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Promoting Senior High School Students' Acquisition of Science Process Skills in Biology Using Experiential Learning Approach in Anambra State, Nigeria

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Abstract: The study explored the impact of experiential learning approach (ELA) on acquisition of science process skills (SPS) by biology college students. The research design is quasi-experimental research, adopting the non-randomized manipulated group of 2x2 factorial research design. 58 (22 males and 36 females) Senior High School II students in Awka Education Zone, obtained with multi-leveled sampling method made up the sample size. The sampled students who were in two separately grouped classes were randomly assigned to experimental and control groups using a flip of a coin. A Biology Science Process Skills Acquisition Test (BSPSAT) with 0.71 reliability coefficient ascertained with Kuder Richardson formula 20 was used to collect data. Average Mean and Standard deviation were adopted to describe the research questions and Analysis of Covariance to test the null hypotheses. The findings showed that ELA promoted students' acquisition of SPS in biology more than the Conventional Lecture Method. Gender alone as well as its interaction effect with the teaching methods had no significant effect on acquisition of SPS by students in biology. The study resolved that ELA is an activity-based approach that engages students actively throughout the learning process, hence promoting their acquisition of SPS. In line with the findings, the study advised that biology teachers should adopt ELA in schools to promote students' acquisition of SPS.

Keywords: Experiential Learning Approach (ELA), Science Process skills (SPS), Biology

1. Introduction

Science has long been recognized by many as catalyst for modern day technological advancements. Its application to every sphere of life has necessitated every nation, both developed and still developing ones, to strive for its advancements in science. Supporting the above assertion, Obialor and Osuafor (2016) stated that the impact of science on the society cannot be over emphasized, which is probably why in latest times, nations all around the globe specially growing ones like Nigeria is making every effort to expand technologically and scientifically for the reason that right functioning of lifestyles relies significantly on technological know-how. Taking cognizance of the importance of science to man for technological and scientific advancements, it becomes imperative that students' right from their basic level in schools be taught what science is, its processes and the skills applied in learning science.

Science process skills (SPS) are a set of intellectual skills used to perform scientific research to solve problems. Samba *et al.,* (2020) simply defined them as abilities needed by scientists to carryout scientific investigations. They are skills that one uses in one's existence which promotes scientific literacy, quality and standard of life as they help one in comprehending the nature of science (Mbonu-Adigwe *et al.,* 2021). Similarly, Ibe and Nwosu (2017) defined science process skills as abilities, potentials, technical know-how which can be developed by experience and are used in carrying out mental operations and physical actions in science. Hence, Science process skills may simply be defined as those cognitive and intellectual skills applied during the learning of science to help understand and solve scientific problems.

Science process skills formerly, at various times, referred to as scientific method, scientific thinking, and critical thinking according to Achor *et al.,* (2018) were popularized by the curriculum project named "Science- A Process Approach (SAPA)" which was developed in December 1971 by the American Association for the Development

of Science. SAPA grouped the science process skills into two types, basic and integrated SPS. Basic science process skills according to Nworgu and Otum (2013) form the backbone of the more advanced (integrated skills) problem-solving skills thus providing the intellectual groundwork or foundation for learning the integrated ones. Supporting the premise, Rambuda and Fraser cited in Maison *et al.,* (2019) asserted that these basic science process skills are applied specifically at the foundation of cognitive functioning and form the basis of the more advanced (integrated) skills. The basic (simpler) science process skills according to Akpotohwo and Ehimen (2014) include observing, inferring, measuring, communicating, classifying, and predicting.

In the same vein, Nworgu and Otum (2013) defined the Integrated (more complex or advanced) science process skills as immediate skills employed in problem solving which are formed by the combination of two or more basic process skills. Ekon and Eni (2015) opined that these integrated SPS are more complex and can only be effectively utilized once one has mastered the basic SPS. Funk cited in Nworgu and Otum (2013) outlined these integrated science process skills as follows: identifying variables, formulating hypotheses, describing relationship between variables, designing, investigations, experimenting, acquiring data, organizing data in tables and graphs, analyzing investigations and their data, formulating models, defining variables operationally, understanding cause and effect relationships.

Despite the grouping of the SPS into basic and integrated, Jack (2018) opined that the two groups of the science process skills are complementary of each other, providing opportunities for students to attain significant knowledge of science as these skills allow students to conduct investigations and reach conclusions while developing their higher knowledge capabilities such as problem-solving, critical thinking and decision making in the process. In line with the premise, Obochi and Samuel (2018) stated that SPS are foundations from which suitable science tasks are being constructed as these skills allow students to be active, grow a feel of responsibility, foster the permanence of mastering, and imparting research methods. The attainment of SPS is the basis for scientific inquiry and improvement of highbrow talents as these abilities have a long-lasting impact on college students' capabilities to reply questions and resolve issues even if the records base of technology and generation changes (Ibe & Nwosu, 2017). Summarizing the above, Okoye and Osuafor (2021) asserted that SPS comprise the foundation of science and are paramount to the accession of scientific knowledge which is useful in solving everyday problems in life.

In recognition of the above benefits of SPS in learning science, the Federal Republic of Nigeria in its National Policy on Education (NPE, 2014) restructured the secondary school science education curriculum to teach students not just what science is, but also equip them with the necessary scientific skills needed to enable them define existing problems, observe events in their society, analyze and hypothesize possible solutions as well as conclude, generalize, and apply gathered information for the betterment and advancement of his community. Derilo (2019) explained that these group of skills when mastered can help students comprehend the very nature of science which could help increase the standard and quality of their lives, survive the challenges of everyday life and even enhance their academic achievement. Mindful of this, the study was undertaken to determine if using experiential learning approach will enhance students' acquisition of SPS in biology.

Biology, a science subject learnt in Nigerian secondary school, according to Basila and Jajua (2019), is a crucial part of science that centres on living things (flora and animals). It is that branch of science that studies living things and their interactions with each other and their environment (Nwuba *et al.,* 2022a). Hence, biology may simply be defined as the study of plants and animals as well as their attributes and relationship with their environment.

Just like science, the overall importance of biology to man and his environment cannot be overemphasized. Ude and Onah (2017) asserted that biology aids in exciting hobbies like gardening, insect collection and bird watching, environmental protection and conservation as well as understanding the basis of hereditary and its application in genetic engineering, crime detection, blood transfusion, banking, and the determination of paternity of children. Similarly, Basila and Jajua (2019) stated that the knowledge of biology forms the bedrock for science needed for technological boom of the nation in areas of medicine, forestry, nursing, agriculture, biotechnology and so on. To achieve these benefits, it becomes imperative that biology be taught in such a way that students do not just acquire its knowledge but also acquire the necessary scientific process skills associated with learning the subject, which can help them become true biologists. In this light, the study advocated for the adoption of experiential learning approach, which is an innovative approach that actively engages students in hands on minds on activities that may help foster their acquisition of science process skills in biology.

Experiential learning approach (ELA) is simply "learning by doing" that promotes active-engaged learning. It is a learning approach that makes learning an experience that moves beyond the classroom and strives to bring a more involved way of learning, as it involves students in synthesizing, analyzing information and applying knowledge to new situations which develops their critical thinking abilities (Beard & Wilson, 2010). Marin (2015) described ELA as an approach to learning in which learners are engaged intellectually, emotionally, socially, politically, spiritually, and physically in an uncertain environment, where the learner may experience success, failure, adventure, and risk taking. Similarly, Nwuba and Osuafor (2021) defined it is an instructional approach that encourages hands-on minds-on learning, actively involving learners in the teaching and learning process. Hence, ELA may be defined as an activity-based instructional approach that provide opportunities for learners to be actively involved in the learning process fostering their problem solving and decision-making skills.

Experiential learning approach was first introduced by David Kolb in 1984. Kolb emphasized that for students to expand their knowledge and practice problem solving, practical learning must go through four processes namely concrete experience, reflective observation, abstract conceptualization, and active experimentation. As an initial process, concrete experience learning emphasizes on individual learners being open-minded and able to adapt to a systematic approach to problem situations. In the reflective observation process, students observe simple demonstrations by displaying virtual visualizations as well as try to express opinions on why and how they can occur. As such, reflection is essential for transforming experience into learning as it allows one to question the validity and usefulness of experiences. The abstract conceptualization process emphasizes on students understanding of concepts in general, referring to the processes of concrete experience and reflective observation. This abstract conceptualization process requires students to use critical thinking to understand problems. After that, it is completed with the active experimentation process. In this stage, students are able to use the theory obtained during the abstract conceptualization process to make predictions and solve their problems. In using the four stages, Jennings and Wargnier (2010) concluded that experiential learning approach improves students' creativity, critical thinking, and problem-solving skills as it provides a learning environment where the learner is actively involved in the learning process. Supporting the premise, Glick and D'Amore-McKim (2013) confirmed that experiential learning activities are very useful for energizing students, supporting students' motivation, enhancing students' critical thinking skills and experience as well as developing their ability to investigate the unknown, accept uncertainty and to build their self-confidence. In light of these benefits associated with teaching and learning with ELA, the study sought out to ascertain its effect (effect of ELA) on secondary school students' acquisition of the science process skills in biology irrespective of students' gender.

Gender is a social construct that differentiates male and female in the society (Nwuba *et al.,* 2022b). Pan-Anyaeji and Okeke (2019) defined it as any physical and behavioural difference between male and female which are socio culturally based. Hence gender may simply be defined as a cultural and biological construct that distinguishes males from females. The influence of gender on students' educational outcomes in science, till today, has persevered as a difficult problem to science teachers based on the number of research carried out to that effect. Still, there is no consensus as to whether it affects students' acquisition of SPS or not. While some researchers (Ibe & Nwosu, 2017; Achor *et al.,* 2018; Jack, 2018; Okoye & Osuafor, 2021; Pius & Okoli, 2021) in their respective studies in different science subjects reported that male students have higher science process skills than the female students, others (Okafor, 2020; Mbonu-Adigwe *et al.,* 2021) in their study in chemistry and basic science respectively reported that female students have higher science process skills than their male counterparts. However, when statistically tested, the same group of researchers (Ibe & Nwosu, 2017; Achor *et al.,* 2018; Jack, 2018; Okafor, 2020; Okoye & Osuafor, 2021; Pius & Okoli, 2021; Mbonu-Adigwe *et al.,* 2021) have statistically reported in their respective studies that gender influence on students SPS acquisition in science subjects is insignificant.

These inconsistent findings on gender calls for further investigation to find out if gender has any influence on students' acquisition of science process skills in science or not. Therefore, in this study, gender differences in science process skills acquisition among secondary school students' taught biology using experiential learning approach was also investigated. it is then against this backdrop that the researcher deemed it necessary to find out the effect of experiential learning approach on secondary school students' acquisition of science process skills in biology in Awka Education Zone of Anambra State.

To achieve the purpose of the study, the following research questions were formulated, and null hypotheses tested at 0.05 alpha level:

R1 Is there a distinction between the pretest posttest mean SPS acquisition test scores of students taught biology with Experiential learning approach (ELA) and that of those taught with CLM?

R2 Is there a distinction between the pretest posttest mean SPS acquisition test scores of students taught biology with ELA with respect to gender?

Ho1 No statistically significant difference exists between the mean SPS acquisition test scores of students taught biology with ELA and that of those taught using CLM

Ho2 No statistically significant distinction exists between the mean SPS acquisition test scores of students taught biology using ELA with respect to gender.

Ho3 There is no interaction effect of gender and teaching methods on students' acquisition of SPS in biology.

2. Methods

2.1 Research Design

The research is Quasi-experimental research, adopting the pretest posttest non-randomized manipulated groups of 2x2 factorial.

2.2 Participants

4755 senior high school II (SS2) students constituted the population. Multi-level sampling method was used to obtain the sample size of 58 (22 males and 36 females) SS2 students, sampled from two government owned co-educational schools, in Awka Education Zone of Anambra State. The research participants were randomly sampled into two intact, experimental (13 boys and 19 girls) and control (9 boys and 17 girls), groups using a flip of a coin.

2.3 Instrument

Biology Science Process Skills Acquisition Test (BSPSAT), with 25-question items, developed by the researchers, with reference to Nnorom (2016), using a well-structured table of specifications was used for data collection. The questions in the BSPSAT, which were based on the topics (Plant nutrition and Animal nutrition) taught during the treatment process, were obtained from the West African Secondary School Certificate Examinations (WASSCE) compiled past questions.

The BSPSAT comprised of sections A and B. Section A consists of 10 questions on practical skills test and section B, 15 objective practical question items with four options A, B, C, D. The idea to use practical questions for evaluation in sections A and B was based on empirical activities that can measure the basic science process skills of observing, inferring, measuring, communicating, classifying, and predicting, which the study focused on.

1. Specimens A, B, and C are different liquids of food materials. Carry out the following tests (i-v) to identify the food content of specimens A, B and C. Wash the test tube after each use to avoid contaminating the next sample. Record your observations and inference in the table below.

S/No	Test	Observation	Inference
i.	To small portion of specimen A (about 5cm^3), add three droplets of Reagent D and shake.		
ii.	Rub a droplet of specimen "B' on a white piece of paper and hold the paper to a light source.		
iii.	To small portion of specimen C (about 5cm^3), add four drops of Reagent E, shake and then heat		

2. Specimens H and J are potted plants. H was planted and kept in an open environment while J was kept in a dark cupboard. Using a detached leaf from the two specimens, carry out tests I-V. Record your observations and inference in the table below.

S/No	Test	Observation	Inference
i.	Leaf from specimen H + test for starch		
ii.	Leaf from specimen J + test for starch		

To establish face validity, BSPSAT was submitted to three experts from fields of Biology Education and Measurement and Evaluation. To establish reliability of BSPSAT, Kuder-Richardson 20 formula for internal consistency was employed. The reliability coefficient of the BSPSAT was found to be 0.71.

2.4 Experimental Procedure

This was conducted in two stages. Stage one and stage two. Stage one was the training and briefing of the research assistants, who were the regular biology teachers, at the two sampled schools. In the experimental group, the research assistant was trained on how to use and implement ELA using the lesson plans developed by the researcher while the research assistant of their counterpart was briefed on the objectives of the study, given the lesson plans on CLM and then asked to teach as usual. In stage two, the treatment process commenced with the administering of the pretest (BSPSAT) to both groups. The teaching process in both ELA and CLM groups lasted for four weeks in which the concepts of plant and animal nutrition in biology were taught to the two groups. In the last week of the teaching, a posttest (reshuffled BSPSAT) was administered again to the research participants of the two groups. The two administered tests (pretest and posttest) were collected, scored, and recorded by the researcher.

2.5 Data Analyses

Administered tests scores were interpreted using Mean and Standard deviation in describing the research questions, and Analysis of Covariance (ANCOVA) in testing the null hypotheses at 0.05 alpha levels. In taking decisions, null hypothesis was rejected if the Probability value is less than or equal to the alpha level (0.05), if otherwise, do not reject the null hypothesis.

3. Results

Research Question One: Is there a distinction between the pretest posttest mean SPS acquisition test scores of students taught biology with ELA and that of those taught with only CLM?

Table 1: Science Process Skills Acquisition Test Mean and Standard Deviation Scores of students taught biology using ELA and those taught with CLM

		Pretest		Posttest		
Method	N	Mean	Std. Dev.	Mean	Std. Dev.	Mean Gain
ELA	32	11.47	0.44	17.41	0.54	5.94
CLM	26	11.27	0.53	11.31	0.57	0.04
Difference in mean		0.20		6.10		5.90

Table 1 above showed that students in the ELA group had a pretest and posttest mean scores of 11.47 and 17.41 respectively in their SPS acquisition test while their counterparts in the CLM group had mean SPS test scores of 11.27 in their pretest and 11.31 in their posttest. The gain in mean for ELA and CLM, showed that research participants in the ELA group had improved SPS acquisition in biology more than those in the CLM group with a mean difference of 5.90. The finding indicates that using experiential learning approach promoted acquisition of SPS by students as it provided a hands-on minds-on learning environment where students were actively engaged throughout the learning process.

Research Question two: Is there a difference between the pretest posttest mean SPS acquisition test scores of students taught Biology with ELA with respect to gender?

Table 2: Science Process Skills Acquisition Test Mean and Standard Deviation Scores of male and female students taught biology using ELA

		Pretest		Posttest		
Gender	N	Mean	Std. Dev.	Mean	Std. Dev.	Mean Gain
Male	13	12.54	0.62	17.85	0.61	5.31

Female	19	12.37	0.65	16.31	0.91	3.94
Mean Difference	22	0.17		1.54		1.37

Analyzing the table above, it shows that male participants in the ELA group had pretest posttest SPS mean test scores of 12.54 and 17.85 respectively test while their female counterparts, in the same group, scored 12.37 in the pretest and 16.31 in the posttest. Mean difference in gains for boys and girls instructed biology using ELA is 1.37. Considering the mean gain, one can conclude that the boys had higher SPS acquisition test scores than the girls when taught biology using experiential learning approach.

Null Hypothesis 1: No statistically significant distinction exists between the mean SPS acquisition test scores of students taught biology with ELA and that of those taught with CLM.

Table 3: ANCOVA Test of Significant Difference between the Mean SPS Acquisition Test Scores of Students Taught Biology Using ELA and that of those Taught Using CLM

Dependent Variable: PreBSPSAT					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	71.656[a]	4	17.914	3.083	0.023
Intercept	95.953	1	95.953	16.511	0.000
PostBSPSAT	59.158	1	59.158	10.180	0.002
METHOD	31.674	1	31.674	5.450	0.023
GENDER*METHOD	16.975	1	16.975	2.921	0.093
Error	307.999	53	5.811		
Total	7890.000	58			
Corrected Total	379.655	57			

a. R Squared = .189 (Adjusted R Squared = .128)

ANCOVA test from the table above reveals that at F-value 5.450, the Probability value is 0.023. Since the Probability value is less than 0.05 alpha level at degree of freedom of 1 and 53, null hypothesis one was rejected. This indicates that a significant distinction exists between the mean SPS acquisition scores of students taught biology with ELA (experimental group) and CLM (control group) in favour of those in the ELA group. The result reveals that ELA enhances students' acquisition of SPS in biology.

Null Hypothesis 2: No statistically significant difference exists between the mean SPS acquisition test scores of students taught biology using ELA with respect to gender.

Table 4: ANCOVA Test of Significant Difference between the Mean SPS Acquisition Test Scores of Students Taught Biology Using ELA with Respect to Gender

Dependent Variable: PreBSPSAT					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31.421[a]	2	15.711	2.582	0.093
Intercept	61.207	1	61.207	10.059	0.004
PostBSPSAT	31.198	1	31.198	5.127	0.031
GENDER	.615	1	.615	.101	0.753
Error	176.454	29	6.085		
Total	5158.000	32			
Corrected Total	207.875	31			

a. R Squared = .151 (Adjusted R Squared = .093)

ANCOVA test from above shows that at F-value 0.101, the Probability value is 0.753. Since the Probability value is above 0.05 alpha level, null hypothesis two was not rejected. Revealing that no notable distinction exists between boys and girls mean SPS acquisition test scores when both are taught biology using ELA. Hence, indicating that the ELA is a gender friendly approach that promotes both boys' and girls' acquisition of science process skills in biology.

 10.54392/ajir2243

Hypothesis 3: Gender and teaching methods have no interaction effect on students' acquisition of the science process skills in biology.

ANCOVA test from table 3 above shows that at F-value 2.921, the Probability value is 0.093. Considering that the level of significance (0.05) is less than the Probability value, null hypothesis three was accepted. Revealing that gender and its interaction effect with the methods of instruction had no influence on acquisition of SPS by students in biology. This implies that the two-way interaction (gender*methods) is not a notable factor on biology students' acquisition of SPS.

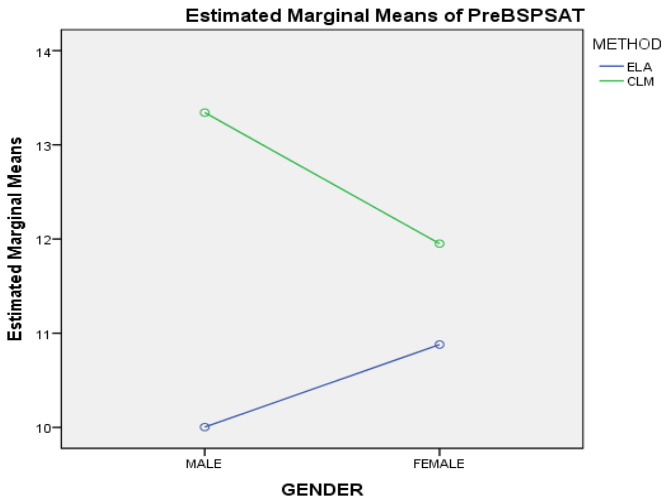

Figure 1 Gender and Teaching Methods Interaction Effect Profile Plot on Students' Acquisition of SPS in Biology.

4. Discussion

The finding revealed that students exposed to experiential learning approach (ELA) showed improved science process skills acquisition average score in biology more than those taught with the Conventional Lecture Method (CLM). This improved acquisition of SPS in biology was proved statistically significant by test of null hypothesis one in table 3. This significant increase in acquisition of SPS by students in biology may be ascribed to the unique nature of experiential learning approach as it provides a learning environment where students are actively engaged throughout the learning process, developing, and fostering their critical thinking and decision-making skills. The above findings concur with the findings of Ibe and Nwosu (2017), Achor *et al.,* (2018), and Okoye and Osuafor (2021) who statistically reported in their respective studies in biology that innovative approaches similar to ELA promotes acquisition of SPS by students in biology. On a similar note, the above findings also support the findings of Okafor (2020) and Pius and Okoli (2021) who reported in their respective studies in chemistry that innovative approaches, such as context-based learning and problem-solving approach respectively, enhanced high school students' acquisition of SPS. In the same vein, studies carried out by Samba *et al.,* (2020) and Mbonu-Adigwe *et al.,* (2021) in basic science using E-learning and multimedia integrated instruction respectively also reported, in their findings, that both approaches enhanced students' acquisition of SPS concur with the discoveries of this study.

On gender influence on students' acquisition of SPS, the study reported that the boys had higher SPS acquisition test scores than the girls when both are taught biology using experiential learning approach. This finding agrees with that of Ibe and Nwosu (2017), Achor *et al.,* (2018), and Okoye and Osuafor (2021) who reported that in their respective studies in biology that male students had higher science process acquisition test scores than their female counterparts. But null hypothesis two tested in table 4 showed that the distinction is not statistically notable. This negligible gender influence on students' acquisition of SPS when taught biology using ELA may be attributed to the hands-on minds-on activities associated with using ELA in the classroom, in which both male and female students actively and collaboratively work together to find answers to their questions. This statistically insignificant influence of gender revealed in the study concur with the findings of Ibe and Nwosu (2017), Achor *et al.,* (2018), Jack (2018), Okoye and Osuafor (2021), Pius and Okoli (2021) and Mbonu-Adigwe *et al.,* (2021) who stated in the various studies they carried out in science subjects that influence of gender on students' acquisition of SPS in science is negligible.

On interaction effect of gender and teaching methods on students' acquisition of SPS, the study revealed that gender and teaching methods have no interactive effect on students' acquisition of SPS. That is, the effects of the instructional approaches were consistent across gender. This finding is in concurrent with that of Ibe and Nwosu (2017), Mbonu-Adigwe et al., (2021), and Pius and Okoli (2021) who reported in their respective studies that gender and instructional methods have no interaction effect on students' acquisition of SPS in science subjects. This finding is however contrary to the findings of Okoye and Osuafor (2021).

5. Conclusion

Everyday importance of biology to scientific and technological advancements has presented the need for teachers to adopt instructional approaches that can help learners not only acquire the knowledge but also the science process skills (SPS) associated with learning the subject, which are needed for one to effectively carry out scientific investigations, to solve their everyday problems.

In light of the premise, the study adopted ELA to ascertain its effect on acquisition of SPS by students in biology irrespective of gender. From the interpretation of the collected data, it was statistically revealed that biology students taught with ELA attained higher significant mean SPS acquisition test scores than those taught with the CLM. Thus, revealing that ELA fostered students' acquisition of SPS better than the use of conventional lecture method.

On gender, the study showed that although the boys had higher mean SPS acquisition test scores than the girls in the same experimental (ELA) group, gender influence was not statistically significant. This implies that ELA is not gender biased.

The study also showed that gender and teaching methods had no interaction effects on students' acquisition of SPS in biology.

Given these findings, the study advocated that:

1. Biology instructors in high schools should incorporate ELA during the teaching and learning process to promote students' acquisition of the SPS in biology.

2. Education stakeholders should familiarize teachers with ELA and how to effectively implement the approach in the classroom though organization of workshops and conferences for biology instructors.

3. Teacher training colleges and institutions should emphasize the use of ELA in training student-teachers.

Taking into account the findings, the following application of this investigation to knowledge was made:

1. The study statistically revealed that ELA has enhanced acquisition of SPS by students in biology irrespective of gender. Hence, by implication, if this approach is adopted by teachers in the classroom, students' acquisition of SPS will be enhanced, which in the long run will improve their academic achievement in examinations.

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