INFLUENCE OF STUDENTS' "BIOLOGY PRACTICAL PROCESS SKILLS" COMPETENCY ON THEIR ACHIEVEMENT IN AND ATTITUDE TOWARDS BIOLOGY IN GUCHA SOUTH SUB-COUNTY, KISII COUNTY, KENYA

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A THESIS SUBMITTED TO THE SCHOOL OF POST-GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE AWARD FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN CURRICULUM AND INSTRUCTION OF THE SCHOOL OF EDUCATION AND HUMAN RESOURCE DEVELOPMENT, DEPARTMENT OF CURRICULUM, INSTRUCTION AND MEDIA, KISII UNIVERSITY

APRIL 2021

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DEDICATION

To my children Gregory Odawa, Mitchelle Nyamanga, Shirnell Alukaya and Blessing Montessori whose inspiration always gave me the synergy to propel my research forward day and night. May you grow and live to become great scholarly icons.

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ABSTRACT

Students are expected to perform better in Biology examinations if and when the right heuristic teaching methodologies and approaches are adopted during Biology instruction. There has been persistent decline in learner achievement in Kenya Certificate of Secondary Education (KCSE) Biology examination in Gucha South sub-County despite the continued emphasis on the role of biological knowledge on the wellbeing of the individual and the society. This study aimed at determining the contribution of learner competence in six Biology practical process skills: observing, inferring, measuring, communicating, interpreting data and experimenting on learner achievement and attitude of form two students in Gucha South Sub-County. The objectives of the study were to: determine the contribution of Biology Practical Process Skills Teaching Approach (BPPSTA) on learners' achievement in Biology, establish the gender difference in achievement between learners taught using BPPSTA and those taught via conventional method, to investigate the influence of BPPSTA on learners' attitude towards Biology when taught via BPPSTA as compared to when taught using conventional methods and, determine whether there is a gender difference in attitude of learners towards Biology when taught via the BPPSTA and when taught via the conventional methods. The study adopted the Constructionism theory by Seymour Papert and Cognitive consistency theory by Frizer Heider. The study adopted the Solomon four-group non-equivalent control group design and survey design. The target population comprised 2,946 form two students and 64 teachers of Biology. Four co-educational County level secondary schools were purposively sampled. The sample size was all the 401 form two students and seven form two Biology teachers both from the four sampled County level schools. They were selected using purposive sampling technique. Data for this study were collected using Biology Attitude Questionnaire for Students (BAQS), Biology Practical Observation Schedule (BPOS), Process Skills Assessment Test (PSAT) and Biology Achievement Test (BAT). Reliability of the BAQS and PSAT was determined through split-half and a reliability of 0.87 and 0.94 respectively were established. Validity of data collection instruments was established through input from senior university lecturers to specifically ascertain the face and construct validity. Ethical research considerations were strictly adhered to. Data collected were analyzed both qualitatively and quantitatively. Qualitative data were organised thematically then analysed using content-analysis. It was then presented on the basis of the study objectives. For quantitative data, means and standard deviations were used to compare the group performances then one-way ANOVA and independent samples t-test at $\alpha = 0.05$ significance level were used to determine the effect of BPPSTA on learner achievement. The study found out that: the BPPSTA positively influenced learner achievement, BPPSTA did not influence the achievement of male and female learners differently, use of BPPSTA led to a more positive attitude towards biology among learners and the BPPSTA influence on learner attitude did not vary by gender. The study recommends that MOE through its QASOs should promote the use of process skills in Biology teaching and regularly supervise the implementation of this approach, Biology teachers should always use the BPPSTA so as to promote better achievement and positive attitude in both gender. The study findings may provide insights to the Biology teachers on the appropriate improvement in the administration of practical activities in Biology lessons. It may also inform the MOE and QASO of the quality and efficacy of practical lessons in Biology.

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LIST OF ABBREVIATIONS

AAAS - American Association for the Advancement of Science

BPOS - Biology Practical Observation Schedule

BPPS - Biology Practical Process Skills

BPPSTA - Biology Practical Process Skills Teaching Approach

KCSE - Kenya Certificate of Secondary Education

KICD - Kenya Institute of Curriculum Development

KLB - Kenya Literature Bureau

MDGs - Millennium Development Goals

MOE - Ministry of Education

PDSI - Plan, Do, See, Improve

SPS - Science Process Skills

SPSTA - Science Process Skills Teaching Approach

TSC - Teachers' Service Commission

LIST OF ACRONYMS

ASEI - Activity, Student, Experimentation, Improvisation

BAT - Biology Achievement Test

BAQS - Biology Attitude Questionnaire for Students

CEMASTEA - Centre for Mathematics, Science and Technology Education in Africa

EFA - Education For All

KNEC - Kenya National Examination Council

NACOSTI - National Commission for Science, Technology and Innovation

PSAT - Process Skills Assessment Test

QASO - Quality Assurance and Standards Officer

SAPA - Science A Process Approach

SCORE - Science Community Representing Education

SMASSE - Strengthening of Mathematics and Science in Secondary Education

TIMSS -Trends in International Mathematics and Science Study

UNESCO - United Nations Educational, Scientific and Cultural Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Knowledge and skills of Biology holds a pivotal value and importance in the present day society and this position should be underscored. The knowledge in Biology influences not only those who study it but also the entire society and the environment where they live in. An English biologist by the name T. H. Huxley was the first person to propose the integration of Biology into the curriculum in 1875 (Suzuki, 2007). The design of the curriculum then involved the inclusion of concepts of plants, animals, their systems and natural selection. He designed this course as 'Biology' rather than 'Natural History' and it developed not only in England but also in many other countries. The knowledge of Biology is significant to humankind since it enables human beings to have a better understanding of their bodies, their resources and potential threats in the environment. Biology is a branch of science that deals with the study of living organisms (Alcamo, 2002; Anastasia & Kelemba, 2005; MOE, 2016a). Biology is the most popular natural science subject that entails the study of living organisms and their basic structures, functions, and growth (Okoye, 2016). The syllabus emphasizes teaching that is tailored towards the eight goals of education in Kenya as seen in the attached Appendix (XV). The teaching of Biology is expected to facilitate learners achieve the ten general objectives of secondary school Biology as seen in Appendix (XVI) (MOE, 2002). The teaching of biology in secondary school require the use of heuristic instructional approaches for the objectives to be achieved.

The study of Biology enables pathologists to; have good knowledge of the human body, to understand the physiology of the different body organs, know the infections that attack the human body with their etiology, their symptoms and, how they can be prevented and controlled. Environmentalists engage in the study of Biology so as to have an understanding of how the activities of man affect the environment and the habitat of other living organisms (Sharpe, 2012). Arokoyu and Chukwu (2017) reiterate that the knowledge of Biology is not only a foundation but also a prerequisite for entry into careers such as agriculture, biochemistry, microbiology, nursing, pharmacy and medicine. A student with a dream or ambition to pursue a career in these areas cannot achieve it without Biology. Daba, Anbassa, Oda and Degefa (2016) observes that the great contribution of the knowledge of Biology has been in the medical and technological applications; which has therefore had far reaching effects on human health, lifestyle and the general welfare. The present study recognizes that these ambitions and aspirations will not be achieved if teaching goes on through the traditional expository approaches.

Appropriate instructional approaches should be embraced by Biology teachers unlike the conventional teacher centred methodologies such as lecture among others. Ajayi, (2017) observes that use of discussion method may degenerate into, out of context talk that may be dominated by a few learners. The consequence is arriving at a conclusion that is wrong. Eila, Irmeli and Eija (2016) observe from their study carried out in Finland that, in science laboratories, learners can develop the skills of experimentation as they prepare and do small practical activities. According to Connell, Donovan and Chambers (2016) active learning pedagogies have an aim of improving science environments towards increased learner-centred teaching so that the learners are more engaged in the process of constructing knowledge. In Australia, passive learning as opposed to active learning is evident as a result of continued use of conventional instructional methods. Learners get bored, confused and become less innovative which in the long run demotivates them from learning Biology. Once demotivated, the learners will develop a negative attitude towards the subject (Wingate, Andon, & Cogo, 2011). In many countries, the key tenet associated with science subjects that makes them different from others is that their teaching encompasses practical lessons. This tradition if explored in developing countries such as Kenya, the outcome would be expected to be great. The present study explored the use of Biology Practical Process Skills Teaching Approach (BPPSTA) for instruction among form two students.

In England, Biology is well founded and these roots can be of great benefit if explored for purposes of practice in the teaching of other science-related disciplines (Howarth & Slingsby, 2006). A study by Sturman, Ruddock, Burge, Styles, Lin, and Vappula (2008) found out that in England, science teachers often use 'hands-on' approach during instruction. In this country, science teachers have embraced the need to develop the three knowledge domains in the learner with emphasis on the psychomotor domain. This emanates from the goals and aims of science in these countries which too emphasize science practical during instruction process. The present study sought to find out if such trend in practice of practical lessons in Biology is evident in Kenyan Biology classrooms.

Chebii (2011) observes that science is a route or path through which one gets a remedy or solution to a problem. The actual process of teaching and learning Biology using practical activities can be successful if science process skills (SPS) are incorporated into the lesson (Youssef & Mohammed, 2015). Different scholars give various interpretations and definitions of what science process skills are. According to Padilla (1990), SPS are abilities that are broadly transferable which are suitable to most science disciplines and portray scientists’ behaviour. SPS are defined as the ability to have an understanding of procedures, tenets and approaches of scientific investigation (American Association for the Advancement of Science [AAAS], (1993); Bilgin, 2006).

SPS are cognitive and psychomotor skills that are applied during identification and solving of a problem, when collecting data, in the process of interpretation and communication of the data (Akinbobola & Afolabi, 2010). These skills engage most of the senses of the learner during the learning process. Hill (2011) defines SPS as the underlying suppositions and skills which control the scientific method. Furthermore, SPS are often used to collect information concerning nature. Abungu, Okere, and Wachanga, (2014) describes science process skills as activities, that learners carry out in scientific investigations so as to facilitate them in acquiring scientific knowledge and skills. According to Susanti Anwar, and Ermayanti, (2018), SPS are transferable intellectual abilities, befitting to all scientific studies and spheres. The described definitions are in convergence at a point where active learning is an associated tenet of SPS. Active learning which was the concern of this study required learner’s involvement in manipulation of resources. SPS entails the abilities, suppositions and activities that can be learnt and hence transferred to the learner through active learning. These skills are practised during science instruction through scientific investigations. Therefore, SPS integration in teaching culminates in to Science Process Skills Teaching Approach (SPSTA). SPSTA is an approach advocated for in science teaching. This approach is important because it contributes to the understanding of most abstract concepts in the field of science, which would remain tacitly assumed if they are taught theoretically (Gultepe, 2016). As an instructional approach, it would be expected that learners too gain more when this approach is used in the classroom. This standpoint prompted the present study to be conducted so as to investigate whether this position holds.

Science A Process Approach (SAPA) is a programme that was launched by the commission on science education of the American Association for the Advancement of Science (AAAS). This programme underscored the laboratory method of instruction and the learning of scientific procedures. According to SAPA, process skills are grouped into two: basic SPS and integrated SPS. AAAS (1993) reports that the basic science process skills include; observing, measuring, inferring, classifying, communicating, and predicting while the integrated science process skills comprise of controlling variables, formulating variables, defining operationally, experimenting, interpreting data, and formulating models. Since then, other scholars have come up with varied lists and numbers of SPS. Okere (1996) on the other hand, identified fifteen science process skills that comprise of; observing, classifying, recording, measuring, experimenting, estimating, analysing, extrapolating, predicting, evaluating, hypothesizing, inferring, communicating, interpreting and applying. Aslan (2015) opines that SPS are not only required in the moulding of upcoming scientists and technologists, but also for everyone who require scientific literacy. SPS are a lifelong learning process that create a foundation for thinking analytically thereby resulting into new knowledge through learners' hands-on engagement (Aslan, 2015).

Similarly, Science Community Representing Education [SCORE] (2008) concludes that science taught in the absence of practical work is like swimming without water. The implication from this analogy therefore is that science learning is not complete without practical lessons. Sadhana (2017) reiterates that practical learning in science should be promoted while rote learning should be discouraged. Such learning becomes more permanent, meaningful and concrete. Ekon and Eni, (2015) contend that science content learnt can be easily forgotten but on the other hand process skills learnt usually remain in the mind of the individual for a comparatively longer time. The purpose of learning science at early stage is not so as to behave like scientist, rather the purpose is to develop process skills, concepts and attitudes towards science which will enable them to cope up effectively for their further education and achievement. This purpose in not always the drive, however it requires appropriate induction of the instructor on such a purpose. The present study organized for an induction of biology teachers so as to equip them with these skills together with the purpose of teaching via process skills approach.

In Nigerian secondary schools, there is a tendency for science teaching being dominated by expository instructional approach. This is due to the fact that science teaching lays a great emphasis on content with the use of "chalk and talk" method at the expense of more constructive methodologies that enhance meaningful learning (Obiekwe, 2008). Therefore, the minimum practice of activity oriented-method in the teaching of science subjects results into abstraction of concepts that end up making learners less active and hence they end up being more involved in rote memorization of scientific knowledge, skills and principles. Nwagbo (2006 p. 41) stated that:

> The use of practical activities (approach) to the teaching of biological concepts should therefore be a rule rather than an option to Biology teachers, if we hope to produce students that would be able to acquire the necessary knowledge, skills and competence needed to meet the scientific and technological demands of the nation…

If these sentiments are anything to go by, then the impact of practical activities would be expected to be evident through learners' performance in Biology and specifically Biology practical across the nations. The insufficiency of some teachers in SPS affects their ability to practice these skills during classroom instruction (Pekmez, 2001; Aydogdu, 2015). However, studies continue to show that teachers who have advanced well in these

SPS are likely to use them (Aydogdu, 2015). Eila et al. (2016) contends that several topics and content in Biology require methods and approaches that enhance experimental, problem-solving and process-hinged skills. Therefore, the failure to adequately practice or teach using process skills approach could be due to this reason. Therefore, the present study had a concern to interrogate the use of BPPSTA and its contribution to learner academic achievement and attitude.

Molefe and Michele (2014) carried out a study on science teacher educators' views and practice regarding science process skills in South Africa. The study found out that the teacher training education policy lays a lot of emphasis on the competence of teachers 'in procedures, methods, principles, knowledge, skills and values. The competence of teachers in these areas is much relevant to the scientific discipline and practices' (Department of Higher Education and Training, 2011, p. 49). The study document does not exclusively refer to SPS; however, SPS are inherent in the methods and procedures that are aforementioned. From the foregoing arguments it implies that the process of classroom instruction in the present era is expected to portray precise scientific attributes; key among them is the role of the learner in the learning process. The knowledge and skills should develop the learner wholly. The Biology practical process skills that were explored in the present study are vital in ensuring effective understanding of biological knowledge, skills and attitudes.

Agogo (2002) carried out a study on the attitudes of students as a factor in the learning of integrated science and affirmed that, the actual learning of integrated science has to do with the learners' attitudes so as to develop interest in the learners towards learning process. The study found out that there was correlation between attitudes that the integrated science students come with to the science class and their academic achievements in the subject. Adodo and Gbore, (2012) moreover, carried out another study to determine the prediction of attitude and interest of science students of different abilities on their academic attainment in basic science process skills. From their study, they concluded that the solution to changes in the attitude of learners lies squarely in the teachers' hands. This study however did not consider methodology as the key ingredient through which the teacher influences attitude. Therefore the present study sought to investigate whether or not BPPSTA influenced learner attitude.

According to Dania (2014) gender related disparities have been featuring in the Kenyan education system at all levels from the national to the local level. This is evident in all tiers of education from the primary level to the postgraduate level. Boys are perceived to be more favoured by the programmes, resources and even the methodologies used. Besides, majority of girls in secondary school have the misconception that science subjects (especially Biology) are meant for males, more involving and difficult to study. This has ultimately led to more female learners seemingly shying away from learning science subjects, which results in to more male scientists as compared to female ones (Jegede & Olu-Ajayi, 2017). Kashu (2014) observes that gender equity in education requires fair treatment of both male and female learners in relation to their specific gender demands. This may either imply equal treatment or one that is varied but equivalent in aspects of rights, benefits, obligations and opportunities (IFAD, 2014). The present study narrowed down to determine whether or not gender as a factor was influencing learner academic achievement and their attitude towards Biology after instruction via BPPSTA

Different studies have yielded contrasting results on the role of gender on learner attainment. Some report that there is a correlation among the two variables while others report there is not. Educators and researchers all over the world have developed a great interest in studies concerning gender differences and their influence on learner achievement. Jegede and Olu-Ajayi (2017) observe that out of the students under study, female learners portrayed greater anxiety towards Biology learning in relation to their male counterparts. From another study on influence of gender on school achievement by Okereke and Onwukwe (2011) it was observed that male learners showed a better achievement than female learners under study. However, there is evidence of continued gender stereotyping in science education from society, textbooks, teachers and even students themselves. This study had a concern to find out whether gender has an effect on learner achievement and attitude towards Biology. This study also considered gender differences in achievement and attitude towards Biology.

Samikwo (2013) observes that, success in life has so much been associated with one's performance in examination. Students who do well in examinations get a chance of proceeding to higher levels of studies and consequently, being a source of manpower in many Biology-related careers. Students' failure in Biology is a precursor for manpower shortage in these Biology-related professions. This is because Biology forms the foundation necessary for pursuing a myriad of careers in future. Various studies continue to reveal that the rare use of inquiry teaching approaches by science teachers is hinged to challenges which include: inadequately equipped laboratories in schools, large class sizes with high teacher-learner ratios and also incompetency issues emanating from science teacher training (Sifuna & Kaime, 2007; Ngesu, Gunga, Wachira, & Kaluku, 2014).

Inappropriate instructional approaches, and the abstractness of most science concepts have been cited by researchers and education stakeholders as among the key causes of poor performance in science (Keraro & Okere, 2019). The Competence Based curriculum (CBC) initiation in the education system partly would be expected to mitigate these inadequacies. CBC that was initiated in primary schools in the year 2019 is anticipated to be rolled out at secondary school level as from the year 2023. Nyakangi (2021) observe that CBC emphasises learner engagement rather than learner involvement. The key components of CBC are learner competencies. It is along such conformity that the present study aims at ensuring learner improved achievement through the use of BPPSTA. Nyakangi further notes that CBC is anchored on seven core competencies. Among the seven are: communication and collaboration, imagination and creativity, problem solving creativity and, learning to learn. These competencies are well acquired and practiced through practical hands on activities. SPS is a subset of practical work that would be expected to enable effective achievement of these competencies. Therefore the focus of this study was to investigate the influence of BPPSTA on learner achievement.

Practical activities promote understanding of biological concepts and principles (Owiti, 2015). A practical activity can be carried out by learners individually or in groups. Each learner or a group of learners perform an identical experiment at the same time. When teaching resources are insufficient, learners can also perform two or three experiment activities in turns to give everyone a chance to perform all the experiments (Imanda, 2013). Several studies have indicated that gender and learner attitude towards the subject influence learner achievement in science. The present study was concerned with whether or not BPPSTA affects attitude and achievement on the basis of gender in Biology. It should be noted that Biology is one of the science subjects taught in secondary schools in Kenya (Kenya National Examination Council [KNEC], 2015).

Learners' attitude affects learner achievement and learner achievement equally affects learner attitude (Owiti, 2001). Wabuke (2013) however notes that, an interest in Biology influences performance. Abungu et al. (2014) on the other hand found out from their study that the interests of learners are captured when the learners are involved in hands-on activities. As a result of this, the learners end up performing better in the science subject. A similar standpoint is held by Ogutu, Yungungu, Osman, and Ogolla (2015) who observe that, student interest influences performance in KCSE Biology. Furthermore, the study observes that this is so because when a learner has interest it develops a positive attitude towards the subject, hence this motivates the learner to put in more effort in learning of science. However, these studies do not reveal whether the attitude of the learners is influenced by the methodology used to teach. It was therefore necessary to investigate if the attitude of learners is influenced by using BPPSTA as opposed to the use of the conventional teaching methodologies.

Rotich and Mutisya (2013), observe that continued poor academic performance in sciences in KCSE has drawn the attention of many education stakeholders. Learner performance in Biology in the 2017, 2018 and 2019 KCSE national examinations has consistently been dismal to the extent that a very small number of form four graduates were admitted into biological science-related courses in universities and tertiary institutions in Kenya (KNEC, 2020). A paltry 18% of the 2017 KCSE candidates managed to attain a mean grade of C+ or over in Biology (KNEC, 2018). This grade is the minimum requirement for one to be admitted in to a biological-related degree course in the Kenyan universities. Such poor performance in Biology is not only experienced in Kenya but equally in several other countries in Africa (Trends in International Mathematics, and Science Study [TIMSS], 2011). This low attainment has continued to be witnessed amongst candidates whenever they sit for the national examinations. Table 1.1 presents the mean mark attained since the year 2011 in the three sciences in KCSE examinations.

Table 1.2: Comparison of Learner Performance in KCSE in Science Subjects

Year	MARKS SCORED IN SCIENCE SUBJECTS		
	Physics (%)	Chemistry (%)	Biology (%)
2011	36.64	23.65	32.43
2012	37.86	27.93	26.20
2013	40.10	24.50	31.63
2014	36.84	32.15	31.84
2015	43.68	34.80	34.36
2016	39.75	23.71	29.19
2017	35.05	24.05	18.93
2018	34.27	26.88	25.69
2019	32.59	26.09	25.69

Source: KNEC, 2020

Table 1.1 indicates that all the three science subjects had a mean mark that is low. It is only physics that had a mean mark of over 35%. For chemistry and Biology, their mean mark is comparatively low. In the year 2017 Biology had the least mean mark at 18.93%. This leaves room for speculation of why the poor performance continue to recur in all these science subjects and especially in Biology in which SPS are advocated for. Samikwo (2013) posits that unlike other science subjects, Biology is expected to be performed much better because the subject matter touches on life and life processes that are expected to be interesting and motivating to the learners however, this is not the case. This created a gap for the present study to establish whether or not the learners are taught using the BPPSTA.

SPS are necessary for the acquisition of scientific knowledge and skills required during societal problem solving process (Abungu, et al., 2014). Biology is a science subject that is taught at the basic education level in Kenya (KNEC, 2015). It would be expected that possession of SPS by learners would ultimately impact on Biology performance. However, statistics still indicate poor performance in Biology national examination (KNEC, 2018). This is depicted from the annual analysis done by KNEC. The continued poor performance by learners might be associated with the continued use of inappropriate instructional methods.

Furthermore, from Table 1.1, it is observed that the highest mean mark in Biology attained in the years presented is 34.36% which was attained in 2015. The mean marks in Biology for the years presented show that, nationwide learner performance in Biology is wanting (KNEC, 2018). This performance is very low considering that Biology is a science whose contribution to welfare of a country and technological skill empowerment cannot be underestimated. The mean grade a candidate gets in KCSE national examination is in part attributed to the 40% attained in practical examination (Biology paper three) (KNEC, 2018). The poor performance as seen in the Table 1.1 could in part be an attribute of poor performance in practical work (Wanjiru, 2015). This in turn could be attributed to the continued use of the traditional expository instructional methods.

KNEC (2015) report on the KCSE examination of 2014 indicate that, questions involving knowledge application were poorly performed by candidates in comparison to those that required factual knowledge. KNEC (2018) reiterates similar observations across the three Biology examination papers (paper 1, 2 and 3). Questions that demanded for the learners' extra effort to infer, interpret, comprehend (from a photograph, a diagram, a process and data) were poorly performed as compared to questions that were straight-forward. This could be as a result of less emphasis by Biology teachers on development of Biology process skills and critical thinking skills. Furthermore, questions involving biological processes were equally performed poorly (KNEC, 2015). Some candidates had the point but could not write it down coherently as per the requirements of biological procedure. This could be an indication that these candidates simply memorized the points therefore could not use them to build the biological process in the task (KNEC, 2015; KNEC, 2018). Biology has never been difficult, but we only need to integrate what students are taught and how they are taught. These observations are a clear indication that the teaching approach in the Biology classroom is ineffective or less effective. In part, these deficiencies on the part of learners are attributed to the continued instruction by Biology teachers whereby they mainly employ expository approaches. The use of Biology practical process skills teaching approach might salvage this situation.

The poor performance nationally in Biology is also witnessed at the local level. The data on learner achievement in Biology KCSE examination for the past nine years in Gucha South sub-County is presented in Table 1.2.

Table 1.3: Biology KCSE Performance in Gucha South Sub-County Since 2011

Year	Candidature	Mean Mark	Mean Grade
2011	1650	31.08	D+
2012	1710	26.17	D
2013	1801	35.92	D+
2014	1800	35.67	D+
2015	1917	31.83	D+
2016	2046	21.50	D-
2017	2314	16.97	E
2018	2461	21.27	D-
2019	2513	21.98	D-
AVERAGE		**26.9**	**D**

Source: Gucha South Sub-County Education Office

Table 1.2 indicates that learners' attainment in KCSE Biology examination is still poor. The year when the learners attained the highest mean mark is 2013 which was 35.92(D+). This mean mark is low considering that the maximum attainable mark is 100. The average mean mark for the nine years presented in the Table is 26.9(D). This indicates that just like at the national level (KNEC, 2020), learner performance in the sub-County is equally low in Biology. This trend has continued despite the continued effort by the government to invest in education through facilitating training, recruitment and further, in-service training of teachers especially the science teachers. Furthermore, Gucha South sub-County performed dismally in the 2017 KCSE examination; it was ranked position seven out of the nine sub-counties in Kisii County (MOE, 2018). The teaching approach adopted by a teacher is an important factor that affects learners' motivation to learn and hence influences learners' attainment (Imanda, Okwara, Murundu, & Bantu, 2014; Orora, Keraro, and Wachanga, 2014). With all these studies in support of influence of teaching and teaching approach on learner achievement, it deemed necessary to probe the use of BPPSTA and its influence on learner achievement and attitude.

1.2 Statement of the Problem

Student performance in KCSE Biology examination in Kenya has continually been poor over the years. Similarly, this has been the trend in Gucha South sub-County. Analysis of overall mean attained by learners in the sub-County in KCSE Biology examinations has shown a declining trend since the year 2013 as seen in Table 1.2 in section 1.1. The learners' attitude towards Biology too has been observed to be negative. The negative attitude has been observed both in male and female learners. The poor learner academic attainment and negative attitude witnessed in Gucha South sub-County might be attributed to continued use of expository instructional methods in Biology. This study therefore, aimed at establishing the contribution of the Biology practical process skills on learners' academic achievement and on learners' attitude towards Biology in secondary schools in Gucha South sub-County.

1.3 Purpose of the Study

The purpose of this study was to investigate the contribution of form two students' competency in Biology practical process skills' on their achievement and attitude towards Biology in Gucha South sub-County, Kisii County. The study aimed at investigating the ability of Biology practical process skills teaching approach in improving learner achievement in Biology and developing of a more positive attitude towards Biology.

1.4 Objectives of the Study

The study was guided by the following specific objectives that were to:

i. Determine the contribution of Biology Practical Process Skills Teaching Approach (BPPSTA) on learners' achievement in Biology in Gucha South sub-County.
ii. Establish whether or not there is a gender difference in achievement between learners taught via the BPPSTA and via Conventional Methods.
iii. Investigate the influence of BPPSTA on learners' attitude towards Biology when taught using BPPSTA as compared to those taught via the conventional methods.
iv. Determine whether or not there is a gender difference in attitude of learners towards Biology when taught via the BPPSTA and via Conventional Methods.

1.5 Research Hypotheses

This study was guided by the following research hypotheses:

$H0_1$: There is no significant difference in achievement between learners taught via the BPPSTA and via conventional method.

$H0_2$: There is no significant gender difference in academic achievement in Biology between learners taught via the BPPSTA and those taught via Conventional Methods.

$H0_3$: There is no significant difference in attitude towards Biology between learners taught via the BPPSTA and those taught via the conventional methods.

$H0_4$: There is no significant gender difference in attitude towards teaching Biology via the BPPSTA and via the Conventional Methods.

1.6 Scope of the Study

The study focused on one Biology topic; transport in plants (MOE, 2016b) as presented by the Kenya Institute of Curriculum Development (KICD) syllabus (K.I.E, 2002). The topic was chosen since in the years it has been tested in the KCSE Biology examinations, the performance has been dismal (KNEC, 2015). The study was conducted in four co-educational public secondary schools in Gucha South sub-County of Kisii County in Kenya. The participants were form two Biology students and secondary school Biology teachers. The Biology Process Skills Assessment Test (PSAT) was a teacher-made test which required learners to carry out the activities and record short answers while the Biology Achievement Test (BAT) was a test with multiple choices. In addition, the learners were subjected to Biology Attitude Questionnaire for Students (BAQS) with a view of finding out their attitudes before and after the use of Biology Practical Process Skills (BPPS) during teaching. Four co-educational secondary schools took part in the study due to the nature of the research design; Solomon four non-equivalent control group design. In this design there were four non-randomized groups; two of which were control and the other two were experimental groups.

1.7 Limitation of the Study

The findings of this study have two limitations. The first one is that, only six Biology practical process skills were tested out of the twelve identified by the AAAS. The justification of studying the six was informed by a study by Ongowo and Indoshi (2013) who found that these six were the often tested skills by KNEC in KCSE examinations. Therefore, the findings of this study may not be generalized to all the twelve practical process skills. However, they give a general indication on the use of BPPS in Gucha South sub-County. Secondly, the population of this study was restricted to form two students in secondary school. However, this class just like the other classes (form 1, 3 and 4) not included are taught by the same teachers. Therefore, the findings from this study are generalizable since form two biology teachers equally teach the other classes.

1.8 Assumptions of the Study

The assumptions for the study were two: First, the students in County level secondary schools in the sub-County attained KCPE marks within the range recommended by the ministry of education for admission to such level of schools (MOE, 2015). The second assumption was that the researcher's presence and that of the equipment used for video recording in the class environment did not interfere with the behaviour that was observed in the classroom. To neutralize the unforeseen effect, the researcher introduced the video recording equipment in the lesson preceding the Biology lesson of interest. This helped to reduce the anticipated anxiety during the actual Biology lesson hence learners concentrated on the instructional process rather than the recording instruments in class.

1.9 Theoretical Framework

This study was guided by the constructionism theory as proposed by Seymour Papert (1991) and the Cognitive consistency theory by Frizer Heider (1958). These two theories guided the study in so far as learner achievement and Attitude are concerned respectively. In his own words, Papert (1991 p.1) notes:

> …Constructionism shares constructivism views of learning as building knowledge structures through progressive internalization of actions. However, in constructionism, this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity whether it is a sand castle, on the beach or a theory of the universe.

Constructionism theory guided this study in as far as the practising of the skills by the learners is concerned especially now that it occurred in the laboratory. The BPPS under study are well taught and learnt if the hands-on activities are embraced specifically in the laboratory just as Papert (1991) emphasizes that learning should be in situ or in context.

The competing theories include social constructivism and cognitive constructivism by Lev Vygosky and Jean Piaget respectively.

Constructionist learning takes place when students are involved in the construction of mental models so as to have an understanding of their environment. Constructionism is in support of learner-centred instruction in which the learner uses prior knowledge to acquire new concepts (Sabelli, 2008). This theory suggest that learners learn meaningfully when they are involved in activities that engage them to construct their own knowledge. Further, constructionism theory suggests that learning can happen more effectively when learners are active in making tangible objects in the real world. In this sense, constructionism is connected to experiential learning and it is an advancement on Jean Piaget's theory of constructivism (Alesandrini & Larson, 2002). In the present study learners were to practice the BPPS in the laboratory and in the field on plants. This interaction with realia was intended to enhance the biology instruction process through the use of BPPSTA. The effect would then be expected to be felt on the learner academic achievement and attitude.

Papert (1991) is of the view that learners should be engaged in activities that involve them in the construction or generation of knowledge during the learning process. He is interested with how learners make interaction with the environment and how these interactions boost self-directed learning. Ediyanto, Atika, Hayashida, & Kawai (2017) observe that SPS involves the interaction of learners with their learning environment in a scientific manner and that this can only happen effectively through process skills. Process skills are therefore the pathway through which learners explore and acquire evidence that they finally apply when evolving scientific ideas. According to Papert, knowledge remains naturally rooted in contexts and is modified depending on the uses. He adds that the support received from external sources is to strengthen and ensure that the skills and knowledge actually remain in the mind for use.

The greater strength of Papert's theory of constructionism unlike Piaget's and Vygosky's theories of cognitive and social constructivism respectively is that, it is more situated and more pragmatic; in this sense it well suits the context of Biology learning and engages both the cognitive and practical psychor-motor skills inherent in the learners. Papert and Harel (1991) posit that the strong claim constructionism is a much better theory for practice as compared to the prevalent "instructionist" models propagated in most schools. They further add that it is the only model that has been proposed, that accommodates a variety of intellectual techniques and alternatives that get a point of balance. This balance in relation to the present study is in relation to the aspects of the study that include: SPS, learner attitude and gender.

Therefore on the basis of the aforementioned, constructionism theory was deemed as the most appropriate for this study since Biology as a science subject is naturally practical-oriented. The theory accommodates learner engagement and in so doing the theory enables learners to own the learning process and it moulds their attitude. Similarly Maria Montessori viewed that effective learning is achieved when learners interact with instructional material. The fact that constructionism accommodates learning in its environment, for instance learning of biology in the laboratory or in the field, provides an avenue for the learners to develop a more positive interest and attitude towards the learning process and hence Biology. This is because they are interacting with real learning material. As Papert's theory proposes that new knowledge and skills build of prior knowledge, the attitude of both the male and female learners would in turn be impacted on through such learning process that occurs in context. As a result of active involvement in learning, it would be expected that the attitude of learners towards biology becomes more positive. A positive attitude would be a motivating factor for further biology learning.

Papert (1991) is more concerned with the agitation for change. Parpert reiterates the fragility of the mind especially at times of transition. The concern is how different learners think once their convictions break down, once alternative views come in to play; when one is adjusting, stretching, and expanding their present perception of the world. As the mind is adjusting, the attitude of the learners would be modelled to change. This attitude change component emanating from this theory informed the researcher in choosing it due to its suitability for the present study. Ackermann (2010) points toward the instability, contingent, and resilience of knowledge being constructed by constructionist learner. Process skills are transferable skills that require the involvement of one or several of the leaner's five body senses; these include touch sight, taste, smell and hearing. The present study investigated six BPPS and their influence on learner academic achievement and attitude towards Biology. These six BPPS included: observation, inferring, measuring, communication, interpreting data and experimentation. Manipulation is paramount in the learning and application of these process skills.

Heider (1958) proposed the theory of attitude in learning called the Cognitive consistency theory. The consistency theory proposes that there is consistency between individual attitudes and behaviours. The main focus of the theory is on both the positive and negative attitude of the learners. When the individual feels unbalanced, the theory proposes that he will restore balance by changing cognitive attitudes. Heider further notes that when there exists an unbalanced state of attitude it creates tension and produces a force to restore balance; for a balanced state, it means that the perceived individual coexists with the feelings of the emotion without pressure. When individuals' attitudes and behaviours are balanced, the tension can be released. Specifically, the theory of consistency assumes that individuals will strive to guide their beliefs and feelings, consistent with behaviours (Hsu & Huang, 2018). The behaviour includes improved practicing of the skills, being able to apply the skills in real life situations and even academic attainment. The BPPSTA were expected to have an influence learner attitude towards biology.

Heider (1958) theory of cognitive consistency is based on attitude change component. Consistency is described as the "compatibility of many simultaneously transpiring mental processes" (Grawe, 2007, p.170). Forecasts based on consistency theory are more quantitative than those made by balance theory. The relationship between beliefs, feelings and behavioural tendencies leads to the development of various attitude organizations and change theories. Consistency theorist believes that people can use a variety of ways to reduce tension, and that argumentation is an effective way to alleviate this tension. The theory proposes that behaviour and attitude of the learners meet at a point of equilibrium which results in to relieving of tension: that the interaction of learners with the environment should model the attitudes. Therefore it would be expected that once the BPPSTA are effectively used in instruction there should be an attitude change and thus a change in behaviour of the learner. The focus in this study was the

BPPSTA as used during instruction by biology teachers. Such an environment that is rich in hands-on activities would be expected to mould their attitude hence behavior.

The strength of the cognitive consistency theory is that it has a consideration that the attitude can take any direction: positive or negative (Hsu & Huang, 2018). They furthermore observe that attitude change is initiated within the individual from the interaction with the material around the learner, which therefore reinforces it more. The shortcoming of Heider's consistency theory however is that, it is too simple to show the direction of the relationship, but it does not indicate the extent of the relationship.

The two theories together anchored the present study by providing an opportunity for the exploration of the achievement of the learners and their attitude towards biology after instruction via the BPPSTA. The theories led to the collection of data and shaping of the results from the study to reveal that indeed BPPSTA had an effect on learner achievement and attitude.

1.10 Conceptual Framework.

This study is concerned with how the learner competency in Biology practical process skills affects their achievement in Biology and their attitude towards Biology. The relationship between the variables is shown in Figure 1.1.

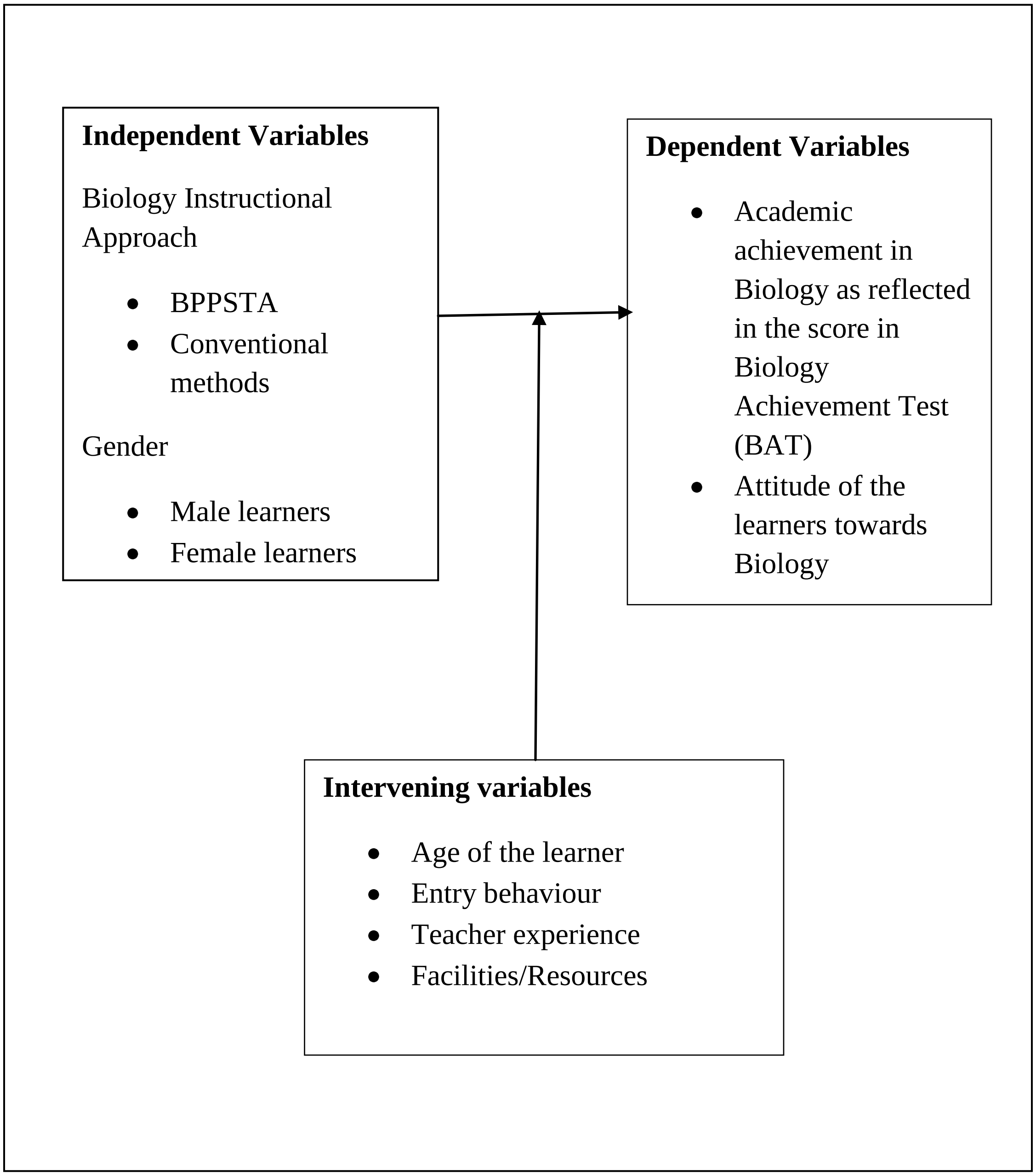

Figure 1.1: A Conceptual Framework Showing the Interaction Between Variables

From Figure 1.1, in relation to this study, Biology instructional approach and gender were the independent variables. The instructional approach and methods that the study focused on were: Biology practical process skills teaching approach and the conventional methods. This study aimed at determining whether or not the BPPSTA had a contribution towards learner academic attainment and attitude towards Biology. The Biology practical process skills that the study focused on include: observation, inferring, measuring, communication, interpreting data and experimentation. The quality of learning that Biology teachers facilitate to learners is greatly dependent on classroom teacher-learner interactions (Imanda, 2013). Therefore, when moulding the students of today so as to end up as prosperous scientists of tomorrow, it is important that science and mathematics teachers facilitate learning with the effectiveness it demands. Teachers need to have an understanding of the process through which learners learn science and mathematics and the best approach to use while teaching them. Adjusting how to teach and what to teach in science is becoming a concern of many educators and education researchers. There is a need for modern teachers to focus and adjust their science lesson presentations away from conventional methods to approaches that are more learner-centred (Prokop, Tuncer, & Chuda, 2007). BPPSTA is one such approach which is expected to result in to active learning. The dismal learner attainment in biology is becoming a worrying trend in the country and specifically in Gucha South sub-County. The present study through adopting constructionism theory explored the contribution of BPPSTA on learner academic achievement and attitude.

In the present study, learner academic attainment in Biology and their attitude towards Biology were the dependent variables. Achievement was identified as the major indicator of learning in education at the international conference of education for all (EFA) in Jomtien, Thailand (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2000). In the present study this position justified the use of learner achievement as a measure of learning in Biology. Learners' achievement in the present study was determined in terms of the learner attainment in Biology Achievement Test (BAT). In addition, a BAQS was used to determine the learners' attitude towards Biology.

The intervening variables in this study were age of the learner, entry behaviour, teacher experience, and facilities. Age is a factor that affects learner achievement; age of the learner is likely to be an influence on his or her performance depending on the class level (Owiti, 2015). The Intelligent Quotient (IQ) level of a learner is measured in relation to the chronological age of the learner. This position is supported by Wanjiru (2015) who reported that age is a factor affecting mental ability. Therefore, if a student is overage or underage with respect to a given class, his performance is expected to deviate from the normal expectations from learners of that class. However, in this study most of the participants were of a narrow age bracket of between 14 to 17 years.

According to Owiti (2015), entry behaviour of a student in school influences the language, cognitive and social development of the learner in relation to his interactions. Owiti adds that, entry behaviour also improves the learner' interaction with the peers, intellectual development and social adaptations both within and out of school. All the schools selected for this study were County-level schools. The learners in these schools were presumed to have almost uniform academic abilities in terms of entry behaviour. The facilities in these schools too, were presumed sufficient for the topic selected for this study. The teachers who took part in the present study were those employed by Teachers' Service Commission (TSC). These teachers were subjected to a short induction training on their role in relation to BPPSTA and the expectations of the study. At this level the

BPPSTA were used during instruction by those teachers in the experimental groups while those in the control groups used the approaches that they usually use.

1.11 Significance of the Study

The study findings and recommendations may provide opportunities for form two learners to experience effective instruction of the topic transport in plants and animals with the use of BPPSTA; in the long run this will improve the learner attainment in this topic and Biology at large. The findings will also provide insights to the Biology teachers on the appropriate improvement on planning and administration of the practical lessons. This will make it possible for the impact of practical lessons on the achievement of Biology to heighten. The findings of this study too may enlighten the school administrators including school principals and heads of departments on the best approaches to be emphasized and observed during Biology lessons. The study may also help ministry of education and quality assurance and standards officers find out the quality and efficacy of practical lessons in secondary school. Furthermore, the findings will help KICD and curriculum specialists in provision of important data on the areas to lay more emphases during the development of curriculum for pre-service teacher training. Finally, the findings and suggestions from this study are hoped to fill a gap in the available literature on Biology practical process skills. Therefore the other researchers can get insights on areas that need greater research attention. In so doing it will add up on the available knowledge in this area of study that is important to researchers who will carry out studies after this one.

1.12 Definition of Operational Terms

Achievement – Gain in the score of a student in Biology after a treatment or after teaching has been done using a given approach or methodology.

Assessment – This is the process of finding out or determining whether the learner has acquired or has not acquired the practical process skills being considered in this study.

Attitude – This is tendency of a learner to either like or dislike Biology which is to be determined through one's opinion.

Biology Process Skills – these include are a set of abilities which can be effectively exchangeable from teacher to learner or learner to learner that are appropriate to Biology discipline and tend to portray the character of biologists. They are often attainable during practical Biology instruction. For purposes of this study, the skills of concern were six: observing, communicating, inferring, measuring, interpreting data and experimenting.

Class- A cohort of students of the same school level at secondary school such as form one, two, three and four.

Competency – Ability of a learner to carry out the process skill accurately and appropriately. It will be measured by the Practical Skills Assessment Test (PSAT).

Conventional methods – These are traditional teaching methods that are teacher-centred in which it is the teacher who dominates in the classroom such as the lecture method.

Entry behaviour – These is the mark that a learner attained in KCPE which is used for placement in various categories of secondary schools in Kenya.

Gender - This is the biological state of a participant being either male or female.

Intervention – This is the exposure to the learners in the experimental groups of the present study to the instructional approach that promotes Biology process skills

Performance -The extent to which learners are carrying out the tasks given in a Biology practical activity in relation to the Biology practical process skills under study. This will be measured using a Biology PSAT.

Practical Lesson – It is a formal learning session that incorporates any biological learning activity where learners, either in groups or individually, actively manipulate or observe realia.

Sciences – The three subjects; Biology, Chemistry and Physics as taught in secondary school curriculum.

Stream– This is a sub-group of students in a given class who are learning in the same room in secondary school in institutions that have many students in form two who cannot be accommodated in one physical room for learning purposes.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter is sub-divided into the following sections: Introduction, Practical lessons in teaching and learning Biology, Use of science process skills in teaching Biology, Contribution of practical lessons on the learner achievement in Biology, Gender difference in academic achievement in Biology, Leaners' attitude towards Biology practical lessons and, Gender difference in learner attitude towards Biology.

2.2 Practical Lessons in Teaching and Learning Biology

The main reasons why Biology education is taught at secondary school level is to bring about awareness of the value of scientific knowledge in our daily life, to promote technological and socio-economic development in our society; This is in accordance with the national goals of education in Kenya (KIE, 2002) (see attached Appendix XIV). The practical activities that learners carry out in the classrooms provide the basis for technological development and also prepare the learners to pursue courses that are related to science at post-secondary school level (Abungu et al., 2014). Biological knowledge and skills continues to have a great significance in our society. The knowledge and skills acquired through such approach are important to the learner in school and beyond school life. This knowledge has found a great application in the field of Agriculture in controlling diseases and increasing yields through plant and animal breeding; human population control by developing contraceptives that are hormone based; environmental management and wildlife protection (Maundu, Sambili & Muthwii, 2005; Arokoyu & Chukwu, 2017). This great contribution of Biology in real life must be viewed as having a great implication on teaching methodology. It is this great importance that made it necessary for this study to be conducted to determine whether the learners exiting from the system acquire these requisite skills.

Yandila, Komane, and Moganane (2015) carried out a study titled, towards learner-centred approach in senior secondary school science lessons. The study had a purpose to determine whether or not the student-centred teaching approach in Botswana General Certificate of Secondary Education (BGCSE) syllabi was being implemented in the senior secondary school science lessons. The study adopted the case study design. From each of the 18 sampled schools out of the 27 secondary schools in Botswana, three science classes were sampled. Data collection involved observation of an 80 minutes' lesson which was video-recorded and then analysed qualitatively. The findings from the study revealed that majority of science teachers rarely practice the advocated instructional methods and procedures for science assessment. This study relates to the present study in terms of its interest on teaching methodology and the data collection methodology by use of video recording. However, their study findings reveal that practical methodology was not being embraced in the Biology classroom without providing evidence whether this in turn affects learner achievement. This is a gap that the present study intends to fill by investigating whether there is an effect of BPPSTA on learner achievement and attitude.

Nwagbo and Chukelu (2012) carried out a study on the effects of Biology practical activities on students' process skill. Their study adopted a quasi-experimental research design pretest, posttest, non-equivalent control group design. Learners in the experimental group were taught via practical hands-on activities while on the other hand the learners in the control group underwent instruction via the conventional methods. The syllabus topic of interest in this study was animal nutrition. The data collected were analyzed using mean, standard deviation and Analysis of covariance (ANCOVA) at 0.05 level of significance. The findings indicate that Biology practical activity method was found to be more effective in enhancing learners' acquisition of SPS as compared to the conventional methods. The study found no relationship between teaching method and gender on learners' attainment of process skills. The nature of the design used for this study creates a gap such that the posttest result cannot ultimately be attributed to the treatment. This gap is addressed in the present study by adopting Solomon four non-equivalent control group design. In this design the treatment can singly be isolated to be the cause of any change in the experimental group after the intervention (incase there is any effect); this is because of the two additional groups: control group-2 and experimental group-2. This study also narrowed down to the topic nutrition which is relatively well performed in the Kenyan context; KCSE examinations. However, the present study narrowed down to the form two topic, transport in plants in which performance has been dismal (KNEC, 2015) in the past few years whenever tested.

Ngakhala, Toili and Tsingalia. (2017) opine that use of practical as a teaching approach entails learners being given an opportunity to carry out hands-on activities during the learning process within the confines of the teachers' directions. The teacher avails instructional material and resources and also the instructions that should guide the learners either individually or in groups. This is usually carried out during a practical lesson. An important feature of effective learning in Biology is when learners are able to follow the given instructions as they use the scientific methods in problem solving with minimum teacher support. Okoli and Egbunonu (2010) describe the practical teaching approach as one that engages learners in active learning process by enabling manipulation of available resources and equipment. They further argue that this approach also gives a chance to the learners to carry out experiments, to manipulate variables, gather data, analyse data and make concrete conclusions. Several research studies have attributed students' underachievement in the science subjects to poor teaching techniques (Imanda et al., 2014; Samba, Achor, Bash, Stella, & Iortim, 2015; Achor, Adoh & Abakpa, 2018). Therefore, it was probably the practical lessons that was to lead to the fruition of this intention. This necessitated the present study to be conducted.

According to Nwagbo (2012), several factors have been found to be resulting in the ineffective attainment of process skills by learners in secondary schools which ultimately result into poor learner performance. One of such factors identified is the teacher factor; this encompasses the teaching methodology and teacher's training. Furthermore, Opateye (2012) and Imanda (2013) found out that most science teachers use traditional expository teaching approaches majorly the lecture method. The teachers have a tendency to avoid the use of activity-based teaching methods that are learner-centred (such as inquiry method, discovery method, investigative laboratory work, BPPSTA among others). The findings from another study in South Africa by Awelani (2014) reveal that the teachers under study reported that they were unable to use experimentation method of teaching due to inadequately equipped laboratories in their respective schools. The teachers had to resolve to instruction via non-laboratory based teaching methods. Therefore, due to insufficient exposure of learners to practical activities, they ended up having low mark in the examinations. Unlike the described study whose focus was on laboratory based methodologies, the present study specifically was concerned with the contribution of BPPSTA on learner achievement.

Ona (2007) argue that, the proponents in support of the use of practical activities in science instruction should come out and justify this standpoint. Ackon (2014) therefore presents methods of teaching science lessons; some of the methods include group activity, project work, practical work, inquiry, discovery, discussion and demonstration. The study observes that among all these methods, practical work is more powerful when it comes to exposure of learners to hands-on activities. Through practical work experiential learning is achieved. Within a science course and in particular Biology, the practical lesson is considered to include any activity involving students in real situations using genuine materials and proper working equipment (Wingate, Andon & Cogo, 2011; Eila et al., 2016). Practical lessons have long been considered the unique feature of education in a science discipline. This is due to the fact that most of the physical and biological sciences are essentially empirical in nature. Samba et al. (2015) reveal from their study that the experimental methods (Use of Graphic Organizers and Experiential Learning) under study had a great potential in fostering the development of critical thinking as well as promoting meaningful learning in students. As much as practical work would be expected to positively influence learner achievement, the way it is planned and administered is paramount. The present study was concerned with a well-planned and administered practical with emphasis on biology practical process skills.

Eila et al. (2016) opine that students should be engaged in Biology practical activities such as exercises, experiences and investigations during the learning process. Training in using practical activities often would involve guiding teachers through the process of understanding learning theories and the appropriate application of these theories in Biology instruction. The responsibility of the teacher in the process of instruction is indispensable hence all teachers need to be well trained so that they can handle learners in all issues that pertain to the learning process (Ngesu et al., 2014). It can be observed from the results of a study by Ackon (2014) that some learners from the selected schools under study were not able to perform their practical activities when it came to their turn. Students' questionnaire results revealed that, 73% of the participants indicated that they were not able to perform their practical activities. The study further revealed that this inability was attributed to lack of students' participation during practical lessons. The practicals did not provide learners with an appropriate avenue to actively carry out hands-on science activities. The described study relied on questionnaires for its judgment on learner abilities. Questionnaires alone as data collection instruments tend to elicit views that are convenient to the respondent hence weakening reliability. The present study in addition to questionnaires in an attempt to fill this gap, also used teacher made tests and observation schedule.

According to Ona (2007), if we should expect better and improved student acquisition of knowledge and skills, there is need to adopt new methods that deviates from the traditional approach presently being used in most institutions. These methods lead to increased knowledge and skill acquisition and allow them apply the skills that they have acquired through the learning process (Ona, 2007). No wonder, Ibukun (2009) observed that there can be no system of education that can rise beyond the teachers' quality in any given country. Many studies continue to reiterate that most science teachers are still consistently teaching science subjects with the traditional expository methods such as the lecture method. The claim of such teachers is that this methodology enables a wider coverage of syllabus (Imanda, 2013; Ona, 2007). Adoption of the practical activities in the classroom environment is important in demystifying Biology which is one of the sciences. In addition the activities enhance the understanding of the knowledge and skills by learners. Guantay (2015) from another study found out that most teachers under study were using more of the non-laboratory teaching methods. Ngakhala et al. (2017) reiterate that the poor results in Biology practical in Lugari sub-County, Kakamega County, Kenya, may be due to poor teaching and lack of exposure of learners to the required practical knowledge that should guide them for success in the higher class levels. The study did not conclusively attribute the poor performance to methodology. This prompted the present study to be initiated. The present study hence narrowed down on the contribution of BPPSTA on learner achievement.

Ngesu et al. (2014) in their study on some of the determinants of students' performance in KCSE found that the teacher among other factors, is key in affecting student performance in Biology. They found that teacher attitude and teaching methodology are among key attributes of a teacher that influence the learning of Biology hence performance. Basically their study involved Biology teachers, form four students and school principals as the participants. The study adopted a survey design in which collection of data was through questionnaires and interview schedule. Data analysis was carried out both qualitatively and quantitatively. The study revealed that practical sessions and discussions were important requirements for improved learner attainment in Biology. As much as this study provides a good insight on the basis that practical lessons are an ingredient of good performance, it did not go further to actually link the views of the learner participants to their actual performance. This would be attributed to the methodology used which restricted data collection using questionnaires and interview schedule only. Singh (2012) opines that the limitation of questionnaires is that the participants have a tendency to answer in a socially desirable manner rather than truthfully. On the other hand, interviews have a limitation in that the participants may give inaccurate information in absence of correct information and also the interviewer's predispositions and biases may affect the responses of the participant (Singh, 2012). The present study improved on these gaps by using the Solomon four non-equivalent control group design. Apart from the learners responding to questionnaires, they were also subjected to a Biology practical assessment test and also an achievement test. This aimed at clearly bringing out the cause of change in learner attainment.

In another study, Wanjiru (2015) investigated the effect of practical skills on students' attainment in Biology practicals in secondary schools in Kiambu County in Kenya. Stratified sampling drew 49 form three students from a national school, 47 from County school and 114 from sub-County schools. Ten Biology teachers were selected using the stratified sampling technique. The study adopted a descriptive survey design. The findings of the study indicate that there was a significant relationship between students' performance in practical skills and achievement in KCSE. The findings further indicate highest competence in Biology observation skills and low competence in the skill of interpretation and execution. From the foregoing, it is observed that students' competence in practical biological skills is significantly related to learner academic attainment. These skills are reflected through understanding of instructions and procedures, execution of practical, observation and interpretation of results. Despite the fact that the described study exposed learner participants to actual practical, it lacked the ability of ruling out the possibility of effect of prior knowledge hence extraneous variables. The present study by adopting a methodology with pre-test, post-test and control groups was able to appropriately solve these inadequacies in the aforementioned studies. Therefore, the effect that the independent variable had caused on the dependent variable was clearly identified and hence reported in chapter four.

2.3 Use of Science Process Skills in Teaching Biology

Teaching with emphasis on the science process skills is a key component in modern science instruction. As aforementioned in section 1.1 the 12 SPS identified by SAPA have been grouped into two: basic and integrated skills (Padilla, 1990; Molefe and Michele, 2014). Basic SPS are simpler and easily learned and practiced. On the other hand the integrated SPS require the foundation of the basic SPS for them to be learnt. Furthermore for effective learning and practice of integrated SPS, the learners should be taught for not less than two weeks (Padilla, 1990). Science is expected to inculcate within learners' knowledge and skills that are necessary for economic growth and sustainability in the society (UNESCO, 2017). Sadhana (2017) observes that in science, the ways of thinking, measuring, solving problems and critical thinking are called processes. The type of reasoning and thinking that is anticipated in the science environment during instruction constitutes the process skills. SPS forms the foundations for scientific method. Science is about both thought and action. Science as a thought entails the ideas, concepts, and beliefs about the natural world while the action entails the methods and the processes. The teaching of science encompasses both the content and process components of science. Underestimating content over process or process over content is inappropriate, both are important. Content consists of subject matter which includes science knowledge, concepts, principles and procedures while process comprise of vital skills which learners require to develop during the process of learning (Inan, Inan, & Aydemir, 2014). The present study considered the process skills as content and process. This was achieved by teachers undergoing induction training on SPS as content then followed by the process component. This approach was adopted to ensure effective practice of the skills at classroom level.

Acquisition of science process skills helps learners understand science concepts better than the rote learning practised by most science teachers in schools (Ekon & Eni, 2015). These skills enable learning to proceed as an active process with active learner engagement. This enables learners to interact with realia during the learning process. In the present study six skills were selected for study. The skills are: observing, measuring, communication, inferring, interpreting data and experimenting. The choice of these six process skills was informed by a study by Ongowo and Indoshi (2013). From the findings of their study on SPS in the practical Biology national examination in Kenya, it is clear that these six skills had been the most tested by KNEC in a span of ten years (2002-2012). The format and testing used in the KCSE examination influences the teaching approach (Gacheri & Ndege, 2014). It is upon this assertion that the top six ranked skills of the twelve in Ongowo and Indoshi's (2013) study were selected for this study. Unlike in their study where they focused on analyzing SPS in KCSE examination, the present study was concerned with the actual practice of the process skills in the classroom during Biology instruction.

Many educators and researchers perceive the nurturing of SPS in learners to be the main aim in science education (Aslan, 2015). SPS are vital not only in terms of preparing future scientists and technologists, but also for the whole population that require scientific literacy so as to live and function in a world in which science relates on almost every aspect of personal, social and global life. Process-based learning is tailored towards nurturing learner independence during the instructional process. It also provides an avenue to problem solving by providing a guideline under which curriculum activities and practices can be conducted (Eila et al., 2016). SPS are a lifelong learning processes that forms a foundation for analytical thinking, creating knowledge by principles of 'learning by doing' used during the process of problem solving (Aslan, 2015). Ekon and Eni (2015) contends that effective instruction arising from the use of hands-on teaching approaches during learning influences students' acquisition of SPS and ultimately results to higher academic achievement. The modern methods of teaching science do not only involve the understanding of facts, concepts and principles (product) but they also involve the understanding of the way this knowledge is obtained such as observing, measuring, classifying, collecting data, experimenting (process) (Ona, 2007). In their study, questionnaires were used as data collection instruments. The present study on the other hand, in addition to questionnaires, it subjected the participants to tests that were analysed quantitatively. The use of several instruments was not only to improve on validity but also for triangulation.

Gacheri and Ndege (2014) carried out a study on the application of SPS in the assessment of Biology practicals in secondary schools in Maara district, of Tharaka Nithi County in Kenya. The target population for the study comprised form three students in the 45 secondary schools who were taking Biology and their respective Biology teachers. Stratified sampling method was used to arrive at a sample size of 182 participants.

Descriptive survey design guided this study while the questionnaire and analysis of Biology KCSE Biology practical past papers were used as the key data collection instruments. The data collected in this study were analysed using descriptive statistical analysis methods. The results of the research indicate teachers did not sufficiently evaluate learners' abilities in SPS in Biology practical examination. Analysis of KCSE Biology practical examinations showed that the skills of measurement and drawing were the most adequately tested. Furthermore the study revealed that learners were rarely exposed to Biology practical tests in their respective schools. In their study however, the authors failed to empirically relate the poor performance to the inadequate practice of SPS. Their study used Biology KCSE results of past year and associated them with the claims of students currently in school. Such an approach is deficient in methodology of research and creates a gap in the study which the present study identified. In the present study this gap was therefore filled by using classroom observations and teacher-made test administered to the same participants. This enabled the researcher to attribute learner achievement and attitude to the methodology used in the instruction process which in essence was the main focus of the present study.

Rambuda and Fraser (2004) maintain that there is a great interdependence in the basic science process skills, such that educationalists carrying out investigations may select and use several of the SPS in one learning activity. They go further to explain that for instance, to 'measure' the area in an ecological study, the learner has to begin by 'observing the characteristic features in the habitat, then in turn they 'measure' the dimensions of the area under study and finally communicate it either in writing or verbally. After which it may also be necessary to calculate the area of the habitat and present it either numerically or graphically. This scenario shows that for the learners to arrive at the skill of measurement, many other SPS are intertwined with it. From this example, it is observed that the skills that the learners engaged in were: observing, measuring and communication. This clearly portrays the aspect of SPS interdependency hence, Biology teachers need to be cognizant of this fact. It is on this premise that the present study selected six skills that are not only often tested but also interdependent.

Akinbobola (2008) analyzed SPS in West African senior secondary school certificate physics practical examinations in Nigeria for a period of 10 years (1998-2007). The study was guided by the ex-post facto research design. The study found out that 63% of the examination had basic SPS while a paltry 37% was integrated SPS. The findings also indicate that there was significantly more basic SPS evident in the reviewed practical examination papers as compared to the integrated SPS. The study therefore recommended that integrated SPS should be included more in the practical examinations so as to enable the learners to develop creativity, problem solving, reflective thinking, originality and invention which are important tenets of science. In response to this recommendation, in the design of the tests that were used in the present study, a consideration was put in place to adequately include both the basic and integrated SPS.

Achor et al. (2018) from their study found significant differences in the mean attainment of SPS scores of learners who were taught Biology concepts using laboratory strategy and expository method which was in favour of laboratory strategy group. In another study by Gacheri and Ndege (2014), they came up with findings that, most of the learners under study agreed that the Biology tests that they had been exposed to required them to assemble apparatus as one of the skills of manipulation that had been tested. These studies affirm that SPS are increasingly found to be important in teaching of science and for technological development of any nation. The practice of SPS would make learners to be open-minded and can easily come up with innovatiotions such as those in the science and engineering fair competitions often conducted in Kenyan secondary schools. The described studies are in support of the fact that SPS are vital in Biology instruction. However, they do not clearly rule out the possible effect of other factors to the claimed learner attainment. The present study addressed this by using teacher-made tests and also the Solomon four non-equivalent control group design.

The literature relating to the six Biology practical process skills that this study investigated has been reviewed and discussed. These six skills discussed are observing, Communicating, inferring, measuring, interpreting data and experimenting.

2.3.1 Observing

Observation is a vital skill in the process of Biology instruction because it forms the foundation of the other process skills. It requires the learner to observe carefully and in details what is relevant and not observe everything. Observation is the process of using the five senses to collect information that relates to an object or event (K.I.E, 2006). Almost each and every activity in science commences with observation about everything around. Observation requires the learner to keenly and safely use their senses, and then identify morphological similarities and differences; identifying the details of the observations (Nyakan, 2014; Amoah, Eshun, & Appiah, 2018). Memories start with making of an observation and the best way to raise retention of learners' memory is to make sure that your experience with the world is as clear and meaningful as possible (Maranan, 2017). An example of an observation is, describing a pencil as yellow.

Observing is a fundamental process skill such that the ability for a learner to make accurate observation is a precursor for nurturing and perfecting in the other SPS (Ekon & Eni, 2015). Orado (2009) further contends that students who record their experimental data with highest degree of precision, display high level competence in observation skill in practical Biology and therefore perform highly. Therefore the present study identified observation as one of the skills for investigation since it is the lowest level requirement skill for acquisition of the other SPS.

For a learner to be said to be accurate in the skill of observation it is expected that s/he is able to use and make correct readings from biological instruments, notice the color change that takes place in a systematic manner, keenly notice relevant details in a given specimen, identify specific parts and structures in specimen accurately (Amoah, 2011). Ediyanto et al. (2017) contends that learners use the skill of observation to actively experience the natural world around them; they make use of the five senses in observation of object and events, and then look for relevant trends in those observations. Alkaslassy and O'Day (2001) observe that, we make observation of objects and events using one or a number of our five senses. This is how we get to learn and understand our surrounding. Learner's ability to make correct observations is essential towards the development of all the other SPS. Irrespective of whether learners observe using the five senses or with aid of instruments, there is need to guide them to make better, accurate and more detailed descriptions of what they have observed. For this to be well done, the teacher can listen to or read the learners' observations for the first time and then if they are inadequate, they can be prompted to elaborate. For example, in the process of learners describing what they observed, they might describe only the color of the object but not its size or shape. Then the teacher prompts the learners to further observe the shape and the size of the object. In the present study, the teacher's role was to guide the learners so as to facilitate them in acquisition of the skill of observation with accuracy.

According to Onamu (2011), secondary school students face difficulties when drawing tables, they fail to give adequate space for recording data or observations. Onamu's findings concur with SMASSE (2007) findings that most secondary school students under study in Thika West Sub-County exhibited low degrees of precision in observation skill. Findings from other studies suggest that shortage of material for teaching leads to poor observation as students do not have adequate interaction with the resources (Akpan, 2006; Imanda, 2013; Owino, Osman & Yungungu, 2014). In a study by Ngakhala et al. (2017) an interesting finding was that over 80% of the form two students who participated in the study were rated below average. The study focused on learners' ability to practice the science process skill called observation. This finding reflects the poor performance in this important skill in secondary school. This finding prompted the present study to find out whether the continued low attainment in Biology examination could be as a result of the use of conventional teaching approaches instead of activity-oriented approaches.

2.3.2 Communicating

Communication is the second of the basic SPS, and often communication goes in tandem with the skill of observation. Communication involves the use of both spoken and written words, diagrams, tables, graphs, and other information presentations which includes those that are technology-based in describing an action, object or event (Ekon & Eni, 2015). Maranan (2017) posits that, whether it is orally or in writing, learners communicate what they know and what they are able to do during the learning process. An example of communication would involve a learner describing the increase in the height of a bean seedling as it grows over a period of one week. This description could be well done either through writing or through a graph (Steiner, McNair & Butcher, 2001). Through communication learners are able to share their observations with other students, the teacher and generally the other outside world. Therefore the communication must be clear, precise and biologically acceptable if the people in the outside world should clearly understand the communication (Ekon & Eni, 2015). The present study investigated the ability of learners to communicate observed information through tables, drawing and writing.

Data must be presented in a manner that can clearly reveal any trend and relationships anticipated and also allows results to be passed on to others. Since science has proven that, raw data often has little meaning, a common practice by scientists is therefore to arrange and present the data. The data are well analysed statistically, organised through tables and graphs then communicated to other persons (Maranan, 2017). Learners too as upcoming scientists need to follow the same path by perfecting their skill of communication. This can be perfected if the classroom instruction process encompasses and lays emphasis on the appropriate communication of scientific knowledge, skills and principles.

Steiner et al. (2001) observes that one important feature of effective communication is through the use of referents; this involves associating through reference of the item that the person already knows. For example, colour description is best done through the use of referents. Common colour referents include; sky blue, safaricom green, grass green, or lemon yellow to describe various shades of blue, green, or yellow. The purpose of referents usually is to communicate using familiar descriptive words for which all people are conversant with and both people share a common understanding (Ekon & Eni, 2015). When referents are not used where they should have been used, then there is a tendency to communication being misunderstood. For example, when one describes an object as hot or rough, the audience might not clearly comprehend how hot or how rough the object might be. In an attempt of a student describing the size of a pinecone, for purposes of making the description much clearer they might use the size of his or her shoe as the referent. The learner can communicate by describing the pinecone as being either larger or smaller than his shoe. This requires that the skill be effectively taught to the learners. The teachers involved in the present study underwent one-day induction training on how to effectively inculcate the skill of communication to learners.

2.3.3 Inferring

Inference is the process where someone makes an 'educated guess' about an object or event on the basis of prior data or information that was collected. An example would be: saying that the student who used a pencil in writing made more errors since the size of the eraser had greatly reduced. Ekon and Eni (2015) observe that inferring is the drawing of a conclusion about a given event in line with the observations made and data collected; it involves the explanations that arise from observations. However, unlike observations, which are essentially direct evidence that is collected concerning an object or an event, on the other hand inferences are explanations or interpretations that arise from the observations made. For example, it is an observation for a student to report that the insect released a dark, sticky liquid from its mouth. However, it is an inference for the learner to explain the reason why the insect produced the liquid; the insect released the liquid from its mouth since it was angered and therefore it was in the process of defending itself. Maranan (2017) found out that the skill of inferring was significantly related to evaluation of dimensions. This relationship implies that for a learner to arrive at sound judgment, there is need for the learner to have accurate inferences. This requires the learner to go further by interpreting or explaining the set of observations made using any of the five senses. The practical activities adopted for this study had activities that were to enable the learners effectively practice the use of the skill of inferring.

Susanti et al. (2018) note that when we have the ability to appropriately infer, make correct interpretation and explaining or expositions of events provided to us, then we can confidently deduce that our appreciation and understanding of the science world around us is better. The role of SPS in the learning and understanding of scientific concept, principles and values is vital. For the relevant intended evidence to be gathered, there is need for these skills to be nurtured properly. Furthermore, inferences that are not founded on facts or those that ignore evidence, pose a great problem for the world around to understand them. Inferences about investigations provide a basis on which scientists formulate hypotheses about why scientific happenings occur as they do. There is need for the distinction between observations and inferences to be well explained to learners during the teaching process. Learners need to be able to differentiate the evidence they collect about their environment as observations and the explanations in form of inferences (Steiner et al., 2001). Learners can then have an opportunity to infer explanations and modify their inferences as new information is revealed since scientific knowledge is dynamic which is subject to new ideas arising (Ediyanto et al., 2017). A similar position is held by Sadhana (2017) who posits that scientific ideas are always tentative; all scientifically held propositions are liable to revision or falsification. The present study identified the skill of inferring as one of the six SPS to be investigated. This was because the observations made and communicated would not make sense unless there are inferences drawn from them. This position is linked to the aforementioned supposition that SPS are interdependent.

2.3.4 Measuring

Measuring is a skill that is continually used in every Biology activity whether is determining volume, length, height, temperature, mass, weight or time. Measuring requires that the leaner develops competency so as to record the right measurement and in the correct units. Measuring involves the use of not only standard instruments like a ruler but also non-standard instruments or estimates such as a rope to describe the dimensions of a given object. Maranan (2017) reiterates that measuring as a SPS involves the learners quantifying descriptions of objects under study or an event presented for study. This skill entails the assignment or attachment of a quantitative value to such an object or event during instruction. An example would be the use of a ruler to measure the length of a cockroach in millimeters. Nyakan, (2014) reiterates that observations are usually expressed through measurements in quantitative terms. The present study required the learners to measure and quantify length of leaf, measure time and temperature. These measurements were to be achieved by use of instruments such as ruler, stop watch and thermometer respectively.

The highest proportion of 95% of the total study population showed mastery of the SPS of measurement among in-service and pre-service teachers (Susanti et al., 2018). Timothy (1992) carried out an investigation into mastery and the effective practice of the skill of measurement by teachers' in Nigerian junior secondary school. The study findings indicate an increase in the mastery of measurement skill with age of students and there was no significant relationship between teacher mastery and student mastery. The study further revealed that trained teachers showed a higher mastery of the skill than the untrained teachers. However, the study failed to reveal whether there was any relationship between mastery of the skill and learner academic attainment in examinations. The present study therefore was well designed to fill this gap so as to determine whether there was existence of such a relationship in Biology in Gucha South sub-County.

Panoy (2013) carried out an investigation into a new differentiated strategy of teaching and tested its effect on the development of SPS. This study was designed with an aim of assisting teachers come up with a strategy that will adapt well with the continuously increasing diversity among students. The study findings indicated that there was a significant difference between the mean gain score of the students in the experimental and control groups in terms of skills of problem-solving, measuring and comparing. These results indicate that the learners in the experimental group outperformed those in the control group in the skill of measuring among other skills under study. This study placed the participants into two study groups. However, in an attempt of the present study addressing this shortfall in design, it adopted a design in which participants were categorized in four study groups; two experimental and two control groups. The additional two groups were to rule out the effect of pre-testing hence increasing the validity and reliability of the findings.

2.3.5 Interpreting data

According to Ango (2002) science inquiry is naturally and historically empirical. As experiments are carried out and observation made, subsequently data is collected. Such data requires to be interpreted so as to make sense and meaning from it. Interpretation of data involves the organization of data and drawing of meaningful conclusions from the data. Data interpretation and inferring are crucial stages that data undergoes in the process of science. Example: A learner may record data obtained from an experiment on growth rate in maize seedlings in a table and makes conclusion that are in congruence with the information that is tabulated. Ediyanto et al. (2017) posits that when data is being interpreted one needs to present the data in an orderly manner so as to draw relevant conclusions from it. The learners in the present study were guided on how to make interpretations from data observed. The practical activity they underwent furthermore required them to interpret step-wise data from the experiments.

Ango (2002) observes that the importance of the skill of interpreting data in any scientific undertaking requires to be made clear to learners. Data interpretation is a key process in Biology learning. This process makes sense from the data collected so that the data can be viewed as having meaning. Data can be numerical or in terms of words but whatever the form, its interpretation is paramount in Biology teaching and learning. The present study dealt with both types of data as interpreted by the learners from the practical activity that they were carried out during the Biology lesson.

2.3.6 Experimenting

Experiment requires an activity to be carried out within a specified framework. Knowledge on procedure implies that one has an understanding on the manner in which an activity is carried out. This understanding of procedures includes methods of inquiry, and criteria for using the skills, techniques, and methods. These are carried out through a logically prescribed procedure for the result to be obtained (Eila et al., 2016). The ability to carry out a valid experiment, includes asking of relevant question, stating a hypothesis, identifying and controlling variables of the study. These are the main tenets of experimentation. Ediyanto et al. (2017) opine that the procedure followed when experimenting includes, operationally defining the variables, designing a valid experiment, conducting the experiment, and interpreting the results of the experiment. These are the tenets of experimentation that the present study strived to inculcate to the learners aided by the Biology teacher.

Further studies on the skill of experimentation indicate that learners' ability to conduct an experiment is connected to the formal thinking abilities as proposed by Jean Piaget (Piaget, 1964; Chebii, 2011). Experimentation is a problem-solving approach that integrates the other SPS. An example would be when a learner is conducting an experiment on the effect of light intensity on the rate of transpiration in green plants. Eila et al. (2016) further note that, several Biology topics can be taught using approaches that promote the skill of experimentation. The target and goal is to follow logical scientific procedures so as to arrive at empirically valid results (Imanda, 2013). However the present study notes that the teacher's guidance is pivotal in learning of SPS. It therefore necessitated an induction training for the teachers so as to ensure effective SPS learning session.

Akben (2014) from another study found out that the prospective teachers realized that the skill of experimentation can be nurtured among learners in relation to their life. It was further noted that conducting experiments can raise the interest of learners in science.

Chebii (2011) observes that if a student has acquired the experimenting skill in a given science subject such as chemistry, it would be expected that such a student will be able to apply the same skill in another science subject, such as Biology. Ediyanto et al. (2017) further note that when a learner has developed a proper understanding of basic science process skills, then he will be in a good position to easily develop the skills that lead to experimenting; which is a key integrated SPS in the Biology classroom. The learners were expected to practice this skill through various activities such as fastening of the slides on to the leaves as seen in Appendix (VII).

2.4 Contribution of Practical Lessons on the Learner Achievement in Biology

Academic achievement has for a long time been used as a measure of learner attainment in school learning process. Sadhana (2017) opines that academic achievement is a magnitude of output and the major adjustments that occur in knowledge, skills and attitude of a person due to experiences gained at school. Practical lessons motivate students by promoting their interest and enjoyment in learning. Practical lessons can be used in teaching experimentation skills, encourage acquisition of scientific knowledge, initiates expertise in using scientific approaches and, enhances the nurturing of scientific attitude which include objectivity and open-mindedness (Gultepe, 2016). Practical lessons provide a better chance for learners to apply new knowledge and skills that they have acquired. According to SCORE (2009), learning objectives should be written in the form in which they apply scientific knowledge, understanding and skills. This minimizes the danger of learners simply following ‘recipes’ when carrying out practical activities. It is well known that, practical lessons when carried out effectively, they can motivate and involve students’ learning actively. Active learning ultimately causes a positive mental and physical challenge to the learners in ways that other science experiences may not be able to. Akiri and Nkechi (2009) are of the opinion that ineffectiveness of teachers in classroom interaction with the learners could be responsible for the observed poor performance of learners and the widely acclaimed fallen standards of education in Lesotho; similar standpoint is held by Annan, Adarkwah, Yawson, Sarpong, and Santiago (2019). The poor academic achievement of learners can be linked to poor teachers' performance in terms of inappropriate teaching habits and methodologies.

Rabacal (2016) undertook a study to determine the academic achievement on science process skills of the BS Biology students of northern Negros state college of science and technology in Philippines. The study aimed at developing learning exercises that would promote their academic attainment on SPS. The descriptive design was used with validated questionnaire as the data collection instrument. The data collected in this study was analysed by use of the independent samples t-test and Pearson product moment of correlation coefficient at 0.05 level of significance. The findings from the study indicate that learners had an average academic performance in both the basic and the integrated SPS of the BS Biology students. The study found that there were no significant differences on the students' academic performance on the basis of gender and year of study. The findings from this study further revealed that there was a significant relationship between academic achievement on the basic and integrated SPS of the BS Biology students. Although the study was able to test the various hypotheses, data was collected descriptively. Such a methodology may hinder the expected expression of important inherent behaviour that can only be manifested during a practical activity (Joppe, 2000).

The present study unlike the one described subjected the student participants to a practical activity adopting a Solomon four non-equivalent control group design. Furthermore, in the described study, the data was collected from university students whose average age is higher than that of the form two students who took part in this study. However, it should be noted that students start developing SPS when in secondary schools before advancing to university, therefore the skills evident when in university were initiated at secondary school level. The present study in an attempt to fill the aforementioned identified gaps had its focus on secondary school Biology students.

In a study carried out in Botswana by Yandila. and Komane (2004**)** towards the end of senior secondary education, learners were given a chance to conduct various practical activities in preparation of their final practical examinations. It was witnessed that science teachers spent a lot of time drilling on how to conduct the practical activities. The act of drilling students did not have any benefit on the learners in as far as acquisition and mastering of the process skills is concerned. Drilling resulted in to the learners memorizing the activities and forgot them immediately after the examinations. This lack of mastery of process skills was later portrayed by the students through their inability to handle simple equipment in their first year science courses at university and college levels of education. Most of them could not manipulate microscopes in Biology, were unable to use electron balances in physics and were unable to prepare molar solutions in chemistry. Although this study was conducted in Botswana, many lessons can be drawn from it since both Kenya and Botswana are developing countries. The inability by learners to master process skills could be in part attributed to the in-exposure to the practice of Biology practical process skills during classroom teaching. The learners might be taught the process skills but with the wrong approach as the case of the described study. Hence, the present study focused on the instruction of Biology using the BPPSTA. The present study had its focus on form two students and the topic of interest was transport in plants and animals since it is poorly performed in the KCSE examinations.

Ackon (2014) conducted a study to investigate the challenges associated with the organization of science practical lessons in some selected Senior High Schools (SHS) in Ghana. The sampling technique adopted was simple random which resulted into a sample of 165 students and 50 teachers from five selected SHS. Data gathering instruments included questionnaire, document analysis and formal observation of some science lessons. Frequency counts and percentages were used in data analysis. The research findings showed that both teachers and students from the selected SHS observed that the most effective means of teaching science was by use of practicals. The study also found out that, most of the schools have science laboratories that have inadequate instructional equipment and materials. In addition, the study found out that, student' participation in science practical lessons is through the demonstration instead of the activity-oriented strategy to enhance students' understanding and experience.

The aforementioned study focused on all secondary school students irrespective of the class of study. These students were at different levels and hence different experiences which might have compromised the findings. This study reveals that demonstrations are the commonly used methodologies citing insufficient resources and equipment in the laboratory. However, it should be noted that Biology is the only science blessed with learning material often locally available; most of which include plant and animal specimen (Rabacal, 2016). Therefore, most practical activities can be conducted relatively cheaply. SMASSE advocates for improvisation of resources in teaching and learning of Biology where possible especially when the resources are insufficient (Imanda et al., 2014). The present study in an attempt to fill the gap, targeted to find out the contribution that practical methodology specifically BPPSTA had on learner achievement and attitude with the main interest being form two students. Furthermore, the sample was drawn from County level co-educational schools which were presumed to have at least the minimum threshold of the resources needed for basic Biology practical.

The appropriate question to be asked before commencement of a practical exercise is: What do I want students to learn by carrying out this activity that could not have been effectively learned through lecturing (Millar, 2004). This question accompanied by its answer provides a justification for practical activity in science. An effective practical should be one that adequately communicates the ideas and tasks is a manner that learners can comprehend. The aim of conducting learner assessment during instruction is usually to avail feedback not only to the student but also to the instructor for students' conceptual understanding (Connell, Donovan and Chambers, 2016). The purpose of carrying out a practical activity could be a factor that should enhance learner improvement in achievement.

It is unfortunate that there has been continued low performance of learners in Biology examination even with the continued reiteration of the role practical lessons in Biology instruction play. For instance, the students scored a mean of 25.69% nationally and 21.98% in Gucha South sub-County in the 2019 KCSE Biology examination (KNEC, 2020). This performance is dismal considering the value that Biology holds in a learners' life and that of the society as aforementioned in section 1.1. This underachievement in

Biology subject is as a result of student-related factors, teacher-related factors and physical factors of school environment (CEMASTEA, 2011; KNEC, 2011; UNESCO, 2012). Of these groups of factors, the teacher plays a crucial role in moderating the learning environment to be more favourable so as to result into better student outcomes. KNEC (2015) reports that questions involving biological process skills were equally poorly performed in addition to those involving application of knowledge. In part, KNEC (2015) attributes this to the use of inappropriate teaching methodologies which encourage memorization of facts instead of use of these facts to build the biological process in the task. The same concerns have continued being reported by KNEC in their subsequent annual KCSE reports for the years 2016, 2018 and 2019. If this trend was to continue then the country may be far from its goal of achieving vision 2030. These concerns necessitated the present study to be conducted.

KNEC makes use of practical examinations to evaluate the extent to which learners' have acquired different Biology practical skills. The skills evaluated are often SPS. The practical activities in these examinations require the learners to conduct the Biology practical activities procedurally and arrive at a pre-determined outcome or result. Data from KNEC has continually shown that the performance of students in the KCSE in Biology practical examinations has been dismal. Biology practical (paper three) is one of the three papers in which biology is tested by KNEC at end of form four level. For instance, in the years 2016, 2017, 2018 and 2019 the students scored means of 10.99, 7.68, 13.65 and 16.00 respectively out of a possible 40 mark in paper three (KNEC, 2020). The national average marks for learners in biology paper three in the four years considered was below 20 marks. This is an indication that the performance in this crucial practical paper is dismal. This is alarming and calls for an interrogation. This prompted the initiation of the present study to determine whether the use of inappropriate instructional methodology might be contributing to this dismal achievement in Biology.

From another study, Gituthu (2014) observed that student-centred teaching approaches had a contribution towards learner achievement in KCSE Biology examination. The study also found out that the declining pattern in learner performance in Biology was in part attributed to the negative attitude of teachers towards the learner-centred instructional approaches. Teachers were also found to be exhibiting minimum practice or implementation of SMASSE teaching approaches especially; Activity, Student-centred, Experiment, Improvisation (ASEI) and Plan, Do, See, improve (PDSI). Data for this study was majorly collected by use of the questionnaire. However, the present study improved on methodology by using both questionnaires, own-made tests and classroom observation schedule. The use of video recording of classroom happenings was important in as far as data review and comparison is concerned. The use of the various data collection instruments for the present study was not only to improve on the validity but also for triangulation purposes.

2.5 Gender Difference in Academic Achievement in Biology

Gender is an attribute that varied roles are socially assigned for feminine and masculine (Okoye, 2016). Gender is a determinant of social outcome and cannot be delineated from the field of Biology or from other economic, cultural, and ethnic class (Kashu, 2014; Owoewe & Agbaje, 2016). Odagboyi, (2015) posits that gender equality is one of the millennium development goals (MDGs) that countries worldwide aspired to achieve. Gin (2011) observes that in contemporary context of our society partriachial values predominate; it is a world where there is belief that women are inferior to men. Nwona and Akogun (2015) noted imbalance against women in Science, Technology Engineering and Mathematics (STEM). Gender, as a concept, has attracted a great interest among educators in Kenya and beyond. This interest is in part attributed to the continued campaign and emphasis for gender equity in many quotas (Figona & Sababa, 2017). The continued difference in Biology achievement as a result of gender has led to education stakeholders scratching their heads in an attempt to address this problem. Research has shown that if the most appropriate approach is selected for teaching a given group of learners then the best results will be achieved. BPPSTA was adopted in this study as an approach that engages the learner. The aim was to determine whether there was a gender difference in attainment after undergoing instruction via the BPPSTA.

Nyakan (2014) from a study carried out in Kenya found out that the performance of boys and girls in physics showed a significant difference, with boys outperforming girls. Abungu et al. (2014) found out a significant difference in academic achievement of learners in chemistry after undergoing instruction via science process skills approach; the boys outperformed girls in the achievement test. Despite the fact that Physics, chemistry and Biology are natural sciences, each subject has its inherent tenets especially in terms of content and methodology. Such inherent variations made it necessary to determine the status for the case of Biology. The present study focused on the use of practical process skills in teaching of biology subject.

There are conflicting research findings emanating from studies on gender influence on learner' academic achievement in Biology (Eddy, Brownell, & Wenderoth, 2014; Dania, 2014; Okoye, 2016; Owoewe & Agbaje, 2016). Achor, et al. (2018) carried out a study whereby the students under study underwent Biology instruction using laboratory strategy and expository method. The study found out that there was no significant difference between the mean acquisition of science process skills scores ($P=0.09>0.05$) of male and female students taught Biology using laboratory strategy. Abubakar and Dokubo (2011) from their study, found out that there was no significant difference between the academic attainment of boys and girls in examinations. These results are in conformity with those by Oduosoro (2011) who equally found no significant difference between the achievement of boys and that of the girls. The conflicting results on the gender subject necessitated the present study so as to reveal the correct position.

Odagboyi (2015) observes that if female learners start schooling with a preformed notion and belief that they are inherently academically inferior to males, then likely this belief will affect their performance. His study revealed that the average marks attained by male learners was statistically significantly different from that of the female learners in the post-test yet in the pre-test there was no significant gender difference. He therefore concludes that the jigsaw method that was used under study led to greater gain by boys than girls in the Biology test. Owoeye and Agbaje (2016) from their study found a lack of significant difference between students' gender and students' academic achievement in Biology. Okoye (2016) carried out a study to determine whether gender and cognitive styles had an effect on students' attainment. The study found out that gender and cognitive styles had no significant effect on learner attainment in Biology examination. Similar findings were obtained from a study by Dania (2014) who found no significant difference between gender composition and learner academic achievement. These conflicting findings created a base for the present study to be conducted.

Bassey, Joshua and Asim, (2011) observe that the underrepresentation of females in science-related subjects and careers has led feminist scholars to deduce that, science as practised in the world is 'gendered' and that it is used to the benefit of 'male world.' Globally, regionally and locally, gender inequality and inequity in participation and performance in STEM has produced inconclusive results (Bassey et al., 2011). The inconclusive and conflicting research findings in this area of gender influence on academic achievement necessitated the present study to be conducted. It is however important to note that the reviewed studies came up with varied findings due to the research methodology, subject of concern, topic from the syllabus that was under study among other reasons. However, the present study relied on teacher-made tests which were administered at different stages of study (as pretest and as posttest) guided by the Solomon four non-equivalent control group design.

Kashu (2014) carried out a survey study to compare the academic attainment between male and female learners in the KCSE for five years' period (2007 to 2011). This study focused on the general performance of male and female learners in all subjects in Kenya. The education trends continue to show declining academic attainment in science. Females' results in KCSE indicate a more declining performance which prompted the study to be conducted. The study findings revealed that boys' performance was higher than that of the girls. In addition, the study found out that girls are perceived and also have the self-perception that they can not do well in sciences especially biology with a claim that these subjects are 'hard'.

The attitudes and expectations of girls themselves, their parents, their families and peer groups impart stereotypes that some subjects are for boys while other subjects are for girls. Furthermore some courses and professions such as mechanics, engineering among others are perceived as a reserve for males only. In addition interaction is biased towards girls which results into feminization and masculination of academic achievement. Equally, socialisation and biological factors contribute to the gender stereotyping. These stereotypes ultimately impacts on their attitude and may result into poor performance if not addressed in time. Furthermore, the findings indicated that, learner performance was varied across top performing schools countrywide: whereby it was found that the performance of boys was much better than that of the girls. These results are in conformity with those by Dania (2014). As the world is in the process of advancing to the new dispensations of the 21st Century and Climate Change crisis, it is unfortunate that the education sector is still grappling with past concerns such as access, gender disparity in performance among others. To that effect, the present study investigated whether the use of appropriate instructional methodologies such as BPPSTA impacts on the learner achievement differently by gender.

Jegede and Olu-Ajayi (2017) opines that the recent continued focus on gender disparity in education in developing countries, necessitates more females to be involved actively in science for national development. Therefore, for more females to be involved in calls for teachers devising instructional methodologies that encourage more of the females to learn and excel in science. Eddy et al. (2014) observe that not only do female learners have their innate and acquired differences, but equally Biology classrooms are never the same; the experience that female learners are exposed to are often influenced by a myriad of factors, including the instructional methods. The instructional method is likely to influence the learners' attainment in class tests and national examinations. The continued comparatively low performance by female learners than male learners in examinations more so in science subjects needs to all stakeholders in education. This trend prompted the present study to be conducted with a specific focus on Biology subject.

2.6 Leaners' Attitude Towards Biology Practical Lessons

The term 'attitude' has received varied definitions which have been suggested in different disciplines of education; including psychology and social science. Evidence exists that show an interrelationship between learners' beliefs and their attitudes. The attitudes towards science practical is described as a more purposeful manner of putting together a wide range of beliefs concerning science that gives room for one to predict the way of science. Learner attitude toward science practical, however, may be conceived as a wide variety of beliefs that are held by learners towards science practical (Ackon, 2014). These are the thoughts and beliefs that the present study was concerned with.

Sadhana (2017) observes that attitudes are mental predispositions towards people, objects, and events. Learner attitude towards practical lesson would be expected to influence their participation in science and hence achievement. Abrahams (2011) opines that, if the claim of most students is that they like practical lessons with their reason being, it motivates them, then one would expect these learners to advance in science related careers. However, whilst many students reported that they liked science practical lessons, there was little evidence that this motivated them to study science (Abrahams, 2011). Hussein (2015) observes that it is necessary for science teachers to cultivate in students a positive attitude towards science subjects. However, studies continue to indicate that the manner in which students are taught science is not interesting to students' success. The responses collected from students through a survey design study using questionnaires yielded a mean score of 85, such that those students with less than 85 were termed as having a negative attitude while those with a score of 85 and above were termed as having a positive attitude. The researcher then subjected the data to chi-square analysis which revealed evidence of low attitude towards Biology by learners irrespective of the gender amongst most students. Unlike the described study which relied on questionnaires for data analysis, the present study in addition teacher made tests and observation schedule. Furthermore the study relied on rigorous independent samples t-test analysis for group comparison. This filled the gap in the aforementioned study in relation to methodology.

According to Prokop et al. (2007) most of the learners under study believed in the necessity of knowledge of Biology in future careers. However, older students showed a significantly higher tendency not preferring careers related to Biology. Of great concern was a paltry 20% of the learners who claimed that they like watching videos about nature and therefore they would wish to get into careers that are Biology-related. Ramsden (1998) cited in Suzuki (2007) observes that students need to perceive the study of Biology as a gate pass to various professions; they need to develop positive attitude towards the subject since it can lead them to careers such as nursing, pharmacy, medicine among others. The most powerful feature of learner attitude towards Biology will be emanating from student confidence on gaining high scores in the subject. The study further notes that generally boys' tendency of a more positive attitude as compared to girls and that learners interest in science declines as the age of the learner declines. When there is a balance in the curriculum content the varied attitude between girls and boys would not be witnessed. Suzuki (2007) observes that development of attitudes within learners in school is a continually inherent occurrence. However, the teacher can organise learning experiences so that they encourage the development of more positive attitudes towards Biology practical and subject as a whole; this emanates from how Biology is taught and the implication that arise from the content being taught. This supposition informed the present study and hence necessitated it to be conducted.

Ango (2002) from another study observes that practical lessons do not only encompass SPS that befit scientific inquiry but also leads to development of attitudes that are required in the field of science during inquiry. The inquiry approach to instruction can be best explored in the teaching process through the use of SPS. The findings by Bevins, Bryne, Brodie, and Price (2011) and Cleaves (2005) were that the learners had a positive attitude towards Biology practical. These findings disagree with those by Sharpe (2012) who found out that, only a few students from the total study population preferred Biology practical lessons over chemistry or physics. Their claim was that Biology practical activities were directly relevant to their lives and also that they were comparatively easy to carry out. Although the two studies were conducted in different study locations, the controversy in the findings creates a gap that needed to be filled. This controversy in research creates a need for further research. It therefore necessitated the present study to be conducted so as to find out whether the instructional approach used in the Biology classroom influenced the learners' attitude towards Biology.

Sharpe (2012) carried out a descriptive study on secondary school students' attitudes to practical work in school science. Schools were sampled using convenience sampling technique whereby they were identified and selected through acquaintance with heads of science departments in the schools. In this approach open sampling of schools well known to the researcher from three different counties and educational authorities was done. The findings revealed that secondary students' attitudes towards practical work are generally positive. However comparatively of the three sciences, learners had the least attitude in Biology. In addition, it was revealed from the study that the extent to which these attitudes towards practical work differed, not only across the three sciences, but also a significant decline as the leaners advanced up the classes.

Cohen, Manion, and Morrison (2011) observe that in practice, concerns about external validity during the interpretation of study findings and arriving at conclusions when using convenience sampling approach can lead to very low levels of validity. Therefore, the present study addressed this shortfall about the approach by selecting schools that had an almost equivalent entry behaviour using purposive sampling technique. In addition, in Sharpe's study, the researcher assumed that the participants were already exposed to practical sessions hence the study did not expose them to practicals, but just went in to get their attitude towards practical. This is a gap in the study which the present study had an intention to fill by first getting attitudes of learners before they were taught using BPPSTA. There after they were taught using BPPSTA and then their attitude was sought again. This provided an avenue for the researcher to make an informed report on their attitude change after undergoing instruction through BPPSTA.

There is an interrelationship between learner attitude towards Biology and learner achievement in Biology. Students' attitude towards science is more likely to influence achievement in science subjects than achievement influencing attitude. This position is supported by a study by Akinyemi (2009) who found out from his study that enhanced students' attitude towards Biology influenced students' academic achievement in

Biology. Ngesu et al. (2015) from their study observes that learners' attitude towards Biology was rated as neutral on a three predictor scale. The study further conceives that this neutral attitude is the contributing factor to the poor performance that was witnessed by the participants in the Biology examination. Similar findings have been reported by Ogutu et al. (2015) who asserts that, positive learner attitude culminates into high academic attainment in examinations while if neutral or negative it leads to poor learner attainment in examinations. This position can only hold depending on the instructional methodology in use. The present study on the other hand sought to determine the direction the learners' attitude will take after students having undergone instruction using BPPSTA.

Mei, Kaling, Xinyi, Sing, and Khoon (2007) in a study, explored ways in which Singapore students who had participated in a curriculum innovation programme named, 'Science ALIVE' acquired SPS and perceived the relevance of science to their life. The study investigated whether students had improved in their application of SPS after the programme. Likert scale type of questionnaire was the only instrument that was used in data collection. The data was analyzed using means and standard deviations. The findings showed that students' perception of skill competency had significantly increased. In addition, most of the learners perceived that the programme had increased their awareness of the importance of science in their lives. Likert type of questionnaire alone tends to provide rather shallow data on perspectives (Reid & Skryabina, 2002; Kind, Jones, & Barmby, 2007). To fill this gap, present study used a questionnaire containing both open-ended and close-ended questions. The open-ended questions got deeper to elicit the underlying perceptions and emerging issues hence attitude of the participants. In addition, present study further subjected the learners to a test before and after the intervention so as to relate the change in the scores to the results of the questionnaire on attitude.

Nyakan (2014) carried out a quasi-experimental study to find out the factors influencing SPS on gender disparity in performance, perception and attitude to enrolment in secondary school physics. The study findings indicate that SPS instructional approach did not impart any impact on change in learner attitude towards physics learning. As much as the approach under study did not influence improved performance in the subject, it significantly resulted into positive change in attitude for those who underwent instruction using physics SPS instructional approach. On the other hand, this change was not witnessed among those learners who underwent through traditional instructional approach. Although both physics and Biology are sciences, there might be variation before and after the intervention. The present study therefore focused on Biology subject and sought the learners' attitudes before and after the treatment. This filled the gap that was evident in the study by Nyakan as described.

2.7 Gender Difference in Learner Attitude Towards Biology

According to Akogun (2015), in many countries in sub-Saharan Africa the participation of girls in science subjects compared to that of boys is low. In another study by Prokop et al. (2007) it was found out that female learners showed a higher level of interest in Biology than their male counterparts. Furthermore, the study revealed that the interest of young learners towards Biology was relatively higher compared to the elderly ones. Gender and grade were also found from the study to be significantly correlated. Therefore, generally Slovak learners have a more positive attitude toward Biology subject and that girls and younger Slovak learners like Biology more. As learners progress through school, their interest towards Biology declines. The learners claimed they liked Biology more when it involved interaction with live animals and plants during the lessons. This is a study that was carried out in Slovakia and considered learners of different grades hence different ages. In the described study the gap that is identified is in terms of methodology and the sample used. The present study singled out form two students whose age is relatively within a narrow bracket of 14 to 19 years and subjected them to pretest and posttest questionnaires for empirical comparison.

In an exploratory survey study by Ferreira (2004) to determine whether secondary school students had certain preferences regarding the Biology they study at school and whether learners in co-educational or single-sex schools hold the same opinions. The study employed survey schedule as the key data collection instrument. The study findings showed that male and female learners in single sex schools were more contended with the quantity of practical lessons carried out. However, male learners in co-educational schools opined that the quantity of practical lessons they had been exposed to were not sufficient. The preference was dependent on gender in that, male learners irrespective of their school type enjoyed practical lessons whose content was about animals while female learners had a liking of practical lessons that was about flowers. The content that was taught in the present study was about plants only.

In a similar study in Japan by Suzuki (2007) however, contrasting findings were obtained. In most areas boys and girls held similar attitude but it was found that boys had a greater interest in topics which relate more to the world outside of them like the role of Biology to the society. On the other hand, girls had a tendency to prefer topics which relate to human interaction such as body structure and functioning and how it works. Such conflicting findings made it necessary for the present study to be carried out to come out with a clear standpoint position on gender attribute on attitude of Biology students. Kashu (2014) on this aspect posits that, in an attempt to encourage a larger proportion of women into STEM-related fields, appropriate interventions must be put in place so as not only to focus on academic achievement of the women but also on the best ways to make STEM-related professions more interesting to young women. Such an intervention should commence early enough when learners are in the basic education level, since their interest and attitude in science begins at such a time. The present study mainly focused on learners at the basic level; form two students.

Mwanda, Odundo, Midigo, and Mwanda (2016) conducted a study on the adoption of constructivism teaching approach in secondary schools in Kenya. They investigated the relationship between the teaching approach and student performance in various classes. Quasi-experimental non-equivalent group design was used which involved a pre-test and a post-test. Primary data were obtained from four boys', four girls', and four mixed schools with a total of 477 students. The form three topic, ecology was the content area that the study focused on. Data analysis involved the use of mean, standard deviation, *t*-tests and ANOVA. All the learners instructed through the constructivist approach registered marked improvement in achievement. However, the girls' classes showed the highest improvement followed by the mixed sex classes and finally the boys' classes. This study strictly focused on the 5Es instructional model which encompasses; engagement, exploration, explanation, elaboration, and evaluation. Review of this study shows, it narrowed down to the effect of instructional approach on learner performance without a keen focus on the science process skills as the present study did. Furthermore, the present study drew its participants from form two class since the topic often poorly performed in the KCSE examination was from this class which is ‘transport in plants and animals’ (KNEC, 2015).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the research design and methodology that will be used in this study. It presents the study design, area of study, target population, sample size, sampling techniques and data collection instruments. In addition, the procedures that were applied to ensure the instruments used in data collection were valid and reliable are presented. Piloting of instruments, data collection procedure and the data analysis techniques that were used in this study are also explained in this chapter. Finally, the ethical considerations and issues adhered to in this study have also been described.

3.2 Research Design

This study adopted two research designs: descriptive survey design (Cohen et al., 2013) and quasi-experimental research design using the Solomon four non-equivalent control group design, (Gall, Borg & Gall, 2007; Orodho, 2009). The descriptive survey design attempts to describe effects being felt and the trends that are emerging (Singh, 2012). Survey design require that primary data collection be done through questionnaires (O'Leary, 2017). This design has a purpose of better defining the opinion, attitude or behaviour by a group of people in a given subject and also gives an indication of the changes of the participants' opinions, attitudes and behaviour over time. Cohen et al. (2011) argues that, the great advantage of survey design is that you can gather more data within a short duration. In this study, the survey design was appropriate to enable gathering of data on the learners' attitude. The views of the learners towards various aspects of Biology went a long way in facilitating addressing the set objectives.

On the other hand, Gall et al (2007) are of the view that the Solomon four non-equivalent control group design counters most of the threats of internal validity that may end up plaguing research. The design also gives an opportunity to the researcher to minimise the effect of confounding variables which included age of learner, entry behaviour, teacher's experience and school facilities. The design also enabled the establishing of whether or not the pretest administered had any effect on the participants as proposed by Mugenda and Mugenda (2003). Therefore, in line with this study, this design was the most suitable since it enabled the participants to be in four non-randomized study groups. It enabled provision of quantitative data which upon analysis guided on the decision to be taken on the hypotheses stated. The groups in the design as was administered are presented in Table 3.2.1.

Table 4.2.1: Groups in the Solomon Four Non-Equivalent Control Group Design

GROUP	TIME 1	TIME 2	TIME 3
E1	O_1	X	O_2
C1	O_3	-	O_4
E2	-	X	O_5
C2	-	-	O_6

Source: Beaumont, (2009)

Key: -
Experimental group-1 - E1
Control group-1 - C1
Experimental group-2 - E2
Control group-2 - C2
Pre-tests - O_1 and O_3,
Post-tests - O_2, O_4, O_5 and O_6
Treatment - X

As observed in Table 3.2.1, this design encompasses four groups; two control groups (C1 and C2) and two experimental groups (E1 and E2). Groups E2 and C2 were not subjected to the pretest. Group C1 and C2 were not subjected to the experimental treatment. The experimental treatment involved form two students being taught by their usual Biology teachers who had undergone an induction training on how to teach using the BPPSTA. On the other hand, learners in groups C1 and C2 were taught with the usual approaches that the respective Biology teachers use in those schools. All learners in the four groups; E1, C1, E2 and C2 had a posttest administered to them. The pre-test and post-test were similar tests designed by the researcher in consultation with university supervisors. This research design made it possible for the determination of the effect of pre-testing by comparing the posttest results of groups C1 and C2 (Gall et al., 2007; Beaumont, 2009). The two research designs were adopted since they well suited to this study in so far as collecting of sufficient data that aided in answering of the research objectives.

3.3 Area of Study

The location of this study was Gucha South sub-County in Kisii County. Gucha South sub-County is one of the ten sub-counties in Kisii County. In the 2017 KCSE examination results in Biology, Gucha South sub-County was ranked position seven out of eleven sub-Counties in the County (MOE, 2018). In addition, the performance in Biology has been low; the subject recorded a mean score of 4.27 out of a possible 12 points in the 2015 KCSE examinations. The dismal performance has continued to date. In 2019 KCSE the sub-County was ranked position eight out of the eleven sub-Counties in Kisii County. The infrequent use of BPPSTA by teachers might have been the cause of the poor learner attainment in biology and hence overall performance. Such dismal learner performance informed the researcher on the need for this study to be conducted in Gucha South sub-County. The sub-County is administratively divided into four divisions: Nyamarambe division, Tabaka division, Etago division and Moticho division. The 2019 National population census results indicate that, the study area had a population of 167,410 persons (Republic of Kenya, 2020). The area covers 203.3 square kilometers with a population density of 777 persons per square kilometer making it to be among the least densely populated sub-counties in Kisii County (Republic of Kenya, 2019). Therefore, education and specifically biological knowledge and skills need to be inculcated through appropriate approaches so that the learners from this area can benefit more and transform their economic ability after school.

3.4 Target Population

The target population for the study was all the form two Biology students in secondary schools in Gucha South sub-County and all the form two Biology teachers. There are 48 secondary schools in Gucha South sub-County. Out of these, 47 are public secondary schools while one is private. The present study was concerned with only public secondary schools. Therefore, the target population was drawn from the 47 public co-educational secondary schools in the sub-County. Table 3.4.1 presents a summary of the secondary schools in Gucha South sub-County.

Table 3.4.1: Number of Secondary Schools in Gucha South Sub-County

Category of School	Boys' Schools	Girls' Schools	Co-educational Schools	Total
Extra County	2	1	0	**3**
County	1	0	4	**5**
Sub-County	0	2	37	**39**
Private	0	0	1	**1**
TOTAL	**3**	**3**	**42**	**48**

Source: MOE, (2017)

Table 3.4.1 indicates that in the entire sub-County there are only five County level schools; four of which are co-educational schools while one is a boys' school. The boys' school was therefore excluded since the study was interested with performance of both boys and girls in co-educational schools; all learners in form two class from the four co-educational County level secondary schools took part in the study. Form two students were deemed the most appropriate target population being a class where all students take Biology; unlike form three and four students who have already selected subjects. On the other hand, form one students are a bit new in secondary school hence their attitudes may not reflect the real situation. In these schools there are 2,946 form two students and 64 Biology teachers according to MOE (2017).

3.5 Sample and Sampling Techniques

3.5.1 Sample

The sample size for the study was restricted by one of the research designs adopted; Solomon four non-equivalent control group design. Mugenda and Mugenda (2003) argued that in determining sample size in a study a number of considerations come in to play. They include: research design adopted in the study, data analysis method to be used in the study and the size of accessible population. At least 30 participants are recommended in every study group for experimental studies. This threshold guided the researcher in the choice of appropriate groups for the present study. Table 3.5.1 presents summarized data of the sample size.

Table 3.5.1: Sample size

School	Study Group	Total Number	Sample Selected	Percentage Sample per School
A	Experimental Group - 1	119	119	100
B	Control Group - 1	64	64	100
C	Experimental Group - 2	113	113	100
D	Control - 2	105	105	100
	TOTAL	**401**	**401**	**100**

Source: Researcher's design

From Table 3.5.1, the sample size comprised of 401 form two students out of the total 2,946 form two students in the sub-County (MOE, 2019). These were the form two students in all the four co-educational county-level secondary schools in the study area. Form two students were deemed most suitable class for this study since they had been exposed to foundational Biology content to influence their attitude towards Biology. Students' interest in Biology declines slowly as they advance up the various classes (Barmby, Kind & Jones, 2008; George, 2006). In addition, the report by KNEC (2015) indicates that the least performed topics were from form two class. County level schools were the most appropriate since learners in these schools had relatively similar entry mark to form one and the schools had minimum resource requirement for the study.

Out of the 64 Biology teachers in the sub-County, seven were also identified as participants in this study. These seven were all the form two Biology teachers in the four co-educational schools. This sample size provided a reasonable proportion whose findings could easily be generalized to the accessible population to an acceptable level (Mugenda & Mugenda, 2003). Each one of the four schools was assigned to only one of the four groups as per the research design. The assignment of schools to the four groups was guided by the location of the school in terms of the administrative division; this ensured that the four groups were far apart to reduce the possibility of inter-group learner interaction. In so doing, the experimental group schools were identified as those that were far apart from the control group schools. Such a distance apart ensured there was increased accuracy of the outcome from the study.

3.5.2 Sampling Techniques

To select four co-educational County level secondary schools in the sub-County, purposive sampling technique was used. County schools were selected for the study because learners who get admission to these schools had relatively comparable academic abilities emanating from the form one selection process after the KCPE examination. Four co-educational County secondary schools were selected due to the nature of the research design; Solomon four non-equivalent control group design. Purposive sampling was then used to select all the form two students in each of these schools to take part in the study. All the form two students in these schools took part in the study irrespective of the number of streams of the form two class in the sampled schools.

3.6 Research Instruments

Four data collection instruments were used in this study. These instruments were; Biology Attitude Questionnaire for Students (BAQS), Biology Practical Observation Schedule (BPOS), Process Skills Assessment Test (PSAT) and Biology Achievement Test (BAT). Each one of these instruments is described as follows:

3.6.1 Biology Attitude Questionnaire for Students (BAQS)

The researcher developed a questionnaire that was used to gather data on the learners' attitude towards Biology. Both open-ended and closed-ended question items were included in the questionnaire. Part of section B of the BAQS was adapted from Sharpe, (2012). The questionnaire was partly open-ended, so as to give the students a chance to openly give their views and any emerging belief. This instrument was basically seeking for the learners' attitude towards practical lessons in Biology. The instrument further sought the learners' views on their competency in these process skills. A questionnaire as a data collection tool when used has the ability to collect a great wealth of information from large sample within a short duration (Bell, 1999).

The BAQS contained 27 question items for the students to respond to as presented in Appendix (I). This instrument is sub-divided in three sections; Biodata, students' attitude towards Biology practical and students' views on teaching and learning of Biology. The first section sought background data concerning the schools together with the participants. In the second section the purpose was to collect data on the views, opinions and thoughts of the participants in relation to the Biology practical lessons. The question items in this section were Likert-type. The third section sought to collect data from learners on how the practical lessons are taught. The third section had only open-ended question items.

3.6.2 Process Skills Assessment Test (PSAT)

A teacher-made test was developed by the researcher with a purpose of assessing the actual learner performance of the BPPS during a practical lesson; see attached Appendix (II). The question items were adapted from the past KCSE examinations by KNEC with appropriate modifications. KNEC questions were preferred for the study since KCSE is a standardized test. The test aimed at determining the ability of the learners to demonstrate the skills of observing, measuring, communicating, inferring, experimenting and interpreting data. These were the Biology practical process skills that this study was concerned with.

3.6.3 Biology Practical Observation Schedule (BPOS)

Biology Practical Observation Schedule (BPOS) was prepared by the researcher. This instrument was to guide on the specific sections of the PSAT where the six Biology practical process skills are evident. It also showed the parts where the process skills could be marked during the practical session as presented in Appendix (III). In the instrument letter "P" was used to denote the sections where the Biology practical process skills were to be identified and scored during the practical observation session. This instrument assisted the researcher at two stages; during the lesson observation stage and later during the stage of marking of learners' work in PSAT. During practical session stage it guided the researcher to score the manipulative process skills. On the other hand, during marking stage it guided on the other process skills presented through the students' work in the PSAT. This process was necessary so as to sum up the total performance of the learners in the BPPS as observed during the practical (from BPOS) totaling 14 marks and as reflected in the learner's written work totaling to 26 marks (from PSAT) so as to add up to 40 marks.

The BPOS was used for the experimental group only on one occasion. The observation was done on the experimental group with an aim of assessing learner performance in the six BPPS under study. This lesson was also video-recorded to corroborate the classroom observation. One of the lessons of the control group was also video-recorded for purposes of ascertaining the conventional methodology during instruction. Andima (2014) observes that, the advantage of video recording during lesson observation is that the researcher has the opportunity to watch the recorded interactions a number of times before drawing objective conclusions.

3.6.4 Biology Achievement Test (BAT)

A teacher-made test to be scored out of 20 marks was constructed to evaluate the learners' achievement after practicing the practical skills in the study as attached Appendix (VI). It also revealed whether teaching using BPPSTA could impact on learner attainment. A multiple-choice test was adopted for the study. Each question item had four answers suggested; one of the four answers being the correct one while the other three were alternatives which were distracters. Rabacal (2016) opine that a major consideration in the construction of multiple-choice test is that the distracters should be credible and have an ability to appear like the correct responses. To achieve this in the present study, senior university lecturers in the Department of Curriculum, Instruction and Media, validated the multiple choice questions and answers.

The multiple choice format of testing was adopted due to its merits. These merits include; its ability to provide for adequate sampling, it gives a better item pool, its relatively easier to administer the test, it saves time in analysis and yields high reliability when scoring (Rabacal, 2016). The question items in the BAQS and PSAT were developed with close consultation with curriculum experts in Kisii University who are senior lecturers in the Department of Curriculum, Instruction and Media. Being experts in testing they were able to look at both content and the structuring of the question items.

Test item analysis is determined statistically using the two procedures: item difficulty index and item discrimination index. Difficulty index is the proportion of participants who choose the correct response to an item as compared to those giving the wrong response to the question item (Nyakan, 2014). Reiner (2018) observes that item difficulty index is a very useful statistical tool especially when it comes to the determination of validity of test questions. According to Haladyna, and Rodriguez, (2002) difficulty index of a question is the proportion of participants who pick the correct response to the question to the participants who get the incorrect answers to the question item. The lower the difficulty index the harder the question item. Difficulty index is calculated from the formular:

$$D = \frac{c}{n}$$

Where:

D = Question item difficulty index

c = No of learners who got the correct answer

n = number of learners who responded to the question item

Difficulty index ranges from zero to one. The greater the index as it gets nearer to one the easier the question item. The smaller the value as closer to zero the more difficult the question item.The study retained all the question items with difficulty index between 0.3 – 0.8 according to Reiner (2018). All the twenty questions had a value between 0.4 – 0.7 and so all of them were retained for data collection purposes in the BAT.

Discrimination index is another analysis that was carried out on the data emanating from the pilot of BAT. Discrimination index is the ability of item responses to discriminate between individuals who got high scores in a test and those who got low scores on the same test. Haladyna and Rodriguez (2002) argue that discrimination index basically measures the validity of a question item. It indicates the extent that overall content knowledge or skill mastery are related to the responses to a question item. Discriminatory index ranges from –1 to +1. When a negative discrimination index is obtained, it implies that surprisingly learners who score low on the test are most likely to give the correct answer, or that the most knowledgeable learners get the item wrong and the least knowledgeable ones get the item correct. A greater positive value that is closer to one indicates a stronger relationship between the overall test performance and performance on that specific question item. Discrimination index is calculated using the following formular:

$$DI = \frac{a-b}{n}$$

Where:

DI = Item discrimination Index

a = Question item response frequency of the upper quartile

b = Question Item response frequency of the lower quartile

n = Number of participants in the upper quartile

For purposes of this study, the DI obtained from each of the 20 question items in the BAT ranged from 0.5 to 0.9. Two question items, each had a DI of 0.12 and 0.17 and hence they were revised appropriately so as to be included in the instrument.

3.7 Piloting of Instruments

Before conducting this study, a pilot study was conducted in one of the County level co-educational schools in Gucha sub-County; which boarders Gucha South. The school used for piloting was from Gucha sub-County because all the County level schools in the sub-County had been sampled to take part in the study. However, the school identified for the purpose of piloting had similar characteristics as those schools that were to take part in the study; such characteristics include: rural set-up, similar entry behaviour characteristics of students and being co-educational. In this school, a class of 45 form two students and one Biology teacher participated in the pilot phase. Consent was sought from the participants before administration of the instruments was done (see attached Appendix (XIV). The time to be used to answer the question items was also being pre-tested at the piloting stage. As Cargan (2007) observes that piloting is conducted to ensure that the data collection tools will provide data that is reliable and standardized so that administration of instruments in the main study will ultimately be a success.

Bell (1999) observes that a pilot study is conducted so as to get rid of 'bugs' during the main study. Bugs include statements, phrases and wordings that were likely to elicit unintended responses hence becoming threats to the validity. The BAQS was piloted and the outcome from the piloting led to rephrasing of two of the questions so as to make the responses from these questions more valid. The pilot study also aided in the modification of the grammar to simplify the concept being tested. This is emphasized by Johnson and Christensen (2008) who posit that pilot–testing of instruments can unearth questions that have a wording problem, questions that are not well understood, and detect any ambiguities in the question items. It also helps check how long it takes participants to complete the test under circumstances similar to those of the actual study.

A pilot observation was carried out as the students were carrying out a practical session to try out the PSAT. This enabled the researcher to identify any unforeseen challenges in the practical session and BPOS for modification in advance. It also enabled the research assistant familiarize himself with the expectations of lesson video-recording process so as to perfect it when the study was to be carried out. Furthermore, the pilot observation informed the researcher of the moderate level of anxiety of the learners due to the presence of the research assistant in class. This necessitated the video-recording instruments to be introduced in the preceding lesson so as to minimize such anxiety during the Biology lesson. The video-recorded lesson was reviewed together with the research assistant for appropriate advice, modification and improvement in the actual study. Some of the modifications included the practical activities being done in groups in intervals in the laboratory so as to be effectively captured by the research assistant. In addition, the learners were to be provided with the material and the requirements of the practical in advance so as to ensure the lesson is well covered within the allocated duration. The duration that the learners were to take to carry out the practical (PSAT) was also adjusted from 40 minutes to 80 minutes as a result of the piloting.

3.8 Validity and Reliability of Instruments

3.8.1 Validity of Instruments

According to Orodho (2009) validity is the ability of an instrument to measure that which it was meant to measure. For purposes of this study, a number of measures were taken to ensure that the data collection instruments were valid. The questionnaire items on attitude in the BAQS were verified and adapted from Sharpe (2012) in close consultation with the university supervisors. By referring the instruments to experts in the Department of Curriculum, Instruction and Media of Kisii University, evidence was collected for demonstrating that the content of the items in the research tools corresponded to the responses expected. Their suggestions and corrections were incorporated so as to improve on the content and face validity.

The PSAT was designed by the researcher. The designing process involved adapting most questions from the past KCSE examination papers with modifications; this was aimed at increasing internal validity of the test. The test was then given to senior university lecturers in the Department of Curriculum, Instruction and Media to validate on the wording of questions, marks allocation and also validate the marking scheme. This was also aimed at improving on the face validity of the PSAT.

The BPOS was validated in line with the expectations of the question items that were in the PSAT. The pilot observation that was conducted provided an impetus on the modifications to be made during the observation so as to improve on the construct validity. The instrument was also validated by the senior lecturers in the Department of Curriculum, Instruction and Media of Kisii University.

The multiple choice question items in the BAT were validated by senior lecturer in measurement and evaluation. They did not only concentrate on the questions but also the multiple choice distracters. Furthermore, pilot-testing provided data that aided in the calculation of the difficulty and discrimination indices of every question item in the BAT. These indices values obtained aided in ensuring the construct and content validity of the question items in the BAT. Multiple sources of evidence were used in the present study to increase construct validity and also for triangulation purposes (Bell, 1999). The use of multiple sources increased the chance to view and report the happenings on the ground as perceived by the participants (Nyakundi, 2007). Similar observations have been made by Justi and Gilbert (2005) who explain that, when a study employs a variety of methods and research tools a better understanding of the reality in the science environment is gained.

3.8.2 Reliability of Instruments

Split-half method was used to determine the reliability of the research instruments (Bell, 1999) to a sample of 45 form two students from a County level co-educational school in the neighbouring Gucha sub-County. The 45 students who took part in the pilot study responded to the questionnaires which were then used to determine the reliability. Orodho (2009) opines that when using split-half method to determine reliability, completed questionnaires should be given to about five identical participants not included in the study sample. The BAT was split into two halves of items on the basis of either odd or even. The two set of scores from the even and the odd lots were correlated; The Pearson Moment Correlation Coefficient was used to measure the magnitude of relationship in the two sets. A coefficient of $r = 0.87$ was obtained indicating a high reliability level of the research instrument. Gall et al. (2007) suggests a value of $r \geq 0.7$ as a sufficient reliability value. On the other hand, Bryman and Cramer (2001) recommends 0.8 as the minimum value for reliability. The $r = 0.87$ obtained therefore met this threshold for reliability test. The same approach was used for the PSAT which yielded a reliability coefficient value of 0.84. Split-half method involving 45 learners was used to determine the reliability of the BAQS. Cronbach's alpha was used to determine the reliability level of the attitude questionnaire items for internal consistency of the test and a value of 0.94 was obtained implying a high level of reliability. By the instruments meeting the reliability threshold, it implied that they were reliable enough to be used for data collection in the study.

3.9 Data Collection Procedures

An introduction letter from Kisii University was obtained which was used to apply for the research permit (see attached Appendix XI) and a research authorization letter (see attached Appendix X) from the National Commission for Science, Technology and Innovation (NACOSTI) so as to conduct this study. The researcher then paid a courtesy call to the Kisii County Director of Education (CDE) to facilitate the access to the sampled schools in the County. Self-introduction to the school principals and teachers of Biology in secondary schools under study was done physically; in addition, an introductory letter was written by the researcher, clearly stating the purpose and significance of the study. This significance together with the aim of the study were then communicated to the students through their respective Biology teachers. The participants' consent was sought through their Biology teachers before commencement of the study as seen in Appendix (XIV). The participants were assured that the information they were to give was to be confidential and was to be used for research purposes only. They were also informed that anonymity was to be adhered to during reporting of the data.

The BAQS was administered at two levels: before and after the experimental treatment. Before the treatment, all the study groups were expected to fill-in the BAQS. One week after the administration of BAQS, the participants were subjected to BAT to respond to. The pretest for BAT was administered first to two of the four groups (one control and one experimental group) after which the experimental groups were subjected to the treatment (teaching using the Biology practical process skills). Two weeks later, the learners were subjected to the PSAT. PSAT involved the students in the experimental groups being taught practical lessons infused with the six BPPS under study for four weeks. A module for four practical lessons was designed and used by the Biology teachers during the teaching. The module is attached as Appendix (IX). After the four weeks, the students were subjected to a practical test (PSAT) that involved practice of Biology practical process skills guided by provided procedure and associated questions. The PSAT instrument is attached as Appendix (II). One week after administering the

PSAT, the posttest BAQS was administered. This was the same BAQS that had been administered at the pretest stage. After another week, rearrangement of the question number and items in the BAT was done. It was then administered again as a posttest to all the four study groups. The BAT aimed at determining whether the learners were capable of correctly answering questions from the learnt topic having been taught using BPPSTA (for those in the experimental groups) and conventional methods (for those in the control groups). In both administration of the BAT, the participants were given clear instructions on how to respond to the questions. During this testing phase the Biology teacher invigilated the administration of the test.

The second administration of BAT and BAQS aimed at finding out whether the experimental treatment had any effect on the achievement and attitude of the participants respectively. After 40 minutes, the papers were collected from the learners and packed for onward forwarding to the researcher for marking. Mugenda and Mugenda (2003) opines that a response rate of over 90% is very good. The researcher personally supplied the questionnaires to the sampled schools. The Biology teachers then administered the questionnaires to the participants. The researcher then came back the following day to pick the filled-in questionnaires. This short period was so as to increase the response rate; the researcher was able to attain a response rate of 100%. On the other hand, by using four groups in the study, the test wiseness effect was unveiled so as to address issues of internal validity (Gall et al., 2007).

The PSAT was administered as a Biology practical test whereby the learners were expected to record their answers as they carried out the activities. The test had 26 marks; however, it was scored out of 40 marks. This was because there were 14 marks that were to be scored by the researcher guided by the BPOS as the learners were carrying out the activities involving direct manipulation so as to give a total of 40 marks. The test was scored guided by a prepared marking guide as attached Appendix (IV). The PSAT was administered concurrently with BPOS. A week before the day of the practical when PSAT was to be administered, the Biology teacher was provided with a confidential list of the requirements for the practical as in Appendix (V) for prior preparation.

The researcher used a research assistant to aid in the process of video recording the classroom behaviour during the Biology learning process. Training of both prospective and current science teachers to develop the skills of science process is the best way of promoting SPS (Susanti et al., 2018). The Biology teachers underwent a one-day induction training, organized and administered by the researcher on the expectations during teaching as in Appendix (IX). The video recording personnel was on the other hand trained specifically in recording of the classroom behaviour using a video recorder. For efficiency the research assistant was trained on the behaviours to be recorded during the Biology lesson. The training focused on likely activities anticipated as well as the maneuverability in the classroom environment.

The video was turned on at the start of the lesson and then the PSAT was distributed to the learners. The instructions were given by the Biology teacher before they started the activities in the PSAT. The research assistant continued recording the lesson happenings throughout the class until when the lesson ended and the video recorder was turned off. Once the lesson was over, the question papers were collected from the learners, packed then labelled awaiting marking and analysis.

During the practical the researcher guided by BPOS (as seen in attached Appendix V) scored the learners work on manipulative skills evident in the practical. As the lesson went on, the researcher used the BPOS to identify and tick appropriately the evidence and practice of the Biology practical process skills in the lesson. The process of identification of BPPS during the Biology lesson went on throughout the lesson. Each learner was scored separately for the evidence of BPPS using the BPOS. The versatility and accuracy of a video camera in recording most of the classroom activities was the main strength that guided the researcher in using it in the study. It deemed as the most appropriate for this study since it captured well the manipulative skills synonymous with BPPS under investigation. Furthermore, it allowed for viewing and reviewing again during data analysis stage (Andima, 2014).

The effect of video recording on learners' anxiety and level of participation in classroom activities was minimized by introducing the video recording equipment in a lesson preceding the Biology lesson. However, the other skills that were manifested were to be scored after the practical, guided by the marking scheme attached as Appendix (IV).

3.10 Method of Data Analysis

Both descriptive and inferential statistics were used to analyse the quantitative data that was collected in this study. On the other hand, qualitative data emanating from the questionnaire was analysed through content analysis (Orodho, 2009). Conceptual content analysis was opted for by use of hands rather than use of computer software so as to improve on validity. The open-ended responses in the BAQS were transcribed after which a summary was done into emergent themes. This summary was carried out in relation to the study objectives that the themes addressed. In this method, the intensity of certain words, points of view, and emotional laden words were sought and then critically reviewed to bring out the attitude expressed. The frequency of the various terms and emotion-laden words were identified and tallied so as to generate numerical data. The data was then tabulated and presented appropriately. Orodho (2009) observes that content analysis improves the reliability of the observations and interpretations.

Responses from closed-ended question items were coded (Blanche, Durrheim & Painter, 2008). After coding was done, tabulation of the responses was done. Tallying was then done to determine the frequencies which were then transformed into percentages. Descriptive statistics which included mean and standard deviations were used in the analysis. In addition, inferential statistics including independent samples t-test were used to analyze data for the closed-ended Likert-type question items in the BAQS (DeWinter & Dodou, 2010). Learners' responses about their attitude towards Biology as depicted in the BAQS before and after experimental treatment were compared. The t-test was used to establish whether there was any change in attitude after the treatment. The video-recorded data was viewed and reviewed with a purpose of noting any information that may have escaped the researcher's attention during the prior classroom observation session. These information was used to complement data on BPPS collected using BPOS and PSAT.

The BPOS were used during the actual practical session and also during the marking of PSAT. The data from BPOS and PSAT was condensed to the PSAT then analysed. PSAT data were analysed using descriptive statistics to reveal the mean and standard deviation of the learners in the various groups. A correlation analysis was then conducted between the mean attainment in PSAT and that of learners in the BAT. This was to reveal whether the two; practical test (PSAT) and theory test (BAT) were correlated.

The quantitative data emanating from the BAT pre-test and post-test mean scores of various categories of students in the four groups was analyzed using: descriptive statistics, One-way ANOVA, Pearson's Product Moment Correlation, and Independent Samples t-test. This analysis was aided by use of Statistical Package for Social Sciences (SPSS) version 22. Experimental group - 1 results for pretest and posttest were compared to establish whether BPPSTA had impacted on achievement. The change in experimental group - 1 was compared to that of control group - 1 to ascertain that any change observed was actually as a result of the treatment. Experimental group - 1 and Experimental group - 2 were compared to reveal whether the effect of pretesting was felt on the post-test. Experimental group - 2 was compared to the control group - 2 to ascertain that actually the observations are neither as a result of pretest nor chance. These comparisons were done using the independent samples t-test at a significance level of $\alpha = 0.05$. The mean for the various groups and observations was compared using the SPSS version 22. The significance value in the t-test for equality of means determined whether the means of any two groups of concern were significantly different. When the value was less than 0.05 then the two means were deemed as significantly different while in cases that the value was greater than 0.05 then it implied that the two means were not significantly different. Cohen *d* was further used to calculate the effect size between the experimental groups and the control groups. Cohen, (2002) observes that Cohen *d* aids to determine the magnitude that the independent variable has on the dependent variable.

The mean attainment of learners in the four study groups was subjected to a one way-ANOVA test to establish whether the group means were significantly different. This was to further inform whether the difference could be attributed to the experimental treatment only. The rejection or failure to reject the null hypotheses was determined at significance level of $\alpha = 0.05$ guided the testing of these results. This was to direct the decision to be taken as far as the hypothesis testing is concerned. A correlation test was run on the dependent and independent variables so as to determine whether they are highly correlated. A correlation value of, $r_{xy} \geq 0.7$ was to be an indication of high correlation (Orodho, 2009).

The results emanating from the data analyzed by the various quantitative methods described above using SPSS were then presented in form of percentages and tables. This aided the researcher to effectively interpret it in line with the hypotheses and objectives of the study so as to draw appropriate conclusions.

3.11 Ethical Issues and Considerations

Ethical principles such as confidentiality, informed consent, anonymity and adherence to human and public relations were paramount during the study. These basic ethical principles ensured the protection of participants' dignity, safety, rights, and wellbeing took precedence over all other aspects according to Harris, Macsween and Atkinson, (2017). Knowledge sources were appropriately acknowledged through citation and later referencing. The thesis was run through an anti-plagiarism software and a similarity index of less than 20% obtained as seen in Appendix (XIII).

Since the participants were minors, their consent was sought through their respective Biology teachers. The teachers of Biology in the respective sampled schools filled-in a consent form on behalf of each one of the learners as attached in Appendix (XIV). Confidentiality of information to be provided by participants was assured to them. The participants who were to take part in the study were informed of their role in the study in advance before the administration of the instruments. The participants were requested to respond to the questions and concerns of the researcher voluntarily; the students were informed that it was their right to either stop or continue participating in the study (Orodho, 2009).

Codes were assigned to the participants so that their names remained concealed from the researcher and any other person according to Bell (1999). Only the researcher and his assistant handled the test papers. After the test had been done, the scripts were marked immediately within a week. Once marking was through, vital information targeted for by the researcher was extracted from the scripts after which the scripts were safely stored. The performance of each learner and school in the tests were treated with high level of confidentiality. However, the schools that took part in the study were assured that they could access the results if they so wished.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, data collected through the various instruments is analysed, followed by presentation of results and then discussion of the findings. The findings are presented from the data analysed so as to respond to the four research objectives that guided this study. The data were collected from form two Biology students in secondary schools sampled from Gucha South sub-County, Kisii County, Kenya. The results are presented in line with the four study objectives that were to:

1. Determine the contribution of Biology Practical Process Skills' Teaching Approach (BPPSTA) to learners' achievement in Biology.
2. Establish whether or not there is gender difference in achievement between learners taught via the BPPSTA and conventional methods.
3. Investigate the influence of BPPSTA on learners' attitude towards Biology when taught using BPPSTA as compared to when taught via conventional methods.
4. Determine whether or not there is gender difference in attitude of learners towards Biology when taught via the BPPSTA and via conventional methods.

4.2 Age and Gender of the Participants

The present study involved 401 participants who were form two students from four County level co-educational secondary schools in Gucha South sub-County, Kisii County. The study established the age and the gender of the study participants. Table 4.2.1 gives the descriptive statistics for the age of the participants according to their gender.

Table 4.2.1: Age and Gender of the Study Participants

Gender	N	%	MIN.	MAX.	MEAN	SD
Male	196	48.9	15	19	16.74	1.156
Female	205	51.1	14	19	15.61	.955
Total	**401**	**100**	**14**	**19**	**16.17**	**1.02**

Table 4.2.1 indicates that the participants of male gender who took part in this study comprised of 48.9% of the total population while the female participants were 51.1%. The minimum age of the student participants was 14 years while the maximum was 19 years. The mean age of the male learners who took part in the study was 16.74 years while 15.61 years was the mean age of the female learners who took part in the study. The standard deviations from the means of male and female learners were 1.156 years and .955 years respectively. The total average age of all the study participants was 16.17 years. It is observed that males had a higher mean age than that of the female learners under study. The boys had a relatively higher standard deviation from the mean as compared to the girls. However, the standard deviations generally are small implying that most of the learners were of age that is around the class mean within a range of 1.02 standard deviation. This was narrow enough to yield results that would minimally be affected by age as a factor. This was key in ruling out age which was an extraneous variable, as impacting on the outcome of the present study.

The mean age of participants was analysed on the basis of gender and study group. Table 4.2.2 presents the age of the participants in relation to the groups and gender.

Table 4.2.2: Age of Participants in Relation to Gender Across the Four Study Groups

Group	Gender	N	Mean	SD
Experimental –1 (E1)	Male	64	16.828	1.203
	Female	55	15.527	1.034
Control –1 (C1)	Male	32	17.094	1.201
	Female	32	15.281	1.143
Experimental –2 (E2)	Male	50	16.680	1.35
	Female	63	15.794	.901
Control –2 (C2)	Male	50	16.560	.812
	Female	55	15.473	.690

From Table 4.2.2, the highest age mean is 17.094 years for male participants in group C1. On the other hand, the lowest age mean is 15.281 for female participants of the same group C1. The highest standard deviation recorded was 1.203 by the male participants in group E1. The lowest standard deviation is .690 for the age of the female participants in group C2. The results further indicate that 15.2 years was the lowest mean age while 17.0 years was the highest mean age of participants. This range is narrow enough to inform the study that such learners have an almost equal level of cognitive, psychomotor and affective abilities and experiences.

4.3 Pretest and Correlation Analysis

A correlation analysis was run for BAT and PSAT and the results from the analysis presented. Furthermore, a comparison was done between the BAT results of the E1 pretest and C1 pretest groups. The analysis was to inform the researcher whether these two groups had equal abilities academically before they were subjected to the intervention. Table 4.3.1 presents results of the analysis of the mean marks of the BAT administered to the E1 group as a posttest and the PSAT.

Table 4.3.1: Descriptive Statistics for BAT in the Experimental Group - 1 Posttest and PSAT

Test	N	Minimum	Maximum	Mean	SD
BAT	119	10.00	38.00	24.75	6.31
PSAT	119	14.00	39.00	26.49	6.10

Results in Table 4.3.1 indicate that the mean mark of the E1 group in BAT was 24.75 while that one of the same cohort of learners in PSAT was 26.49. The standard deviations for the two groups was found to be 6.31 and 6.10 respectively. It is clear that the standard deviation from the mean is higher for the BAT than for the PSAT. From the two mean marks it is clear that the learners had a higher mean score in PSAT than in BAT. A Pearson correlation analysis was run on the data to find out if the learner attainment in the two tests correlate. Table 4.3.2 presents the output from the analysis.

Table 4.3.2: Correlation of Groups E1 and C1 pretest Scores for BAT and PSAT

Group	N	r	Sig
E1	119	.839	.000
C1	64	.791	.000

The Pearson's r value obtained as shown in Table 4.3.2 for the group E1 and group C1 are .839 and .791 respectively. These correlations are significant at the 0.01 significance level. Gall et al. (2007) observes that such r values imply that the relationship that exists between the marks attained by learners in PSAT and that obtained in BAT for the E1 pretest show a strong positive correlation. A similar relationship exists also in the C1 pretest group. These results imply that, the marks attained by learners in the practical activity is correlated to the mark a learner attains in the achievement test done. Therefore, the learners' performance in practical activities has a correlation to their achievement in

Biology. This justifies the essence of using PSAT scores as a predictor of the attainment in the BAT in the present study.

Since the study involved two experimental groups, there was need to further conduct a correlation analysis between the BAT scores in the E2 posttest group and the scores in the PSAT. Table 4.3.3 presents the analysis.

Table 4.3.3: Posttest Correlation of BAT and PSAT

Group	N	r	Sig
E1	119	.773	.000
E2	113	.712	.000

Table 4.3.3 displays results that indicate the mean marks of learners in the two tests; BAT and PSAT, for groups E1 and E2 had correlation coefficient values of + 0.773 and + 0.712 respectively. These values indicate a strong positive correlation between the E1 posttest group and E2 posttest group scores in the BAT and the scores in the PSAT. This shows that the relationship between effectiveness of the method on both the practicals and theory paper was positive. This further implies that the PSAT was a predictor of the performance in the BAT.

To ascertain equivalence in study groups in academic attainment prior to the start of the study, groups E1 and C1 pretest BAT scores were subjected to an analysis. This comparison analysis was aimed at confirming randomization. Table 4.3.4 presents these results of comparison.

Table 4.3.4: Pretest Mean Scores and Independent Samples t-test in BAT for Groups E1 and C1

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 pretest	119	17.03	5.988	181	2.865	.055
Control group - 1 pretest	64	16.38	5.929			

Table 4.3.4 indicate that there is no significant difference in the pretest mean scores of E1 group (M=17.03, SD=5.988) and the pretest mean scores of C1 group (M=16.38, SD=5.929) for the attainment in the BAT; t(181)=2.865, p=.055. Since the p-value obtained of 0.055 is > 0.05 therefore there is no significant difference between the mean score of learners in E1 pretest and C1 pretest. This implies that the learners in the E1 and C1 pretest groups had the same level of cognitive abilities in BAT. This meant that the learners in these groups of study had comparable abilities before the intervention was administered. Annan et al. (2019) in an attempt to assess the inquiry methodology influence on learner' attainment in Biology in Ghana found out that learners involved in this study had the same cognitive abilities before the commencement of their intervention. Just like in the current study the lack of significant difference implies that the learners in the two groups had similar characteristics academically before any intervention was introduced.

4.4 Objective 1: Contribution of Biology Practical Process Skills' Teaching Approach (BPPSTA) to Learners' Achievement in Biology.

In an effort to determine the contribution of BPPSTA to learners' achievement, BAT and PSAT were administered and the data thereafter analysed. Table 4.4.1 displays the mean scores attained in the BAT done by the students who had been taught using the BPPSTA and the conventional learning methods.

Table 4.4.1: Analysis of Learners' Scores in BAT Across the Four Study Groups

Group	Pretest/ Posttest	N	Mean	SD
E1	Pretest	119	17.03	5.988
	Posttest	119	24.71	6.391
C1	Pretest	64	16.38	5.929
	Posttest	64	17.41	5.959
E2	Posttest	113	23.26	5.184
C2	Posttest	105	17.10	4.891

Table 4.4.1 indicate that the lowest mean attained was 16.38 for the students in the C1 pretest. The standard deviation for this group is 5.929. Comparatively, the mean attainment for learners in the E1 posttest is the highest at 24.71 marks with a standard deviation of 6.391. This is one of the two groups that had been subjected to a pre-test, treatment and finally posttest. The treatment involved the teachers of the various schools in the experimental groups under study teaching the Biology concepts step by step using the BPPSTA module, refer to Appendix (VII). The teachers laid more emphasis on the six Biology Practical Process Skills (BPPS) under study. The learners in the control groups underwent instruction under the guidance of their respective Biology teachers via conventional methods. Learners in C1 posttest group, recorded a lower mean score (17.41) as compared to the one posted by the learners in the E1 posttest group (24.71). The learners in E2 group equally posted a superior mean score than the learners in the C2 group. Learners in experimental groups therefore, generally posted relatively higher mean scores than those in control groups.

A one-way ANOVA was further conducted to determine whether the difference in BAT posttest mean scores for the four study groups were significant. Table 4.4.2 presents these results.

Table 4.4.2: One -Way ANOVA Results for Posttest BAT Across the Four Study Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4628.483	3	1542.828	48.785	.000
Within Groups	12555.128	397	31.625		
Total	17183.611	400			

Results in Table 4.4.2 shows (df=3,397; F=48.785, p=.000) which are interpreted to mean that there was a significant difference in at least a pair of the posttest group mean scores. Since the p-value obtained of .000 is < 0.05 therefore the mean scores of learners in the four study groups are significantly different. A post hoc test through multiple comparison analysis was done on the BAT posttest mean scores using the Least Significant Difference (LSD) and the output from the analysis is presented in Table 4.4.3.

Table 4.4.3: Multiple Comparisons of Posttest Mean Differences for Groups E1, C1, E2 and C2 Using the LSD

(I)Study Groups	(J) Study Groups	Mean Difference (I-J)	Std. Error	Sig.
Experimental - 1 (E1)	Control -1	7.308*	.872	.000
	Experimental - 2	1.458	.739	.059
	Control - 2	7.610*	.753	.000
Control -1 (C1)	Experimental - 1	-7.308*	.872	.000
	Experimental - 2	-5.850*	.880	.000
	Control - 2	.301	.892	.735
Experimental - 2 (E2)	Experimental - 1	-1.458	.739	.059
	Control -1	5.850*	.880	.000
	Control - 2	6.152*	.762	.000
Control - 2 (C2)	Experimental - 1	-7.610*	.753	.000
	Control -1	-.301	.892	.735
	Experimental - 2	-6.151*	.762	.000

*The mean difference is significant at α = 0.05 level

Table 4.4.3 presents results that show that there is a significant difference between Experimental group- 1 (E1) and Control group - 1 (C1), ($p=.000 < \alpha =.05$) with group E1 attainment being better than group C1. Group E1 attainment also was better than that of group C2 ($p=.000 <\alpha = .005$). There is a significant difference between the Experimental group - 2 (E2) and also control group - 2 (C2) ($p=.000 < \alpha=.05$). Mean scores of control group-1 (C1) and that of Experimental group -2 (E2) were significantly different; whereby group E2 recorded a higher attainment mean score than C2 ($p=.000 < \alpha =.05$). The results also show that there was no significant difference between the mean scores of groups E1 and E2 ($p=.059>\alpha= .05$) and groups C1 and C2 ($p= .735 > \alpha= .05$). This shows that there was no significant difference between the treatment groups and also between the control groups, implying that the BPPSTA is a better approach for Biology instruction than the conventional methods. Generally, it is vital to note that learners in the groups that used the BPPSTA for instruction had mean scores that differed significantly with those of leaners in the control groups who underwent instruction using the conventional methods. These results corroborate the findings by Cimer, (2004) and the claims by Arokoyu and Chukwu, (2017) that hands-on teaching approaches when used in science teaching are more effective ways of teaching Biology. Similarly, Eila et al. (2016) from another study supports these findings by reiterating that the most recommended instructional approaches were those in which learners worked in groups and were actively involved in the learning processes.

To determine whether the learners' scores in the BAT in the E1 pretest group were significantly different from those of the learners in the posttest of the same group an independent sample t-test was conducted. Table 4.4.4 presents these result.

Table 4.4.4: An Independent Samples t-test for the BAT for Experimental Group - 1 Pretest and Posttest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 pretest	119	17.03	5.988	236	7.086	.000
Experimental group - 1 posttest	119	24.71	6.391			

Table 4.4.4 indicate a significant difference in the pretest mean scores (M=17.03, SD=5.988) and the posttest mean scores (M=24.71, SD=6.391) for the E1 group; t(236)=7.086, p=.000. Since the p-value of .000 obtained is < .005 it means that there is a significant difference between the mean score of learners in the pretest and posttest of E1 group. The leaners who underwent instruction via BPPSTA had a significantly higher achievement in the posttest as compared to the pretest. This is interpreted to imply that the rise in the mean attainment of the posttest of the E1 group can be attributed to the intervention that the learners had been subjected to. The posttest mean score increased above the pretest mean by 5.689.

These results concur with Ajaja (2013), who found out significant impact of the instructional approach on learners' academic attainment and retention; Learners in the group that underwent instruction using constructive teaching approach performed better in academic achievement as compared to those who were in the group that underwent teaching via the lecture method. Ngakhala et al. (2017) reiterates that Biology teachers should adopt a learner-centred approach in teaching so that learners may show greater participation in practical activities and learn by self-discovery. Biology teachers should also increase the frequency with which they expose learners to practical activities in the learning of Biology. Furthermore, they should ensure that all Biology practical activities done by learners are discussed thereafter; this is so as to enable learners comprehend and understand the difficult concepts that they were unable to conceptualize.

To check if there was any difference in the BAT scores for the control group's post-test scores against the pre-test scores an independent samples t-test was conducted. Table 4.4.5 presents the output from the analysis.

Table 4.4.5: An Independent Samples t-test Analysis of the BAT Scores for Control Group - 1 Pretest and Posttest

Group	N	Mean	SD	df	t-value	p-value
Control group - 1 pretest	64	16.38	5.929	126	.981	.328
Control group - 1 posttest	64	17.41	5.959			

Table 4.4.5 results show that there was no significant difference in the C1 pretest mean scores (M=16.38, SD=5.929) and the posttest mean scores (M=17.41, SD=5.959) for the control group; t(126)=.981, p=.328. Since p-value of .328 was > .05 therefore it implies that the mean of the learners in the BAT administered as a pretest and the mean attained by the same group of learners in the posttest of C1 group are not significantly different. It is important to note that the pretest BAT was administered after which a posttest was administered to the same learners in this group. The learners in this group had undergone instruction via the conventional teaching methods. The lack of statistical difference in the mean score in the pretest and posttest of this group directs the researcher closer to the conclusion that the probable cause of a variation in the learners' means attainment between the E1 pretest and posttest can only be attributed to the treatment. The treatment in this study involved teaching learners in the experimental groups using the BPPSTA. The posttest mean was greater than the pretest mean score. Arokoyu and Chukwu (2017)

notes that instructional approach has both positive and negative influence on students' attainment in Biology. They further reiterate that students' assessment result are an appropriate criterion for judging the influence of instructional method on learners' academic achievement. Chebii (2011) from another study found out, the learners in the experimental groups performed better as compared to those in the control groups. Learners in the experimental groups developed a better mastery of the selected SPS (observation, experimenting and inferring) unlike the learners who were in the control groups. The present study findings resonate well with the described study findings.

The mean score attainment of learners in the E1 posttest and the C1 posttest were determined and compared. This was done so as to confirm the effect of the intervention on the learner achievement. An independent samples t-test analysis was conducted and the output from the analysis is as presented in Table 4.4.6.

Table 4.4.6: An Independent Samples t-test Analysis for the BAT Scores in the Experimental Group -1 Posttest and Control Group - 1 Posttest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 posttest	119	24.71	6.391	181	7.308	.000
Control group - 1 posttest	64	17.41	5.959			

The data in Table 4.4.6 presents results that show that there was a significant difference in the E1 posttest mean scores (M=24.71, SD=6.391) and the C1 posttest mean scores (M=17.41, SD=5.959) in attainment; $t(181)=7.308$, $p=.000$. Since the p-value obtained of .000 was $< .05$ it implies that the mean score in the BAT for E1 and C1 posttests are significantly different. It can also be observed that the mean differences for the two groups is 7.3 which indicates that the E1 posttest group mean score was higher as compared to that of the C1 posttest group. The learners in the E1 group therefore had generally performed better and attained a much higher mean score in the posttest as compared to those in the C1 group. This significant difference can be attributed to the different teaching approaches that had been used in the two groups. The high attainment in the E1 group can be attributed to the use of the BPPSTA.

Cohen's *d* analysis was carried out after the independent samples t-test analysis as recommended by Omondi, Keraro and Onditi (2018). Cohen's *d* statistic determines the effect size. This is the degree of difference between means of two or more study groups. In relation to the present study, Cohen *d* was used to determine the magnitude of the difference in the achievement mean by learners in the experimental group-1 as compared to that of learners in the control group-1. Cohen (2002) suggests that Cohen *d* value of less than 0.2 is trivial, a value of between 0.21 and 0.5 is weak, that one from 0.51 to 0.8 is moderate and finally a *d* value greater than 0.8 is strong. Groups E1 and C1 post-test BAT results were analysed using Cohen's *d* and the output from the analysis was; Cohen's *d*= (24.71-17.41/6.178) =1.18. Therefore, the value of *d* obtained was 1.18 which is greater than 0.8. This implies that the effect size of BPPSTA is strong. Hence, the treatment had a greater effect on the learner achievement in BAT.

These findings confirm those by Annan et al. (2019) who found out from their study that the learners' mean achievement in the posttest for experimental and control groups that took part in the study showed a wide significant difference. This difference was in favour of learners in the experimental group who had undergone instruction via the inquiry methods, as opposed to those in the control group who had been instructed via the lecture method. Similar findings were obtained in a study by Ona (2007) in which it was found that learners in the group where the inquiry method had been used for instruction had a better achievement of 72.6% while in the control group in which learners were taught Biology using conventional method had a lesser achievement of 53.85%. The study therefore concluded that the learners who were in the experimental group had a better performance than those in the control group. Just as the study theory by Papert (1991) proposed that learners involved in learning through construction of knowledge and skills in situ, the same was replicated. Since the learning occurred in the laboratory and environment, great achievement was observed among the E1 group as compared to the C1.

A further analysis was conducted to compare the mean attainment of the E1 pretest mean and that of the C1 posttest mean. The intent of this comparison was to show how effective the treatment was on the outcome of the groups. The output from the Independent samples t-test analysis is presented in Table 4.4.7

Table 5.4.7: An Independent Samples t-test Analysis of BAT for Experimental Group - 1 Pretest and Control Group - 1 Posttest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 pretest	119	17.03	5.988	181	1.778	.077
Control group - 1 posttest	64	17.41	5.959			

Table 4.4.7 presents results that show that there was no significant difference in the E1 pretest mean scores (M=17.03, SD=5.988) and the C1 posttest mean scores (M=17.41, SD=5.959) in attainment; t(181)=1.778, p=.077. Since the p-value of .077 obtained was > .05 therefore it implies that there is no significant difference between the mean attainment in E1 pretest and the C1 posttest groups. These results indicate that the learners' mean

attainment of these groups were having similar attainment abilities. To further confirm the effectiveness of the treatment, the mean attainment of the learners in the E1 posttest group was compared to that of the C1 pretest group. The output from the analysis is as presented in Table 4.4.8

Table 4.4.8: An Independent Samples t-test Analysis of BAT for Experimental Group - 1 Posttest and Control Group - 1 Pretest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 posttest	119	24.71	6.391	181	8.629	.000
Control group - 1 pretest	64	16.38	5.929			

Table 4.4.8 presents results that show that there was a significant difference in the E1 posttest mean scores (M=24.71, SD=6.391) and the C1 pretest mean scores (M=16.38, SD=5.929) in attainment; t(181)=8.629, p=.000. Since the p-value of .000 obtained was < .05, this implies that the mean scores of the E1 posttest and C1 pretest groups are significantly different. These results further indicate that the mean score of the former is significantly greater than that of the latter by 8.33 marks. These results indicate that actually the treatment (use of BPPSTA) was effective in as far as producing the improved learner academic achievement in the BAT is concerned. Therefore, the intervention can be reported as having been the cause of the significant increase in learner academic achievement.

Another comparison of learner academic attainment was conducted for the E1 posttest and C2 posttest groups. To determine whether the difference was statistically significant, the mean scores of learners in BAT in these two groups were subjected to an independent samples t-test. The output from the analysis is presented in Table 4.4.9.

Table 4.4.9: An Independent Sample t-test Analysis of BAT Scores for the Experimental Group - 1 Posttest and the Control Group - 2 Posttest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 posttest	119	24.71	6.391	222	9.905	.000
Control group - 2 posttest	105	17.10	4.891			

Table 4.4.9 presents results that show that there was a significant difference in the E1 posttest mean scores (M=24.71, SD=6.391) and the C2 posttest mean scores (M=17.10, SD=4.891) in attainment; t(222)=9.905, p=.000. Since the p-value of .000 obtained was < .05 therefore it implies that the mean scores of the E1 and C2 posttest groups are significantly different. These results further indicate that the mean student attainment in the former group was much better as compared to the latter. This can therefore be attributed to the treatment that the participants in the E1 posttest group had been subjected to. Arokoyu and Chukwu (2017) found out that, amongst other factors that, instructional methods used should be learner-friendly so as to promote Biology learners' assimilation and performance not only in internal examinations but also in external ones. Ngakhala et al. (2017) reports from their study that, over 60% of the participants in form two and form three classes were unanimous that they did less than five practicals per school term, while 59% of the form ones agreed that they had done more than five practical lessons per school term. Therefore as the learners' progress in the various classes, practical lessons are given lesser and lesser emphasis. This always makes learners reach their final year unprepared in practical lessons and this contributes immensely in the poor performance in Biology practicals. These findings are in line with those obtained in the present study.

A further analysis was conducted on the BAT posttest for the control groups. The data was subjected to the independent samples t-test analysis for purposes of comparison of the means so as to determine whether they were significantly different. Table 4.4.10 displays the output from the analysis.

Table 4.4.10: An independent Samples t-test analysis for BAT for the Control Group - 1 Posttest and Control Group - 2 Posttest

Group	N	Mean	SD	df	t-value	p-value
Control group - 1 posttest	64	17.41	5.959	167	.357	.721
Control group - 2 posttest	105	17.10	4.891			

Table 4.4.10 presents results that show that there was a significant difference in the C1 posttest mean scores (M=17.41, SD=5.959) and the C2 posttest mean scores (M=17.10, SD=4.891) in attainment; t(167)=.357, p=.721. Since the p-value of .721 obtained was > .05 it shows that the mean attainment by the participants in the C1 posttest group and that of the C2 posttest group are not significantly different. It is important to note that learners in C1 and C2 groups were not subjected to the treatment, but instead their role in the study was to provide comparison groups so as to actually ascertain that the increase (in case there was) in the mean attainment by learners in the E1 posttest group as compared to those in the E1 pretest group is due to the treatment and not the pretest. The comparison of means of these two groups was to inform the researcher whether the pretest administered in this research had any influence on the attainment in the posttest. Related claims have been obtained by Cimer (2004) from a study conducted on an investigation of views necessary for effective Biology instruction using surveys and interviews. Data was collected from both Biology teachers and secondary school students. The study revealed that teachers under study consistently practiced expository

instructional approaches which neither encompassed experiments nor hands-on activities. The study therefore suggests that, appropriate remedy be put in place not only through pre-service teacher training but also in-service teachers' professional development.

Arokoyu and Chukwu (2017) found out that only effective teaching methods and approaches can yield effective learning; therefore, teachers need to be creative and more flexible towards this requirement so as to ensure that the trend in learner achievement is rising. The present study therefore reports that the mean attainment by learners in control groups was the least of the four study groups. The difference between the mean attainments for learners in the control groups was not significant which informed the researcher that these groups indeed had minimum gain. This minimum gain that was not significantly different for the control groups must have been as a result of the use of conventional instructional methods. Therefore it is deduced that the use of BPPSTA has ultimately positively impacted on the learners' abilities and hence attainment in Biology.

The results from the participants in the E1 posttest group were compared to those of the E2 posttest group. This comparison had a purpose of revealing whether the mean increase in the E1 posttest group as compared to E1 pretest group was as a result of the treatment or as a result of the learners 'prior exposure to the pretest. To determine whether the mean scores were significantly different, an independent samples t-test was conducted. Table 4.4.11 presents the output.

Table 4.4.11: An independent Sample t-test Analysis for BAT for the Experimental Group - 1 Posttest and Experimental Group - 2 Posttest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 1 posttest	119	24.71	6.391	230	1.902	.058
Experimental group - 2 posttest	113	23.26	5.184			

Table 4.4.11 presents results that show that there was a significant difference in the E1 posttest mean scores (M=24.71, SD=6.391) and the E2 posttest mean scores (M=23.26, SD=5.184) in attainment; t(230)=1.902, p=.058. Since the p-value of .058 obtained was > .05 the implication is that the posttest group mean scores for E1 and E2 are not significantly different. As earlier mentioned, since the objective of including E2 group in the study was to aid in ruling out the effect of the pretest in E1 posttest group, these results therefore confirm that the increase in the mean attainment in the BAT in the E1 posttest group as compared to the mean in the BAT of E1 pretest is not as a result of the pretest but rather, it is as a result of the treatment that had been administered. Susanti et al. (2018) reiterates these findings by observing that, development of learners' SPS is a very crucial undertaking in the process of science teaching, since it may enable the nurturing of better learning abilities and also support inherent critical thinking skills among the learners.

Another comparison was done between learners' mean scores in the E2 posttest group and the C2 posttest group. This was to compare these two groups that had earlier on not been subjected to a pretest. The rationale of this comparison was to rule out the possibility that it was neither pretest nor chance as the cause for the increase observed in the posttest mean score of the E1 in relation to that of learners in the E1 pretest group. To establish whether the mean scores were significantly different, an independent samples t-test was conducted and the output from the analysis is as presented in Table 4.4.12.

Table 4.4.12: An Independent Samples t-test for BAT in the Experimental Group - 2 Posttest and the Control Group - 2 Posttest

Group	N	Mean	SD	df	t-value	p-value
Experimental group - 2 posttest	113	23.26	5.184	216	8.996	.000
Control group - 2 posttest	105	17.10	4.891			

Table 4.4.12 presents results that indicate that there was a significant difference in the E2 posttest group mean scores (M=23.26, SD=5.184) and the C2 posttest mean scores (M=17.10, SD=4.891) in BAT attainment; t(216)=8.996, p=.000. Since the p-value of .000 obtained was < .05 therefore it implies that the learner mean attainment of the E2 posttest group and that of the C2 posttest group are significantly different. Such results clearly show a difference in the experimental groups as compared to the groups that were not subjected to the treatment. Therefore, it confirms that the difference in the learners' mean score between the posttest of the experimental groups and the control groups is neither as a result of pretest nor chance but instead it can solely be attributed to the treatment. The treatment involved the teaching using the BPPSTA.

Learners BAT mean scores in E2 and C2 posttest groups were analysed using Cohen's *d* so as to determine the effect size of the treatment. Posttest scores for groups E2 and C2 were also analyzed using Cohen's *d* to establish the effect size of treatment of groups that were only exposed to posttest only. The two groups were included in the study so as to rule out the effect of pretest and chance. Therefore, the Cohen *d* analysis on these groups was to reveal the magnitude of the effect of BPPSTA on learner attainment. Cohen's *d* result was *d*= 23.26-17.10/5.0039=1.22. The value of *d* obtained of 1.22 is greater than 0.8. This implies that the effect size of BPPSTA is strong. Therefore, the treatment had a greater positive effect on the learner achievement in BAT of the learners in E2 as compared to C2. The results of the present study concur with those of other studies (Nwosu, 1994; Mandor, 2002; Ekon & Eni, 2015). In their studies separately, they found a great positive relationship between constructivist instructional approaches and learner academic achievement. However, Maranan (2017) obtained contrasting results to those from the present study; the study found out that there was partial support of the null hypothesis under study that, there was a significant relationship between the mean level of learners' mastery of the basic process skills and their performance in science.

The relationship of cause and effect has been sought through the various analyses with a major focus on the use of BPPSTA as the cause and how it influences learner academic achievement. This relationship as depicted in the present study agrees with the principle of experimental research as reiterated by Wiseman (1999); Borich (2004) and Ajaja (2013). They all agree that when conducting an experimental research, a treatment must be confirmed to be responsible for any difference noticed in the experimental group. The analysis that have been conducted in the present study, indeed reveal that it was the BPPSTA that caused the positive change in learner academic achievement in Biology tests. Therefore Biology process skills learning approach is therefore conclusively reported as to be having a positive influence on students' academic achievement. When learners undergo instruction via the BPPSTA they ultimately end up having higher academic gains as compared to when they undergo instruction via the conventional instructional methods.

4.5 Objective 2: Gender Difference in Achievement Between Learners Taught Using BPPSTA and Conventional Methods

The second objective focused on establishing whether gender influenced the acquisition of Biology practical process skills. Therefore, the researcher was interested in finding out whether male and female learners responded differently on acquisition of BPPS. Various group means were compared through statistical analyses so as to unveil the output. The comparison was done for each of the study groups by gender. Table 4.5.1 presents a summary of the means, standard deviations and standard errors for the various group categories on the basis of gender.

Table 4.5.1: Descriptive Statistical Analysis of BAT for the Four Study Groups by Gender

Group	Pretest/Posttest	Gender	N	Mean	SD	STD. Error
Experimental - 1	Pretest	Male	64	17.697	6.258	.708
		Female	55	16.392	5.510	.743
	Posttest	Male	64	24.953	6.501	.813
		Female	55	24.527	6.131	.827
Control - 1	Pretest	Male	32	16.675	4.654	.823
		Female	32	15.875	6.719	1.188
	Posttest	Male	32	17.875	5.129	0.907
		Female	32	16.938	6.739	1.191
Experimental - 2	Posttest	Male	50	23.960	4.682	.662
		Female	63	22.505	5.198	.655
Control - 2	Posttest	Male	50	17.500	5.330	.754
		Female	55	16.689	4.345	.586

Table 4.5.1 presents results that show that the highest mean score (24.953) attained by male learners in the E1 posttest group while the least mean score (15.875) was posted by female learners in the C1 pretest group. The highest standard deviation was 6.739 among the female learners in C1 posttest group. The group with the highest standard mean error of 1.191 was the females in the C1 pretest group. It is observed from these results that in all the study group means presented, the males have a comparatively higher attainment. This higher attainment was witnessed not only in the experimental groups but also in the

control groups. However, the males in the experimental posttest groups have generally recorded a higher mean score than the male learners in the control groups. Studies conducted in Biology on gender differences in achievement offer conflicting results (Eddy et al., 2014). The literature reviewed in chapter two indicate that there are contrasting findings by various scholars.

The mean scores for learners in the four study groups by gender as presented in Table 4.5.1 were further subjected to a one-way ANOVA analysis to establish whether they were significantly different. The aim was so to inform the researcher whether the mean score difference between the male learners and female learners in the study groups was actually significant. Table 4.5.2 displays the results from the analysis.

Table 4.5.2: One-way ANOVA Test for the Four Study Groups by Gender

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6328.424	11	575.311	17.383	.000
Within Groups	18930.931	572	33.096		
Total	25259.354	583			

Results in Table 4.5.2 shows (df=11,572; F=17.383, $p=.000 < \alpha = 0.05$) indicating that there is a significant difference in at least a pair of the groups. Since the p-value of .000 obtained was < .05 it implies that the mean scores of the males and females in at least one group are significantly different. To further determine which specific study groups had mean scores of males and females that were significantly different, it necessitated each set of mean scores to be compared. Independent samples t-tests were conducted to determine whether the mean scores on the basis of gender in each group were significantly different.

To start off the process, the mean learner attainment in the BAT by gender in the E1 pretest group were compared. The statistical results that were yielded from the SPSS software output showing the mean mark and t-test results is as shown in Table 4.5.3.

Table 4.5.3: An independent Samples t-test Analysis for BAT Scores for Experimental Group - 1 Pretest by Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	64	17.697	6.259	117	1.874	.063
Female	55	16.392	5.510			

Table 4.5.3 presents results that show that there was no significant difference in the learners' mean scores of males in E1 pretest group (M=17.697, SD=6.259) and the mean score of the female learners in the same group (M=16.392, SD=5.510) in attainment; t(117)=1.874, p=.063. Since the p-value of .063 obtained was > .05 therefore it implies that the mean attainment by males and that by females in E1 pretest group for the BAT are not significantly different. Therefore, the mean attainment of male learners was not significantly different from that one of the female learners in the BAT in this group. To ascertain whether the same learners of E1 had similar variation in the posttest, further analysis was carried out. An independent samples t-test was conducted to ascertain whether the mean attainment of male and female learners in the E1 posttest were significantly different. Table 4.5.4 presents the output from this analysis.

Table 4.5.4: An independent Samples t-test Analysis for BAT Scores for Experimental Group - 1 Posttest by Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	64	24.953	6.501	117	.366	.715
Female	55	24.527	6.131			

Table 4.5.4 presents results that show that there was no significant difference in the posttest mean scores of males in E1 (M=24.953, SD=6.501) and the mean score of the female learners in the same group (M=24.527, SD=6.131) in attainment; t(117)=.366, p=.715. Since the p-value of .715 obtained was > .05, it was interpreted to mean that there is no significant difference in the mean attainment of the males and females in the posttest of the E1 group. These results indicate that the male and female learners did not have a varied attainment before the intervention; that the male and female learners had equivalent mean scores in the BAT both before and after the intervention. Therefore, it implies that the intervention did not influence the male and female learners differently.

These results are in contrast with the findings from other studies which have been carried out by various scholars. Prokop et al. (2007) and Abungu et al. (2014) came up with similar findings from their studies; separately they reported that, in Slovakia and in Kenya respectively, both boys and girls in secondary schools find science concepts difficult to understand, which in the long run leads to learners performing dismally in national examinations in science subjects. Similarly Ajaja (2013) who carried out an investigation to find out the strategy that is most appropriate for Biology teaching. The methods under investigation were; 5E (engagement, exploration, explanation, elaboration, and evaluation) teaching cycle, cooperative teaching and concept mapping. The findings from the study revealed that there was a non-significant difference between male and female learners on academic attainment and retention in all the methods of instruction that were under study. Owoeye and Agbaje (2016) equally obtained similar results from their study and therefore concluded that there was no significant relationship in the learners' gender and learners' academic achievement in Biology. However, Nasr and Soltani (2011) came up with contrasting findings in Iran: the study found out that girls' academic attainment was significantly better than that of boys after an intervention. These controversies in findings from the described studies necessitated the present study to be conducted.

The BAT results in each of the C1 pretest group were analysed on the basis of gender. The descriptive statistical output from the analysis is presented in the Table 4.5.5.

Table 4.5.5: An independent Samples t-test Analysis of BAT scores for the Control Group - 1 Pretest by Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	32	16.675	4.654	62	2.076	.052
Female	32	15.875	6.719			

Table 4.5.5 presents results that show that there was no significant difference in the pretest mean scores of males in C1 (M=16.675, SD=4.654) and the mean score of the female learners in the same group (M=15.875, SD=6.719) in attainment; $t(62)=2.076$, $p=.052$. Since the p-value of .052 obtained was > .05 therefore, it implies that the male and female learners' mean scores in the C1 pretest group are not significantly different. An analysis was further conducted on the mean scores attained by the learners in the C1 posttest so as to determine whether they varied by gender. Table 4.5.6 presents these results.

Table 4.5.6: An independent Samples t-test Analysis of BAT scores for the Control Group – 1 Posttest by Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	32	17.875	5.129	62	.626	.053
Female	32	16.938	6.739			

Table 4.5.6 presents results that show that there was no significant difference in the pretest mean scores of males in C1 (M=17.875, SD=5.129) and the mean score of the female learners in the same group (M=16.938, SD=6.739) in attainment; t(62)=.626, p=.053. Since the p-value of .053 obtained was > .05, it indicates that the mean score obtained by male learners and that by the female learners in the C1 posttest group were not significantly different. This implies that the learners of these two gender in the C1 group in the pretest did not have results that differed significantly. Since these results were from a study group whose learners underwent instruction via the conventional methods, these results therefore indicate that the conventional approach did not lead to a significant difference in learner attainment by gender. Gender was found not to influence academic achievement by learners in the C1 study group.

Further analysis was carried out so as to compare the male and female learners mean scores in the E2 posttest. To determine whether the difference in the mean scores of male and female learners in E2 group who had been exposed to the intervention were significant, the data was subjected to an independent samples t-test analysis. Table 4.5.7 presents the results from this analysis.

Table 4.5.7: An Independent Samples t-test Analysis for the BAT for the Experimental Group - 2 Posttest by Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	50	23.960	4.682	111	3.241	.062
Female	64	22.505	5.198			

Table 4.5.7 presents results that show that there was no significant difference in the posttest mean scores of males in E2 posttest group (M=23.960, SD=4.682) and the mean score of the female learners in the same group (M=22.505, SD=5.198) in attainment; t(111)=3.241, p=.062. Since the p-value of .062 obtained was > .05, this implies that the mean score attained by male learners and that attained by female learners in the BAT of the E2 posttest group are not significantly different. The males outperformed their female counterparts in posttest of this group. However, the difference was not significant. Hence the attainment of male and female learners was not influenced differently by the use of BPPSTA as an instructional approach.

These results are in agreement with the findings from another study by Amoah et al. (2018). In their study they formulated a task that they used to assess the SPS of observation among Biology learners at SHS- 3. Mann Whitney U-test was used during the analysis so as to answer the research questions. Their study findings indicated that the performance of male and female learners in the SPS of observation was the same. The mean ranks obtained from the analysis showed that despite the fact that male learners had a higher mean score as compared to their female counterparts, this difference was not significant. However, it is necessary to be cognizant of the fact that in their study they focused on one Biology process skill: observation whilst the present study focused on six Biology practical process skills. Similar claims have been raised from a study by Ekon and Eni (2015) who found out that there was no significant gender difference in learner academic attainment after instruction using science process skills approach. From another study by Achor et al. (2018) no significant gender difference was found in the learner attainment in Biology.

Despite the previous studies yielding contrasting results, the findings from the present study are in contrast with those by Odagboyi (2015) who found a statistical difference in mean attainment of boys and girls in favour of boys. Ndirika, (2013) and, Aniodoh and Eze, (2014) separately from their two independent studies found out that boys got better mean scores as compared to girls in the achievement tests. The difference in these performances was significant in favour of the male learners. Kashu (2014) equally found out that boys took a relatively longer time to learn as compared to girls however, they potrayed a tendency of outperforming girls especially when it came to information retrieval and work-related tasks. The methodology, syllabus topic of interest, area of study and the nature of the participants in the present study were a justification for the findings obtained therein. The present study therefore provided important findings to fill this gap that has existed.

The gender comparison was equally conducted on the C2 posttest group. This data was analysed to provide evidence whether the differences in the means for males and females were significantly different. Table 4.5.8 presents the results from this analysis.

Table4.5.8: An Independent Samples t-test for BAT for the Control Group - 2 Posttest by Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	50	18.00	5.33	103	1.808	.014
Female	55	16.29	4.35			

Table 4.5.8 presents results that show that there was a significant difference in the posttest mean scores of males in E2 (M=18.00, SD=5.33) and the mean score of the female learners in the same group (M=16.29, SD=4.35) in attainment; t(103)=1.808, p=.014. Since the p-value of .014 obtained was < .05, this output is interpreted to imply that the difference in mean attainment of male and that of female learners in the C2 BAT posttest group. The mean score attainment by male learners in this group was higher than that of the females by 1.71 marks. The implication is that the attainment of learners in BAT in this C2 group differed significantly on the basis of gender. Therefore, the conventional instructional methods led to varied learner attainment by gender.

4.6 Objective 3: Influence of BPPSTA on Learners' Attitude Towards Biology when Taught Using BPPSTA as Compared to when Taught Using Conventional Methods.

To reveal the perceptions, views and inherent thoughts of the learners towards Biology, Biology practical and Biology practical process skills, a questionnaire dubbed BAQS was administered to the learners. The questionnaire had three sections: first section on bio data, the second section on the students' attitude towards Biology practical measured on a Likert scale and finally the third section on students' attitude towards the teaching of Biology subject using open-ended responses. The first section gave rise to data that yielded the general characteristics of the participants in terms of age and gender (Refer to section 4.2 as earlier discussed). The third section had question items that were open-ended which yielded data on the attitude of learners on the significance of Biology practical in the learning of Biology as a subject (as discussed in section 4.6.4 ahead). A 5-point Likert scale was used to measure their responses in the second section. Analysis of the learner responses in the BAQS in this section was done quantitatively aided by the SPSS software (version 22) so as to reveal the learners' attitude (DeWinter & Dodou, 2010). An attitude level ≥ 3.00 was taken to imply a positive attitude. The greater the value above 3.00 the more positive the attitude is while the lesser the value below 3.00 the more negative the attitude is towards the aspect of interest. Table 4.6.1 displays the attitudinal means obtained from the responses of the learners in the four study groups.

Table 4.6.1: Descriptive Statistics Analysis for the BAQS for the Four Study Groups on their Attitude

Group	Pretest/Posttest	N	Mean	SD	Std. Error
Experimental group-1 (E1)	Pretest	119	3.177	1.382	0.127
	Posttest	119	3.636	1.245	0.123
Control group -1 (C1)	Pretest	64	2.947	1.270	0.159
	Posttest	64	3.003	1.118	0.152
Experimental group -2 (E2)	Posttest	113	3.567	0.909	0.125
Control group -2 (C2)	Posttest	105	2.989	1.025	0.135

Table 4.6.1 shows that the lowest attitudinal mean of less than 3.00 was attained from the participants in the E1 pretest group and the C2 posttest group. These results therefore imply that the learners' attitude was initially negative but after the intervention, there was a rise in the positive direction in the attitude of the learners towards Biology. A comparison of the learners' attitudinal means in the E1 posttest group and C1 posttest group, shows that the experimental group - 1 had a larger deviation from pretest to posttest attitudinal means of 0.459 from 3.177 to 3.636 in comparison to that of the C1 pretest group to posttest attitudinal mean of 0.056 from 2.947 to 3.003. This shows a generally higher positive rise in the experimental groups than in the control group.

Generally, the results indicate that the highest attitudinal mean was attained by those in the E2 posttest group. A further analysis was done so as to reveal the actual attitude of the learners to the Biology constructs at hand. For purposes of analysis and data presentation, the responses in the questionnaire were analyzed, presented and discussed in three sections as follow:

4.6.1 Learner Attitude Towards Biology Subject

Question items 1 to 5 in the BAQS were addressing the learner attitude towards Biology as a subject. The items were identified, tallied and fed in to SPSS for analysis. Independent samples t-test was used to analyse each group of data so as to reveal whether there was a significant difference between the attitudinal means of the learners in the four study groups. To set off the analysis process, the E1 pretest and posttest data was subjected to the t-test analysis. Table 4.6.2 displays the output from the analysis.

Table 4.6.2: An Independent Samples t-test for the BAQS for the Experimental Group - 1 Pretest and Posttest for Question Items 1 to 5

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 1 Pretest	119	3.432	1.250	236	4.065	.003
Experimental Group – 1 Posttest	119	3.72	1.062			

Table 4.6.2 presents results that show that there was a significant difference in the learners attitudinal mean in E1 pretest group (M=3.342, SD=1.25) and the attitudinal mean of learners in posttest of the same group (M=3.72, SD=1.062) for the attitude in the BAQS; $t(236)=4.065$, $p=.003$. Since the p-value of .003 obtained was $< .05$ it was indicative that there is a significant difference in the attitudinal mean between the E1 pretest and posttest groups. The attitudinal mean for the posttest group was significantly higher than the pretest attitudinal mean. The posttest mean came about after the learners

in this group had been subjected to the intervention. The posttest learners' attitude towards Biology show a positive change in the attitude level of the participants after having been taught via the BPPSTA. Findings that are in agreement with those of the present study have previously been gotten by Samikwo (2013) who posits that, for learners to have the ability of competing with others globally, there is need for schools to motivate learners so as to develop and nurture an interest and positive attitude towards Biology. Owoeye and Agbaje, (2016) from their study found out that there was a significant relationship in the learners' attitude towards Biology and their academic achievement in Biology. Their study also found out that there was a significant relationship in the learners' interest in studying Biology and their academic achievement in Biology subject.

These five question items were tailored towards getting the view of the learners pertaining Biology. The question items were structured to reveal the inherent opinions about how the learners perceive Biology and whether this will in turn direct them to pursuing a career that is Biology-related. The results indicate therefore that there is an improvement in their attitude towards the positive direction. Therefore, it can be deduced that the BPPSTA has led to a positive change in the participants' attitude towards Biology. Prokop, et al. (2007) from their study found out that only a paltry 9% of the study population would like to become biologists in the future.

A further analysis was carried out by comparing the responses on attitude towards Biology between participants in the E1 posttest and the C1 posttest groups. This was done with a purpose of establishing if the attitude level of the learners who had been subjected to the intervention was different from that of those who had not been subjected to the intervention. According to Heider (1958) theory of cognitive consistency, attitudes are quantifiable and can take the negative or positive direction. This conformed well to the 5-point Likert scale measure where value three was the central attitudinal value. A value above 3 meant a positive attitude while that one below three meant a negative attitude. The first five question items were analysed to determine whether they were significantly different. To this effect, an independent samples t-test was conducted and the output from the analysis yielded the results in Table 4.6.3.

Table 4.6.3: An Independent Samples t-test for the BAQS for the Experimental Group - 1 and Control Group - 1 Posttest for Question Items 1 to 5

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 1 Posttest	119	3.720	1.062	181	4.357	.005
Control group – 1 Posttest	64	3.314	1.242			

Table 4.6.3 presents results that show that there was a significant difference in the learners' attitudinal mean in E1 posttest group (M=3.720, SD=1.062) and the attitudinal mean of learners in posttest of the C1 group (M=3.314, SD=1.242) for the attitude in the BAQS; t(181)=4.357, p=.005. Since the p-value of .005 obtained was < .05 it was indicative that the difference in the attitudinal mean between the E1 posttest and C1 posttest groups was significant. The attitudinal mean for the E1 posttest group was significantly greater in comparison to that of the C1 posttest group. The attitude of the students in the E1 group where instruction had taken place through the use of the BPPSTA had a more positive attitude. Prokop, et al. (2007) did a critical analysis of the question item in the instrument used in data collection so as to reveal certain trends. The analysis showed that the lowest attitudinal scores were observed in those question items that dealt with, learners taking their Biology teacher as a role model and also those

wishing to become biologists in future. The study attributes such low scores to the teacher-centred instructional approaches adopted by such teachers during Biology classroom teaching.

A further analysis was carried out to compare the attitude of the learners in E2 group and the C2 group. Learners in both groups had not been subjected to the pretest BAQS however, the E2 group was taught through BPPSTA while the C2 group were taught via the conventional methods. To determine whether the difference was significant, an independent samples t-test analysis was done. Table 4.6.4 presents the output from the analysis.

Table 4.6.4: An Independent Samples t-test for the BAQS for the Experimental Group - 2 and Control Group - 2 Posttest for Question Items 1 to 5

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 2 Posttest	119	3.404	1.253	181	3.877	.013
Control group – 2 Posttest	64	2.940	1.277			

Table 4.6.4 presents results that show that there was a significant difference in the learners attitudinal mean in E1 posttest group (M=3.404, SD=1.253) and the attitudinal mean of learners in posttest of the C1 group (M=2.940, SD=1.277) for the attitude in the BAQS; t(181)=.877, p=.013. Since the p-value of .013 obtained was $< .05$ it implies that there was a significant difference between the attitudinal mean of learners in E2 and C2 groups. The attitude of the participants in the E2 group who had been taught through the use of BPPSTA had a comparatively greater positive value as compared to the participants in the C2 group who had been taught through the conventional methods.

For the purposes of ascertaining if the significance difference that was existing was by chance or was an attribute of the intervention that had been put in place for the experimental groups, the performance in learner attitude for the C1 pretest and C1 posttest groups were compared. The same group of students had been subjected to the BAQS, after four weeks' period a similar questionnaire with the questions re-arranged was administered to them.

Another statistical test was carried out to ascertain if the differences in the means in the various question items were significantly different. An independent samples t-test therefore had to be conducted to compare the attitudinal mean of C1 pretest and C1 posttest groups. Table 4.6.5 presents the output from this comparison analysis.

Table 4.6.5: An Independent Samples t-test for the BAQS for Control Group - 1 Pretest and Posttest in the Question Items 1 to 5

Group	N	Mean	SD	df	t-value	p-value
Control group – 1 Pretest	64	3.394	1.230	126	0.413	.705
Control group – 1 Posttest	64	3.314	1.242			

Table 4.6.5 presents results that show that there was no significant difference in the learners' attitudinal mean in C1 posttest group (M=3.394, SD=1.230) and the attitudinal mean of learners in posttest of the same group (M=3.314, SD=1.242) in the attitude in the BAQS; t(126)=0.413, p=.705. Since the p-value of .705 obtained was > .05 it implies that the attitudinal mean attained by learners in the five question items for the C1 pretest group and that attained in the C1 posttest group are not significantly different. We can therefore not claim that the learner attitudinal mean for the C1 pretest group is different from that one of C1 posttest in relation to the five question items. This gives room for the

earlier premise to hold that the difference that occurred between the attitudinal mean of learners in the E1 pretest and that of the learners in the E1 posttest was neither as a result of chance nor a result of pre-testing but as a result of the intervention that had been put in place; The intervention involved instruction via the BPPSTA. Samikwo (2013) found out that practical lessons equip learners with the necessary skills to handle real life practicals; hence students will not shy from Biology related careers since they will be able to apply the skills they had acquired.

4.6.2 Learner Attitude Towards Biology Practical Lessons

Question items 6 to 14 were specifically to get the attitude of the learners towards the practical lessons in Biology. Biology practical is a key component in development of Biology concepts, skills, values and attitudes in Biology. To this end the question items that addressed the learners' attitude towards practical in their learning of Biology were analysed. A comparison of the attitudinal mean of learners in various groups were compared. An independent samples t-test was conducted in the various sets of study group attitudinal means. To start with, a comparison was done for the pretest and posttest attitudinal means of the E1 group. Table 4.6.6 displays the output emanating from this comparative analysis.

Table 4.6.6: An Independent Samples t-test for BAQS for Experimental Group -1 Pretest and Posttest for Question 6 to 14

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 1 Pretest	119	3.191	1.437	236	3.678	.007
Experimental group – 1 Posttest	119	3.837	1.354			

Table 4.6.6 presents results that show that there was a significant difference in the learners' attitudinal mean in C1 posttest group (M=3.191, SD=1.437) and the attitudinal

mean of learners in posttest of the same group (M=3.837, SD=1.354) in the attitude in the BAQS; t(236)=3.678, p=.007. Since the p-value of .007 obtained was < .05 for these question items where the concern was the views of participants about the Biology practical lesson, therefore it implies that the attitudinal mean scores were significantly different. The interpretation from such results was that the learner attitudinal mean observed in the C1 posttest group is significantly greater than that obtained in the posttest for the respective question items by 0.646. This implies that the attitude of the learners in the E1 changed and became more positive after the learners in this group undergoing instruction via the BPPSTA. Therefore, for these nine question items the learners' attitude level towards Biology practical lessons had improved to the positive direction.

Ackon, (2014) posits that, when learners are engaged in classroom practical activities in groups, they tend to learn more by advancing more positive attitude towards the subject, their peers and also their teachers. In the present study the learners carried out the practical activities in small groups of about 5 to 6 students. From another study by Gultepe (2016), similar observations have been made; that majority of the teachers who took part in the study were of the view that SPS can best be acquired through the use of laboratory activities in which not only learners are involved in but also teachers. In the present study learners underwent instruction using BPPSTA which was an entirely practical hands-on approach. In the approach learners carried out various practical activities that emphasized on the six practical process skills under study. The activities required learner active participation and involvement. The results are therefore showing a positive rise in the learners' attitude after instruction through the BPPSTA.

A further analysis was carried out to compare the learners' attitude towards Biology practical lessons in E2 and the C2 groups for question items 6 to 14 in the BAQS. Learners in the E2 group had been taught via BPPSTA in comparison to the learners in the C2 group who had undergone instruction via the conventional methods. The attitude of the learners in these two study groups therefore had to be compared to determine whether the attitudinal difference between them was significant. To that effect, an independent samples t-test analysis was conducted for the purpose of this attitudinal comparison. Table 4.6.7 shows the output from the analysis.

Table 4.6.7: An Independent Samples t-test for the BAQS for the Experimental Group - 2 and Control Group - 2 Posttest for Question Items 6 to 14

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 2 Posttest	113	3.888	1.332	216	4.050	.004
Control group – 2 Posttest	105	3.122	1.475			

Table 4.6.7 presents results that show that there was a significant difference in the learners' attitudinal mean in C1 posttest group (M=3.888, SD=1.332) and the attitudinal mean of learners in posttest of the same group (M=3.122, SD=1.475) in the attitude in the BAQS; t(216)=4.050, p=.004. Since the p-value of .004 obtained was < .05 it indicates that there is a significant difference between the learners' attitudinal mean for E2 and C2 posttest groups for question items 6 to 14 on attitude towards practical lessons. The attitude of the participants in the E2 group who had been taught through the use of BPPSTA was more positive as compared to that of the participants in the C2 group who had been taught through the conventional methods by 0.766.

The essence of Solomon four non-equivalent control group design is to rule out any other possible cause of the change (in case there is) in the experimental group posttest results and attribute it to the treatment that was applied alone. Therefore, a further comparison was carried out between the attitudinal responses of the learners in the C1 pretest group and the attitudinal responses of learners in the C1 posttest group. This was the group in which the learners had undergone instruction through the conventional methods. Their attitude was determined before the instruction as pretest and then also after the instruction as posttest. An independent samples t-test was conducted so as to determine whether the learners' attitudinal means in C1 pretest and posttest group were significantly different. Table 4.6.8 presents the output from this analysis.

Table 4.6.8: An Independent Samples t-test for the BAQS for the Control Group - 1 Pretest and Posttest in the Question Items 6 to 14

Group	N	Mean	SD	df	t-value	p-value
Control group – 1 Pretest	64	3.506	1.300	126	.915	.654
Control group – 1 Posttest	64	3.529	1.262			

Table 4.6.8 presents results that show that there was no significant difference in the learners attitudinal mean in C1 posttest group (M=3.506, SD=1.300) and the attitudinal mean of learners in posttest of the same group (M=3.529, SD=1.262) in the attitude in the BAQS; t(126)=.915, p=.654. Since the p-value of .654 obtained was > .05 it shows that the difference between the attitudinal mean of the learners in the C1 pretest and posttest groups were not significant. Having undergone instruction through the conventional approaches did not impact on the learners' attitude towards Biology practical. This implies that the use of the conventional teaching methods did not result into any significant change in the learners' attitude towards Biology practical lessons.

These results of comparison of the attitude of the control group given at two different intervals provide a good ground that informs the study that, the prior difference that was witnessed in the attitudinal mean responses in the pretest and posttest of the E1 group cannot be attributed to chance. However, it can specifically be attributed to the intervention that the participants in the E1 group had been subjected to prior to the posttest BAQS administration. The researcher can therefore associate the improved positive attitude of the learners to the use of the BPPSTA. According to Susanti et al. (2018) the SPS need to be the fundamental goal that should be targeted in science instruction. They influence every output from the science learning classroom. Abungu et al. (2014) opines that the main reasons for inclusion of science in the secondary school curriculum are; to create awareness on the effect of the knowledge of science in everyday life, to promote technological and socio-economic development in society. The practical activities through BPPSTA carried out by students in class provide a positive attitude, foundation of technological development and make them ready to pursue courses that are related to science at tertiary level and beyond.

4.6.3. Learners' Attitude Towards the Biology Practical Process Skills

Question items 15 to 23 enabled gathering of data on the learners' attitude towards Biology practical process skills. The learners' responses equally were captured on a Likert scale. Abungu et al. (2014) observes that science practical activities provide students with opportunities to develop and practice the application of SPS that are vital in problem solving process not only in their life but also necessary for national and societal development. SPS activities when carefully practiced in the science classroom under the guidance of the teacher, results into competence among learners in carrying out of scientific investigations that ultimately lead to acquisition of scientific knowledge. The attitudinal means of learners in the various study groups were compared so as to reveal whether the learners' attitude had changed. To ascertain if the learners' attitudinal mean attained in the pretest of the E1 group was significantly different from that of the learners in the posttest of the same group of participants, an independent samples t-test was carried out. Table 5.6.9 displays the output from this analysis.

Table 4.6.9: An Independent Samples t-test Analysis for the BAQS for the Experimental Group - 1 Pretest and Posttest for Question Item 15 to 23

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 1 Pretest	119	2.596	1.400	236	3.484	.045
Experimental group – 1 Posttest	119	3.240	1.493			

Table 4.6.9 presents results that show that there was a significant difference in the learners attitudinal mean in E1 pretest group (M=2.596, SD=1.400) and the attitudinal mean of learners in posttest of the same group (M=3.240, SD=1.493) in the attitude in the BAQS; t(236)=3.484, p=.045. Since the p-value of .045 obtained was < .05 therefore it implies that there is a significant difference between the attitudinal mean of the learners in the E1 pretest group and that of the learners in the E1 posttest group. The learners' attitudinal mean in the E1 posttest had risen as compared to the pretest mean by 0.644. Therefore, the intervention has positively affected the attitude of the learners under study. The present study therefore reports that the emphasis of Biology practical process skills in the teaching process results into a positive influence on learners' attitude towards Biology practical process skills. These findings are in congruence with those from several other previous studies that have been carried out. From a study by Sanja (2012) on learners' attitudes towards science and mathematics it was observed that, learners under study had a preference for practical activities and hands-on experimentation. It was

further observed that after learners use the aforementioned classroom approaches and activities they expressed a more positive attitude towards science and mathematics. Ackon (2010) equally observes that, most students from the selected schools in the Sekondi-Takoradi Metropolis in Ghana also possessed positive attitudes toward practical lessons in science. Maranan (2017) from another study however, obtained results that are in contrast with the present study findings. The study reported a lack of significant difference between the learners' attitude towards science and their academic achievement. However, the present study adopted a methodology that was more reliable hence the findings that were obtained.

A further comparison was carried out between the attitudinal mean of learners in the E2 and the C2 groups. These two groups had learners who were not subjected to the pretest BAQS. The aim of inclusion of these two groups in the study was to rule out any possible effect of pretest BAQS which might influence their responses in the posttest BAQS. The study sought to confidently associate the change in E1 attitudinal mean to the intervention alone. Therefore, it was necessary to conduct a t-test analysis to establish whether the difference in the attitudinal means of E2 and C2 were significant. Table 4.6.10 presents the output from this analysis.

Table 4.6.10: An Independent Samples t-test Analysis for the BAQS for the Experimental Group - 2 and Control Group - 2 for Question Item 15 to 23

Group	N	Mean	SD	df	t-value	p-value
Experimental group – 2 Posttest	113	3.519	1.368	216	6.032	.000
Control group – 2 Posttest	105	2.908	1.355			

Table 4.6.10 presents results that show that there was a significant difference in the learners attitudinal mean in E2 posttest group (M=3.519, SD=1.368) and the attitudinal mean of learners in C2 posttest group (M=3.240, SD=1.493) in the attitude in the BAQS; t(236)=6.032, p=.000. Since the p-value of .000 obtained was < .05 it shows that there is a significant difference between the attitudinal mean of learners in the E2 and C2 groups. Therefore, the higher attitudinal mean witnessed in the E2 group can be attributed to the intervention which involved the learners in this group teaching through the BPPSTA in comparison to the learners in the C2 group who were taught through the conventional methods. The high attitudinal mean portrays a more positive attitude of learners towards BPPS. To rule out any other cause for the above described improved attitude, it was worth for a comparison to be done on the attitude of the learners in the pretest and posttest for the control group - 2 in BAQS. This was to reveal if really the change in attitude observed is as a result of the BPPSTA. To establish whether the learner attitudinal mean in the C1 pretest group and post-test group were significantly different, an independent samples t-test analysis was conducted. Table 4.6.11 presents the output from this analysis.

Table 4.6.11: An Independent Samples t-test for the BAQS for the Control Group - 1 Pretest and Posttest in Question Items 15 to 23

Group	N	Mean	SD	df	t-value	p-value
Control group – 1 Pretest	64	2.965	1.262	126	0.707	.951
Control group – 1 Posttest	64	2.896	1.161			

Table 4.6.11 presents results that show that there was a significant difference in the learners' attitudinal mean in C1 pretest group (M=2.965, SD=1.262) and the attitudinal mean of learners in the posttest of the same group (M=2.896, SD=1.161) in the attitude in

the BAQS; t(126)=.707, p=.951. Since the p-value of .951 obtained was > .05 it therefore implies that there was no significant change in attitudinal mean of the learners in the C2 group before and after instruction. The learners in this study group had undergone instruction through the conventional methods. These results point in the direction of confirming the earlier noted positive attitude in this study in the E1 posttest group in comparison to the attitudinal mean in E1 pretest group. This further confirms that the effect of the intervention that was of interest in this study cannot be underscored. Therefore, BPPSTA has had a positive impact on the learner attitude towards BPPS.

Overall posttest attitudinal means for learners in groups E1 and C1 as depicted in Table 4.5.1 were analyzed using Cohen's *d* to establish the effect size of the treatment for groups that were subjected to both pretest and posttest. Cohen's *d* result was *d*= 3.636-3.003/1.183=0.54. The Cohen *d* value obtained was 0.54 which is between 0.51 and 0.8 (Cohen, 2002) which implies that the effect of size is moderate. Therefore, the BPPSTA had a moderate effect on the learners' attitude towards Biology. Posttest attitudinal means for learners in groups E2 and C2 were also analyzed using Cohen's *d* to establish the effect size of the treatment of groups that were subjected to post-test only. Cohen's *d* result was *d*= 3.567-2.989/0.938=0.6. The Cohen *d* value obtained was 0.6 which is between 0.51 and 0.8 (Cohen, 2002) which implies that the effect size is moderate. Therefore, the BPPSTA had a moderate effect on the learners' attitude towards Biology.

Similar findings have been obtained from a study by Samikwo, (2013). The study found out that students' attitudes towards Biology affects their performance. Furthermore, the students in the study with positive attitude towards Biology were found to score better marks in examinations as compared to those who had been found to have a negative attitude towards Biology. The positive attitude was reported to have been a motivator for the learners to work hard. This hard work was ultimately reflected in the good marks scored by these learners in the examinations that they did. Abungu et al. (2014) reiterates this position by observing that, when students are involved more in science practical activities it improves their mastery of SPS and improves their understanding and application of scientific concepts. These findings from the two studies described are in congruence with the findings of the present study. The point of convergence for both studies is that the use of appropriate classroom instructional approaches and practices is a precursor to a more positive learner attitude towards Biology practical process skills.

4.6.4 Learners' Attitude on the Teaching and Learning of Biology Practicals

In the BAQS question items 24 to 27 required learners to respond on the instructional process during Biology practicals. These were open-ended question items that were analysed qualitatively. The learners were required to tell, which Biology topic among selected topics was most enjoyable. Their responses were analysed and summarized according to the topic the aspect they mentioned was emanating from. The intention was to summarize their responses in line with the Biology syllabus prescribed topics. Table 4.6.12 presents data on the views that learners gave on how they enjoy learning the various Biology topics.

Table 4.6.12: Opinion of Learners on the Most Enjoyable Biology Topic

TOPIC	FREQUENCY	PERCENTAGE (%)
Introduction to Biology	32	7.98
Classification I	202	50.37
The Cell	29	7.23
Cell Physiology	96	23.94
Nutrition in Plants and Animals	25	6.24
Transport in Plants and Animals	17	4.24
Total	**401**	**100**

Table 4.6.12 provides a summary of the learners views from which, it can be deduced that the most enjoyable topic as reported by the form two learners was classification I with a proportion of 50.37%. This was followed by 23.94% for cell physiology as the second most enjoyable. Transport in plants and animals was the least enjoyed by learners with a rating of 4.24%. Out of the six topics that had been learnt by the form two students under study, it is this topic (transport in plants and animals) that was reported as the least enjoyable. The present study narrowed down on this same topic; Transport in plants and animals. The focus had been informed by the continued dismal learner performance in KCSE Biology examination in this topic (KNEC, 2018). Such least enjoyment of learning the topic ultimately results in to reduced interest by the learners in the topic which finally leads to dismal performance (Wabuke, 2013). The extent to which learners have a liking and enjoyment in learning a given content ultimately affects their attitude and also achievement in that subject. These results are in conformity with the KNEC report of the year 2018, where it was reported that learners have continually scored low marks in questions that required them to put in an extra effort to comprehend, interpret, and infer which resulted into poor performance in Biology (KNEC, 2018). Learner incompetence described by KNEC in these skills would be countered if BPPSTA was embraced during Biology instruction.

It would be expected that when learners report a given topic or content as being enjoyable, then there must be a reason behind it. The learners were therefore asked to cite reasons for their preferences in rating the topics as being more enjoyable than others. Varied responses were received from the learners which were then categorized for purposes of presentation of the data. The categorization was on the basis of emerging key thematic areas. Table 4.6.13 presents the views of the learners on the reasons why they enjoy the various Biology topics earlier mentioned.

Table 4.6.13: Reasons Cited by Learners why they Enjoy Learning the Various Biology Topics

Reasons	Frequency	Percentage (%)
The topic is easy	71	17.71
The topic entails our day to day encounters	89	22.19
Learners engaged in many practical activities	187	46.63
Teacher presented content logically	35	8.73
No reason given	19	4.74
Total	**401**	**100**

From the reasons given in Table 4.6.13, it is clear that majority of the learners (46.63%) like learning the topic aforementioned due to them being engaged more through hands-on activities. The second rated reason was because the topic entails content that relates more with the learners' day to day encounters both at home and at school. This second reason was proposed by 22.19% of the learners under study. Of the total study population, 4.74% of the learners did not cite any reason for the choice they had given. This proportion of learners that gave no reason was too small to influence the result that the majority of the study population had cited. It is worth to note that of the 187 students who gave their reason as engaging more in practical activities, over 70% of them had given their favourite topic as Classification. This implies that when learners engage in more hands-on activities, they tend to develop interest in the topic or concept that they are studying.

From these results, it is observed that the continued low attainment in Biology could be attributed to the negative attitude that has developed among the students over time. This negative attitude can be attributed to the use of conventional instructional approaches in

Biology. Such instructional methodologies and approaches ultimately result in to learners developing a dislike to the Biology concepts, content, topics and subject at large. The findings of the present study are in agreement with those from a previous study by Prokop et al. (2007) who posits that there is every reason for the education stakeholders need to understand the importance of learners' attitudes so as to nurture them and direct them towards improved achievement and more interest in science learning process.

When asked how frequent their Biology lessons were conducted through practical activities, 68.3% of the total study population reported that they are occasionally exposed to Biology practical work. It can therefore be deduced that Biology teachers in the study area teach occasionally by use of the practical method. These findings are in congruence with those from a study by Ngakhala, et al. (2017) who reveal that the students under study reported having done only five Biology practicals in one school term. This trend of keeping off from a powerful hands-on teaching approach ends up affecting negatively the learner performance and attainment in Biology tests.

The learners reported from two other question items the role that the teacher and they play during practical activities. It emerged that key among what the teachers do during practical activities is to avail the apparatus and give directions on how the practical should be conducted. Majority of the students mentioned the teacher as organizing, preparing and availing most of material requirements for the various practical activities.

The results further indicate that the learner too had a role during the Biology practical activities. The findings reveal that the learners' responsibility was to keenly carry out the practical activities and then record their observations and conclusions. The views from the learners give an indication that teachers take a larger control of the outcome of the experiments. By virtue that practicals are occasionally conducted in Biology in the area of study, this is a precursor to the learner having a lesser role in the actual Biology teaching process.

4.7 Objective 4: Gender Difference in Attitude of Learners Towards Biology when Taught Using the BPPSTA and When Taught Using Conventional Methods

The study intended to determine whether there were any gender differences in attitude between male and female learners after having undergone instruction using Biology Practical Process Skills Teaching Approach (BPPSTA). The Biology Attitude Questionnaire for Students (BAQS) was used to collect data to test this hypothesis. The questionnaire was structured to collect data at three levels; Biology subject, Biology practical and Biology practical process skills. The analysis therefore shall be presented and discussed in these three key areas.

4.7.1 Learner Attitude Towards Biology Subject by Gender

The data obtained from the BAQS was analysed with the aid of the SPSS software (version 22) so as to facilitate a comparison of the learners' attitudinal mean responses of the male and female participants in the E1 pretest group. Descriptive statistical analysis was conducted with an aim of comparing the attitudinal means of students in the four study groups by gender. The mean and standard deviation of the various groups were determined. Table 4.7.1 presents the descriptive statistical analysis output.

Table 4.7.1: Descriptive Statistics for the BAQS for the Various Groups by Gender

Group	Pretest/Posttest	Gender	N	Mean	SD	STD. Error
Experimental -1(E1)	Pretest	Male	64	3.199	1.305	.162
		Female	55	3.155	1.398	.189
	Posttest	Male	64	3.708	1.263	.158
		Female	55	3.564	1.316	.177
Control -1 (C1)	Pretest	Male	32	2.836	1.312	.232
		Female	32	3.058	1.199	.213
	Posttest	Male	32	3.021	1.294	.138
		Female	32	3.044	1.171	.217
Experimental -2 (E2)	Posttest	Male	50	3.418	1.275	.180
		Female	63	3.516	1.316	.166
Control – 2 (C2)	Posttest	Male	50	3.003	1.366	.193
		Female	55	2.976	1.365	.184

Table 4.7.1 provides results from which it can be observed that the highest attitudinal mean out of the four study groups was 3.708 by the females in the E1 posttest group while the least was 2.838 by the males in the C1 pretest group. The study group whose learners had the responses greatly dispersed away from the mean was the females in the E1 pretest with a standard deviation of 1.473. From the same Table it can further be observed that, the least standard deviation was recorded as 1.19 by the females of the C1 pretest group. To determine whether the differences in the attitudinal mean of the learners were significant, independent samples t-test analyses were conducted to compare each set of data in the various study groups by gender. To start off the gender comparison, the data for E1 pretest group was analysed. An independent samples t-test was used for comparison so as to determine whether the attitudinal means of male and female learners in E1 pretest group were significantly different. Table 4.7.2 displays the output from the analysis.

Table 4.7.2: An Independent Samples t-test for BAQS for the Experimental Group - 1 Pretest by Gender for Questions 1 to 5

Gender	N	Mean	SD	df	t-value	p-value
Male	64	3.448	1.150	117	2.009	.116
Female	55	3.390	1.310			

Table 4.7.2 indicate that there is no significant difference in the attitudinal mean of male learners in E1 pretest group (M=3.448, SD=1.150) and the attitudinal mean of female learners in the same group (M=3.390, SD=1.310) for the attitude in the BAQS; t(117)=2.009, p=.116. Since the p-value of .116 obtained was > .05, the implication from this results was that the attitudinal mean of the male learners and that of the female learners in the E1 pretest group are not significantly different. These results give an indication that prior to the study being conducted, the attitude of male and female learners in this group was not significantly different. The males and females had similar level of attitude towards Biology. The learners in this group were then subjected to the intervention which involved instruction via BPPSTA for four weeks: this involved the group being taught by their respective teachers using a moderated lesson plan that laid great emphasis on practicing of BPPS. After which the BAQS was again administered to the same group. Their responses in the BAQS in relation to their gender after using BPPSTA were analysed. An independent samples t-test was therefore conducted to ascertain if the differences were significant. Table 4.7.3 provides the output from the analysis for this comparison.

Table 4.7.3: An Independent Samples t-test for the BAQS of the Experimental Group - 1 Posttest by Gender for Question Items 1 to 5

Gender	N	Mean	SD	df	t-value	p-value
Male	64	4.080	0.935	117	1.749	.113
Female	55	3.691	1.154			

Table 4.7.3 indicate that there is no significant difference in the attitudinal mean of male learners in E1 pretest group (M=4.080, SD=.935) and the attitudinal mean of female learners in the same group (M=3.691, SD=1.154) for the attitude in the BAQS; t(117)=1.749, p=.113. Since the p-value of .113 obtained was > .05 it therefore implies that, the attitudinal mean of male and that of female learners in the E1 posttest group for BAQS administration was not significantly different. The attitude of the male and that of the female learners after the intervention did not vary significantly. Prokop et al. (2007) is in support of these findings: from their study, no tangible difference was found between the male learners' and female learners' attitude towards science.

For purposes of further comparison on the basis of gender, the E2 posttest group results were analysed. To ascertain whether the mean differences of the male and female learners in the E2 posttest group were significant, an independent samples t-test was conducted. Table 4.7.4 displays the output from this analysis.

Table 4.7.4: An Independent Samples t-test Analysis for the BAQS for the Experimental Group - 2 Posttest by Gender for Question Items 1 to 5

Gender	N	Mean	SD	df	t-value	p-value
Male	50	3.276	1.287	111	1.126	.560
Female	63	3.499	1.193			

Table 4.7.4 presents information that indicate that there is no significant difference in the attitudinal mean of male learners in E2 posttest group (M=3.276, SD=1.287) and the attitudinal mean of female learners in the same group (M=3.499, SD=1.193) for the attitude in the BAQS; t(111)=1.126, p=.560. Since the p-value of .560 obtained was > .05 it implies that the attitudinal mean of male and that of female learners towards Biology were not significantly different. This is after the participants had been subjected to the intervention whereby they underwent instruction through the BPPSTA. The learners in this second experimental group had not been subjected to pretest BAQS. However, they were subjected to the intervention whereby they were taught using BPPSTA. After the intervention, they were again given the posttest BAQS to respond to. The results indicate therefore that the intervention did not influence the males and females differently: it therefore can be deduced that for this group, the intervention did not result in to varied attitude by gender.

There was need to further analyse the data from the groups into which the intervention had not been tried. To this end the control groups' attitude for learners was sought by gender. The attitudinal means for the C1 pretest group were analysed by gender to ascertain if there was a statistical difference. This was to reveal if the attitude of learners in this group varied by gender. A further analysis was done using the independent samples t-test to find out whether there was a significant difference between the male and female learners of this group. Table 4.7.5 presents the output from this analysis.

Table 4.7.5: An Independent Samples t-test for the BAQS for the Control Group - 1 Pretest by Gender for Question Items 1 to 5

Gender	N	Mean	SD	df	t-value	p-value
Male	32	3.300	1.253	62	.958	.472
Female	32	3.493	1.193			

Table 4.7.5 presents information that indicate that there is no significant difference in the attitudinal mean of male learners in C1 pretest group (M=3.300, SD=1.253) and the attitudinal mean of female learners in the same group (M=3.493, SD=1.193) for the attitude in the BAQS; t(62)=.958, p=.472. Since the p-value of .472 obtained was > .05 which therefore implies that there is no significant difference between the attitudinal mean of the male and that of the female learners. These findings are in agreement with those from a study by Nasr and Soltani (2011) who found no significant difference in the learners' attitude towards Biology.

These results imply that both the male and female learners' in C1 pretest group had an attitude that did not vary significantly at the onset of the study. The participants then underwent instruction through the conventional methods, after which they were again subjected to a posttest BAQS. This was to reveal whether the conventional method had influenced their attitudes differently by gender. The data from the posttest BAQS was analysed using the independent samples t-test with an aim of ascertaining if the difference in the attitudinal mean of male and female learners was significantly different. Table 4.7.6 presents the output from the analysis.

Table 4.7.6: An Independent Samples t-test Analysis on the BAQS for the Control Group - 1 Posttest by Gender for Question Items 1 to 5

Gender	N	Mean	SD	df	t-value	p-value
Male	32	3.300	1.234	62	.075	.353
Female	32	3.331	1.225			

Table 4.7.6 presents information that indicate that there is no significant difference in the attitudinal mean of male learners in C1 posttest group (M=3.300, SD=1.234) and the attitudinal mean of female learners in the same group (M=3.331, SD=1.225) for the attitude in the BAQS; t(62)=.075, p=.353. Since the p-value of .353 obtained was > .05 therefore the difference in the attitudinal mean of the male and that of the female learners in this control group after they had been taught via the conventional methods was not significant. Fancovicova & Prokop (2011) found a lack of significance difference in the attitude of male and female learners in the control group. The implication from these results is that the attitude of both male students and that of female learners did not change significantly after the learners had undergone instruction through the conventional methods.

A further analysis was conducted on the attitudinal means of learners in the C2 group. This group equally comprised of learners who were taught through the conventional approaches. An independent samples t-test analysis was conducted to ascertain whether the difference in the attitudinal mean of the learners was significant. Table 4.7.7 presents the results from the analysis.

Table 4.7.7: An Independent Samples t-test Analysis on the BAQS for the Control Group - 2 Posttest by Gender for Question Items 1 to 5

Gender	N	Mean	SD	df	t-value	p-value
Male	50	2.896	1.299	103	.859	.504
Female	55	2.978	1.249			

Table 4.7.7 presents information that indicate no significant difference in the attitudinal mean of male learners in C2 posttest group (M=2.896, SD=1.299) and the attitudinal mean of female learners in the same group (M=2.978, SD=1.249) for the attitude in the BAQS; t(103)=.859, p=.504. Since the p-value of .504 obtained was > .05 it implies from these results that the difference between the attitudinal mean of the male students and that of female students in the C2 posttest group was not significant. This group of learners underwent through the instruction process using the conventional methods. These outcome implies that the attitude of the male and female learners was not impacted upon differently. The control groups were included in the study so as to rule out any other possible cause of the outcome other than the variables that were being investigated. For this case the variable of concern was gender. It is therefore coming out clearly that gender did not affect the learner attitude towards Biology subject.

4.7.2 Gender influence on Learner Attitude Towards Biology Practical Lessons

The attitude of the participants was sought in relation to Biology practical lesson by gender. This analysis was carried out for each of the study groups so as to determine whether the learners' attitude towards Biology practical varied by gender. To that effect, an independent samples t-test was done so as to reveal whether this variation in the attitudinal mean of males and females was significantly different. The results are presented in Table 4.7.8.

Table 4.7.8: An Independent Samples t-test for the BAQS for the Experimental Group - 1 Pretest by Gender for Question Items 6 to 14

Gender	N	Mean	SD	df	t-value	p-value
Male	64	3.166	1.383	117	1.147	.372
Female	55	3.221	1.486			

Table 4.7.8 presents information that indicate that there is no significant difference in the attitudinal mean of male learners in E1 pretest group (M=3.166, SD=1.383) and the attitudinal mean of female learners in the same group (M=3.221, SD=1.486) for the attitude in the BAQS; t(117)=1.147, p=.372. Since the p-value of .372 obtained was > .05 it shows that the difference between the attitudinal mean of the male students and the female students in the E1 pretest group for BAQS is not significant. The attitude of male and female learners in the E1 pretest group did not significantly vary. Therefore, the results indicate that for these nine question items, the attitudinal mean for the female learners is not significantly different from that of the male learners in the E1 pretest group.

Another comparison was done on gender attitudinal mean for the E1 posttest group in relation to question items 6 to 14 which pertains the learner attitude towards Biology practical. An independent samples t-test was then conducted so as to reveal whether the difference was significant. Table 4.7.9 presents the analysis.

Table 4.7.9: An Independent Samples t-test for the BAQS for the Experimental Group - 1 Posttest by Gender for Question Items 6 to 14

Gender	N	Mean	SD	df	t-value	p-value
Male	64	3.788	1.360	117	1.536	.272
Female	55	3.893	1.299			

Table 4.7.9 presents results that indicate that there is no significant difference in the attitudinal mean of male learners in E1 posttest group (M=3.788, SD=1.360) and the attitudinal mean of female learners in the same group (M=3.893, SD=1.299) for the attitude in the BAQS; t(117)=1.536, p=.272. Since the p-value of .272 obtained was > .05 it indicates that the attitudinal mean of male and that of female learners in this E1 posttest group are not significantly different. Therefore, it shows that the BPPSTA did not influence the attitude of the leaners differently on the basis of gender; gender as a variable had no influence on learner attitude towards Biology practical after the intervention had been administered.

A further analysis of gender difference in attitudinal means led to the comparison of males and female learners' attitudinal means in the E2 posttest group. The output from the analysis of this group attitudinal mean were to enable the researcher to rule out the possibility of the pretest as having influenced the outcome. The data on attitude for learners in this group was analysed by gender. An independent samples t-test was conducted on this data and the output from the analysis is presented in Table 4.7.10.

Table 4.7.10: Independent Samples t-test Analysis for the BAQS for the Experimental Group - 2 Posttest by Gender for Question Items 6 to 14

Gender	N	Mean	SD	df	t-value	p-value
Male	50	3.911	1.270	111	1.589	.256
Female	63	3.873	1.329			

Table 4.7.10 results show that there is no significant difference in the attitudinal mean of male learners in E2 posttest group (M=3.911, SD=1.270) and the attitudinal mean of female learners in the same group (M=3.873, SD=1.329) for the attitude in the BAQS; t(111)=1.589, p=.256. Since the p-value of .256 obtained was > .05 it indicates that the attitudinal mean of the male learners is not significantly different from that of the female learners after undergoing instruction using the BPPSTA. The intervention under study did not influence differently the male and female learner' attitude towards Biology practical lessons. Gender as a variable was therefore found not to be influencing the learners' attitude towards Biology practical lessons. It was necessary to carry out another comparison between the males and females of the control group – 1 pretest. To ascertain if the attitudinal mean difference was significant, an independent samples t-test was done. Table 4.7.11 presents the output from the analysis.

Table 4.7.11: Independent Samples t-test for the BAQS for the Control Group - 1 Pretest by Gender for Questions 6 to 14

Gender	N	Mean	SD	df	t-value	p-value
Male	32	3.344	1.352	62	1.023	.383
Female	32	3.667	1.233			

Table 4.7.11 presents the analysis which show no significant difference in the attitudinal mean of male learners in C1 pretest group (M=3.344, SD=1.352) and the attitudinal mean

of female learners in the same group (M=3.667, SD=1.233) for the attitude in the BAQS; t(62)=1.023, p=.383. Since the p-value of .383 obtained was > .05 it implies that there is no significant difference between the attitudinal mean of the males and that of the females in the C1 pretest group for BAQS. These responses were made before the participants in this group had undergone instruction via the conventional instructional methods. These results imply that the attitude of both male and female learners in this group were not significantly different before the instruction was done. It was therefore necessary to carry out another comparison of attitude between the males and females of the C1 posttest group. The attitudinal responses that the learners in the C1 group gave from the BAQS that was administered after they had undergone instruction via the conventional methods formed the basis of this analysis. To ascertain if the attitudinal mean of the males and females in the C1 posttest group were significantly different, an independent samples t-test was conducted. The output from the analysis is presented in Table 4.7.12.

Table 4.7.12: An Independent Samples t-test for the BAQS for the Control Group -1 Posttest by Gender for Question Items 6 to 14

Gender	N	Mean	SD	df	t-value	p-value
Male	32	3.764	1.434	62	1.479	.387
Female	32	3.972	1.351			

Table 4.7.12 presents output from which it can be observed that there is no significant difference in the attitudinal mean of male learners in C1 posttest group (M=3.764, SD=1.434) and the attitudinal mean of female learners in the same group (M=3.972, SD=1.351) for the attitude in the BAQS; t(62)=1.479, p=.387. Since the p-value of .387 obtained was > .05 it means that the attitudinal mean for males and that of females

towards Biology practical in C1 posttest BAQS are not significantly different. This is after the participants had undergone instruction through the conventional methods. These results imply that the instructional method used in the C1 group did not influence male learners differently as compared to how it influenced female learners. The attitude of the learners in C1 group before and after instruction through the conventional methods did not differ by gender.

It was also necessary to analyse the results from the participants in C2 group; this was the second control group whose members were not subjected to the pretest BAQS. The attitude of the participants in the C2 group was also analysed to establish the existence of a gender difference that is significant in the learner attitude. To that effect an independent samples t-test was conducted to unveil this difference in case there was. Table 4.7.13 presents the output from this analysis.

Table 4.7.13: An Independent Samples t-test for the BAQS for the Control Group -2 Posttest by Gender for Question Items 6 to 14

Gender	N	Mean	SD	df	t-value	p-value
Male	50	3.151	1.457	103	0.932	.398
Female	55	3.095	1.486			

From the output in Table 4.7.13 it can be observed that there is no significant difference in the attitudinal mean of male learners in C2 posttest group (M=3.151, SD=1.457) and the attitudinal mean of female learners in the same group (M=3.095, SD=1.486) for the attitude in the BAQS; t(103)=.932, p=.398. Since the p-value of .398 obtained was > .05 it implies that the attitude of male and that of female learners towards Biology practical are not significantly different for the participants in the C2 posttest group. These results are interpreted to indicate that the male learners' attitude and that of the female learners after the treatment did not show a significant difference. The attitude of the male and female learners towards Biology practical lessons was influenced by the use of BPPSTA.

The results from the analysis of data from the various study groups indicate absence of a significant difference in learners' attitude by gender after instruction using the BPPSTA. From the results, it is equally observed that both male and female learners did not show a significant difference in their attitude towards Biology practical lessons after undergoing instruction via the conventional instructional methods. It is therefore deduced that the BPPSTA did not result in to varied attitude levels for male and female learners. Therefore, the study found out that the teaching approach used did not significantly influence differently the attitude of male and female learners towards Biology practical lessons.

4.7.3 Gender Influence on Learner Attitude Towards Biology Practical Process Skills

Gender is a key determinant of many variables studied in education. In this section data was analysed so as to help determine whether gender was a factor that influenced the attitude of learners towards the Biology practical process skills. The key data analysed was emanating from the question items 15 to 23 in the BAQS. The data of the various study groups was analysed with a keen focus on the trend of male participants' attitude in comparison to female participants' attitude but in the same study group. The first group to be compared was the E1 pretest group. An independent samples t-test analysis was done so as to determine whether the difference in the attitudinal means was significantly different. Table 4.7.14 presents these results.

Table 4.7.14: Independent Samples t-test for BAQS for the Experimental Group-1 Pretest by Gender in Question Items 15 to 23

Gender	N	Mean	SD	df	t-value	p-value
Male	64	2.986	1.383	117	1.120	.393
Female	55	2.854	1.400			

The result in Table 4.7.14 show that there is no significant difference in the attitudinal mean of male learners in E1 pretest group (M=2.986, SD=1.383) and the attitudinal mean of female learners in the same group (M=2.854, SD=1.400) for the attitude in the BAQS; t(117)= 1.120, p=.393. Since the p-value of .393 obtained was > .05 it implies that the difference between the attitudinal mean of the male and female learners of the E1 pretest group is not significant. The attitude of male and that of female learners towards Biology practical process skills is not significantly different for the learners in the E1 group. At this point of administration of the BAQS, the participants had not been subjected to the intervention. After the participants in E1 group had responded to question items in the pretest BAQS, they underwent an intervention which involved instruction for four weeks via BPPSTA. After the intervention, the learners were again subjected to a BAQS so as to respond to it. To ascertain whether the attitudinal mean differences between the male and female learners of E1 posttest group was significant, a t-test analysis was done. Table 4.7.15 presents the output from the analysis.

Table 4.7.15: Independent Samples t-test for the BAQS for the Experimental Group - 1 Posttest by Gender for Question Items 15 to 23

Gender	N	Mean	SD	df	t-value	p-value
Male	64	3.255	1.493	117	.568	.595
Female	55	3.111	1.495			

The result in Table 4.7.15 show that there is no significant difference in the attitudinal mean of male learners in E1 posttest group (M=3.255, SD=1.493) and the attitudinal mean of female learners in the same group (M=3.111, SD=1.495) for the attitude in the BAQS; t(117)= 1.568, p=.595. Since the p-value of .595 obtained was > .05 it therefore indicates that the difference between the attitudinal means of male and female learners in E1 posttest group is not significant. The attitude of males and that of females towards Biology practical process skills is not significantly different for the participants in the E1 posttest group. Therefore, for both the pretest and posttest BAQS there was no difference in the attitude of male and female learners. As Papert's (1991) constructionism theory postulates as discussed in section 1.9 that learning in situ leads to meaningful acquisition of knowledge and skills. Therefore it is evident that both the male and female learners benefit equally when an appropriate instructional approach such as BPPSTA is used.

There was need to further carry out an analysis on the attitudinal responses of the students in the E2 group. Learners in this group had not been subjected to the pretest BAQS. The essence of having this additional group was so as to rule out any unforeseen effect of pretesting on the outcome of E1 group. The data from the E2 group therefore were compared by gender. The attitudinal means of male and female learners of the E2 group were analysed using the independent samples t-test. Table 4.7.16 presents the output from the E2 group responses analysis.

Table 4.7.16: An Independent Samples t-test for the BAQS for the Experimental Group - 2 Posttest by Gender in Question Items 15 to 23

Gender	N	Mean	SD	df	t-value	p-value
Male	50	3.922	1.268	111	.921	.495
Female	63	3.776	1.426			

In Table 4.7.16, presented is the output from which it can be observed that there is no significant difference in the attitudinal mean of male learners in E2 posttest group (M=3.922, SD=1.268) and the attitudinal mean of female learners in the same group (M=3.776, SD=1.426) for the attitude in the BAQS; t(111)= .921, p=.495. Since the p-value of .495 obtained was > .05 it implies that the difference between the attitudinal mean of male and female learners in the E2 posttest group is not significant. This is interpreted that gender did not influence the learners' attitude after having undergone instruction through the BPPSTA. These results indicate that after the learners undergoing instruction via the BPPSTA, their attitude did not significantly vary by gender. The results from this group clearly confirm the results earlier obtained in the E1 group for posttest BAQS. That the absence of significant difference in the E1 group is not indeed as a result of the prior exposure of learners in E1 to the pretest BAQS. Therefore, gender as a factor did not affect change in learner attitude after the intervention. Similar findings by Suzuki (2007) from a study on attitude of Japanese students in relation to school Biology were obtained. The study found out that male and female learners' attitude towards Biology did not differ. Conversely Cherian and Shumba, (2011) found that boys had a more positive attitude towards science as compared to girls in South Africa. However, their study generally focused on science unlike the present study that specifically focused on biology subject.

There was need to further determine whether there was a gender difference in the attitudinal means for learners in the C1 pretest group. This would reveal whether the learners' attitude towards Biology process skills in C1 pretest group was different by gender. The data was analysed using the independent samples t-test and the output from the analysis is as presented in Table 4.7.17.

Table 4.7.17: An Independent Samples t-test for the BAQS for the Control Group - 1 Pretest by Gender in Question Items 15 to 23

Gender	N	Mean	SD	df	t-value	p-value
Male	32	3.010	1.331	62	1.003	.390
Female	32	2.920	1.170			

In Table 4.7.17, presented is the output from which it can be observed that there is no significant difference in the attitudinal mean of male learners in C1 pretest group (M=3.010, SD=1.331) and the attitudinal mean of female learners in the same group (M=2.920, SD=1.170) for the attitude in the BAQS; t(62)= 1.003, p=.390. Since the p-value of .390 obtained was > .05 it implies that there is no significant difference between the male learners' attitudinal mean and that of the female learners in the C1 pretest group. Male and female learners' attitude towards Biology practical process skills did not differ significantly for BAQS posttest. At the onset of the study, both male and female learners in C1 did not have an attitude that varied significantly.

The learners in C1 group then underwent instruction through the conventional instructional methods and after which they were subjected to a BAQS again. The purpose was to find out if there had been any change in the attitude after undergoing instruction through the conventional methods. The data from the BAQS was then subjected to an independent samples t-test analysis. Table 4.7.18 presents an output from the analysis.

Table 4.7.18: An Independent Samples t-test for the BAQS for the Control Group - 1 Posttest by Gender in Question Items 15 to 23

Gender	N	Mean	SD	df	t-value	p-value
Male	32	2.449	1.222	62	.664	.563
Female	32	2.431	0.938			

Table 4.7.18, presents output from which it can be observed that there is no significant difference in the attitudinal mean of male learners in C1 posttest group (M=2.449, SD=1.222) and the attitudinal mean of female learners in the same group (M=2.431, SD=.938) for the attitude in the BAQS; t(62)= .664, p=.563. Since the p-value of .563 obtained was > .05 it implies that, the difference between the attitudinal mean of male and female learners in the C1 posttest group is not significant. The attitude of males and that of females towards Biology practical process skills did not differ for BAQS posttest. Therefore, it implies that the attitude of the learners in this group was not significantly different after they underwent instruction via the conventional methods. Both before and after instruction via conventional methods in the C1 group, it is concluded that the gender attitudinal difference was not significant.

Learners' attitude in the C2 posttest group were equally analysed to find out whether they varied by gender. An independent samples t-test was used for this analysis so as to bring out the comparison. Table 4.7.19 presents the output from the analysis.

Table 4.7.19: An Independent Samples t-test for the BAQS for the Control Group - 2 Posttest by Gender in Question Items 15 to 23

Gender	N	Mean	SD	df	t-value	p-value
Male	50	2.964	1.342	103	.867	.508
Female	55	2.855	1.360			

Table 4.7.19, displays the output after the analysis from which it can be observed that there was no significant difference in the attitudinal mean of male learners in C2 posttest group (M=2.964, SD=1.342) and the attitudinal mean of female learners in the same group (M=2.855, SD=1.360) for the attitude in the BAQS; t(62)= .664, p=.508. Since the p-value of .508 obtained was > .05 it therefore shows that the difference in the attitude of male and female learners in the C2 posttest group for BAQS is not significant. The overall results show that the attitude of the learners in the two control groups did not vary by gender irrespective of whether they had undergone instruction via BPPSTA or conventional methods.

The control groups were included in the study so that the results of learners in these groups would provide a base for comparison with those of the learners in the experimental groups. This comparison had a purpose of enabling the study to rule out any other factor other than the ones under study that might have caused a change in learners' attitude in the experimental groups. This was to rule out any chance occurrence outcome and attribute any change in the experimental group posttest results to only the intervention. This aim was achieved satisfactorily. It is therefore emanating from the results that the attitude of male and female learners under study were not influenced by the instructional approach which was BPPSTA.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The purpose of this study was to investigate the contribution of form two students' competency in Biology practical process skills' on their achievement and attitude towards Biology in Gucha South sub-County, Kisii County. The present study aimed at investigating whether or not the BPPSTA had an influence on learner's academic achievement in Biology and attitude towards Biology. Along these grounds, this chapter presents the summary of the findings that were presented in chapter four, followed by appropriate conclusions that have been derived from the findings and finally the corresponding study recommendations.

In this study form two students from Gucha South Sub-County, Kisii County were the key participants of focus. The sample size comprised of 401 form two students drawn from four co-educational secondary schools. Data was collected using Biology Attitude Questionnaire for Students (BAQS), Biology Practical Observation Schedule (BPOS), Process Skills Assessment Test (PSAT) and Biology Achievement Test (BAT). The instruments were pilot-tested in one co-educational secondary school in the neighbouring sub-County. They were then modified and used in the sampled schools with the assistance of seven Biology teachers in the respective schools and one video recording personnel.

5.2 Summary of Findings

This study was guided by four objectives as presented in section 1.3. The study presents a summary of the findings in line with each of the four study objectives and hypotheses as aforementioned in section 1.4 and 1.5 respectively.

5.2.1 Contribution of Biology Practical Process Skills Teaching Approach (BPPSTA) to Learners' Achievement in Biology

In comparison of the mean attainment of learners in the BAT as compared to PSAT, it was found that the mean for PSAT was greater as compared to that in BAT for the E1 posttest group. The two means were however found to have a high positive correlation coefficient of .773. A high positive correlation of .712 was also obtained for the E2 posttest group mean in BAT and PSAT. A correlation value above 0.7 is a sufficient indication of a strong correlation between the variables (Gall et al., 2007; Orodho, 2009).

The comparison mean attainment in BAT for the E1 pretest and posttest groups showed a higher mean in the posttest than pretest. On further analysis the difference between the means were found to be significant. A comparison of the mean in BAT for E1 posttest group and the C1 posttest group showed the E1 posttest group as having a much greater mean than the control group. An analysis using independent samples t-test was then conducted, the mean difference was found to be significant. When a comparison of the means of the C1 pretest group and C1 posttest group was conducted, it revealed that the means were not significantly different. Therefore, it was necessary to compare the means of the C1 posttest group and the E2 posttest group. The mean of the E2 posttest group was found to be greater than that of the C1 posttest group and when they were subjected to an analysis using the independent samples t-test, it was found that the difference in the achievement means was significant.

Another comparison between the E2 posttest group mean and the C2 posttest group mean revealed that the E2 posttest group mean was greater than the C2 posttest mean. When subjected to independent samples t-test, it was found that the difference in the means of the two groups was significant. The E1 posttest group mean was further compared to the C2 posttest group mean and it was found that the E1 group mean was greater in relation to that of the C2 group mean. On subjecting the means to independent samples t-test, it came out clear that the difference in the means was significant.

Another comparison of the mean attainment by participants in the E1 posttest group with that of the participants in the E2 posttest group was done and it was found that the E1 posttest group mean was comparatively greater than that of the participants in the E2 posttest group. On subjecting the means of these two groups to the independent samples t-test so as to determine whether the difference was significant, it was clear that the achievement means of these groups were not significantly different.

5.2.2 Gender Difference in Achievement Between Learners Taught Using BPPSTA and Conventional Methods

The second objective was to determine and find out whether teaching using BPPSTA had a varied impact on male and female learners. In line with this second objective, a comparative analysis of learner attainment in the BAT was used to establish the gender differences in all the groups under study at a significance level, $\alpha = 0.05$. The mean attainment of the E1 pretest group revealed that male learners had a greater mean attainment than the female learners. When an independent samples t-test was used to analyse the data, it was revealed that the differences between the means was not significant. Another gender comparison analysis in the E1 posttest group revealed male learners as having a greater attainment mean score than the female learners. When the attainment means were analysed using the t-test by gender, it emerged that the mean scores of learners in E1 were equally not significantly different. The comparison of gender performance in the C1 pretest group revealed that the mean attainment of the males was greater as compared to that of the female learners. The mean score attainment of learners in this group was analysed using the independent samples t-test and the output from the analysis indicated that the difference was not significant. The posttest of the same control group mean revealed that male learners equally had a comparatively greater mean score attainment than the female learners. An independent samples t-test analysis revealed no significance difference between these mean scores for C1 group by gender.

The E2 posttest group mean score comparison for males and females revealed the male gender having a comparatively higher mean score attainment than the females. An independent samples t-test analysis output indicated that the difference between the mean score of male and female learners in the E2 posttest group were not significant. The C2 posttest group comparison by gender revealed results in which males had a higher mean score as compared to the female learners. The t-test analysis showed that the mean scores were significantly different by gender.

5.2.3 Attitude Towards Biology Between Learners Taught via BPPSTA and those Taught via the Conventional Methods

The learner attitude towards Biology as revealed in the study was high. On comparison of the attitude of the E1 pretest and posttest of learners in the same group, a positive rise in attitude was observed. The attitudinal means of learners in the E1 posttest group and that of learners in C1 posttest group revealed a higher attitudinal mean in the former and the difference was found to be significant. A comparison of the C1 pretest and posttest groups revealed that the attitudinal means were not significantly different.

There were question items that learners responded to which were addressing their attitude towards Biology practical lessons. The comparison of their responses in the E1 pretest group and that of the E1 posttest group reveal an increased attitude value in the pretest than the posttest. The output was then analysed using the independent samples t-test analysis, the general mean comparison was found to be significantly different. When the C1 posttest group attitudinal means were compared to those of the E1 posttest group, it was revealed that the means for the experimental group were higher. The output from the analysis indicated a significant difference between the means of learners in these groups. A further comparison of the means of the C1 pretest group and the C1 posttest group, revealed that the means were not significantly different.

On the sub-theme of learner attitude towards the Biology practical process skills under study, question items 15-23 addressed this. The mean attained in the responses for learners in the E1 were compared; the pretest mean was compared to the posttest mean. The output revealed a positive rise in the posttest means as compared to the pretest means. A t-test analysis conducted revealed that the means of the two groups were significantly different. A further comparison was conducted between E1 posttest group and C1 posttest group attitudinal means. The E1 group attitudinal means were found to be higher. The data was analysed further using the independent samples t-test, it emerged that the difference in the attitudinal means of learners in these groups were significant. In addition, a further comparative analysis was done on the attitudinal means of learners in the C1 pretest and posttest groups. The independent samples t-test analysis revealed that the mean differences of these two groups were not significant.

From the study findings it also emerged that, learners had greater passion in learning the topic classification at 50.37% followed by Cell physiology at 23.97%. The most mentioned reason given that contribute to the learners liking the topic was due to the involvement in more hands-on activities during the learning of this topic. They further reported that they were occasionally exposed to Biology practical sessions during the teaching of Biology.

5.2.4 Gender Difference in Attitude Learners Towards Biology when Taught via the BPPSTA and Conventional Methods

A comparison between the attitude of the male and female students in the E1 posttest group revealed that the attitude of the males varied from that of the female. However, the difference in the attitudinal mean was not significant. Attitudinal responses of learners in the E1 posttest group were analysed and the output revealed no significant difference of the attitude by gender. The attitudinal mean for the male participants did not significantly vary from that of the female learners.

The difference in C1 pretest attitudinal means of male and female learners was not significant. The attitudinal mean for learners in the C1 posttest equally revealed a no significant difference by gender. The E2 posttest group results equally point to the fact that the means of both gender were not significantly different.

The results from the participants in line with the learners' attitude towards Biology subject as was deduced from the responses of question items 1 to 5 indicate no significant difference in gender attitudinal responses for the various study groups. The same results have been obtained for the responses emanating from question items 6 to 14 which were seeking for the learners' attitude towards Biology practical. The last group of question items 15 to 23 sought the learners' attitude towards Biology practical process skills. The analysed data reveal no statistical difference between by gender for the various study groups under study.

5.3 Conclusions

The conclusions of the study were made in line with the four objectives and hypotheses that guided the study. These conclusions are presented in this section.

5.3.1 Contribution of Biology Practical Process Skills Teaching Approach (BPPSTA) to Learners' Achievement in Biology

The study sought to test the null hypothesis that, there is no significant difference in achievement between learners taught using BPPSTA and the conventional method. The decision made on the basis of the data collected and analysed is to reject the null hypothesis. Therefore, it implies that there is a significant difference in achievement between learners taught using BPPSTA as compared to those learners who underwent instruction via the conventional methods. The groups that were taught using the BPPSTA had a significantly higher mean attainment in the posttest in relation to those who underwent instruction via the conventional instructional methods. Therefore, the use of BPPSTA can be deduced to lead to an improved learner attainment in Biology. BPPSTA had a great positive contribution towards learner academic attainment in Biology. The influence of BPPSTA on learner academic achievement in Biology was found to be so strong.

5.3.2 Gender Difference in Achievement Between Learners Taught via BPPSTA and via Conventional Methods

The second hypothesis that was tested was, there is no significant gender difference in academic achievement in Biology between learners when taught using BPPSTA and when taught using conventional methods. This hypothesis was tested and the decision that was made was to fail to reject the null hypothesis. Therefore, it implies that the variation in academic attainment of males and female learners in the posttest was not significant and hence could not be attributed to the instructional approach that was used. There was no significant difference in the males' posttest attainment as compared to the attainment of the females in the BAT. Instruction using BPPSTA does not influence differently the learners' achievement by gender. Therefore, BPPSTA is an appropriate instructional approach that doesn't discriminate leaners by gender.

5.3.3 Attitude Towards Biology Between Learners Taught via BPPSTA and Those Taught via the Conventional Methods

The study sought to test the third null hypothesis which was, there is no significant difference in attitude towards Biology between learners taught using the BPPSTA and those taught using the conventional methods. The hypothesis after being rigorously tested the result was to reject the null hypothesis. Therefore, the difference in the attitude of those who underwent instruction using BPPSTA and those who underwent instruction using the conventional teaching methods was significant. Despite the fact that both the students who learnt using the BPPSTA and conventional learning approaches had a positive attitude, the study found a significant increase in attitude after the learners had learnt using the BPPSTA. The influence of BPPSTA on learners' attitude towards Biology was found to be moderate. BPPSTA was thus found to be positively contributing to learners' attitude towards Biology. Therefore, it can be concluded that instruction via BPPSTA leads to a more positive attitude towards Biology among the learners unlike when instruction is carried out via the conventional instructional methods. It further emerged that, the use of BPPSTA during instruction enhances learner attention. However, Biology teachers do not often use practical process skills teaching approach during classroom instruction.

5.3.4 Gender Difference in Attitude of Learners Towards Biology when Taught via the BPPSTA and via Conventional Methods

The fourth hypothesis that was tested was, there is no significant gender difference in attitude towards the teaching of Biology via BPPSTA and Conventional Methods. After testing the hypothesis on the basis of the set significance level $\alpha=0.05$, a decision was made not to reject the null hypothesis. This implies that indeed there is no significant difference in attitude of males and female learners towards Biology when they undergo instruction via the BPPSTA as compared to when they undergo instruction via conventional methods. This implies that the learners' attitude towards Biology did not vary by gender. Therefore, gender did not significantly influence the learners' attitude towards Biology. The BPPSTA is an appropriate approach to use in Biology instruction since it will influence equally the learners' attitude irrespective of the gender.

5.4 Recommendations

Based on the results and conclusions made from the present study, a number of recommendations are hereby made for policy and adoption purposes.

1. MOE through its QASOs should encourage the use of process skills in Biology teaching and regularly supervise the implementation of this approach
2. For both male and female learners to equally benefit from the Biology instructional process, teachers should always use the BPPSTA.
3. Biology teachers should often use instructional approaches that promote the practice of process skills so as to ultimately develop and nurture more positive attitude among the learners towards Biology.

4. Biology teachers should always yearn to explore classroom activities that involve both gender of learners so that both the male and female learners in the class can equally benefit when BPPSTA is in use. This will ensure that both the attitude of male and female learners is positively impacted on.

5.5 Suggestion for Further Research

In line with the research findings, the study recommends the following areas for further research:

1. A study be carried out to determine the extent to which BPPSTA influences learner academic attainment
2. A study be carried out on challenges that the learners and teachers experience when instruction is done through the use of Biology practical process skills approach.
3. A study be carried out on teachers' preparedness on the use of Biology practical process skills teaching approach in teaching and learning of Biology.
4. A study be carried out to determine the influence of gender factor on learner attitude when BPPSTA is used in experiential learning environment

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APPENDIX I: Biology Attitude Questionnaire for Students (BAQS)

This questionnaire is for collecting data for a study being conducted by a PhD student at Kisii University. The study is titled, **‘**Influence of students’ Biology practical process skills’ competency on their achievement in and attitude towards Biology in Gucha South sub-County, Kisii County, Kenya.’ The questionnaire is seeking for your view on Biology practical lessons. You are hereby requested to honestly fill in the questionnaire in all sections. The information requested for in the questionnaire, is strictly for research purposes. This information will remain confidential to the researcher; therefore, kindly **do not write your name anywhere on the questionnaire**. Please fill all the parts of the questionnaire.

SECTION A: Biodata

Tick (√) appropriately whenever there are brackets

Name of School: ……………………..

What is your gender? Male ( ) Female ( )

What is your age? …………………… years old

Section B: Student Attitude Towards Biology Practical

Direction on how to fill the questionnaire in this section
Tick (√) in the most appropriate bracket. For each statement tick only one option in each case.
Key:
Strongly agree = SA, Agree = A, Undecided = U, Disagree = D, Strongly disagree = SD

1. **Biology is a subject I like most**
   SA ( ) A ( ) U ( ) D ( ) SD ( )

2. **After school, I plan to take a career related to Biology**
   SA ( ) A ( ) U ( ) D ( ) SD ( )

3. **I always get motivated to score above 50% in Biology examinations**
   SA ( ) A ( ) U ( ) D ( ) SD ( )

4. **Given a choice, I will NOT continue studying Biology in form three**
   SA ( ) A ( ) U ( ) D ( ) SD ( )

5. **I hate Biology because of the way it is taught**
   SA ( ) A ( ) U ( ) D ( ) SD ( )

6. **I enjoy doing practical work in Biology lessons**
   SA ( ) A ( ) U ( ) D ( ) SD ( )

7. **I prefer practical work to non-practical work in Biology lessons**
SA ( ) A ( ) U ( ) D ( ) SD ( )

8. **Doing practical work is my favourite part of Biology lessons**
SA ( ) A ( ) U ( ) D ( ) SD ( )

9. **Practical work helps me understand Biology**
SA ( ) A ( ) U ( ) D ( ) SD ( )

10. **What I do in Biology practical work will be useful when I leave school**
SA ( ) A ( ) U ( ) D ( ) SD ( )

11. **We should do more practical work in Biology lessons**
SA ( ) A ( ) U ( ) D ( ) SD ( )

12. **I prefer the freedom I have during practical work in Biology lessons**
SA ( ) A ( ) U ( ) D ( ) SD ( )

13. **My school science environment makes doing practical work easy in Biology lessons**
SA ( ) A ( ) U ( ) D ( ) SD ( )

14. **My Biology teacher has made me to like Biology more**
SA ( ) A ( ) U ( ) D ( ) SD ( )

15. **I usually make accurate observations during Biology practical sessions**
SA ( ) A ( ) U ( ) D ( ) SD ( )

16. **I am able to record biological observations and results accurately?**
SA ( ) A ( ) U ( ) D ( ) SD ( )

17. **I am able to make accurate biological measurements using measuring equipment such as stop watch, ruler, thermometer, measuring cylinders, etc**
SA ( ) A ( ) U ( ) D ( ) SD ( )

18. **I experience a problem and challenge in using the above measuring equipment(s)**
SA ( ) A ( ) U ( ) D ( ) SD ( )

19. **I usually face a challenge(s) during drawing of biological diagrams**
SA ( ) A ( ) U ( ) D ( ) SD ( )

20. **I am able to accurately interpret the results from Biology practical**
SA ( ) A ( ) U ( ) D ( ) SD ( )

21. **I am able to make meaning of results observed during practical sessions**
    SA ( ) A ( ) U ( ) D ( ) SD ( )

22. **I am able to make conclusions or inferences correctly when carrying out Biology practicals?**
    SA ( ) A ( ) U ( ) D ( ) SD ( )

23. **I am able to set up a biological experiment appropriately on my own**
    SA ( ) A ( ) U ( ) D ( ) SD ( )

SECTION C: Students' views on Teaching and Learning of Biology

Instructions:

In this section **tick (√)** appropriately whenever there are brackets and then fill in the blank spaces as per the requirement of the question.

24.a) Which two topic/subtopic(s) in Biology do you like to study most?
…………………………………………………………………………………………
…………………………………………………………………………………………
b) Kindly, give reason(s) for your answer above
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

25.a) How frequent are you taught Biology using practical work and activities?
Every lesson ( )
Once a week ( )
After two weeks ( )
Occasionally ( )
Any other response
(specify)……………………………………………………...

26. During the Biology practical lessons what role does the Biology teacher play?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

27. During the Biology practical lessons what role do you as a student(s) play?
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

Thank you for your cooperation by filling in this questionnaire

Imanda Isaac (Mr.)

APPENDIX II: Process Skills Assessment Test (PSAT)

Dear Participant,

I am a PhD student at Kisii University undertaking a research on, ‘Influence of students’ Biology practical process skills’ competency on their achievement in and attitude towards Biology in Gucha South, Kisii County, Kenya.’ The researcher has identified you to participate in this study. This test is to assist the researcher in the assessment of learners’ performance in Biology practical process skills. The findings will only be used for purposes of this study. Anonymity and confidentiality in analysis and reporting of results shall be adhered to. Kindly answer all the questions to the best of your ability. Welcome!

Biodata

Name of your school…..……………..

What is your gender? : Male ( ) Female ( )

What is your age? ………. years old

QUESTION ONE (17 marks)

You are provided with:

Amango leaf, a ruler, iodine solution, scalpel, hand lens, microscope slide, cover slip and a dropper

a) Measure the length and breadth of the leaf (1mks)

Length………..

Breadth……….

b) i) Observe the colour of the leaf on the lower and upper surface, compare and record your observation (1 mk)

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

ii) Account for the difference 2mk)

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

c) i) Cut off the petiole, about 2cm from the end where the leaf attaches to the stem
ii) Carefully make several thin cross sections from the piece obtained in a (i) above using a sharp scalpel
iii) Put the sections obtained in water in a petri dish
iv) Mount the thinnest section(s) on a glass slide, add a drop of iodine solution provided

v) Observe the section(s) using a hand lens, and then draw a labeled diagram of the section observed (5marks)

d) Account for each of the following features of specimen H

i) Extensive network of veins (1 mark)

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

ii) Rough leaf blade (1 mark)

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

iii) Strong and extended petiole (1mark)

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

e) State with reasons the class of plants from which the specimen was obtained

i) Class……………………………………………………… (1 mark)

ii) Reason:

…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
(1 mark)

f) Explain why the following procedures were necessary during the preparation of the sections for observation: (3 marks)

i) Putting the section in water in a petridish

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

ii) Adding iodine solution to the specimen

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

iii) Cutting very thin sections

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

QUESTION TWO (9 MARKS)

You are provided with a leafy shoot, anhydrous Cobalt (II) chloride paper, glass slide, cellotape, elastic bands, stop watch or clock, cello tape and a pair of forceps.

Procedure

1. Select one broad healthy leaf on a potted plant growing where there is enough sunlight
2. Using a pair of forceps pick two large pieces of anhydrous Cobalt (II) chloride paper and quickly place each piece on the two surfaces of the leaf. Immediately start the stop watch and note the colour of the anhydrous Cobalt (II) chloride paper
3. Quickly cover them with dry glass slides and note the time
4. Secure the slides into position with elastic rubber bands as shown in the diagram. Have two set ups of this kind by repeating this procedure steps 1 to 4 on another leaf.
5. Separately note the time taken by each of the two Cobalt (II) chloride paper to turn pink. Note the time as soon as the pink spot appears and also when the whole paper turns pink.
6. Hold a covered piece of anhydrous Cobalt (II) chloride paper to act as a control. This can be held in the hand with a pair of forceps
7. Note the time it takes the piece of paper to turn pink in the air. Do not handle anhydrous Cobalt (II) Chloride paper with bare hands
8. Record your results in a table showing time taken by anhydrous Cobalt (II) chloride paper to turn pink while in air or above water, under leaf surface and above leaf surface

a) What was the aim of the experiment? (1 mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

Record the time taken (**in seconds**) for the cobalt (II) chloride paper to turn pink in the table below: (3 mks)

	Time taken(sec) for the	cobalt(II) chloride	paper to turn pink
	Set up 1	Set up 2	Average
Upper surface			
Lower surface			
Held in the hand			

c) Explain the difference noticed between the Cobalt (II) chloride paper on the lower leaf surface and that on the upper leaf surface (3 mks)
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

d) Why was it necessary to have another Cobalt (II) chloride paper held in the hand on a petridish? (1 mk)
………………………………………………………………………………………
………………………………………………………………………………………

e) Why is it not advisable to hold the Cobalt (II) chloride paperwith your bare hands? (1 mk)
………………………………………………………………………………………
………………………………………………………………………………………

END

APPENDIX III: Biology Practical Observation Schedule (BPOS)

(a) QUESTION ONE

S.No.	**Activity**	**Most evident process skill**		**Score (1mk or 0 mk)**
1	Measuring: -length	Measurement	P	
2	-Breadth	Measurement		
3	Colour of upper epidermis	Observation		
4	Colour of lower epidermis	Observation		
5	Reason for different colour upper epidermis	Inference		
6	Reason for lower epidermis	Inference		
7	Cutting a thin section	Experimentation	p	
8	Mounting on slide	Experimentation	p	
9	Staining using iodine	Experimentation	p	
10	Placing cover slip using mounting needle	Experimentation	p	
11	Observing: moving hand lens as the specimen is on table	Observation	p	
12	Drawing the section: - Use of sharp/fine pencil	Communication		
13	- Drawings with continuous line	Communication		
14	- Proportionality of drawing in relation to the specimen	Communication		
15	- Correct identification of parts:- Epidermis	Communication		
16	- Cortex	Communication		
17	- Xylem	Communication		
18	- Phloem	Communication		
19	- Pith	Communication		
20	- Stating Monocot or Dicot	Inference		
21	- Reasons for stating Monocot or Dicot	Interpreting data		
		Interpreting data		
P =	Stands for what will be scored as the	learners manipulate		

(b) QUESTION TWO

S.No.	Activity	Most Evident Process Skill		Score
1	Timing duration for Upper surface	Measurement		
2	Timing duration for lower surface	Measurement		
3	Timing for paper held in the hand	Measurement	P	
4	Holding the papers with forceps	Experimentation	P	
5	Placing the paper on the upper leaf surface appropriately	Experimentation	P	
6	Placing the paper on the lower leaf surface appropriately	Experimentation	P	
7	Holding the control experiment paper carefully with forceps without touching it with bare hands	Experimentation	P	
8	Securing slides with rubber bands	Experimentation	P	
9	Recording time for upper surface	Communication		
10	Recording time for lower surface	Communication		
11	Recording time for paper held in the hand	Communication		
12	Aim of experiment	Interpreting data		
13	Explaining the difference in results of upper and lower surface	Inference Inference Inference		
14	Why not hold the paper with bare hands	Inference		
15	Seeing the pink colour on the paper: - On the upper surface	Observation	P	
	- On the lower surface	observation	P	
	- paper held in the hand	observation		
16	Role of the paper held in the hand on petri dish	Interpreting data		
P =	Stands for what will be scored as the	learners manipulate		

APPENDIX IV: Marking Scheme of the Biology Practical Exercise

Question 1

S.No.	**Answer/behaviour expected**	**Maximum score**	**Student's score**
a	Correct measurements in cm or mm: -length(10 – 20 cm) and breadth (2-5 cm)	1mk	
b (i)	Upper epidermis dark green while lower epidermis light green	1mk	
ii	Palisade tissue which has many chloroplast is closer to upper epidermis; the palisade tissue is a distance from lower epidermis hence the lighter green color	2mk	
p	The cut section should be thin	1mk	
p	Proper mounting of thin section on the slide	1mk	
p	Addition of only one drop of iodine on the section	1mk	
p	Placing of the cover slip at an angle using mounting needle	1mk	
p	During observation hand lens to be moved from specimen on the table and not vice versa	1mk	
c	- diagram drawn using sharp/fine pencil	1 mk	
	- continuous lines on diagram	1mk	
	- diagram to occupy at least ¾ of drawing space provided	1mk	
	- Correct spelling and labeling of Epidermis, xylem, phloem, pith and cortex(1/2 mk each)	2mks	
d (i)	Has vascular bundles to transport water and food material	1mk	
ii	To minimize transpiration	1mk	
iii	To hold the leaf in strategic position for photosynthesis	1mk	
e (i)	Dicotyledonous (Must start with a capital letter)	1mk	
ii	1. Presence of pith 2. Xylem and phloem arranged on a ring	2mks	
f (i)	To make cells turgid / wet	1mk	
ii	- To make cell structures visible/clear	1mk	
iii	- For light to pass through	1mk	
	TOTAL FOR QUESTION 1	**22**	

QUESTION 2 Marking scheme

S.No.	Activity	Maximum score	Student's score
p	Timing duration for Upper surface and lower surface	1mk	
p	Timing for paper held in the hand on petridish	1mk	
p	Paper held carefully in the hand on a petridish	1mk	
p	Cobalt(II) chloride paper placed on the lower and upper leaf surface appropriately and carefully	1mk	
p	control experiment paper being held carefully with pair of forceps without touching it with bare hands	1mk	
p	Securing slides with rubber bands	1mk	
a	Aim: To investigate the rate of transpiration from a leaf surface	1mk	
b	Recorded time for upper surface (2-5 minutes)	1	
	Recorded time for lower surface (6-15 minutes)	1	
	Recorded time for paper held in the hand on a petridish	1	
c)	The lower surface has more stomata than the upper surface; therefore, the many stomata on lower surface led to higher transpiration than the upper surface; hence (the water vapour) caused change of colour of (Cobalt (II)chloride paper) earlier on the lower surface before upper surface;	3mks	
d	This was the control experiment (to be compared with the results of the experiment at the end)	1	
e	The moisture from the body/hands(perspiration) will wet and react with the Cobalt (II) chloride paper	1mk	
p	Learner able to see the pink colour on the Cobalt (II) chloride paper: - On the upper surface and lower surface - Held in the hand – no pink colour will be seen	2mk	
	TOTAL FOR QUESTION 2	**18mks**	

APPENDIX V: Confidential List of Requirements for the Practical

Each student will require the following for the purpose of this study practical activity:

1. A stop watch
2. A 30cm ruler
3. 1 ml Iodine solution
4. A scalpel or razor blade
5. A hand lens
6. A microscope glass slide
7. A cover slip
8. A dropper
9. Leafy shoot
10. Anhydrous Cobalt (II) chloride paper
11. 4 Microscope glass slides
12. 6 Elastic bands
13. Cello tape
14. 1 Pair of forceps

APPENDIX VI: Biology Achievement Test (BAT)

Dear Participant,

I am a PhD student at Kisii University undertaking a research on, **'**Influence of students' Biology practical process skills' competency on their achievement in and attitude towards Biology in Gucha South sub-County, Kisii County, Kenya.' The researcher has identified you to participate in this study. This test is to assist the researcher in the assessment of academic achievement of students in Biology. The researcher assures you that, a high level of anonymity and confidentiality of this information shall be adhered to both during analysis and reporting of findings. Kindly answer all the questions honestly. Welcome!

Biodata

Name of your School: …………………

What is your gender? Male ( ) Female ( )

What is your Age? ………….. years old

INSTRUCTIONS TO THE PARTICIPANT

1. This paper contains 20 question items. Kindly answer **ALL** questions in this paper.
2. Read each question carefully, then read through the four possible answers A, B, C and D provided and choose the most suitable response by circling it.
3. Please, do not circle more than one answer on a single question item.

QUESTIONS

1. What is the role of a midrib on a leaf?
   A. It's the site where chlorophyll is manufactured
   B. It has stomata through which the plant loses water during transpiration
   C. Enables transport of material to and from the leaf
   D. It contains enzymes responsible for the process of photosynthesis

2. In the process of preparation of a temporary slide what is main reason of using a sharp scalpel/ razor blade?
   A. To that the section is cut easily without any difficulty
   B. To get the required thick section
   C. To be careful so that it does not cut the one using it which may cause bleeding
   D. To avoid distorting the cells and cell structures

3. What is the importance of staining a section before observing it under the microscope?
A. To make the structures more visible and distinct
B. To kill any micro-organism on the section
C. To make is appear coloured
D. To remove stains from it that may have remained while cutting it

4. In what tissues is water conducted in the plants?
A. Phloem and xylem
B. Xylem and root hairs
C. Xylem vessels and tracheids
D. Phloem and root hairs

5. What is the difference between Monocotyledonous and Dicotyledonous leaves?
A. Monocotyledon leaves have a pointed apex while dicotyledonous leaves have a rounded apex
B. Monocotyledon leaves have network veins while dicotyledonous leaves have parallel veins
C. Monocotyledon leaves do not have a petiole while dicotyledonous leaves have a leaf sheath
D. Monocotyledon leaves have parallel veins while dicotyledonous leaves have network veins

6. What is the meaning of the term transpiration?
A. Process by which plants lose water in form of water vapour to the atmosphere
B. Process by which plants take out harmful wastes such as CO_2 through the stomata
C. Process by which plants lose water from the leaf to the atmosphere through the stomata
D. Process by which plants make their own food in presence of sunlight and chlorophyll

7. What is the name of the opening through which water leaves the leaf of a plant?
A. Guard cell
B. Pore
C. Stoma
D. Lenticel

8. When transplanting seedlings, it is advisable to remove some of the leaves. Explain?
A. To reduce the nutrients that the plants up just after transplanting that may cause death
B. To protect the plant from attack by leaf eating insect pests
C. To facilitate easy process of transplanting since many leaves may hinder the process
D. So as to lower the rate of transpiration after transplanting which otherwise may cause wilting and drying

9. How does the arrangement of vascular bundles in a stem of a dicotyledonous plant differ from those of Monocotyledonous stem?
   A. In dicots xylem and phloem are scattered while in monocot they are on a ring
   B. In dicots they are scattered while in monocot they are on a ring
   C. In dicots xylem and phloem are on a ring while in monocot they are scattered
   D. In dicots xylem forms a star-shape with phloem in its arms while in monocots they alternate

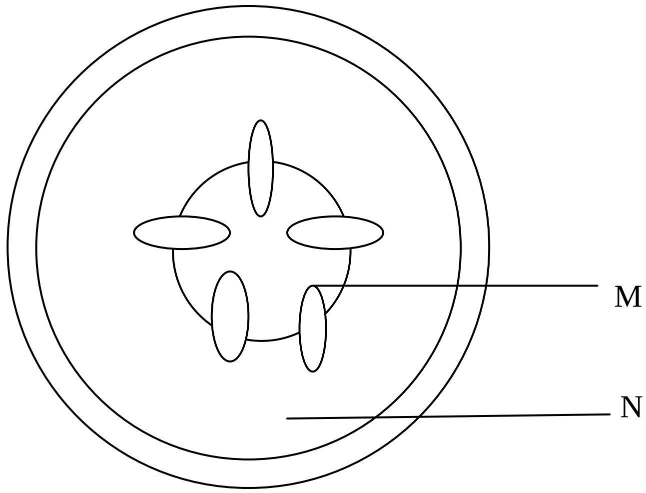
10. Root hair cells in a plant are responsible for the following roles in the plant.
   A. Provide strong support to the plant
   B. Site for storage of food material
   C. Transports water and mineral salts up the plant
   D. Absorption of water and mineral salts from the soil to the plant

11. Under what condition does a plant take in more water from the soil than the water being lost through the leaves?
   A. When the environmental temperatures are too high
   B. When the light intensity is very low
   C. When there is a lot of water in the soil for plants to take in
   D. When the plant is damaged or cut accidentally

12. There are generally few stomata on the upper leaf surface compared to the lower surface so as:
   A. To protect the delicate inner parts of the leaf from direct sunlight
   B. To reduce the amount of water loss through the leaves
   C. To increase the amount of gasses being exchanged through the upper surface
   D. To increase the rate of transpiration

13. What type of cell in plants is responsible for water absorption from the soil?
   A. Root
   B. Xylem
   C. Root hair
   D. Phloem

14. The diagram below shows a transverse section of a young plant. Study it and answer questions 14, 15 and 16



From which plant organ was the section obtained from?

A. Dicotyledonous stem
B. Monocotyledonous root
C. Dicotyledonous root
D. Monocotyledonous stem

15. What is the function of the part labeled M?
    A. Storage of food
    B. Transport of water and mineral salts
    C. Storage of water and mineral salts
    D. Protects the internal delicate parts

16. Identify the part labeled N
    A. Xylem
    B. Pith
    C. Root
    D. Cortex

17. Below are sites through which plants lose water, which one is not?
    A. Lenticel
    B. Guard cell
    C. Stomata
    D. Cuticle

18. Which one of the following is not a significance of transpiration in plants?
    A. Responsible for turgor pressure in plants
    B. Protects plant cells from bursting due to excess water
    C. Helps to cool the plant especially in hot conditions
    D. Enables removal of excess water from the plant

19. Name the instrument used to measure the rate of transpiration

A. Transpirometer
B. Hygrometer
C. Respirometer
D. Potometer

20. It was observed that in a certain tree plant (*Croton spp)* all the leaves were shed when the dry season was about to begin. Explain the main reason for this observation?

A. To reduce the amount of water vapour leaving the plant
B. To provide manure to the soil for the tree to get more nutrients
C. To reduce the amount of respiratory gasses getting into and out of the leaf
D. To increase the amount of respiratory gasses getting into and out of the leaf

END

APPENDIX VII: Lesson Modules for the Experimental Groups

Lesson Module 1
Topic: Transport in plants and animals
Sub-topic: Internal structure of the root
Class: Form Two
Duration: 80 Minutes
No of Students: …….

Rationale

Plant cells rely on turgidity for them to offer support. The larger portion of the sap vacuole that maintains the turgidity is water. Plants absorb water and mineral salts from the soil using their roots and specifically root hair cells. The absorbed water and mineral salts needs to be carried/ transported up the plant through the stem. It is therefore necessary for the learners to experience and observe the internal root structures responsible for these functions in the plant of both the class Monocotyledonae and Dicotyledonae. This will make them able to relate the internal structures of the roots to their functions

Objectives

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

1. Differentiate between the transverse section of a monocotyledonous and dicotyledonous roots
2. Name the structure observed in the transverse section of a root
3. State the functions of the structures of the transverse section of a root

Pre-requisite skills and knowledge

Learners should have been exposed to the following concepts that are a foundation to today's lesson. a) Definition of transport
b) Osmosis and cell turgidity

Teaching and Learning Resources

Root of a young maize seedling
A 30cm ruler
1 ml iodine solution
Ascalpel or razor blade
Microscope
A microscope slide
A cover slip
A dropper

References

1. Secondary School Biology Students' Book Two by KLB, Fourth Edition, pgs 2 - 4
2. Longhorn Secondary Biology Form Two by Jacinta Akatsa, Harun Mwaura and Norman Njoroge, pgs 5-7

Steps of the Lesson

Step/Duration	**Teaching activity**	**Learning activity**	**Learning points**
Introduction (10 minutes)	Going over of previous lesson by asking the learners to name: - significance of transport in plants -Material transported in the plant	Giving the significance of transport in plants Naming material transported in the plant	Significance: Material to reach site for use and storage Remove waste from plants Material transported: water, mineral salts, manufactured food
Lesson Development (60 minutes)	-Introduce the lesson objectives -Avails all the material needed for today's lesson -Distributes dicot root to each student - goes through the procedure demonstrating what the learners should do step by step - Ask learners to name internal parts of a root -Teacher uses direct instruction to explain the functions of the structures named -Directs learners to make observations using their eyes through the lens - draws diagram on chalkboard and emphasizes the drawing skills such as: continuous lines, label lines to originate from structure, Start drawing with outline, be neat in drawing. - From the results, learners are guided to interpret them and reach conclusion that the section is from a dicotyledonous plant	-listen and record in their note books -familiarize with the material for the practical - step by step carry out the procedure: -cut a thin cross section of a maize root Place it on a glass slide Using a dropper stain it with one drop of iodine Dry the excess iodine using clean filter paper Using the hand lens observe the section keenly Make a drawing of the section seen and label the parts Answer the questions on the experiment sheet provided	Internal structures of a root: -piliferous layer -Cortex -endodermis -pericycle -vascular bundles - root hairs
Conclusion and evaluation (10 marks)	Ask learners to name: - the parts of the internal structure of a root -give the functions of the parts of the internal structure of a root	-Name the parts of the internal structure of a root -Give the functions of the various named parts of the internal structure of a root	-piliferous layer -Cortex -endodermis -pericycle -vascular bundles - root hairs

Lesson Module 2

Topic: Transport in plants and animals
Sub-topic: Internal structure of the stem
Class: Form Two
Duration: 80 Minutes
No of Students: …

Rationale

Plants manufacture their own food in the leaves through the process of photosynthesis. Water together with mineral salts are absorbed from the soil by plant roots. Manufactured food needs to be translocated from the leaves, through the stem to other plant parts for use or storage. On the other hand, the absorbed water and mineral salts needs to be carried/ transported up the plant through the stem. It is therefore necessary for the learners to experience and observe the structures responsible for these functions in the plant stems of both the class Monocotyledonae and Dicotyledonae.

Objectives

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

1. Differentiate between the transverse section of a monocotyledonous and dicotyledonous stem
2. Name the structure observed in the transverse section of a stem
3. State the functions of the structures of the transverse section of a stem

Pre-requisite skills and knowledge

Learners should have been exposed to the following concepts that are a foundation to today's lesson:

1. Definition of transport
2. Absorption of water and mineral salts by the roots
3. Photosynthesis process

Teaching and Learning Resources

Petiole of a mango leaf
A 30cm ruler
1 ml iodine solution
Ascalpel or razor blade
A hand lens
A microscope slide
A cover slip
A dropper

References

1. Secondary School Biology Students' Book Two by KLB, Fourth Edition, pgs 5 - 8
2. Longhorn Secondary Biology Form Two by Jacinta Akatsa, Harun Mwaura and Norman Njoroge, pgs 8-10

Steps of the Lesson

Step/Duration	Teaching activity	Learning activity	Learning points
Introduction (10 minutes)	Going through previous lesson by asking the learners to name: -Structures on internal parts of a root - Functions of stem in plants	Naming structures of the internal parts of a root Naming functions of a stem in a plant	Structures of the internal parts of a root Functions of a stem
Lesson Development (60 minutes)	-Introduce the lesson objectives -Avails all the material needed for today's lesson -Distributes dicot stem to each student - goes through the procedure demonstrating what the learners should do step by step - Ask learners to name internal parts of a stem -Teacher uses direct instruction to explain the functions of the structures named -Directs learners to make observations using their eyes through the hand lens - draws diagram on chalkboard and emphasizes the drawing skills such as: continuous lines, label lines to originate from structure, Start drawing with outline, be neat in drawing. - From the results, learners are guided to interpret them and reach conclusion that the section is from a dicotyledonous plant	-listen and record in their note books -familiarize with the material for the practical - step by step carry out the procedure: -cut a thin cross section of a mango petiole Place it on a glass slide Using a dropper stain it with one drop of iodine Dry the excess iodine using clean filter paper Using the hand lens observe the section keenly Make a drawing of the section seen and label the parts Answer the questions on the experiment sheet provided	Internal structures of a stem: -Epidermis -Cortex -Collenchyma -parenchyma -sclerenchyma -pith -vascular bundles
Conclusion and evaluation (10 marks)	Ask learners to name: - the parts of the internal structure of a stem -give the functions of the parts of the internal structure of a stem	-Name the parts of the internal structure of a stem -Give the functions of the various named parts of the internal structure of a stem	Epidermis -Cortex -Collenchyma -parenchyma -sclerenchyma -pith -vascular bundles

Lesson Module 3

Topic: Transport in plants and animals
Sub-topic: Absorption of water and uptake of mineral salts
Class: Form Two
Duration: 80 Minutes
No of Students: 45

Rationale

Plants require water and mineral salts for various physiological processes. These materials are acquired by the plant through its roots from the soil. Among other things, the water is needed for cooling the plant, dissolving food material, it is a raw material for photosynthesis and also necessary for plant growth and development. The lesson aims at giving learners an experience and chance to observe how the process of movement of these material occurs into the plants.

Objectives

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

1. List the importance of water in plants
2. Describe the process through which water and mineral salts are taken into the plant
3. Set up an experiment to determine the rate of transpiration from the leaf surface

Pre-requisite skills and knowledge

Learners should have been exposed to the following concepts that are a foundation to today's lesson: 1. Definition of the term absorption
2. Cell physiological processes

Teaching and Learning Resources

Potted young bean seedlings
Fountain pen ink
Water
100ml Beakers
Stop watch or clock
Scalpel
30cm Ruler

References

1. Secondary School Biology Students' Book two by KLB, Fourth edition, pg 8
2. Longhorn Secondary Biology Form Two by Jacinta Akatsa, Harun Mwaura and Norman Njoroge, pgs 11-12

Steps of the Lesson

Step /Duration	Teaching activities	Learning activities	Learning points
Introduction (10 minutes)	Recap of lesson by asking: Name the functions of a stem of a plant Name the internal parts of a stem Name uses of water in the plant	Naming the functions of a stem Naming the internal parts of a plant stem Naming use of water in plants	-Epidermis -Cortex -Collenchyma -parenchyma -sclerenchyma -pith -vascular bundles
Lesson development (60 minutes)	-Introduce lesson objectives -Distributes the material to be used in the practical - Goes through the procedure -Tells them how to measure 10 cm height and timing of 50 minutes on stop watch - Leads learners in making observations: presence of blue ink at the cut stem section - Leads learners in interpretation of results in relation to the position of xylem vessels -Directs them in making conclusion that the blue ink in the beaker was absorbed together with water and carried up the plants Explains role of osmosis and active transport in the observation/ experiment -Asks them to keenly record their results -Explains to learners how accurately interpret results and arrive at a conclusion of more stomata on lower surface than upper	-listen and record in their note books -familiarize with the material for the practical - step by step carry out the procedure: -Measure 10ml of ink in one beaker and in the other beaker put 10 ml of water. -In each of the two beakers, add 20 ml of water - Uproot two healthy seedlings from the soil with their roots intact but without soil and place each in the separate beakers containing ink and water. - Start the stop watch - Leave the set up for 50 minutes. - Using a ruler measure a height of 10 cm from the base of the stem on both seedlings and cut using separate scalpels -Observe the cut sections and record your observations for the two set ups	-Absorption of water by the process of osmosis -absorption of mineral salts by the process of active transport
Conclusion and Evaluation (10 minutes)	Review of lesson by asking a learner to: -describe the process of osmosis - Explain the role of the second set up with water only	-Respond to the questions asked by the teacher -Learners take short notes	Osmosis as a process that involves the movement of water molecules -Control experiment

Lesson Module 4

Topic: Transport in plants and animals
Sub-topic: Transpiration
Class: Form Two
Duration: 80 Minutes
No of Students: …..

Rationale

Plants continuously absorb water from the soil through the root hair cells. As the water is absorbed, mineral salts too are taken in. The water while in the plant is important in making it possible for various physiological and metabolic processes to occur. After use, the excess water needs to exit the plant. The purpose of this lesson is to make learners aware that this excess water is lost through the stomata of a leaf. Furthermore, the number of stomata on the lower surface is relatively higher than those on the upper surface. This as an adaptation aims at minimizing excessive water loss from the plant since the lower surface is minimally exposed to direct sunlight or high light intensity as compared to the upper surface.

Objectives

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

1. Outline the significance of transpiration
2. Design an experiment to investigate the rate of transpiration from the leaf surface

Pre-requisite skills and knowledge

Learners should have been exposed to the following concepts that are a foundation to today's lesson:

1. Definition of term transpiration
2. Absorption of water from the soil by plant roots
3. Factors that affect the rate of transpiration

Teaching and Learning Resources

Leafy shoot
Anhydrous Cobalt (II) chloride paper
Glass slide
Elastic bands
Stop watch or clock
Cello tape
Pair of forceps

References

1. Secondary School Biology Students' Book two by KLB, Fourth edition, pgs 15 - 17
2. Longhorn Secondary Biology Form Two by Jacinta Akatsa, Harun Mwaura and Norman Njoroge, pgs 16-18

Steps of the Lesson

Step / Duration	Teaching activities	Learning activities	Learning points
Introduction (10 minutes)	Shows learners acacia leaf and that one of a mango and asks them where transpiration is high and why?	Observe the two leaves and contrast in relation to transpiration. Mention which leaf will have higher rate of transpiration and why	Factors affecting rate of transpiration
Lesson development (60 minutes)	-Introduce lesson objectives -Distributes the material to be used in the practical - Goes through the procedure by demonstrating stepwise what the learners will be expected to do - Gives the precautions to be observed in the experiment - Asks learners to carry out the experiment -shows learners how to adjust, start and stop the stop watch accurately -Asks them to keenly record their results -Explains how to accurately interpret results and arrive at a conclusion of more stomata on lower surface than upper	-listen and record in their note books -familiarize with the material for the practical - step by step carry out the procedure: -Select one broad healthy leaf on a potted plant -Using a pair of forceps pick two large pieces of anhydrous Cobalt (II) chloride paper and quickly place each piece on the two surfaces of the leaf. Immediately start the stop watch and note the colour of the anhydrous Cobalt (II)chloride paper -Quickly cover them with dry glass slides and note the time -Secure the slides into position with elastic rubber bands as shown in the diagram -Separately note the time taken by each of the two Cobalt (II) chloride papers to turn pink. Note the time as soon as the pink spot appears and when the whole paper turns pink -Hold a covered piece of anhydrous Cobalt (II) chloride paper to act as a control. This can be held in the hand with a pair of forceps -Note the time it takes the piece of paper to turn pink in the air. Do not handle anhydrous Cobalt (II)chloride paper with bare hands -Record your results in a table showing time taken by anhydrous Cobalt(II)chloride paper to turn pink while in air or above water, under leaf surface and above leaf surface	-Number on the upper epidermis and lower epidermis -Relationship between numbers of stomata and the rate of transpiration
Conclusion and Evaluation (10 minutes)	Ask the learners to explain why the Anhydrous Cobalt (II) chloride paper should not be held with bare hands.	-Respond to the question asked by the teacher -Learners take short notes	Perspiration from the hand

APPENDIX VIII: List of Secondary Schools in Gucha South Sub-County

SCHOOL CATEGORY	S. No.	NAME OF SCHOOL	No. OF STREAMS
EXTRA COUNTY			
	1.	TABAKA BOYS	3
	2	ST. JOSEPH'S NYABIGENA BOYS	4
	3	NDURU GIRLS	3
COUNTY			
	1	NDURU BOYS	3
	2	RIOSIRI SEC*	3
	3	NYANGWETA SDA*	3
	4	MONIANKU*	3
	5	IKOBA*	1
SUB-COUNTY			
	1	NYAKORERE PAG	2
	2	NYAKEMBENE	1
	3	OMOBIRI	1
	4	KIABIGORIA	2
	5	NYAMUE	2
	6	RAMOYA	1
	7	ST. JOSEPH'S KIORORI	1
	8	NYAMONARIA	3
	9	MARONGO	2
	10	NYACHENGE	2
	11	GOTICHAKI	1
	12	IBRAHIM OCHOI	1
	13	TABAKA TOWNSHIP	1
	14	AMAIKO	2
	15	NYANGO	2
	16	KIAGWARE	2
	17	MUMA	3
	18	NYAMONDO	1
	19	NDONYO	3
	20	MARIWA	3
	21	ST. LINUS ETAGO	1
	22	ST. PETER'S NYANGWETA	2
	23	NYABINE DEB	2
	24	RIAGUMO	2
	25	KARUNGU	1
	26	ST. ALPHONCE NYABINE	2
	27	BOGICHONCHO	2
	28	MAROO ESINDE	1
	29	NYASASA	1
	30	NCHORO	1
	31	NYATWONI	1
	32	MESOCHO	1
	33	NYAIMERA	2
	34	NYAKEYO	1
	35	AYORA	1
	36	MOTICHO GIRLS	1
	37	GIASOBERA	1
	38	KIENDEGE	1
	39	NYABIGENA GIRLS	2
PRIVATE			
	1	MERCY BAPTIST	1
TOTAL NUMBER OF SCHOOLS = 48			

*Schools that were sampled to take part in the study

APPENDIX IX: Biology Teachers Training Programme

PROGRAMME FOR INDUCTION TRAINING OF BIOLOGY TEACHERS PARTICIPATING IN THE PHD STUDY BY MR. IMANDA ISAAC ON 1ST MAY, 2019

9:00AM - 9:30AM -Arrival and Registration

9:30AM – 10:00 AM-Introduction

10:00AM – 10:30AM - Purpose and objectives of the study
- Purpose of the induction training
- Expectations during the training

10:30 – 11:00 AM - Tea break

11:00 AM -1:00 AM - Lesson planning
- Science teaching approaches
- Biology practical process skills Approach

1:00 PM – 2:00 PM - Lunch Break

2:00 PM – 3:00 PM - Discussion on Teaching using the specific science process skills

3:00PM – 4:00 PM - Presentation of a sample lesson using Biology Practical Process Skills Approach

4:00PM -4:30 PM - Summary of session, Closing Remarks and Questions

4:30PM – 4:50 PM - Tea break

4:55 PM - Departure at own pleasure

Thank you for your attendance and active participation!!

APPENDIX X: Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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

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

Ref: No. **NACOSTI/P/19/42215/30350**

Date: **30th May, 2019.**

Isaac Imanda Christopher
Kisii University
P.O Box 408-40200
KISII

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"An investigation of students' Biology practical process skills' competency on their achievement in biology in Gucha South, Kisii County, Kenya."*** I am pleased to inform you that you have been authorized to undertake research in **Kisii County** for the period ending **23rd May, 2020.**

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

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

BONFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:
The County Commissioner
Kisii County.

The County Director of Education
Kisii County.

National Commission for Science, Technology and Innovation is ISO9001:2008 Certified

APPENDIX XI: Research Permit

THIS IS TO CERTIFY THAT:
MR. ISAAC IMANDA CHRISTOPHER
of KISII UNIVERSITY, 24-40206
NYAMARAMBE,has been permitted to
conduct research in *Kisii County*

Permit No : NACOSTI/P/19/42215/30350
Date Of Issue : 30th May,2019
Fee Recieved :Ksh 2000

on the topic: *AN INVESTIGATION OF STUDENTS' BIOLOGY PRACTICAL PROCESS SKILLS' COMPETENCY ON THEIR ACHIEVEMENT IN BIOLOGY IN GUCHA SOUTH, KISII COUNTY, KENYA*

for the period ending:
23rd May,2020

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
5. The License does not give authority to transfer research materials.
6. NACOSTI may monitor and evaluate the licensed research project.
7. The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.

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REPUBLIC OF KENYA

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RESEARCH LICENSE

Serial No.A 25070

CONDITIONS: see back page

APPENDIX XII: Journal Publication Evidence

JRIIE Journal of Research Innovation and Implications in Education

Center for Research Implications & Practice

Website: www.jriie.com

ISSN 2520-7504 (Online) Vol.4, Iss.4, 2020 (pp. 1-13)

Contribution of Learners' Biology Practical Process Skills' Competency on Their Achievement in Biology

Isaac Christopher Odawa Imanda, Dr. Ezekiel Omwenga, Dr. George Andima & Dr. Enock Obuba

Kisii University

Email: imanda2020isaac@gmail.com

Received October 10, 2020; Reviewed October 17, 2020; Accepted October 19, 2020

Abstract: *This study aimed at determining contribution of learner competence in six Biology practical process skills on form two learners' achievement in Gucha South sub-County, Kisii County in Kenya. Solomon's four non-equivalent control group design was used. The objectives for the study were: To determine the contribution of Biology Practical Process Skills Teaching Approach (BPPSTA) to learners' achievement in biology and to establish the gender difference in achievement among learners taught using BPPSTA. The study was guided by Constructionism theory as proposed by Seymour Papert. The sample size comprised of 401 form two students out of a target population of 2,946. Data was collected using Biology Practical Observation Schedule (BPOS), Process Skills Assessment Test (PSAT) and Biology Achievement Test (BAT). Means and standard deviations were used to compare the group performances then one-way ANOVA and t-test at α = 0.05 significance level were used to test the hypotheses. The study found that BPPSTA positively contributed to learner achievement with males significantly achievement higher than females. It is concluded that BPPSTA led to an improved learner attainment in biology however, this performance did vary by gender. The study findings may provide insights to the Biology teachers on the appropriate improvement in the administration of practical activities in Biology lessons. The study recommends that biology instruction should lay emphasis on the use of BPPSTA with a greater effort being put in place to engage the female learners*

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Influence of Learners' Practical Process Skills' Competency on Their Attitude towards Biology

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Dr. George Morara Andima
Lecturer, Department of Curriculum Instruction and Media, Kisii University, Kenya
Dr. Enock Obuba
Lecturer Department of Curriculum, Instruction and Media, Kisii University, Kenya

APPENDIX XIII: Plagiarism Report

INFLUENCE OF STUDENTS' "BIOLOGY PRACTICAL PROCESS SKILLS" COMPETENCY ON THEIR ACHIEVEMENT IN AND ATTITUDE TOWARDS BIOLOGY IN GUCHA SOUTH SUB-COUNTY, KISII COUNTY, KENYA

ORIGINALITY REPORT

18%	17%	6%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Kisii University Student Paper	1%
2	mafiadoc.com Internet Source	1%
3	my.unisa.ac.za Internet Source	1%
4	Submitted to Mount Kenya University Student Paper	1%
5	files.eric.ed.gov Internet Source	1%
6	mjltm.org Internet Source	<1%
7	erepository.uonbi.ac.ke Internet Source	<1%
8	Submitted to Kenyatta University Student Paper	<1%

Appendix XIV: Student Participant Consent Form

12/05/2019

This is to consent that, ………………………………………… of …………………. high/secondary school in form/class …………………… will voluntarily participate as a participant in a study titled, **'**an influence of students' Biology practical process skills' competency on their achievement in and attitude towards Biology in Gucha South sub-County, Kisii County, Kenya.' The researcher will treat all the information collected from the participants in this study with high level of confidentiality. Anonymity will strictly be adhered to during analysis and reporting of the data.

Signed by Biology Subject Teacher:

Sign: …………………….…… Date: ………………

Name of Teacher: …………………………………………

Thank you so much for your acceptance and cooperation
Imanda Isaac (Mr.)
Ph.D Student
Kisii University

APPENDIX XV: Goals of Education in Kenya

1. Foster nationalism, patriotism and promote national unity
2. Promote social, economic, technological and industrial needs for national development
3. Promote individual development and self- fulfillment
4. Promote sound moral and religious values
5. Promote social equality and responsibility
6. Promote respect for and development of Kenya's rich and varied cultures
7. Promote international consciousness and foster positive attitudes towards other nations
8. Promote positive attitudes towards good health and environmental protection

APPENDIX XVI: Objectives of Teaching Biology in Secondary Schools in Kenya

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

1. Communicate biological information in a precise, clear and logical manner

2. Develop an understanding of interrelationships between plants and animals and between humans and their environment

3. Apply the knowledge gained to improve and maintain the health of the individual, family and the community

4. Relate and apply relevant biological knowledge and understanding to social and economic situations in rural and urban settings

5. Observe and identify features of familiar and unfamiliar organisms, record the observation and make deductions about the functions of parts of organisms

6. Develop positive attitudes and interest towards Biology and the relevant practical skills

7. Demonstrate resourcefulness, relevant technical skills and scientific thinking necessary for economic development

8. Design and carry out experiments and projects that will enable them understand biological concepts

9. Create awareness of the value of cooperation in solving problems

10. Acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific fields.