conventional Teaching Methods.

The present study concurs with the findings of Oloyede and Adeoye, (2012) where the use of Science Process Skills greatly enhanced the tendency of students to think critically and analytically than those who never used them. A t-test for the post-test results also confirmed the statistically significant difference between the groups E1 vs C1, E1 vs C2, C1 vs E2, and E2 vs C2. T-test is important when dealing with two mean scores because it has superior power for detecting the difference between the two means.

Table 4.32:
Critical Thinking Post-test Mean Scores for Groups E1 and C1

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test E1 vs C1	E1	53	10.53	7.298	1.002
	C1	54	7.96	4.322	588

Post-test analysis shows that E1 had a high mean score in their Biology Assessment Test post-test results with E1 having a mean score of 10.53 than their counterparts of C1 who had 7.96 with a difference of 2.57 although their mean scores were at par in their pre-test scores. From the mean scores, E1 had developed good critical thinking skills than their counterparts whose mean score was within the range 0-8 showing poor skills amongst the students of the control group 1. The difference noted in their value addition for both E1 and C1 in the post-test results is after exposure of each group to its defined teaching methods. A post-test t-test to determine whether the differences are statistically significant or not at α 0.05 significant level was necessary as in Table 4.33.

Table 4.33:
Independent Sample t-test of Post-test Scores on Critical Thinking Skills based on Groups E1 and C1

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	*p*-value
BAT	C1	54	7.96	4.322	105	2.217	1.98	.029
	E1	53	10.53	7.298				

*Not significant at $p>0.05$ level
*Critical values (df= 120, t=1.98, $p < 0.05$) Calculated values (df=105, t=2.217 p=0.029
t- Computed > t- critical
Significant

Results from Table 4.33, shows that groups E1 and C1 had their t-computed value at 2.217, which is greater than the t-critical value of 1.98. The significant value is α 0.029 which is below the significant level of α=0.05 hence the two groups had a statistically significant difference which could have been attributed to the interventions of the Science Process Skills Teaching Approach given to the experimental group 1 (E1).

Students of the E1 group outperformed those of the C1 group and therefore the Science Process Skills Teaching Approach had a significant improvement on the student's critical thinking skills in the biology concepts taught during the research period. It is from these results of the analysis that the hypothesis there is no statistically significant difference in biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected.

Table 4.34:
Critical Thinking Post-test Mean Scores for groups E1 and C2

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test E1	E1	53	10.53	7.298	1.002
vs C2	C2	45	7.93	4.098	.611

Post-test mean score analysis shows that the students of E1 had a high mean score in their BAT post-test results of 10.53 then the C2 that had 7.93 with a difference of 2.60. This difference is clear that there must be a statistically significant difference between these two groups. The difference necessitated for a t-test to determine whether the differences in their mean scores were statistically significant or not at the level of 0.05 as in Table 4.35.

Table 4.35:
Independent Sample t-test for Groups E1 and C2 Post-test Scores on Critical Thinking

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	p-value
BAT	E1	53	10.53	7.298	96	2.118	1.98	.037
	C2	45	7.93	4.098				

*Significant at p <0.05 level
*Critical values (df= 120, t=1.98, p < 0.05) Calculated values (df=96, t=-2.118 p=0.000
t- Computed > t- critical
Significant

Table 4.35 shows the t-computed value at 2.118, which is greater than the t-critical value of 1.98 for groups E1 and C2. This meant the two groups were already statistically different. The significant value is α 0.037 which is below the significant level of α=0.05 hence the two groups had a statistically significant difference which could have been attributed to the interventions of the Science Process Skills Teaching Approach used by the experimental group E1. The students of the E1 group outperformed those of the C2 group and therefore the Science Process Skills Teaching Approach had a significant improvement on the students' critical thinking skills in biology to the experimental group 1 compared to the control group 2.

The results of the independent t-test mean score analysis for the experiment group E1 against C1 and C2 showed it to be more superior due the interventions with the Science Process Skills Teaching Approach. It is from these results of the analysis that the hypothesis there is no statistically significant difference in biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected.

Therefore, the present study revealed that Science Process Skills Teaching Approach positively and significantly relate to critical thinking skills and students' better understanding of concepts in biology. The conclusions were on the basis that the experimental groups taught using the Science Process Skills Teaching Approach outperformed the control groups that used the Conventional Teaching Methods in their critical thinking skills. These findings correlate with those of Oloyede and Adeoye (2012) where Science Process Skills used in the teaching-learning process enhanced students' critical thinking than the Conventional Teaching Methods.

Result of this study disagree with those from (Tasar, Temiz & Tan, 2002). Who found out that acquision of Science Process Skills that have critical thinking skills by students is not enough but also the teachers conducting the lessons should also have them. When the teachers have and believe in the effectiveness of these skills it becomes much easier for the students acquire.

Science Process Skills affected critical thinking hence the high scores experienced by the experimental groups compared to the control groups which is in line with research done by (Inayah, Ristanto, Sigit, & Miarsyah, 2020; Tarchi & Mason, 2020), whose study revealed that Urban and Rural students who used Science Process Skills became more critical than those who never used. Studies by Miri, Ben-Chaim, and Zoller (2007) revealed that students receiving instructions focused on a method with interdisciplinary activities about the real world and mixed approaches showed a significant improvement in critical thinking skills compared to the control groups on critical thinking, which truly agree with the findings of the present study on critical thinking.

4.7 Testing the Hypothesis H_O4 to find out the impact of Science Process Skills Teaching Approach towards Students' Academic Performance

The hypothesis H_O4 that sought to determine whether there was any statistically significant difference in biology students' academic performance between those exposed to Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods was analyzed. The analysis starts by first finding out the homogeneity between the experimental group (E1) and the control group (C1) from their pre-test results mean scores.

Table 4.36:
Pre-test Mean Scores on Students' Academic Performance

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Academic Performance	C1	53	16.87	12.448	1.710
	E1	54	18.26	10.842	1.475

The pre-test analysis showed C1 and E1 to have mean scores that were too close with a difference of 1.39 although the mean score for E1 was higher at 18.26. The students of the two groups were below expectations before the start of the study. There was no significant difference between the two groups' mean scores for the BAT pre-test. This means that with the two groups showing no significant difference in their BAT pre-test mean scores, they were similar and at par in the gaseous exchange topic by the beginning of the study period. A t-test for the BAT pre-test results was used to determine if there was any statistically significant difference between the two groups at α=0.05 level as in Table 4.37.

Table 4.37:
Independent Sample t-test of Pre-test Scores on Academic Performance based on Groups E1 and C1

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	p-value
BAT	E1	54	18.26	12.448	105	-0.617	1.98	0. 282
	C1	53	16.87	10.842				

*Not significant at p>0.05 level
*Critical values (df= 120, t=1.98, p>0.05) Calculated values (df=105, F=-0.617, p=0. 282α)
F- Computed< t-Critical
Significant

The results showed that the experimental group 1 obtained a higher mean score in the Biology Assessment Test pre-test than the control group 1 but there was no statistically significant difference between these mean scores. The t-computed was lower than the t-critical. The *p*-value of α 0.282 was above the significant level of α 0.05. This indicates that the two groups were similar in characteristics in terms of ability and coverage in the

Form Two Biology syllabus especially in the chapter of gaseous exchange by the beginning of the study.

Analysis of the students' post-test Biology Assessment Test (BAT) means scores was necessary to assist in determining the relationship between the Science Process Skills Teaching Approach and students' academic performance in biology after the interventions. It also assisted to find out whether there was any statistically significant difference in students' academic performance between those exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods by use of their post-test mean scores.

Table 4.38:
The Academic Performance Post-test Mean Scores Obtained by the Four Groups

Groups	Mean	N	Std. Deviation
E1	34.15	53	16.636
C1	25.63	54	11.412
E2	36.23	52	12.430
C2	27.36	45	14.356
Total	30.93	204	14.443

From Table 4.38 experimental groups E1 and E2 attained mean scores of 34.15 and 36.23 respectively in their post-test, which were higher than the control groups C1 and C2 who scored 25.63 and 27.36 respectively. The post-test results from E1 and C1 who did their pre-test showed a gain of 15.89 and 8.76 respectively. Comparing the mean gain between the experimental group E1 and the control group C1, the results showed that there was a significant difference between their means, which come up after the interventions with the Science Process Skills Teaching Approach.

Experimental groups outperformed the control groups in their academic performance. The mean gain for C1 after the post-test compared with the pre-test showed minimal difference while that of the experimental E1 showed significant difference from the pre-test results. This shows that Science Process Skills Teaching Approach had a substantial improvement in the students' academic performance compared to the Conventional Teaching Methods. To determine whether there was any difference and it was statistically significant, One-Way ANOVA of post-test mean scores was run as shown in Table 4.39.

Table 4.39:
One-Way ANOVA of the Post-test Scores on students' academic performance

	Sum of Squares	Df	Mean Square	F- computed	t- critical	*P*-value
Between Groups	4102.970	3	1367.657	7.153	2.6519	.000
Within Groups	38240.927	200	191.205			
Total	42343.897	203				

*Significant at p≤ 0.05 level
*Critical values (df= (3, 203), F=2.6519, $p<0.05$) Calculated values (df= (3,200) F=7. 153, p=0.000
F- Computed> t-Critical
Significant

The One-Way ANOVA indicates that the difference between the control groups and the experimental groups' mean scores were statistically significant at F (3,203), $p<0.05\alpha$ significant level where the *p*-value was at α=.000 with the F-computed at 7.153 which is greater than the t-critical value of 2.6519. Therefore, the null hypothesis stating that there is no statistically significant difference in biology students' academic performance between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected.

Since these findings did not indicate which groups were similar and which were different, it was, therefore, necessary to carry out Least Significant Difference (LSD) Post-Hoc Scheffe Multiple Comparisons on critical thinking skills to know which groups had a statistically significant difference. The test compared each group with the other to help get to know which one has a statistically significant difference to the other.

Table 4.40:
Least Significant Difference (LSD) Post-Hoc Scheffe Multiple Comparisons of Academic performance for the Four Groups

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	8.521*	2.674	.019
	E2	-2.080	2.699	.898
	C2	6.795	2.803	.121
C1	E1	-8.521*	2.674	.019
	E2	-10.601*	2.687	.002
	C2	-1.726	2.791	.944
E2	E1	2.080	2.699	.898
	C1	10.601*	2.687	.002
	C2	8.875*	2.815	.021
C2	E1	-6.795	2.803	.121
	C1	1.726	2.791	.944
	E2	-8.875*	2.815	.021

*. The mean difference is significant at α 0.05 level

Table 4.40 shows results there was Least Significant Difference between E1 vs C1 at α=0.019, E2 vs C1 at α=0.002, E2 vs C2 at α=0.02 hence there was a statistically significant difference between these groups because the alpha values were all below α=0.05. However, there was no statistically significant difference in the means between groups E1 and E2 who were exposed to the Science Process Skills Teaching Approach with a *p*-value of 0.898, and groups C1 and C2 with a *p*-value of 0.944 exposed to the Conventional Teaching Methods. The *p*-value was above α =0.05 significant level indicating that there was no statistically significant difference between each of the two groups being compared.

The results further indicated that the students of the experimental groups outperformed their counterparts in the control groups exposed to the Conventional Teaching Methods.

However, there was no statistically significant difference noted using Least Significant Difference for groups E1 vs C2 that come out clearly after performing Chi-Square test. Therefore, the conclusions are that the Science Process Skills Teaching Approach used by the experimental groups was responsible for the increased academic performance shown by the higher mean scores. To find out the statistically significant difference between the groups Analysis of Covariance (ANCOVA) was used with the pre-test as the covariate as in Table 4.41.

Table 4.41:
Analysis of Covariance (ANCOVA) of Students' Post-test Academic Performance with Pre-test Academic Performance as the Covariate

Source	SS	Df	MS	F	*P*
adjusted means	2074.16	1	2074.16	10.46	0.001635
adjusted error	20626.34	104	198.33		
adjusted total	22700.5	105			

*Significant at $p < 0.05$ level
*Critical values (df= (1, 105), F=3.936, $p<0.05$), Calculated values (df= (1,104) F= 10.46, $p=0.001635$),
F- Computed > t-Critical,
Significant

ANCOVA test showed that there was a statistically significant difference between the mean scores of the experimental groups and the control groups, F (1, 105) =10.46, $p<0.05$ at α level of 0.001635 as in Table 46. These results compared with the findings of the Independent Samples t-test of the Pre-test Mean Scores of the Biology Assessment Test based on Experimental group 1 and control group 1 showed a statistically significant difference between the groups.

Therefore, the null hypothesis there is no statistically significant difference in learners' academic performance in biology between the students in the groups exposed to the

Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected.

Wilcox, (2015), talks of ANCOVA to be used to reduce the effects of initial group differences statistically by making a compensating adjustment to post-test mean scores of all groups involved. The main purpose of ANCOVA is to adjust the post-test mean scores for differences among groups on the pre-test because such differences likely occur when intact groups are used. A Chi-square test determined whether the statistically significant difference between the observed and the expected was due to the interventions of the Science Process Skills Teaching Approach.

Table 4.42:
Chi-Square Test on Academic performance between the Observed and the Expected

Observed (O)	Expected (E)	O –E	$(O - E)^2$	$\frac{(O-E)2}{E}$
57	49.8	7.2	51.84	1.04
48	55.2	- 7.2	51.84	0.93
35	42.2	- 7.2	51.84	1.23
54	46.8	7.2	51.84	1. 11
				X^2=4.31

*Critical value 3.84, at df =1, α= 0.05 significant level

Chi-square test computed value of 4.31 was above the critical value of 3.84 at a degree of freedom of 1 and α=0.05 significant level. This means that the distribution between the observed and the expected frequencies was significantly different with equal distribution of all categories. The statistically significant difference in academic performance between the groups exposed to the Science Process Skills Teaching Approach and those to the Conventional Teaching Methods was due to the interventions given to the experimental groups.

These findings are similar to the study done by Ekon and Eri (2008) in Turkey where the students who used the Science Process Skills in the teaching-learning process performed better than those who used the Conventional Teaching Methods. Therefore, based on the Chi-square test's computed value, the null hypothesis that there is no statistically significant difference between the groups exposed to the Science Process Skills and those exposed to the Conventional Teaching Methods was rejected. The statistical difference between groups E1 vs C1 and E1 vs C2 was determined using the t-test as in Tables 4.43.

Table 4.43:
Academic Performance Post-test Mean Scores for Groups E1 and C1

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test Academic performance E1 vs C1	E1	53	34.15	16.636	2.285
	C1	54	25.63	11.412	1.553

E1 had a high post-test mean score of 34.15 in their Biology Assessment Test post-test results than the C1 that had 25.63 with a difference of 8.52. This difference is clear that there must have been a statistically significant difference between these two groups. The difference necessitated for the performance of a t-test to determine whether the differences in their mean scores were statistically significant or not at the level of 0.05 as in Table 4.44.

Table 4.44:
Independent Sample t-test for Groups E1 and C1 Post-test Scores on Academic Performance

Variable	Groups	N	Mean	SD	df	t-computed	t-critical	p-value
BAT	E1	53	34.15	16.636	105	3.095	1.98	.003
	C1	54	25.63	11.412				

*significant at p>0.05 level
*Critical values (df= 120, t=1.98, p < 0.05) Calculated values (df=105, t=-3.095 p=0.003
t- Computed > t- critical
Significant

Table 4.44 shows the F-computed value at 3.095, which is greater than the t-critical value of 1.98 for groups E1 and C1. This means the two groups are already statistically different.

The significant value is α=0.003 which is below the significant level of α=0.05 hence the two groups had a statistically significant difference which could have been attributed to the interventions of the Science Process Skills Teaching Approach used by the experimental group E1. This study concedes with the study from Ardac and Magaloglu, (2002) who found out that students increase their academic performance when taught using a method that has Science Process Skills than when taught using the Conventional Teaching Methods. The students of the E1 group outperformed those of the C1 group and therefore the Science Process Skills Teaching Approach had a significant improvement on the students' Academic Performance.

Table 4.45:
Academic Performance Post-test t-test Mean Scores for Groups E1 and C2

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test Academic Performance E1 vs C2	E1	53	34.15	16.636	2.285
	C2	45	27.36	14.356	2.140

Table 4.45 gives E1 as having a higher Post-test mean score of 34.15 in the BAT post-test results as opposed to C2 that had 27.36 with a difference of 6.79. This difference in the groups' mean scores shows that there was a need to perform an independent sample t-test for post-test scores as in Table 51 to find out whether the mean differences were statistically significant at α=0.05.

Table 4.46:
Independent Sample t-test of Post-test Scores on Academic Performance based on Groups E1 and C2

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	*p*-value
BAT	E1	53	34.15	16.636	96	2.144	1.98	.035
	C2	45	27.36	14.356				

*Significant at p>0.05 level
*Critical values (df= 120, t=1.98, $p < 0.05$) Calculated values (df=96, t=2.144 p=0.035

t- Computed > t- critical
Significant

The results in Table 4.46 show the t-computed value of 2.144 which is greater than the t-critical of 1.98 meaning that there was a statistically significant difference between groups E1 and C2 at α=0.05 because the *p* of 0.035< α0.05. This implies that E1 was more superior than the C2 in terms of academic performance, findings that are similar to those of Ekon and Eri (2005) whose study showed students who used the Science Process Skills Teaching Approach academically performed better than those who never used but instead used the Conventional Teaching Methods. The better academic performance resulted from the interventions of the Science Process Skills Teaching Approach given to the experimental group 1. Academic performance improves as students vary the activities used in teaching-learning process.

Table 4.47:
Academic Performance Post-test t-test Mean Scores for Groups C1 and E2

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test Academic Performance E2 vs C1	E2	52	36.23	12.430	1.724
	C1	54	25.63	11.412	1.553

E2 had a Post-test mean score of 36.23 while C1 had 25.63 with a difference of 10.60. The difference noted was statistically analyzed whether it was statistically significant at α= 0.05 using the independent sample t-test for the post-test scores. The mean difference showed that E2 was superior to C1 but the t-test was to find out the statistical difference between the two groups.

Table 4.48:
Independent Sample t-test of Post-test Scores on Performance based on Groups C1 and E2

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	p-value
BAT	E2	52	36.23	12.430	104	-4.577	1.98	.000
	C1	54	25.63	11.412				

*Significant at $p < 0.05$ level
*Critical values (df= 120, t=1.98, $p < 0.05$) Calculated values (df=104, t= -4.577 p=0.000
t- Computed > t- critical
Significant

The t-computed value of -4.577 was greater than the t-critical of 1.98 at *p* of 0.000, which was less than α0.05 meaning that there was a statistically significant difference between groups E2 and C1. Therefore, the outperformance of E2 over C1 indicated that the experiment group was influenced by the Science Process Skills Teaching Approach method used hence the method was superior to the Conventional Teaching Methods. These findings are similar to those of Aktamis et al., (2008) which showed that students who used the Science Process Skills during their learning process succeeded more than their counterparts who lacked them. The better academic performance noted was because of the interventions of the Science Process Skills Teaching Approach given to the experimental group.

Table 4.49:
Academic Performance Post-test t-test Mean Scores for Groups E2 and C2

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test Academic performance E2 vs C2	E2	52	36.23	12.430	1.724
	C2	45	27.36	14.356	2.140

E2 had a post-test mean score of 36.23 while C2 had 27.36 with a score difference of 8.87. E2 outperformed C2 as it had done to C1 meaning it was superior to both the two control groups exposed to Conventional Teaching Methods. An independent sample t-test for post-test scores was done to find out any statistically significant difference between E2 and C2 at α= 0.05.

Table 4.50:
Independent Sample t-test of Post-test Scores on Performance Based on Groups E2 and C2

Variable	Group	N	Mean	SD	Df	t-computed	t-critical	p-value
BAT	E2	52	36.23	12.430	95	3.264	1.98	.002
	C2	45	27.36	14.356				

*significant at p>0.05 level
*Critical values (df= 120, t=1.98, p < 0.05) Calculated values (df=95, t=3.264 p=0.002
t- Computed > t- critical
Significant

From Table 4.50, it was noted that E2 vs C2 had a statistically significant difference at α=0.05 because the t-computed value of 3.264 was greater than the t-critical of 1.98 and *p* of 0.000 was less than α=0.05. Therefore, this indicated that Science Process Skills Teaching Approach influenced the experiment groups (E2) students' academic performance. The conclusions are that the Science Process Skills Teaching Approach improved the students' academic performance to the experimental group during the period of study.

From these analyses the null hypothesis there is no statistically significant difference in learner's academic performance in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods was rejected since there was a statistically significant difference between the experimental groups (E1 and E2) and the control groups (C1 and C2).

The present study found out that the experimental groups exposed to the Science Process Skills Teaching Approach significantly outperformed those exposed to the Conventional Teaching Methods. This implies that the use of the Science Process Skills Teaching

Approach is effective in enhancing students' academic performance than the Conventional Teaching Methods. These are findings are similar to those of (Martin, 2009) on the effect of teaching science with Science Process Skills where the students were found to understand phenomena, answer questions, develop theories and discover information and subsequently increased their academic achievement in science especially academic performance.

Turpin and Cage (2004) are also in agreement with the findings of this study who found out that mathematics students exposed to integrated Science Process Skills significantly improved in their academic performance. All experimental groups exposed to the Science Process Skills Teaching Approach showed greater improvement in their post-test biology mean scores in the chapter on the gaseous exchange compared to their counterpart control groups meaning they were superior. This concurs with Fah (2008) findings where Science Process Skills Teaching Approach to science academic achievement among forms four students in Malaysia highly improved their academic performance.

Similarly, Amaefuna (2013) reported that students who used Science Process Skills Teaching Approach performed better agreeing with the present study than those exposed to the Conventional Teaching Methods did. Fredericks (2008) found contrary opinion in his study that there is no statistically significant difference in academic performance for the female biology students exposed to Science Process Skills Teaching Approach compared to their male counterparts exposed to the Conventional Teaching Methods.

The findings of this study are also in line with that of Abugu, Okeke, and Wachanga (2014) who found out that the Science Process Skills Teaching Approach fostered high students' academic performance. A study conducted by Durun and Ozdemir (2010) on the effects of

Science Process Skills on Science and Technology in Turkey revealed an improvement in the learners' academic performance which is similar to the present study.

Students of the experimental groups highly succeeded in using the Science Process Skills Teaching Approach activities, which improved their academic performance that was similar to the study done by Aktamis et al (2008) where students who used the activities of Science Process Skills during their learning process academically succeeded more than their counterparts who lacked them.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

5.1. Introduction

This chapter presents the summary of the main outcomes resulting from the analyzed data of the four objectives that guided the study, and conclusions about the findings. Recommendations are for all Kenyan secondary schools' stakeholders with special reference to the relationship of the Science Process Skills Teaching Approach to the learning outcomes in biology. Finally, the chapter winds up citing the study implications, recommendations from the study, and possible areas for further research concerning the Science Process Skills Teaching Approach.

5.2 Summary of the research findings

The summary of the study indicated there was a statistically significant difference between the experimental groups exposed to the Science Process Skills Teaching Approach and the control groups exposed to the Conventional Teaching Methods of teaching from each of the four objectives in the topic of gaseous exchange in biology.

From each of the objectives the research sought to investigate and establish:

i. The relationship of the Science Process Skills Teaching Approach to the learners' self-efficacy levels. To achieve this a null hypothesis that there is no statistically significant difference in learner's self-efficacy in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County was formulated and tested. The findings from the study indicated that the use of SPSTA improved the students' self-efficacy because most of them showed higher levels than those of the control group. Therefore, the results reveal that there is a significant difference in the students' self-efficacy in biology between those exposed to the Science Process Skills Teaching Approach and those exposed to the Conventional Teaching Methods of teaching.

ii. The objective that established the relationship between learners' level of creativity in biology and the use of the Science Process Skills Teaching Approach led to the formulation and testing of the hypothesis. The null hypothesis stated that, there is no statistically significant difference in biology students' level of creativity between those exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods in Makueni County. The results showed there was an increase in biology students' creativity in the two experimental groups whose mean scores were higher than those of the two control groups were. Therefore, this null hypothesis was rejected based on the statistically significant difference noted between the groups. The experimental groups had statistically significant difference at $\alpha=0.05$ with the control groups about their creativity due to the interventions of the Science Process Skills Teaching Approach.

iii. The third objective was to establish the relationship between the students' level of critical thinking and exposure to the Science Process Skills Teaching Approach. The study looked into the null hypothesis (**H_O3)** there is no statistically significant difference in biology students' critical thinking between those exposed to Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods. From the analysis, the study revealed that experimental students taught using the Science Process Skills Teaching Approach had high critical thinking skills in their biological concepts than those of the control groups due to the high mean scores from the BAT. There was a high mean gain experienced from the pre-test results of the experimental groups than it was from the control groups. Comparison of the two experimental groups gave no statistically significant difference in their post-test mean scores meaning they had gained equal potential in their critical thinking skills. There was a statistically significant difference between the experimental and the control groups after the interventions with Science Process Skills Teaching Approach to the experimental groups. Therefore, this resulted to the rejection of the null hypothesis. This implies that the Science Process Skills Teaching Approach positively enhanced the students' critical thinking skills.

iv. The last objective sought to determine the relationship between the students' academic performance in biology and the Science Process Skills Teaching Approach. The null hypothesis (H_O4) states that there is no statistically significant difference in learner's academic performance in biology between the students exposed to the Science Process Skills Teaching Approach and those exposed to Conventional Teaching Methods. The results of the study gave higher academic performance mean scores to all the experimental groups than the control groups. These differences imply that the Science Process Skills Teaching Approach gave the students of the experiment greater ability to use the skills, the confidence of information gained, and good mastery of biological concepts. There was a statistically significant difference between the experimental groups and the control groups at $\alpha=0.05$ which led to the null hypothesis rejected.

5.3 Conclusions of the study

The use of the Science Process Skills Teaching Approach enhanced the acquisition of students' self-efficacy, creativity, and critical thinking skills and which subsequently improved their academic performance. Based on the specific objectives SPSTA in this study has:

i. Increased the students' self-efficacy in biology especially in the topic of gaseous exchange than the Conventional Teaching Methods hence have become more confident than before.

ii. Improved the students' creativity in each of the concepts taught during the study in the topic covered due to the activities it exposes to the students to learn on their own.

iii. Increased students' critical thinking skills, by helping them to solve their own problems. The students were able to look at the concepts of the topic in a critical manner, which promoted their knowledge construction.

iv. Greatly improved students' academic performance in experimental groups in the chapter of gaseous exchange than to the control groups exposed to the Conventional Teaching Methods.

Therefore, students stand to benefit more from exposure to Science Process Skills Teaching Approach than the Conventional Teaching Methods. In conclusion, Science Process Skills Teaching Approach is superior towards learning outcomes than the Conventional Teaching Methods because it has given statistically significant difference after data analysis was completed. These results, therefore, offered a departure of the teaching approach from the Conventional Teaching Methods to the Science Process Skills Teaching Approach that makes the learners more active and the learning process more learner-centered.

5.4 Implications of the findings from the study

Science Process Skills Teaching Approach enhanced meaningful learning and higher biology learning outcomes in the topic of gaseous exchange in biology for the Co-educational Secondary Schools in Makueni County hence effective in the teaching/learning of biology. Teachers can therefore incorporate the use of the Science Process Skills Teaching Approach in the teaching of biology to improve the biology learners' self-efficacy levels in the biological concepts, increase their creativity levels for the formation of new ideas, attain high critical thinking skills about ideas developed, and improve their academic performance.

When the SPSTA flows up from form one to form four, it can end with higher mean scores among the KCSE examination candidates, which would finally provide a good basis for the entry to the biology-oriented courses in the colleges and universities. Infusion of Science Process Skills, which are learner-centered with active learner participation in the teaching of biology using this approach, can also enhance the students' competencies and logical thinking than the Conventional Teaching Methods, which can propagate rote learning if not checked.

The biology teachers' sensitization on how they can benefit from the inclusion of the Science Process Skills Teaching Approach in the teaching-learning process of biology. All teacher training colleges, universities, and workshops/seminars/in-service courses should emphasize the use of the Science Process Skills Teaching Approach in the teaching-learning process especially during the preparation of lesson objectives and lesson presentation. Since the Science Process Skills Teaching Approach has led to improved learning outcomes is useful in the teaching of other science subjects such as chemistry, physics, and mathematics, not forgetting the applied sciences, which have an almost similar orientation to the sciences.

Lastly, the educational stakeholders like the KICD, MoEST, CEMASTEA, and Biology Educators have an additional teaching approach to consider which is more learner-centered and provides the learners with more opportunities to be active participants in the classroom situations. It has the potentials of improving the low learning achievements in secondary schools.

5.5 Recommendations of the study

Based on the results of this study, Science Process Skills Teaching Approach led to improvement of the learning outcomes in biology in the Co-educational Secondary Schools in Makueni County. From these results, the recommendations are:

i. Biology teachers ought to incorporate Science Process Skills Teaching Approach in the teaching-learning process to improve on the learning process and the learning outcomes since during the study it appeared effective by making the learners active participants compared to the Conventional Teaching Methods. It learning outcomes of the experimental groups high due to the intervention used.

ii. The biology teachers should assimilate the Science Process Skills Teaching Approach activities in the teaching of biology to improve the learning outcomes at secondary school level and even the other levels below or above this. During the study, the activities stimulated the learners hence the improved the learning outcomes in the experimental groups compared to the control groups.

iii. Teachers use activities of the Science Process Skills Teaching Approach, which makes the learning process easy to increase the learners' interests in biology and the number of students taking the subject. The students of the experimental groups showed a lot of confidence, creativity, and high critical thinking skills when handling the concepts on gaseous exchange than what figured out in the control groups students. These abilities were low in the control groups not exposed to the interventions.

iv. Teacher training institutions should include the Science Process Skills and activities associated with them in their curriculum to produce teachers with full potentials of using the Science Process Skills Teaching Approach, which is more superior to the Conventional Teaching Methods. This would address the low achievement noted in biology for many years, which improved in the experimental groups.

v. Ministry of Education stakeholders like the CS, CDE CQASO, SCDE, and DQASO should encourage teachers to use Science Process Skills Teaching Approach, which is more effective, and learner-centered. They should encourage them to learn how to use the approach to blend with the other methods for better learning outcomes to be attained. The students from the experimental groups had statistically significant differences from the control groups from all the results of the research objectives because of direct involvement.

5.6 Suggestion for further research

Based on the findings that the Science Process Skills Teaching Approach effectively improves learning outcomes in biology among secondary school students, the following areas needed further research.

i. Studies on the relationship between Science Process Skills Teaching Approach and learning outcomes should be carried out across the other classes in secondary schools because these are different levels and maybe beneficial differently.

ii. Research on the biology teachers' view towards the use of the Science Process Skills Teaching Approach in their teaching profession.

iii. Studies to assess the resources available in the Kenyan secondary schools for proper implementation of the Science Process Skills Teaching Approach in the teaching of biology.

iv. Study on the relationship of Science Process Skills Teaching Approach towards learning outcomes in secondary schools for other science subjects.

v. Study the relationship of Science Process Skills Teaching Approach and learning outcomes per gender in secondary schools.

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APPENDICES

APPENDIX I: QUESTIONNAIRE FOR STUDENTS TO TEST LEARNER'S SELF- EFFICACY IN BIOLOGY

This questionnaire is purely for academic purposes and your responses will be treated with a lot of confidentiality.

Five Likert scale confident as 1=Not at all confident, 2= slightly confident, 3=Confident, 4= Quite confident and 5= Extremely confident.

For each of the questions in the table put a tick against the confidence level that you strongly feel suits your concern on how the lessons were taught.

Question	Not at all confident	Slightly confident	Confident	Quite confident	Extremely confident
	1	2	3	4	5
1. Are you confident that you have learned gaseous exchange to your expectations?					
2. How confident are you that you can complete a Biology assignment in time?					
3. How confident are you that you understood the complicated concepts in the gaseous exchange presented to you?					
4. Are you confident you can in the future answer all questions of different levels in gaseous exchange?					
5. With confidence, can you actively demonstrate the various activities explaining gaseous exchange?					
6. Can you confidently remember what you have learned in gaseous exchange after one year?					
7. Are you confident that you can link gaseous exchange with other related Biology topics?					
8. With a lot of confidence, can you perform all practicals covered in gaseous exchange?					
9. Are you certain that you have the strength to overcome challenging ideas in gaseous exchange successfully?					
10. Can you confidently performed well in gaseous exchange even when ideas are hard					

APPENDIX II: BIOLOGY ASSESSMENT TEST ITEMS FOR STUDENTS

Section A: Questions Testing on Creativity.

1. The table below represents gaseous exchange in the bony fish within 10 seconds in both water in a fishpond and blood in the gills.

Time in seconds	1	2	3	4	5	6	7	8	9	10
Level of oxygen in mg /cm^3 of blood	40	56	60	72	76	80	86	92	98	99
Level of oxygen in mg /cm^3 of water	98	96	90	82	80	78	60	52	40	30

a. Plot the level of oxygen and carbon (iv) oxide in blood and water respectively against time. (8 marks) analysis

b. What is the type of gaseous exchange system illustrated above (1 mark)

--

c. In your own opinion, why is it that there is a simultaneous increase in concentrations between the two gases in their respective media? (5 marks)

----

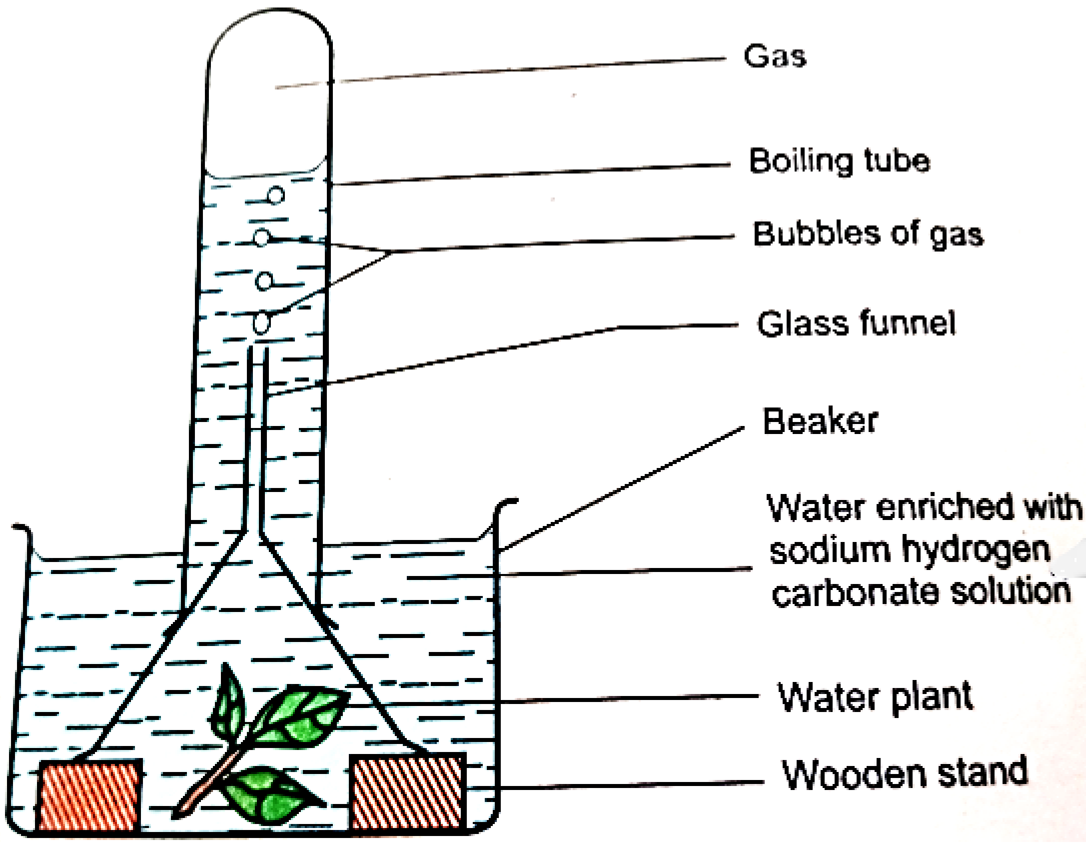
2. What is the effect of oil spilling in a pond where waterweeds are growing? (6 marks)

----

3. How would the breathing rate of a normal and a sick cow be when exposed to the same environmental conditions (6 marks)

----

4. An experiment was carried using a green water plant out as shown below



i. What is the importance of including Sodium hydrogen carbonate solution in this experiment? (1 Mark)

----

ii. Why is replacing the green water plant with any other naturally growing plant on land likely to vary the results of the experiment above? (4 marks)

----

iii. Assuming the green water plant was moved from the dark corners of the sea to the surface of the water by water currents. Explain the variation in air concentration (4 marks)

Section B: Questions Testing on Critical Thinking

5. How is it true that plants take in carbon (iv) oxide and give out oxygen during the mechanism of gaseous exchange? (6 marks)

6. Why is it that there is a difference in the rate of breathing between:-

    i. A runner and a clerk in the office (4 marks)

    ii. A baby and an old man (4 marks)

7. Explain the predictions that a bony fish will survive when out of water for 30 minutes (6 marks)

----

8. What would happen if during breathing in you hardly use your hand to pressed the ribs inwardly (6 marks)

----

9. Justify the fact that breathing rate in human beings is highly affected by occupation, age, and health of the individual (9 marks)

APPENDIX III: BAT's TABLE OF SPECIFICATION ON CREATIVITY

Levels	Number of questions in gaseous exchange in plants	Number of questions in gaseous exchange in lower animals	Number of questions in gaseous exchange in Mammals
Knowledge	1		
Comprehension		1	
Application		2	
Analysis		2	
Synthesis		1	
Evaluation			1

APPENDIX IV: BAT's TABLE OF SPECIFICATION ON CRITICAL THINKING

	Number of questions in gaseous exchange in plants	Number of questions in gaseous exchange in lower animals	Number of questions in gaseous exchange in Mammals
Knowledge			
Comprehension			1
Application			1
Analysis			1
Synthesis	1		
Evaluation		2	

APPENDIX V: BIOLOGY ASSESSMENT TEST ITEMS' SCORING KEY

a) Plot the level of oxygen and carbon (iv) oxide in blood and water respectively against time. (8 marks)

Scale-2 marks, plotting-2 marks, curve-1 mark, labeling- 2 marks.

Creativity tested the aspect of being able to

- ✓ Decide the suitable scale to use that is creating a scale
- ✓ The ability to express individual talent of forming a scale
- ✓ The ability to represent the pattern of the curve through free hand drawing technique and the skill of ensuring the curve passes through each of the plotted point. NB if the curve passes outside any of the point is a signal of low creativity.
- ✓ Using a ruler to draw the curve by the learner is a display of low creativity.

b) What is the type of gaseous exchange system illustrated above (1 mark)

Counter current flow system; using the illustration to identify the system was through creativity about the applicable biology.

c) In your own opinion, why is it that there is a simultaneous increase in concentrations between the two gases in their respective media? (5 marks)

Concentration gradient of oxygen in the blood and in water; oxygen diffuses from the water into the blood; where it combines with hemoglobin to form oxyhemoglobin; then transported to parts of the body; creating room for more absorption of oxygen; water has high oxygen; because it is oxygenated from the water body (from the atmosphere);

‘The learner was creative by showing the level of fluency of the idea. The novel idea of seeing more than one aspect like the relationship between the concentration of the gases and diffusion rate from the individual’s opinion.’

(6 Points max 5).

2. What is the effect of oil spilling in a pond where waterweeds are growing? (6 marks)

Oil obstructs penetration of air (oxygen and carbon (iv) oxide); limited oxygen; reduces the rate of respiration; lowering growth rate of the water weeds; limits carbon (iv) oxide; reducing rate of photosynthesis; less glucose is formed; reducing the rate of growth of the water weeds;

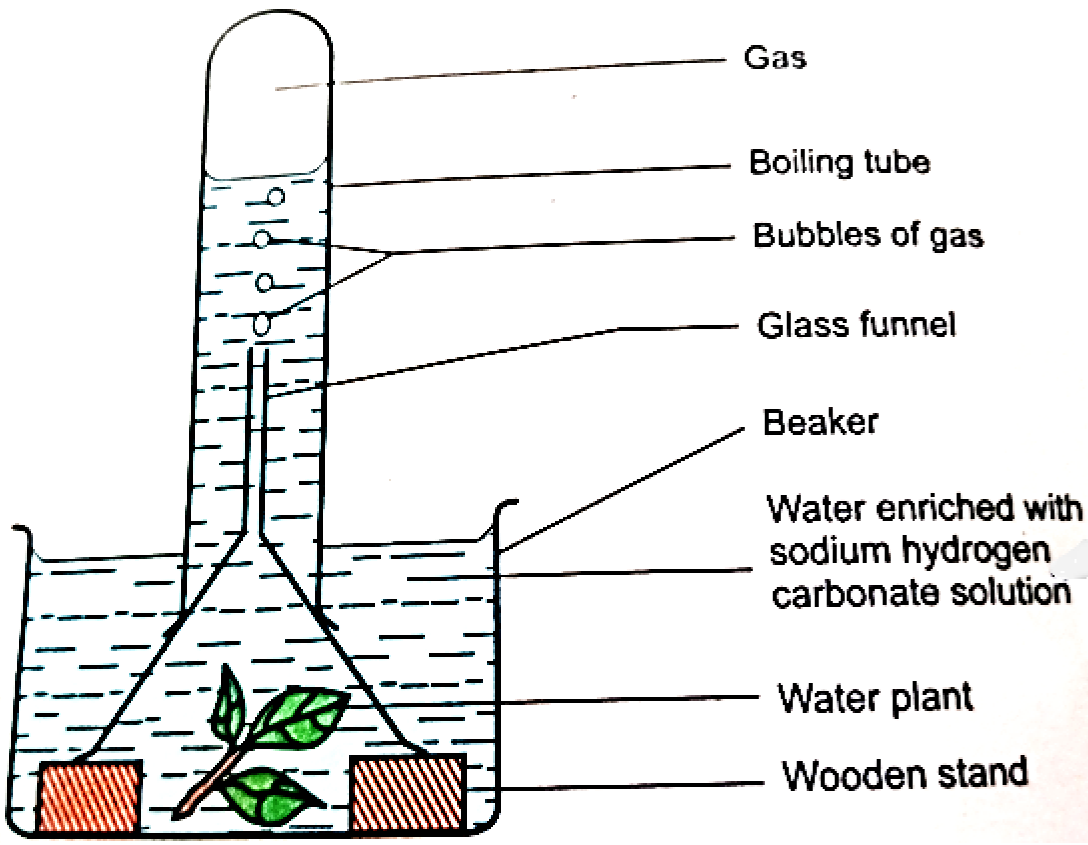
(8 points max 6)

3. How would the breathing rate of a normal and a sick cow be when exposed to the same environmental conditions (6 marks)

A sick cow will have high breathing rate; to increase supply of oxygen; for effective respiration; required to supply energy for cell division to replace the worn-out tissues/ remove the toxic substances; normal will have normal breathing rate; (Acc lower rate) because the body’s physiological process are normal;

(6 points max 6).

4. An experiment was carried using a green water plant out as shown below



i What is the importance of including Sodium hydrogen carbonate solution in this experiment? (1 Mark)

Supply carbon (iv) oxide to the plant; the creativity part of the answer is the learner should identify the commitment of the sodium hydrogen carbonate to the plant without giving the wrong role.

ii Why is replacing the green water plant with any other naturally growing plant on land likely to vary the results of the experiment above? (4 marks)

Naturally, growing plants lack adaptations to aquatic life; where there is reduced oxygen concentration; it may take sometimes for them to adapt; reducing the expected results; or giving wrong results;

‘The creativity that was expected from the answer was the ability to find out the difference between the aquatic and non-aquatic plants. The thought that there is some distribution of the stomata in the leaves of the plants.’

‘Creative idea that plants have vary chlorophyll molecules’

iii Assuming the green water plant was moved from the dark corners of the sea to the surface of the water by water currents. Explain the variation in air concentration (4 marks)

In the dark oxygen concentration is lower than carbon (iv) oxide; because the plant is carrying out respiration producing carbon (iv) oxide; as it moves to the surface light intensity increases; increasing the rate of photosynthesis; leading to more oxygen produced; as more carbon (iv) oxide is used; reducing its concentration on the water surface;

‘The aspect of creativity the test looked into was how the learner perceived the issue of light penetration in the water to reach from different depths’

(7-point max 4)

Section B: Questions Testing on Critical Thinking

5. How is it true that plants take in carbon (iv) oxide and give out oxygen during the mechanism of gaseous exchange? (6 marks)

Carbon (iv)oxide is required for photosynthesis; once used its concentration inside the leaf is lowered; increasing concentration gradient for carbon (iv) oxide; hence inflow; oxygen formed during photosynthesis; is high inside the leaf than outside; creating concentration gradient for oxygen; hence diffusing out;

‘Critically the respondent was to justify is oxygen not carbon (iv) oxide’

(8 points max 6)

6. Why is it that there is a difference in the rate of breathing between?

i. A runner and a clerk in the office (4 marks)

The runner has faster rate than the clerk; runner requires more energy for running; hence more oxygen required; and more carbon (iv) oxide formed; high requirement of oxygen and high concentration of carbon (iv) oxide in the blood (necessitates high breathing); clerk is less occupied; less oxygen is required; less carbon (iv) oxide is formed; due to the reduced respiration rate; (low breathing rate).

(9 points max 4)

ii. A baby and an old man (4 marks)

The baby has high breathing rate than the old man; baby has high rate of growth and development; that requires more energy; hence more oxygen required; and more carbon (iv) oxide formed; which requires high rate of breathing to supply the oxygen and remove the carbon (iv) oxide; old man requires less oxygen; less energy; due to reduced growth and development rate experienced; less rate of breathing to supply the amount of oxygen required and remove the carbon (iv) oxide formed;

'The critical aspect was the conviction the learner could give to qualify the difference and the key attribute'

(10 Points max 4)

7. Explain the predictions that a bony fish will survive when out of water for 30 minutes (6 marks)

Bony fish will die within the 30 minutes; because the gills filaments will cluster/clump together; reducing the surface area for gaseous exchange;

they will become less moist; less oxygen from the water will be absorbed; (due to lack of water) more carbon (iv) oxide will accumulate in the blood; reducing space; for high rate of oxygen absorption; hence suffocation of the fish (leading to death);

‘The learner was expected to prove that water media is key than the terrestrial habitat’

(9 points max 6)

8. What would happen if during breathing in the ribs are hardly pressed inwardly (6 marks

The volume of the chest cavity decreases; lung volume decreases; pressure inside the lungs increases; preventing air to flow from outside to inside; the breathing rate decreases; because pressure inside and outside the body is equal; alveoli will contain more carbon (iv) oxide and less oxygen concentrations;

‘Critically the respondent was justify the activity performed had a great impact on the breathing rate’

(7 points max 6)

9. Justify the fact that breathing rate in human beings is highly affected by occupation, age, and health of the individual (9 marks)

Occupation:

More occupied individual; require more oxygen; to increase energy supply; more carbon (iv) oxide is formed; which need to be removed; increasing the rate of breathing; less occupied require less oxygen; due to less energy required; less carbon (iv) oxide is formed; decreasing the rate of breathing;

Age;

Young individuals have high rate of breathing; to supply a lot of oxygen; for high rate of respiration/increased energy supply; to increase the rate of growth and development; to remove high carbon (iv) oxide formed (from increased respiration); old individual has reduced rate; because they require less oxygen; and less carbon (iv) oxide is formed; due to reduced rate of respiration; and reduced rate of growth and development;

Health:

Sick individuals have a lot of cells/tissues destroyed/high accumulation of toxic substances produced by the micro-organism; the cells/tissues need to be replaced; toxic substances need to be removed which both require a lot of energy; hence the high rate of breathing; to supply more oxygen; and remove the more carbon (iv) oxide produced; the old individual will have reduced rate of breathing; because less cells/tissues are destroyed/less toxic substance from the micro-organism are produced; less energy will be required; hence less oxygen required; and less carbon (iv) oxide accumulate; due to the decreased rate of respiration; (acc reduced energy required). (30 points max 9 each factor 3 points max).

'Justification provided room for the respondent to become critical'

APPENDIX VI: SCIENCE PROCESS SKILLS TEACHING APPROACHMANUAL

The following were the steps the teachers using the interventions were expected to use.

1. Provide gills and lungs of goat for the Students to observe using their senses about the characteristics of respiratory surfaces to acquire qualitative information. Allow time for them to state the differences observed from the specimen.

2. Inferring by formulating assumptions or Hypotheses or possible explanations based upon observed characteristics. Teacher guides the learners towards the formulation of the Hypotheses. Allow the students to state the proposed solutions or expected outcomes.

3. Teacher defines Variables Operationally by explaining how to value the rate of gaseous exchange in living organisms as the learners observe.

4. Classify by grouping the concepts of the respiratory surfaces into categories based on their characteristics. The learners are probed by the desire to construct new information and the teacher provides guidelines.

5. Teacher guides the learners on how to predict or guess the most likely outcome of a change in prevailing conditions during gaseous exchange in living organisms. This is followed by the learners been given time to come up with their own predictions about the phenomenon.

6. Discussing relationships between, the factors influencing the rate of gaseous exchange guided by the teacher as a facilitator.

7. Teachers designing procedures that the learners have to follow and provide the materials and the described procedure to the learners to adopt. The procedure of removing the gills from the operculum by pulling it out, exerting air pressure into goat's lungs then releasing slowing monitoring how they are behaving which similar in human beings, pressing the lungs as the learner exerts air pressure in and observing how the lungs behave, and slicing the lungs to observe the air pockets.

8. Supervision of the Experiments through guiding the learners on the procedure of breathing in and out in mammals and courter-current flow in fish. The teacher keeps close monitoring of the events of the activities.

9. Recording the results of the experiment. Teacher gives learners time and guidelines of how to record the results of the activities they are doing at every moment.

10. Analyzing Investigations and their Data followed by interpreting the data, and formulating conclusions of the results of the experiment. Learners have open controlled discussion of the results of the teaching-learning process in every lesson of the day. Techer guides how to interpret the results to become meaningful to the concepts being learnt. Teacher value learners' conclusions to make them clear and concise.

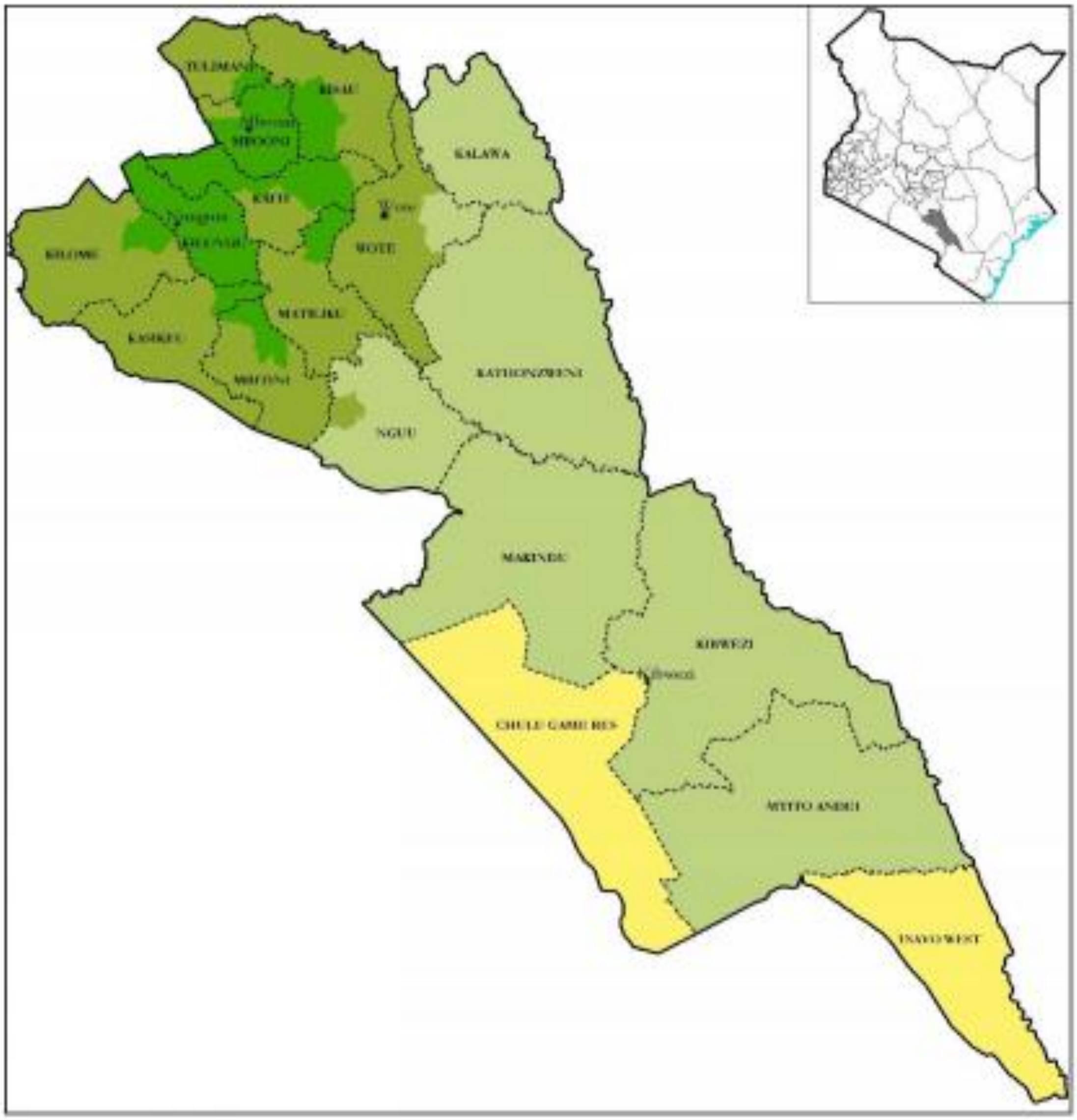
11. Calculation using measurements and scales to justify the rate of gaseous exchange between Oxygen and Carbon (iv) Oxide across a respiratory surface of the fish. Teacher shows how the differences in concentration of the two gases are occurring through calculating.

12. The learners communicate the outcomes of the scientific activities performed by using words, symbols, or graphics describing the phenomenon. Learners allowed by the teacher to share with each other the new discoveries. Drawing of diagrams and graphs with guidance from the teacher to ensure the concepts learned from the activities are well constructed as knowledge in them.

13. Drawing to explain the concepts on gaseous exchange the students are actively learning. The teacher gives time for the learners to come up with the structure of the respiratory surfaces of the plants, fish, and mammals.

14. The teacher to open up the critical thoughts of the relation between gaseous exchange and the nature or state of the media. The teacher to probe the learners by introducing contrasting aspects that determine gaseous exchange like removing the fish out of water or changing the media under which the fish is expected to live.

APPENDIX VII: MAKUENI-COUNTY MAP



APPENDIX VIII: RESEARCH LICENCE

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **433736**

Date of Issue: **24/July/2021**

RESEARCH LICENSE

This is to Certify that Mr.. NDOLO KASEKE FRANCIS of Machakos University, has been licensed to conduct research in Makueni on the topic: RELATIONSHIP BETWEEN SCIENCE PROCESS SKILLS APPROACH AND LEARNING ACHIEVEMENT IN BIOLOGY IN SECONDARY SCHOOLS IN MAKUENI COUNTY, KENYA. for the period ending : 24/July/2022.

License No: **NACOSTI/P/21/11834**

433736

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

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APPENDIX IX: RESEARCH AUTHORIZATION FROM THE GOVERNOR'S OFFICE

REPUBLIC OF KENYA **GOVERNMENT OF MAKUENI COUNTY**

HARAMBEE

OFFICE OF THE COUNTY SECRETARY
P.O. Box 78-90300 - MAKUENI ***Tel No.: 020-2034944***
Email: *county.secretary@makueni.go.ke, contact@makueni.go.ke*
web: *www.makueni.go.ke*

Ref: ADM/12/VI/(165) Date: 27th July, 2021

Ndolo Kaseke Francis
MACHAKOS UNIVERSITY.

Subject: RESEARCH AUTHORIZATION

We acknowledge receipt of research licence No. NACOSTI/P/21/1183424th July, 2021 dated 24th July, 2021 from Director General National Commission for Science Technology and Innovation licensing you to carry out a research on relationship between Science process skills approach and learning achievements in Biology in Secondary Schools in Makueni County for the period ending 24th July, 2022.

The purpose of this communication is to inform you that you have been authorized to carry out the research in Makueni County as per your request.

Benjamin M. Mutie
County Secretary,
HEAD OF THE COUNTY PUBLIC SERVICE &
SECRETARY TO THE COUNTY EXECUTIVE COMMITTEE

COUNTY SECRETARY
MAKUENI COUNTY
27 JUL 2021
P.O. Box 78-90300
MAKUENI - KENYA

APPENDIX X: RESEARCH AUTHORIZATION FROM THE COUNTY COMMISSIONER

OFFICE OF THE PRESIDENT
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

ACCs / Chiefs and Asst. Chiefs kindly accord the Researcher necessary assistance

Telegram:
Telephone:
Fax:
Email: ***makuenicc@yahoo.com***

COUNTY COMMISSIONER
MAKUENI COUNTY,
P.O. Box 1-90300
MAKUENI

Ref: MKN/CC/ADM.6/1 VOL.IV/83

27th July, 2021

Mr. Ndolo Kaseke Francis
MACHAKOS UNIVERSITY

RE: RESEARCH AUTHORIZATION

Reference is made to Director General National Commission for Science, Technology and Innovation letter **Ref. NACOSTI/P/21/11834** dated **24th July, 2021** on the above underlined subject matter.

You are hereby authorized to undertake research on ***"Relationship between Science Process skills Approach and Learning Achievements in Biology in Secondary Schools in Makueni County, Kenya"*** *for* the period ending **24th July, 2022.**

By a copy of this letter the Deputy County Commissioners are requested to give you the necessary assistance.

COUNTY COMMISSIONER MAKUENI COUNTY 27 JUL 2021

P.NYORO
FOR: COUNTY COMMISSIONER
MAKUENI

Cc:
County Director of Education
MAKUENI COUNTY

All Deputy County Commissioners
MAKUENI COUNTY

APPENDIX XI: RESEARCH AUTHORIZATION FROM THE COUNTY DIRECTOR OF EDUCATION

Received.
Assist the Researcher where Necessary

SUB-COUNTY DIRECTOR OF EDUCATION-KIBWEZI
30 JUL 2021
P.O. Box [illegible]-90137,
KIBWEZI.

REPUBLIC OF KENYA

MINISTRY OF EDUCATION
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION

Telephone: ....
Fax: ....
Email:cdemakueni@gmail.com
When replying please quote

COUNTY DIRECTOR OF EDUCATION
MAKUENI COUNTY
P.O. BOX 41 - 90300
MAKUENI

Ref No. MKN/C/ED/5/33/VOL.II/84

27th July ,2021

Mr. Ndolo Kaseke Francis
Machakos University
P.O BOX 136-90100
MACHAKOS

RE: RESEARCH AUTHORIZATION FOR NDOLO KASEKE FRANCIS

This office is in receipt of a letter from the Director General, National Commission for Science, Technology and Innovation (NACOSTI) authorizing you to carry out research on **"Relationship between Science Process Skills Approach and Learning Achievements in Biology in Secondary Schools in Makueni County, Kenya''** for the period ending 24th July, 2022.

Following this authorization, you are allowed to proceed with your research as requested.

COUNTY DIRECTOR OF EDUCATION
DATE: 27/7/2021
P.O. BOX 41-90300
MAKUENI
MAKUENI COUNTY

Dr. Samson Arodi
Fro County Director of Education
MAKUENI COUNTY

CC:
Director General/ CEO, NACOSTI

APPENDIX XII: THESIS PLAGIARISM REPORT

RELATIONSHIP BETWEEN SCIENCE PROCESS SKILLS TEACHING APPROACH AND LEARNING OUTCOMES IN BIOLOGY IN SECONDARY SCHOOLS IN MAKUENI COUNTY, KENYA

ORIGINALITY REPORT

12%	13%	6%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		