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Impact of Integrating Basic Science Process Skills on Students Performance in Biology Practical in Vihiga County, Kenya

Kadenyi Mercy Osotsi, Dr Wambasi Aineah Wang'anya, Dr. Waititu Michael Muchoki

Department of Educational Communication and Technology,

Kenyatta University, Nairobi

Kenya

ABSTRACT

The study investigated impact of Integrating Basic Science Process Skills on students' performance in Biology practical. Research study objective was to determine students level of mastery of Basic Science Process Skills in learning of Biology practical. Form Three students were involved in the study. The study adopted Constructivism theory and Quasi experimental research design. Data was collected using Biology Achievement Test. The tests consisted of both pretest and posttest. The students target population was 4560 Form Three students. A sample size of 384 Form Three students was obtained from the target population using Yamane's formula. Twelve participating schools were selected by applying Stratified and Simple random sampling method. Six experimental and six control group of schools were created using Purposive sampling method. Experimental group were taught using practical activities while control group focused on teacher centered activities. Data was analyzed using Statistical Package for Social Science version 27. Descriptive statistics was used to analyze mean, standard deviation and median. Inferential statistics were used to determine significance of results. Content validity was determined by piloting the study instruments. Internal consistency reliability of the tests was determined using Kuder-Richardson 20 formula (=.978). A two-way ANOVA indicated that there was a significant difference in learners' performance in Biology practical in both experimental group and control group at $p<.05$.

Keywords: Biology Learning, Integration, Mastery of Basic Science Process Skills, Students Performance, Science Process Skills.

1 INTRODUCTION

Teaching the skills of both scientific thinking and science process to students is one of the major objectives of education in the world today (Kuniawati,2021). Science Process Skills are tools needed in processing of scientific data, conducting scientific experiments and solving scientific issues (Umami et al.,2020). Furthermore, Science Process Skills are essential in formulating results from the data that has been gathered by students during a study (Ozgelen,2012). These skills comprise the mental and physical activities that students are involved in collecting data and organizing it, making predictions, understanding and discussing scientific events and learning science as well (Gizaw & Sota ,2023). To encourage mastery of Science Process Skills it is very imperative to emphasize on process-oriented science learning in schools especially when conducting scientific works (Prayitno et al.,2017). This is done with the help of teachers who play an important role in nurturing students' understanding of scientific concepts through application of Science Process Skills which facilitates integration of new knowledge and skills when learning (Maraisane et al.,2024). These skills can be transferred during teaching learning process and are highly accepted in many science fields (Fugarasti et al.,2019). Biology as a science cannot be delinked from Science Process Skills because these skills can be learnt and established through conducting practical lessons (Ongowo & Indoshi, 2013). This is because practical work turns abstract concepts into concrete experiences and this develops curiosity among students (Fadilla et al.,2019). According to Gultepe (2016), teaching of Biology involves content and process learning and this cannot be separated during teaching learning process. In addition, activities or tasks that a leaner does well and with a lot of ease incorporates Science Process Skills (Mushani,2021). This is because when students are exposed

to SPS they develop their own meaning of the world around them (Beichumila et al.,2022). These skills also ensure that active students participation in classroom is achieved (Kerubo et al.,2021). Thus, mastery of SPS in Biology ensures that learners are responsible in their own learning and increases permanent learning among them (Darmaji et al., 2019).

However, Science Process Skills were first mentioned by American Association for the Advancement of Science (AAAS) in conjunction with Science: A Process Approach (SAPA) program (Kara, 2018). SAPA program placed more emphasis on teaching science using a process approach rather than the content approach method in schools. AAAS noted that the process approach method of teaching and learning was more effective in schools (Kara, 2018). Furthermore, AAAS classified these skills into fifteen; measurement, observation, classification, communication, prediction, making conclusions, controlling variables, formulating hypothesis, defining operationally, making models, questioning, using numbers, time relationship, conducting experiments and data interpretation (Bhakti et al., 2020). These skills were further divided into; Basic Science Process Skills and Integrated Science Process Skills. Basic Science Process Skills include; observing, measuring, classifying, communication, predicting and drawing conclusions while Integrated Science Process Skills include; data interpretation, identifying variables, designing experiments, formulating hypotheses, modelling, defining operationally, questioning, time relationship, using numbers (Umami et al,2020). SPS have become key items in science curriculum (Indri & Nurosyid, 2020). This is because they promote scientific literacy among students (Susanti & Anwar, 2018) and help in teaching ways of reaching knowledge (Abdrauf et al., 2013).

2 LITERATURE REVIEW

2.1 Discovery Learning Theory

Discovery learning theory by Jean Piaget (1973) was adopted by the study. Piaget noted that learning occurs through processes that are continuous (Ojose, 2008). In discovery learning, students develop a deeper understanding of major concepts by actively being involved in learning process (Bhakti et al., 2020). Piaget emphasized that, to enhance knowledge acquisition for future use, practice and action should be reinforced during teaching learning process. The theory also stipulates that knowing is not only present knowledge and values, but the new knowledge and values that one arrives at by thinking independently (Chan-Peter et al., 2018). The theory also ascertains that learning through hands-on activities encourages knowledge retention among students and the teacher acts as a facilitator (Bhakti et al.,2020).

2.2 Students' Level of Mastery of Basic Science Process Skills in Learning of Biology Practical

Under science education, activities or tasks that a leaner does well and with a lot of ease incorporates Science Process Skills (Mushani,2021). In science, practical activities enhance mastery and development of Science Process Skills among learners (Jack, 2018). To generate effective science learning in schools physical and mental activities need to be emphasized during teaching learning process to enhance mastery of Science Process Skills (Dahlia et al.,2019). Scientific activities cannot be separated from Biology activities in schools (Inayah et al., 2020). According to Gultepe (2016), teaching of Biology involves content and process learning and this cannot be separated during teaching learning process. Thus, mastery of Science Process Skills in Biology ensures that learners are active, responsible in their own learning and increases permanent learning (Darmaji et al., 2019). Furthermore, when learners are given Scientific Process Skills training there is increased academic achievement and improvement in scientific creativity (Aktamis & Ergin,2008) and it also influences discovery learning among students (Samputri ,2020).

3. METHODOLOGY

Quasi experimental research design was adopted in the study. This is because it helped to establish the cause-effect relationship between the variables. The experimental group were taught using the practical activities while the control group were taught based on teacher centered activities. Public secondary schools involved in the study were selected using Stratified and Simple random sampling method. However, experimental and control group of schools were classified using purposive sampling method. Simple random sampling method was also used to select Form Three students involved in the study. Data was analyzed using descriptive analysis and use of ANOVA.

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4.RESULTS AND DISCUSSION OF THE STUDY

4.1 Research Results

Key findings on students' level of mastery of Basic Science Process Skills in learning of Biology practical are outlined in this section. Biology Achievement Tests (BAT) were done by students to determine their level of mastery of BSPS in both Pretest and posttest practical. Chemical Analysis, Pictorial and Fieldwork Activities were tested.

4.1.1 Students' Performance in Chemical Analysis Activity in Biology practical.

Students performance in Chemical Analysis activity was determined. Their performance at school group level was determined and their results are indicated in Table 1 below.

Table 1: School Group and Students Performance Practical Activities in Chemical Analysis

GROUP	Mean	N	Std. Deviation	Median	Std. Error of Mean	Variance
CONTROL	44.67	60	21.693	43.00	2.801	470.599
EXPERIMENTAL	53.85	60	19.139	60.50	2.471	366.299
Total	49.26	120	20.885	52.00	1.907	436.193

Table 1 indicates that experimental group performed better compared to control group. The experimental group had a Mean of 53.85, SD=19.14 while the control group had a Mean of 44.67, SD=21.69 in Chemical analysis activity.

The relationship between school group, skills tested and students' performance was determined Figure 1 below show their results in Chemical analysis.

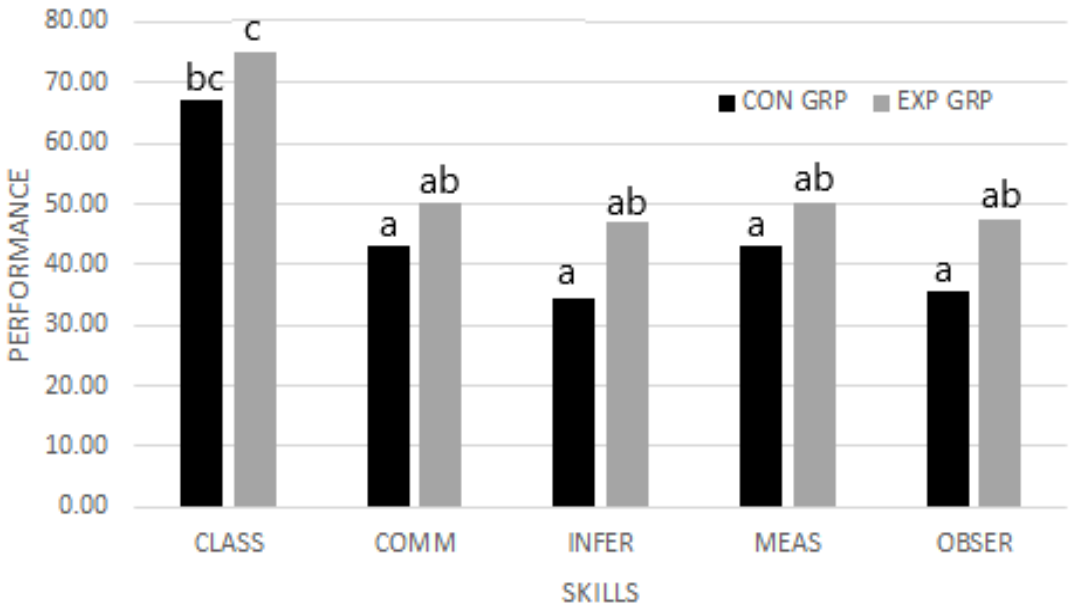

Figure 1: N=60.Means with similar superscript are not significantly different p<0.05 (Turkey HSD post hoc pairwise mean comparison). CON GRP=Control Group and EXP GRP=Experimental Group. CLASS-Classification, COMM-Communication, INFER-Inference, MEAS-Measurement, OBSER-Observation.

Figure 1 above, indicates that the experimental group had a higher performance in the skills tested compared to control group**.** The performance in the Experimental group was as follows; Classification (*Mean*=74.58, *SD*=13.892), Communication (*Mean*=50.08, *SD*=17.12), Measurement (*Mean*=50.08, *SD*=17.117), Observation (Mean=47.33,

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SD=17.26) and Inference (*Mean* =47.17, *SD*=17.11). Control group had the highest mean in Classification (*Mean*=67.17, *SD*=17.34), Communication (*Mean*=43.08, *SD*=18.43), Measurement (*Mean*=43.08, *SD*=18.43), Observation (*Mean*=35.50, *SD*=19.870) and Inference (*Mean*=34.50, *SD*=19.68).

Test of between subjects' effects that is school group, skills tested and students' performance results are indicated in Table 2 below**.**

Table 2: Test of Between School Group, Skills and Students' Performance Effect in Chemical Analysis.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17458.408[a]	9	1939.823	6.194	.000
Intercept	291166.008	1	291166.008	929.741	.000
School Group	2530.008	1	2530.008	8.079	.005
Skill	14737.533	4	3684.383	11.765	.000
Error	34448.583	110	313.169		
Total	343073.000	120			
Corrected Total	51906.992	119			

Two-way ANOVA Table 2 above, indicates that there was a significant effect $F(1,110) = 8.08$, $p<0.05$ between school group and students' performance in chemical analysis activity in Biology practical. A significant effect $F(4,110) = 11.77$, $p<0.05$ between skills tested and students' performance in chemical analysis activity in Biology practical was also noted.

Relationship between Pretest, Posttest and students' Performance in Chemical Analysis activity in Biology Practical was also determined as indicated in Table 3 below.

Table 3: Pretest, Posttest and Students' Performance Relationship in Chemical Analysis Activity in Biology Practical

Skills	**Control group**				**Experimental group**			
	Pretest	**S.D**	**Posttest**	**S.D**	**Pretest**	**S.D**	**Posttest**	**S.D**
Classification	54.0[ef]	12.7	80.3[gh]	9.1	62.3[fg]	7.26	86.8[h]	3.4
Communication	29.1[ab]	12.8	57.0[f]	10.9	35.2[abcd]	9.43	65.0[fg]	4.7
Inference	19.7[a]	13.1	49.3[bcde]	12.4	32.0[abc]	7.48	62.3[fg]	6.0
Measurement	29.2[ab]	12.8	57.0[f]	10.9	35.2[abcd]	9.43	65.0[fg]	4.7
Observation	20.5[a]	11.8	50.5[cde]	13.7	32.0[abc]	7.48	62.7[fg]	6.0

N=120. Means with similar superscripts are not significantly different p<0.05 (Turkeys HSD post hoc pairwise comparison).

It is noted that students in the experimental group had a better performance compared to students' in control group in both pretest and posttest in chemical analysis activity in Table 3 above. Tukey HSD post hoc pairwise mean comparison was done and the results are as shown in Table 3 above.

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4.1.2 Students Performance in Pictorial Activity in Biology Practical

The activity tested on how learners have mastered the concept of picture interpretation in Biology practical. Observation, Communication, Classification, Prediction and Inference skills were tested. Experimental group and control group performance was determined. The tables below indicate students' performance in Pictorial activity in Biology practical.

Table 4: School Group and Students' Performance Relationship in Pictorial Activity

School Group	Mean	N	Std. Deviation	Median	Std. Error of Mean	Variance
CON GRP	46.27	60	14.100	46.00	1.820	198.809
EXP GRP	61.08	60	14.664	59.00	1.893	215.027
Total	53.68	120	16.141	55.00	1.473	260.524

CON GRP=Control group and EXP GRP=Experimental group

Table 4 above, indicates that students in experimental group performed better (Mean= 61.08, SD=14.67) compared to students in control group (Mean=46.27, SD=14.10) in pictorial activity. Relationship between Pretest, Posttest and Students Performance in pictorial activity in Biology practical was also determined as indicated in Table 5 below.

Table 5: Pretest, Posttest and Students Performance Relationship in Pictorial Activity in Biology Practical

Skills	Control Group				Experimental Group			
	Pretest	**SD**	**Posttest**	**SD**	**Pretest**	**SD**	**Posttest**	**SD**
Classification	41.7^{ab}	8.3	46.0^{abcd}	14.1	58.3^{abcde}	16.4	63.3^{bcdef}	6.9
Communication	46.3^{abcd}	5.24	46.5^{abcd}	17.0	55.7^{abcde}	5.5	72.00^{ef}	11.3
Inference	35.5^{a}	14.5	58.5^{abcde}	15.0	44.3^{abc}	10.3	67.8^{def}	10.6
Observation	46.3^{abcd}	5.24	63.0^{bcdef}	11.1	55.7abcde	5.5	84.0^{f}	6.8
Prediction	35.5^{a}	14.5	43.7^{abc}	11.8	44.3^{abc}	10.3	65.3^{cdef}	7.5

N=120.Means with similar superscript are not significantly different p<0.05. (Tukey HSD post hoc pairwise mean comparison).

Table 5 above, indicates that experimental group had a better performance compared to students in control group in pictorial activity in both pretest and posttest. Table 5 above also indicates Tukey HSD post hoc pairwise mean comparison results.

Test between subject effects that is test, school group and skills tested was also conducted as indicated in Table 6 below.

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Table 6: Test, School group, Skills and Students' Performance Effect in Pictorial Activity.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	18765.492[a]	19	987.657	8.071	.000
Intercept	345720.675	1	345720.675	2825.246	.000
Test	6409.408	1	6409.408	52.378	.000
School Group	6586.008	1	6586.008	53.821	.000
Skills	2965.617	4	741.404	6.059	.000
Error	12236.833	100	122.368		
Total	376723.000	120			
Corrected Total	31002.325	119			

Table 6 above, indicates a significant effect $F(1,100) = 52.38$, $p<0.05$, between test and students' performance in pictorial activity. A significant effect $F(1,100) = 53.82$, $p<0.05$ between school group and students' performance in pictorial activity was noted. A significant effect $F(4,100) =$, $P<0.05$ was also noted between skills and students' performance in pictorial activity.

4.1.3 Student Performance in Pictorial/Fieldwork Activity in Biology Practical.

Performance in Pictorial/Fieldwork activity in Biology practical was determined. Relationship between school group and students' performance in Pictorial/Fieldwork activity was determined as indicated in Table 7 below.

Table 7. School Group and Student Performance Relationship in Pictorial/Fieldwork activity

School Group	Mean	N	Std. Deviation	Std. Error of Mean	Median	Variance
CON GRP	40.82	60	15.053	1.943	40.00	226.593
EXP GRP	55.08	60	16.240	2.097	56.00	263.739
Total	47.95	120	17.159	1.566	48.00	294.418

The results in Table 7 above, indicates that experimental group performed better (Mean= 55.08, SD=16.24) compared to students in control group (Mean of 40.82, SD=15.053) in Pictorial/Fieldwork activity.

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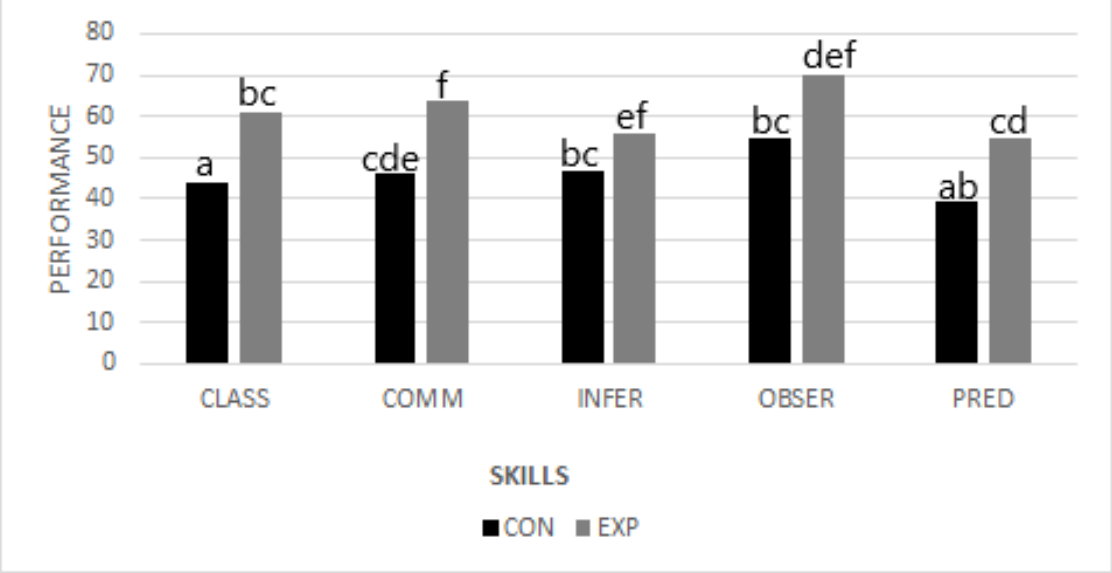

Figure 4.2.: Mean with similar superscript are not significantly different p<0.05. (Turkey post hoc pairwise mean comparison). N=120

Figure 2 shows that experimental group performed better compared to control group in classification, communication, inference, observation and prediction skills. The following means were achieved by experimental group; Classification (Mean=44.42, SD=18.48), Communication (Mean=66.58, SD=17.11), Inference (Mean=60.83, SD=12.16), Observation (Mean=57.92, SD=9.82) and Prediction (Mean=45.67, SD=11.23). The Control group had the following mean; classification (Mean=30.58, SD=15.88), Communication (Mean=52.25, SD=15.106), Inference (Mean=44.33, SD=12.18), Observation (Mean=44.75, SD=8.65) and Prediction (32.17, SD=11.96). Turkey post hoc pairwise mean comparison was conducted and results are indicated on Figure 2 above. A two-way ANOVA Table 8 below indicates the test between subject effects.

Table 8: Test of Between School Group, Skills and Students' Performance Effect in Pictorial/Fieldwork Activity

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	14672.867[a]	9	1630.319	8.807	.000
Intercept	275904.300	1	275904.300	1490.435	.000
School Group	6106.133	1	6106.133	32.985	.000
Skills	8524.867	4	2131.217	11.513	.000
Error	20362.833	110	185.117		
Total	310940.000	120			
Corrected Total	35035.700	119			

A two-way ANOVA Table 8 above indicates a significant effect F(1,110) =32.99, p<0.05 between school group and students' performance in Pictorial/Fieldwork activity in Biology practical. A significant effect F(4,110) =11.51, p<0.05 was also noted in skills tested and students' performance in Pictorial/Fieldwork activity in Biology practical.

Students performance in pretest and posttest was also determined. The findings are indicated in Table 9 below.

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Table 9: Relationship Between School Group, Test, Skills and Students' Performance in Pictorial/Fieldwork Activity.

Skills	Control Group				Experimental Group			
	Pretest	SD	Posttest	SD	Pretest	SD	Posttest	SD
Classification	22.50[a]	11.61	38.67[abc]	16.23	28.83[ab]	12.75	60.00[de]	2.45
Communication	41.00[abcd]	8.74	63.50[ef]	11.04	52.17[cde]	10.94	81.00[f]	5.02
Inference	35.50[abc]	9.63	53.17[cde]	6.82	53.33[cde]	10.31	68.33[ef]	9.18
Observation	41.00[abcd]	8.74	48.50[bcde]	7.37	52.17[cde]	10.94	63.67[ef]	3.62
Prediction	27.50[a]	8.19	36.83[abc]	13.98	38.17[abc]	10.15	53.17[cde]	6.27

N=24.Means with similar superscript are not significantly different p<0.05 (Turkey HSD post hoc pairwise mean comparison).

The results in Table 9 above, indicates that students in experimental group had a higher performance in both tests compared to students in control group. Tukey HSD post hoc pairwise mean comparison are indicated in Table 9 above. A two-way ANOVA Table 10 below indicates the test between subject effects.

Table 10: Test Between School Group, Skills, Tests and Students' Performance Effect in Pictorial/Fieldwork Activity

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	25497.033[a]	19	1341.949	14.069	.000
Intercept	275904.300	1	275904.300	2892.483	.000
School Group	6106.133	1	6106.133	64.015	.000
Skill	8524.867	4	2131.217	22.343	.000
Test	9152.533	1	9152.533	95.952	.000
Error	9538.667	100	95.387		
Total	310940.000	120			
Corrected Total	35035.700	119			

Table 10 above, indicates that School groups had a significant effect $F(1,100) = 64.015$, $p<0.05$ on students' performance in Pictorial/Fieldwork question in Biology practical. It was also noted that skills tested had a significant effect $F(4,100) = 22.34$, $P<0.05$ on students' performance in Pictorial/Fieldwork question in Biology practical. Test also had a significant difference $F(1,100) = 95.95$, $p<0.05$ on students' performance on Pictorial/Fieldwork question in Biology practical.

4.2 Discussion of the Study Results

In chemical analysis activity, the experimental group had a higher performance compared to students in the control group. This is because teaching learning activities in the experimental group revolved around students centered activities as opposed to control group where teaching revolved around teacher centered activities during Biology lessons. This led to high mastery of the Basic Science Process Skills tested that is classification, communication, inference, measurement and observation. This performance is in line with Safaah et al., (2017) work that learners' ability to master Science Process Skills is highly achieved by actively involving them in learning process. This is

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because when learners participate actively in learning process there is increased academic achievement and improvement (Aktamis & Ergin,2008).

Picture interpretation in Biology is also a necessary concept. In pictorial activity, the experimental group had a higher mastery of Basic Science Process Skills tested that is classification, communication, inference, observation and prediction. Exposure to several picture activities during Biology lesson contributed to their high performance in the activity by the experimental group compared to control group. High level of mastery of Basic Science Process Skills is in line with Samputri (2020), sentiments that students taught using discovery learning model have a higher performance compared to students taught using conventional teaching method.

In Pictorial/Fieldwork activity, students in experimental group also performed better compared to students in control group. Skills tested included classification, communication, inference, observation and prediction. This performance is in line with Olanyika (2019), research that when students are taught using fieldtrip and peer tutoring instructional strategies they have a higher mastery of the skills tested in both pretest and posttest compared to learners taught using teacher expository method. It is also noted that the experimental group also performed better in both posttest and pretest compared to control group due to maximum exposure to practical activities hence high knowledge retention (Eluket et al, 2019). This is because when learners are given a guided inquiry model in teaching learning process in schools a significant difference is noted in their performance (Wardani & Djukri, 2019).

5. RECOMMENDATION

The researcher recommends that Teachers of Biology should actively integrate SPS in teaching of Biology in schools to improve students' performance. More learner centered activities should also be put in place during teaching learning process of science subjects that is Biology, Physics and Chemistry.

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