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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

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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 $\alpha = 0.05$ 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 more.*

Key words*: Contribution, Competency, Biology practical process skills, Achievement*

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1. Introduction

The teaching approach adopted by a teacher is a strong factor that affects learners' motivation to learn and hence influences their attainment (Imanda, Okwara, Murundu, & Bantu, 2014; Andima, 2014). The commission on science education of the American Association for the Advancement of Science (AAAS) in their programme "Science A Process Approach (SAPA)," emphasise the laboratory method of instruction and learning of scientific processes. The programme categorises science process skills(SPS) into two: basic and integrate (Science Community Representing Education [SCORE] (2008). According to AAAS the basic science process skills comprise of: observing, inferring, measuring, communicating, classifying and predicting while the integrated science process skills comprise of: controlling variables, defining operationally, formulating variables, interpreting data, experimenting and formulating models. Aslan (2015) notes that SPS are not only important in preparing future scientists and technologists, but also for the whole population who need scientific literacy. Science process skills are defined as lifelong learning processes that form the basis for analytical thinking, creating knowledge by principles of "learning by doing" useful for problem solving (Aslan, 2015). Similarly, SCORE (2008) concluded that science without practical is like swimming without water. The implication from this analogy therefore is that science learning is not complete without practical activities. Sadhana (2017) observes that practical

learning should be promoted and rote learning should be discouraged. Practical learning therefore becomes more permanent, meaningful and concrete. The purpose of learning science at an 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 learners to effectively cope up with the demands for further education and achievement. Biology is one of the science subjects in which learners require to develop skills that will enable them to be relevant in the scientific world.

It is however noted that teachers continue to use traditional approaches to science instruction. For instance, Obiekwe (2008) observes that all is not well with science instruction in Nigerian secondary schools, and notes that science teaching lays extreme emphasis on content and the use of "chalk and talk" method neglecting the use of practical activities which enhance effective learning. This negligence and minimum practice of activity oriented-method in teaching biology has led to abstraction, which makes the students less active and more involved in rote memorization. Molefe and Michele (2014) in a study on science teacher educators' views and practice regarding science process skills carried out in South Africa, observe that the national education policy documents for initial teacher education places great emphasis on teachers' competence 'in the knowledge, skills, values, principles, methods and procedures relevant to the phase, subject, discipline or practice' (Department of Higher Education and Training, 2011, p. 49). Although the documents do not exclusively refer to SPS; it is embedded in the aforementioned methods and procedures. Science process skills are key in the learning process. The biology practical process skills that were explored in the present study will play a key role in ensuring effective understanding of biological principles, concepts, skills and attitudes.

Many studies continue to show that most science teachers are still consistently teaching science subjects with the traditional expository methods, basically the lecture method. The claim of such teachers is that this methodology enables a wider coverage of syllabus (Ona, 2007; Imanda, et al., 2014). Adoption of the practical activities in the classroom environment plays a key role in demystifying biology, which is one of the sciences and enhancing its understanding by the learners. Arokoyu and Chukwu (2017) found out that teachers' methods of teaching should be student-centered with more science processes since this will enhance biology students' assimilation and performance in both internal and external examinations.

Students' performance in Kenya Certificate of Secondary Education (KCSE) Biology examination has been poor over the years. Specifically, 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 to date. This is as shown in Table 1.

Table 1: 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	D+
Average		**30.92**	**D+**

Table 1 indicates that in all the years presented, the average mark attained by the learners is low. The year that the subject registered the highest mean in the sub County was 2013 of 35.97%. Ngakhala, Toili and Tsingalia (2017) argue that the poor results in Biology practical in Lugari sub-County, Kakamega County, Kenya, may be due to poor teaching approach and lack of learners' exposure to the required practical knowledge that should guide them for success in the higher class levels. KNEC (2018) reports that across the three biology papers (paper 1, 2 and 3), questions that required an extra effort from candidates to comprehend, interpret, infer (from a diagram, a photograph, a process and data) were poorly performed as compared to questions that were straight-forward. This might be as a result of less emphasis by biology teachers on development of biology practical process skills and critical thinking skills. These skills are lifelong hands-on experiences that learners engage in during biology instruction. Process-based instruction focuses upon developing students' independence in learning and problem solving by providing a framework into which curriculum activities can be placed (Eila, Irmeli, & Eija, 2016). The skills are acquired when the learners are given an opportunity to manipulate and interact with realia. Low learner attainment in biology has continued despite the emphasis placed on the use of learner centered instructional methodologies. Gender disparity in academic achievement has also consistently been observed, especially when teacher-centered methodologies are used in the biology classroom. This

paper presents the findings of a study on the effect of using BPPSTA on learners' academic achievement in biology.

The study was guided by the following two specific objectives: To determine the contribution of Biology Practical Process Skills Teaching Approach (BPPSTA) to learners' achievement in biology in Gucha South sub-County and to establish the gender difference in achievement among learners taught using BPPSTA and those taught using conventional method.

1.1 Research Hypotheses

This study was guided by the following two research hypotheses: $H0_1$: There is no significant difference in achievement between learners taught using BPPSTA and the conventional method. $H0_2$: There is no significant difference in academic achievement in biology among male and female learners taught using BPPSTA?

1.2 Theoretical Framework

This study was guided by the constructionism theory as proposed by Papert (1991). Constructionist learning is when learners construct mental models to understand the world around them. This theory suggest that learners learn meaningfully when they are involved in activities that engage them to construct their own knowledge. Further, constructionism holds that learning can happen most effectively when people are active in making tangible objects in the real world (Alesandrini & Larson, 2002). According to Papert, knowledge, even in adult experts, remains essentially grounded in contexts and shaped by its use. Constructionism theory guided this study in as far as the practicing of the skills by the learners is concerned, especially now that it occurred in the laboratory. The BPPS under study will be well learnt if the hands-on activities are embraced specifically in the laboratory just as Papert emphasizes that learning should be in situ or in context.

2. Literature Review

2.1 Practical Process Skills Influence on Achievement in Biology

Science teaching involves the content and process components of science. Underestimating content over process or process over content is unacceptable, both are equally important. Content consists of subject matter and science concepts while process consists of essential skills that students need to gain. Acquisition of science process skills helps learners understand science concepts better than the rote learning practiced by most science teachers in schools (Ekon & Eni, 2015). 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). According to Connell, Donovan and Chambers (2016) active learning pedagogies have an aim of improving science environments towards increased learner-centered teaching so that the learners are more engaged in the process of constructing knowledge. Sadhana (2017) from another study found out that practical instructional approaches with emphasis on science processes result in to understanding of scientific concepts and principles.

Many educators consider the development of SPS in children to be a major objective of education (Aslan, 2015). These skills are important not only in terms of preparing future scientists and technologists, but also for the whole population who need scientific literacy in order to live and function in a world where science impinges on most aspects of personal, social and global life. SPS are a lifelong learning process that forms a basis for analytical thinking, creating knowledge by principles of 'learning by doing' used for problem solving (Aslan, 2015). Ekon and Eni (2015) opine that effective instruction arising from the use of activity-based methods and approaches during learning influences students' acquisition of science process skills and ultimately results to higher academic achievement. The modern method of science teaching does not only involve the understanding of facts, concepts and principles (product) but it also involves the understanding of the way this knowledge is obtained such as observing, measuring, classifying, collecting data, experimenting (process) (Ona, 2007). The questionnaire was used as the main data collection instrument. The present study on the other hand, in addition to questionnaires, it also subjected the respondents to a test that was analysed quantitatively.

In the present study six skills (observing, measuring, communication, inferring, interpreting data and experimenting) were selected. The choice of these six process skills was informed by a study by Ongowo and Indoshi (2013). From the findings of their study on, science process skills in the KCSE biology practical examinations, it is evident that the 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 adopted for this study. Unlike in their study where they focused on analyzing the science process skills in KCSE examination, the present study on the other hand was concerned with the actual practice of the process skills in the classroom during biology instruction. From another study Gituthu (2014) concluded that learner-centered instructional strategies had influenced students' biology achievement in KCSE. Gacheri and Ndege (2014) conducted their study on science process skills application

in practical assessments in Maara district secondary schools, in Tharaka Nithi County in Kenya. The findings of the research showed that most of the schools in Maara district do not adequately test students in science process skill in biology practical examination. Analysis of KCSE biology practical examinations showed that drawing and measurement skills are not adequately tested. Students are also rarely given biology practical tests in schools. In this study however, the authors failed to empirically relate the poor performance to the inadequate practice of science process skills. Furthermore, it is evident that this study used biology KCSE results of past year and associated them with the claims of students currently in school. The present study filled this gap by using classroom observations and teacher-made test administered to the same respondents. This enabled the researcher to attribute learner achievement to the methodology used during instruction in the present study.

2.2 Gender Influence on Learner Achievement after Instruction via BPPSTA

Gender is a socially ascribed attribute which differentiates feminine from masculine (Okoye, 2016). Gender is a determinant of social outcome and cannot be separated from biology or from other social, cultural, ethnic, age and economic class (Owoewe & Agbaje, 2016). One of the millennium development goals (MDGs) is gender equality (Odagboyi, 2015. Nwona and Akogun (2015) noted imbalance against women in Science, Technology Engineering and Mathematics (STEM). The continued difference in biology achievement as a result of gender has caused a lot of concern to education stakeholders. Eddy, Brownell, & Wenderoth (2014) observes 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 are often influenced by a myriad of factors, including the instructional methods. The underrepresentation of females in science related subjects and careers has led feminist scholars to deduce that, science as practiced in the world is 'gendered' and that it is used to the benefit of 'male world.' Both globally, regionally and locally, gender inequality and inequity in participation and performance in STEM has produced inconclusive results (Bassey, Joshua, & Asim, 2011).

There are conflicting research findings emanating from studies on gender influence on learner academic achievement in biology (Dania, 2014; Okoye, 2016; Owoewe & Agbaje, 2016). Abungu, Okere, & Wachanga (2014) came up with study findings that indicate a significant difference in academic achievement of learners in chemistry after undergoing instruction via the science process skills approach; the boys outperformed girls in the achievement test. Despite the fact that chemistry and biology are both science subjects, each subject has its inherent tenets especially in terms of content and methodology. Such inherent variations make it necessary to determine the status for the case of biology.

Odagboyi (2015) observes that if girls come to school with a cultural image and attitude that boys are superior to girls, it might affect their zeal to learn. The study further revealed that the mean score of boys in biology was statistically higher than that of the girls in the post-test yet in the pre-test there was no significant difference. The study therefore concluded that the jigsaw method that was under study led to greater gain by boys than girls in the biology test. Mwanda, Odundo, Midigo, and Mwanda (2016) from their study found out that girls' classes had a greater academic gain when constructivist teaching approach was used in Biology. Their study focused on the form three biology topic: ecology. Achor, Odoh, and Abakpa (2018) from a study whereby the students were taught Biology concepts using laboratory strategy and expository method, revealed 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) in their comparison study, found no significant difference between the performance of boys and girls. These results are in conformity with those by Oduosoro (2011) who found no significant difference between the performance of boys and girls. Owoeye and Agbaje (2016) from their study concluded that there was no significant relationship in the students' gender and students' academic performance in biology. Okoye (2016) carried out a study on the influence of gender and cognitive styles on students' achievement in biology and found out that gender and cognitive styles had no significant influence on achievement scores of students in biology. Dania (2014) revealed that gender composition has no significant relationship with students' academic performance.

The 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. Furthermore, the present study focused on the form two biology topic: Transport in plants and animals.

3. Methodology

This study adopted the Solomon Four Non-Equivalent Control Group Design (Gall, Borg and Gall, 2007). This design allows the researcher to reduce the influence of confounding variables and enables to test whether the pre-test has an effect on the respondents (Mugenda &

Mugenda, 2009). The design was administered as illustrated in Table 2.

Table 2: Groups in the Solomon Four Non-Equivalent Control Group Design

GROUP	Pretest	Treatment	Posttest
E1	O_1	X	O_2
C1	O_3	-	O_4
E2	-	X	O_5
C2	-	-	O_6

Table 2 indicates that, this design encompasses four groups; two experimental groups (E1 and E2) and two control groups (C1 and C2). The experimental treatment involved form two students in groups E1 and E2 being taught by their usual biology teachers who had undergone an induction training on use of BPPSTA. On the other hand, learners in groups C1 and C2 were taught with the conventional teaching approaches by their respective biology teachers. Learners in C1 responded to a pretest BAT then they were not subjected to the treatment and finally after eight weeks a posttest BAT was administered to them. All learners in the four groups; E1, C1, E2 and C2 had a posttest administered to them.

Purposive sampling technique was used to select all the four co-educational County level secondary schools in Gucha south sub-County. County schools were used in the study since students admitted to these schools had comparable academic abilities arising from the form one selection process after the Kenya Certificate of Primary Education (KCPE) examination. Four co-educational County level secondary schools were selected due to the nature of the research design; Solomon Four Non-Equivalent Control Group Design. Purposive sampling technique was then used to select all the form two learners in the four county level co-educational schools. This study made use of three data collection instruments: namely; Biology Practical Observation Schedule (BPOS), Process Skills Assessment Test (PSAT) and Biology Achievement Test (BAT). Pilot study was conducted before the actual study in one of the County level co-educational schools in the neighbouring Gucha sub-County. The PSAT was designed by the researcher by adapting most questions from the past KCSE biology examinations; so as to increase test internal validity. The BPOS was validated in line with the expectations of the question items that were in the PSAT. The multiple choice question items in the BAT were validated by senior lecturer of measurement and evaluation. Reliability of the questionnaire was determined through split-half method (Gall et al, 2007) to a sample of 20 form two students from one County level co-educational school in the neighbouring Gucha sub-County. A coefficient of r = 0.87 and 0.84 for BAT and PSAT respectively were obtained indicating a high reliability level of the research instruments.

The data collected from this study was analysed using both descriptive and inferential statistics. The quantitative data emanating from the pre-test and post-test 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 Sample t-test. This analysis was aided by use of Statistical Package for Social Sciences (SPSS) version 22. Various group means comparisons were done using t-test at $\alpha = 0.05$ level of significance. Data was presented by use of tables.

4. Results and Discussion

The results are presented in this section on the basis of the two objectives that guided this study**.**

Objective 1: Achievement of Learners Taught Using BPPSTA and the Conventional Methods

In an effort to establish the contribution of BPPSTA to learners' achievement, BAT and PSAT were administered and the data thereafter analysed. The mean score attained from the data from the BAT done by the students who had been taught using the BPPSTA and the conventional learning methods is presented in Table 3.

Table 3: Descriptive Statistical Analysis of Learners' BAT Scores of the Study Groups

Group	Pretest/Posttest	Mean	N	SD
Experimental group - 1(E1)	Pretest	17.07	119	5.988
	Posttest	24.71	119	6.391
Control group - 1(C1)	Pretest	16.38	64	5.929
	Posttest	17.41	64	5.959
Experimental group - 2 (E2)	Posttest	23.26	113	5.184
Control group - 2 (C2)	Posttest	17.10	105	4.891

Table 3 presents results from which it is observed that the lowest mean attained was 16.38 by the students in the C1 posttest group. The standard deviation for this group was 5.929. On the other hand, the mean score of respondents in the E1 posttest group is the highest at 24.71 marks with a standard deviation of 6.391. This is one of the two groups whose respondents had been subjected to the pre-test, treatment and finally posttest. In the C1 posttest, a mean score of 17.41 marks was recorded which was lower than that of the experimental groups. It is evident that the experimental groups recorded a relatively higher mean score compared to their control group counterparts in the posttest. The results of the descriptive statistical analysis of the mean marks of the BAT administered to the E1 group as a posttest and the PSAT are presented in Table 4.

Table 4: Descriptive Statistics for BAT in the E1 Posttest Group 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

Table 4 indicates that the mean mark of learners in group E1 for 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 its clear that the mean mark attained in the PSAT is higher than that attained in the BAT. A Pearson correlation analysis was run on the data to find out if the learner attainment in the two tests correlate. Table 5 presents this analysis.

Table 5: Pretest Correlation for BAT and PSAT

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

The Pearson's r value obtained as reflected in Table 5 for the group E1 and group C1 are .839 and .791 respectively. Gall et al (2007) notes that this correlation value implies that there is a strong positive relationship between the marks attained in PSAT and that obtained in BAT for the E1 and C1 pretest groups. Therefore, the marks attained by learners in the practical activity is correlated to the mark a learner attained in the achievement test done. It therefore justifies the essence of using PSAT scores as a predictor of the attainment in the BAT in the present study. Since there were two experimental groups involved in the study, it was necessary to further carry out a correlation analysis between the BAT scores in group E2 posttest and the scores in the PSAT. Table 6 presents the output from the analysis.

Table 6: Posttest Correlation BAT and PSAT

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

The correlation in Table 6 indicates that the scores of learners in the two tests for groups E1 and E2 had correlation value of 0.773 and 0.712 respectively. These values indicate a strong positive correlation between group E1 and E2 posttest scores in the BAT and the scores in the PSAT. This shows that there is a positive relationship between effectiveness of the method on both the practicals and theory paper. Therefore, it implies that the PSAT can be used as a predictor of the performance in the BAT. A one-way ANOVA was further conducted to establish if there was a significant difference in BAT posttests among the four groups as presented in Table 7.

Table 7: One -Way ANOVA Output for the Four Posttest Study Groups for BAT

	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			

From the results in Table 7 it can be observed that (df=3,397; F=48.785, p=.000 < α = 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 was interpreted to mean that the mean of at least two study groups was significantly different. This implies that the BAT posttest scores are not the same for all the four groups. 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 as presented in Table 8.

Table 8: Multiple Comparisons of Posttest Mean Differences between the Four Study Groups Using the LSD

(I)Study Groups	(I)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 8 presents information on multiple comparisons of post-tests mean scores. It shows a significant difference between E1 and C1 mean scores, (p=.000 < α =.05) whereby group E1 attainment was better than that of group C1. Group E1 attainment also was better than that of group C2 (p=.000 < α = .005). There is a significant difference between the E2 and also C2, (p=.000 < α .05) C1, had significant differences with E2 whereby E2 has a higher attainment than C2 (p=.000 < α =.05). The results also show that there was no significant difference between group E1 and E2 (p=.059 > α = .05) and groups C1 and C2 (p= .735 > α = .05). This shows that there was no significant difference between the treated groups and also between the control groups, implying that the BPPSTA is a better teaching approach of biology than the conventional methods. This corroborates 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.

To determine whether the learners score in the BAT in the pretest by experimental group was different from that of the posttest of the same group, descriptive statistics and independent samples t-test were determined. Table 9 presents these findings.

Table 9: Mean and t-test Results in BAT for the Group E1 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			

Maximum score =40

Table 9 show 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 was < .05, it was interpreted to mean that there was a significant difference in the mean attainment of the learners in E1 pretest and posttest group. These results suggest that the increase in the mean attainment of the posttest of the experimental group might be attributed to the intervention that the respondents were subjected to. This is in line with the findings from a study by, Ajaja (2013), that found out large effects of the instructional methods on students' achievement and retention. The higher achievement of students in the constructive learning groups was noteworthy, as was the lower achievement and retention of students in the lecture group. Ngakhala et al. (2017) reiterates that Biology teachers should adopt the learner-centered approach in teaching so that learners may show greater participation in practical activities and learn by self-discovery. Biology teachers should increase the frequency with which they teach practical lessons in their classrooms and laboratory. Furthermore, they should ensure that all Biology practical activities done are discussed to enable learners comprehend and understand the difficult concepts that they were unable to conceptualize.

The mean, standard deviation and independent samples t-test was then conducted with a purpose of comparing the C1 pretest and posttest groups. Table 10 presents the output from the descriptive statistical analysis.

Table 10: Mean, Standard deviation and t-test Results for BAT in C1 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 10 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 the p-value of .328 obtained was > .05, it implies that there was no significant difference in the mean attainment of the males and females in the pretest of the E1 posttest group of BAT. It is important to note that the respondents in the control group were given a pretest BAT then no treatment was subjected to them then later after eight weeks they were again given a BAT to respond to as a posttest. The lack of statistical difference in the means of these two groups directs the researcher closer to the conclusion that the probable cause of a variation in the means of the E1 pretest and the E1 posttest groups can only be attributed to the treatment which involved teaching using the BPPSTA. Imanda et al. (2014) and Arokoyu and Chukwu (2017) notes that teachers' methods of teaching have both positive and negative effects on students' performance in Biology. Chebii (2011), from another study found out, the experimental groups out-performed the control groups. Experimental groups were able to master the selected process skills (experimenting, observation and inferences) better than the control groups. Despite the fact that Chebii's study was in chemistry but the focus was on three process skills which the present study too focused on among other skills. Descriptive statistical analysis and independent samples t-test analysis was carried out on the E1 and the C1 posttest groups. The output from the statistical analysis is presented in Table 11.

Table 11: Mean, Standard deviation and t-test Results for BAT in 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 results in Table 11 indicate 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 of .000 obtained was < .05, it was interpreted to mean that there was a significant difference in the mean attainment of learners in E1 posttest and C1 posttest groups. Therefore, the experimental group outperformed the control group. Annan, Adarkwah, Yawson, Sarpong, & Santiago (2019) found out from their study that the mean posttest scores of the experimental group and control groups used for the study showed a wide significant difference in favour of the experimental group that had been taught using the inquiry method as opposed to the control group that had been taught using 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 was used had a mean achievement score of 72.60% while in the control group in which learners were taught biology using conventional method had a lesser mean score of 53.85%. The study therefore concluded that the experimental group performed better than the control group.

Another comparison was done between E2 posttest and C2 posttest groups. 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 of neither pretest nor chance as the cause for the increase observed in the posttest score of group E1. The results for the descriptive statistics are presented in Table12.

Table 12: Mean, Standard Deviation and t-test for BAT Scores for E2 and C2 Posttest Groups

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			

The results in Table 12 reveal 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, it implies that there was a significant difference in the mean attainment of learners in E2 and C2 posttest groups. These results clearly indicate a difference in the experimental groups as compared to the groups that were not subjected to the treatment. Therefore, it shows that the difference in the mean between the posttest of the experimental 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 biology practical process skills. The ability of the present study to establish a cause and effect relationship as

depicted, agrees with the principle of experimental research (Ajaja, 2013; Okoye, 2016; Omondi, Keraro, & Onditi, 2018). They all agreed that when conducting an experimental research, a treatment must be confirmed to be responsible for any difference noticed in the experimental group. The tests that have been conducted indeed have confirmed so; that it was the BPPSTA which caused the positive change in learner academic achievement in biology tests.

Objective 2: To Establish the Gender Difference in Achievement of Learners Who Learn Using BPPSTA

The second objective focused on establishing whether gender influenced the acquisition of Biology Practical Process Skills (BPPS). Therefore, the researcher was interested in finding out whether male and female learners responded differently on acquisition of BPPSTA. Table 13 summarizes the mean, standard deviation and standard error for the experimental group categories on the basis of gender.

Table 13: Descriptive Statistical Data of BAT for the Various Group Categories by Gender

Group	Gender	N	Mean	SD	Std. Error
Experimental 1- pretest	Male	64	17.697	6.258	.708
	Female	55	16.392	5.510	.743
Experimental 1- posttest	Male	64	24.953	6.501	.813
	Female	55	24.527	6.131	.827
Experimental 2- posttest	Male	50	23.960	4.682	.662
	Female	63	22.505	5.198	.655

The results in Table 13 depict a range of mean scores. The highest mean was 24.953 attained by males in the E1 posttest group while the least mean was 14.872 attained by the females in the C1 pretest group. The highest standard deviation was 6.739 in the females of control group- 1 posttest showing a larger dispersion of learners scores from the mean in this group. The group with the highest standard mean error of 1.191 was the females in the C1 pretest group. Independent sample t-tests were then conducted to determine whether the mean scores by gender in each group category were significantly different. A further comparison of the mean learner attainment in the BAT in the E1 pretest and posttest groups by gender was done. The results are presented in Table 14.

Table 14: A t-test Output for BAT Scores for E1 Pretest Group 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			

The results in Table 14 indicate that there was no significant difference in the E1 pretest mean scores for males (M=17.697, SD=6.259) and females (M=16.392, SD=5.510) in attainment; t(117)=1.874, p=.063. Since the p-value of .063 obtained was > .05, it was interpreted to mean that there was no significant difference in the mean attainment of the males and females in the pretest of the E1 group of BAT. Owoeye and Agbaje (2016) equally obtained similar results from another study and therefore concluded that there was no significant relationship in the learners' gender and learners' academic achievement in biology. A further analysis was conducted on the posttest mean scores of the same E1 group. Table 15 presents the t-test analysis output.

Table 15: Mean, Standard Deviation and t-test for the BAT of the E2 Posttest by Gender

GENDER	N	Mean	SD	df	t-value	p-value
MALE	64	24.953	6.501	117	1.366	.715
FEMALE	55	24.527	6.131			

The results in Table 15 indicate that there was no significant difference in the E1 posttest mean scores for males (M=24.953, SD=6.501) and females (M=24.527, SD=6.131) in attainment; t(117)=1.366, p=.715. Since the p-value of .715 obtained was > .05, it was interpreted to mean that there was no significant difference in the mean attainment of the males and females in the pretest of the E1 posttest group of BAT. These findings concur with those by Ajaja (2013) who found a non-significant difference between males and females on achievement and retention in all the instructional methods under study. In his study the methods under investigation were; 5E learning cycle, cooperative learning and concept mapping.

Results in Table 16 indicate the mean, standard deviation and t-test analysis for E2 posttest group by gender.

Table 16: Mean, Standard Deviation and t-test for the BAT of the E2 Posttest by Gender

GENDER	N	Mean	SD	df	t-value	p-value
MALE	50	23.960	4.682	111	3.241	.062
FEMALE	63	22.505	5.198			

An independent samples t-test was conducted to compare mean scores attained by the male and female respondents in the E2 posttest. The results in Table 16 indicate that there was no significant difference in the E2 posttest mean scores for males (M=23.960, SD=4.682) and the E2 posttest mean scores for females (M=22.505, SD=5.198) in attainment; t(111)=3.241, p=.062. Since the p-value of .062 obtained was > .05, it was interpreted to mean that there was no significant difference in the mean attainment of the males and females in E2 posttest group for BAT. Amoah, Eshun and Appiah (2018) from their study indicate that both male and female learners were performing equally in the skill of observation; the difference was not significant. The findings of this study are in congruence with those by Amoah et al. (2018); however, it is important to note that in their study they focused on one biology process skill: observation whilst, the present study focused on six biology practical process skills.

5. Conclusions and Recommendations

5.1 Conclusion

Conclusion in relation to the first objective is that the null hypothesis is rejected: therefore, there is a significant difference in achievement between learners who learn using BPPSTA as compared to those who learn using the conventional methods. The group that learnt using the BPPSTA had a significantly higher mean attainment in the posttest compared to those who learnt using the conventional methods. Therefore, the use of BPPSTA can be deduced to lead to an improved learner attainment in biology. The second null hypothesis is not rejected. There is no significant difference in the males' posttest attainment as compared to the attainment of the females in the BAT. Therefore, BPPSTA did not discriminate learners by gender.

5.2 Recommendation

The study recommends that the Ministry of Education, through its quality assurance and standards officers, should encourage the use of process skills in biology instruction. In addition, Biology teachers should always yearn to explore classroom activities that involve both gender of learners; When teachers teach using BPPSTA a greater effort should be put in place to engage the female learners more with greater attention. For further research, it is recommended that, a study should be carried out on the challenges that the learners and teachers experience when instruction is done through the use of biology practical process skills approach.

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