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Relative effectiveness of generative learning strategy on students' academic achievement in senior secondary school biology

Onanuga [1], Peter Abayomi, Saka [1], Adewale Owodunni, Onyeanwusi [1], Chinneye Stella

1- Department of Science and Technology Education, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

Corresponding author contact: pierrenuga@gmail.com

Abstract. The study investigates the relative effect of generative learning strategy on secondary school students' academic performance in Biology. The research design adopted for the study was pre-test, post-test, control group quasi-experimental with a 2 x 2 factorial matrix. The study also determines the effect of gender as a moderating variable on students' academic achievements. Seventy-six secondary school students (76) in intact classes drawn purposively from two schools that met a set of criteria were selected to participate in the study. The research instrument was a 30-item multiple choice test named Biology Achievement Test (BAT) subjected to face and content validity and reliability tests, the test-retest reliability co-efficient yielded 0.78. Careful analysis of the data collected conducted through the use of both descriptive and inferential statistics and the results point to significant main effect of the strategy on the senior secondary school students' academic achievement in Biology. Further attention is brought to the fact that the students exposed to the Generative Learning Strategy (GLS) achieved higher post-test mean achievement score compared to their counterparts exposed to the conventional method. It was, therefore, recommended that the strategy should be integrated into the teacher education programmes to allow prospective teachers to have adequate understanding and knowledge of its use.

Keywords: Academic achievement, Generative Learning Strategy, Relative effect

1 Introduction

Science can be seen as the bedrock of national development. A nation may find it difficult to achieve sustainable national development and economic prosperity if adequate attention is not devoted to its science education. Advancement in science and technology of every nation always brings that nation competitive advantages over others in all aspects of human undertakings. One of the key science subjects vital for the scientific and technological advancement of any nation is Biology.

Okenyi (2015) describes Biology as a body of knowledge pivotal for the successful understanding of other fields of science such as botany, anatomy, physiology, microbiology, medicine, agriculture, pharmacy, and biotechnology to mention just a few. Biology is the study of life and it illuminates the relationship between living organisms and interactions among them (Nasir, 2013). It is the basis for the survival of mankind because there is no area of human existence that does not encompass the usage of Biology. Application of Biology can be found in the areas such as Bio-fermentation, Biofuels, Bioinformatics, Bioremediation and many more (Sallau, Abubakar & Yau, 2018).

Knowledge of Biology and Biology education are central to achieving sustainable development (Sallau, Abubakar & Yau, 2018). Sustainable development is the ability of the current generation of human beings to meet their needs without jeopardizing the possibilities of future generation to meet their own needs. Meanwhile, Choudhury (2015) observes that the unhindered exploration and manipulation of the natural resources over the years are declining various components of the environment and they may be exhausted very soon if care is not taken. The researcher, however, argues that Biology and its associated bio-based technologies can be used to achieve sustainable development and control the destruction of natural resources because the technologies will ensure consumption of fewer resources, integrate recycling, reprocess materials, and mitigate the production of waste and employ other strategies for supporting the greener world while productivity is enriched. Similarly, French (2019) reported that synthetic biology has the ability to develop new products, materials and services

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that can contribute to the 2030 United Nation's Sustainable Development Goals and advocated the supports of developing nation like Nigeria to support synthetic Biology to be able to enjoy the benefits accruable from such products. This affirms the practical contributions of Biology to sustainable development.

According to the Chief Examiners' Reports by the West African Examinations Council (WAEC), a body saddled with the responsibilities of conducting examinations and to award certificates in public interests in English-speaking West African countries, students' performance in Biology in Nigeria is poor and this implies that the use of Biology to achieve sustainable development can be slowed down. The table below shows the performance of students in Biology examinations conducted by the WAEC over the years from 2014 to 2018:

Table 1. Students' performance in WAEC conducted Biology Examinations

S/N	Year	Total number of candidates	Mean	Standard Deviation
1.	2014	1,415,341	29.00	12.37
2.	2015	1, 182,038	25.00	11.87
3	2016	1,087,921	31.00	10.91
4.	2017	Above 1 million	31.00	11.92
5.	2018	1,087,884	30.00	9.00

Source: WAEC Chief Examiner's Reports retrieved from https://waeconline.org.ng/e-learning/Biology/Biomain.html.

Table 1 reveals that for the five years reviewed, the students mean performances in Biology fluctuated between 25.00 and 31.00. This is not good for a nation that is generally regarded as the "Giant of Arica" and a signatory to Sustainable Development Goals (SDGs) agenda. In fact, there was a sharp decline in the students' mean performance in the subject under discussion in 2015 with mean performance of 25.00 as against 29.00 recorded in 2014. While the mean performance stood at 31.00 in both 2016 and 2017, it declined again, be it slightly, to 30.00 in 2018. The implication of the inconsistent students' performances in Biology is that Nigeria's developmental efforts towards the use of Biology as one of the key disciplines to achieve scientific and technological advancement as well as sustainable development may be hampered because Biology and its associated bio-based technologies have been reported to have significant impact on sustainable development (Choudhury, 2015). Meanwhile, Sallau *et al.* (2018) affirms that any nation that is highly ambitious to be scientifically and technologically advanced must have suitable level of Biology education.

Meanwhile, as part of the measures to redress the ugly trends in students' performance, the Chief examiners reports have consistently emphasized the need for teachers to reconsider the methods of teaching the subject under investigation. According to WAEC Chief Examiners' Report (2016; 2017 & 2018), teachers should teach students the rules for drawing biological diagrams and should encourage the students to draw; teachers should be engaged in seminars and extensive trainings to aid their teaching; and teachers should provide teaching aids and models to help students understand biological concepts. The implication of these is that the conventional method of teaching lacks the capabilities to help the students do well in Biology exams. Conventional teaching method has been blamed for the low academic achievement of students in Biology (Opara, 2011). This was attributed to teacher-centeredness and one-way communication nature of conventional teaching method which makes learners passive information receivers in the process of teaching and learning. Indeed, the 2018 report mandates teachers to attend WAEC marking coordination to understand the expectations of the examining body when it comes to grading of students answers to Biology questions in order to tailor their teaching methods towards these expectations. Hence, there is a strong need for paradigm shift from the conventional method of teaching Biology to other methods capable of addressing the numerous issues

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culminating into the students' poor performances in the subject. Meanwhile, Maknun (2015) argued that one learning strategy capable of easing students' cognitive difficulties in acquiring scientific knowledge is generative learning strategy.

Generative learning strategy (GLS) is a student-centred approach based on the principle that any learning environment that affords learners to be active participants stimulates thinking and can improve learning compared to the conventional teaching strategy which impede students' active participation (Adeyemi & Awolere, 2016). GLS is hinged on the assumption that learning is a generative activity which makes learners actively construct their own knowledge by restructuring their schemas to align the new information being processed with the previously learned materials. It facilitates learners' understanding of the instructional contents for possible reuse in another situation. According to Fiorella and Mayer (2015), generative learning strategy, unlike the others, is capable of facilitating learning by mapping, which is the ability of the learners to arrange words and link these words using graphic organizers for easy understanding and applications of such knowledge. It also promotes learning by drawing with the intent of selecting relevant information (concepts) from the text and produce drawing to show interrelationship among them. In addition, it facilitates learning by imaging which means creation of mental pictures of the contents/materials being learned in the mind/brains of the learners. This means that GLS may cater for most of the students' shortcomings in the learning of Biology especially in the area of biological drawing and representation of biological concepts as mental images in their brains.

Several studies have reported the effectiveness of generative learning strategy in subjects such as Physics (Maknun, 2015); Chemistry (Ulusory & Onen, 2014); Environmental concepts (Adeyemi & Awolere, 2016); and Algebra (Bot, 2018). Hence, this study hypothesized the use of generative learning strategy to further confirm its efficacy in addressing the unstable students' academic achievement in Biology in Nigerian senior secondary schools because the method has not been seriously used in Biology teaching in Nigeria.

In the meantime, despite the United Nations Children's Fund's [UNICEF], (UNICEF 2011) position that gender difference should not create academic performance gap between males and females, studies have shown that learners' gender dictates students' academic performance in school subjects. International Alliance of Research Universities (IARU) observed that gender gap exists in students' academic performances globally (Schubet, 2018). Science, Technology, Engineering and Mathematics (STEM) disciplines are traditionally heavily male-dominated (Arizona State University, 2014). The University also observed that while females and males appear to answer in equal proportion during science class activities, if recognized by the teachers, females usually decline to answer the questions voluntarily unless they are called upon and therefore, recommended the use of presorted list of students' names to ensure random distribution of the questions to both genders rather than allowing the students to signify their intentions. Newal, Gonsalkorale, Walker, Forbes and Highfield (2018) attributed gender differences in academic performance especially in science to genetic make- up which favours male students over their female counterparts.

Expectedly, research findings related to gender gap in students' performance in science subjects are controversial. The study of Afolabi and Olajuyigbe (2018) unveiled significant main effect of gender on students' academic performance in physics. Also, Amedu (2015) reported significant difference between the Biology mean scores of male and female students in favour of the males, after exposure to jigsaw instructional strategy. Conversely, the study of Ariyo and Gabriel (2018) which investigated the efficacy of two innovative strategies on students' academic performance in Biology in Ekiti State, Nigeria reported no significant gender gap in the students' performance. The same trend was reported by Abakpa, Achor and Odoh (2016) who acknowledged no significant difference between male and female students' mean achievement scores in Biology when exposed to investigative laboratory strategy. Meanwhile, Olasehinde and Olatoye (2014) found no significant difference between male and female students in overall science achievement and concluded that teachers should advance instructional strategies that will bridge the gender learning outcomes' gaps in science. It is thus evident that issue of gender gap in students' academic performance is still far from being conclusive. That was the reason why the present study incorporated gender, as moderating variable, with the purpose of determining whether or not the generative learning strategy could reduce the gender performance gaps separating male and female students.

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From the foregoing, it is evident that Biology is central to the advancement of science and technology as well as to the attainment of sustainable development. However, analysis of students' performance in WAEC conducted Biology examinations over five years (2014-2018) revealed students' poor performances and there have been advocacy for methods of teaching capable of addressing the highlighted challenges. It is against this background that the researchers investigated the effect of generative learning strategy on students' academic achievement in Biology. Gender was also built into this study as moderating variable to determine its interaction with the strategy to influence students' academic achievements in Biology.

1.1. Research objectives

The study investigated the relative effect of generative learning strategy on the academic achievements of senior secondary school Biology students in Ijebu-North Local Government Area of Ogun State. Specifically, the study:

i. investigated the relative effectiveness of Generative Learning Strategy on students' academic achievements in Biology.

ii. determined the moderating effect of gender on students' academic achievements in Biology.

1.2. Hypotheses

The study was guided by the following hypotheses tested at 0.05.

$H_0$1: There is no significant main effect of the strategy (generative learning strategy and conventional method) on the academic achievements of the secondary school students in Biology

$H_0$2: There is no significant main effect of gender on the academic achievements of the senior secondary school students in Biology.

$H_0$3: There is no significant interaction effect of strategy and gender on the academic achievements of the senior secondary school students in Biology.

2 Methodology

The research design adopted for this study was pre-test, post-test control group quasi-experimental design involving 2 x 2 factorial matrix. The two groups were randomly assigned to experimental and control groups. The groups were mixed with two levels of gender (male and female) to determine its interaction effect on students' academic achievements in Biology.

The design layout is shown below:

O_1 X O_2 (Experimental group)
O_1 O_2 (Control group)

Where: O_1 = Pre-test
O_2 = Post-test
X = Experimental treatment (Generative Learning Strategy) for experimental group

The population for this study comprised all the senior secondary one (SS 1) students offering Biology in public senior secondary schools in Ijebu North Local Government Area of Ogun state. The SS 1 students were selected because there was no pressure of preparation for external examinations unlike other categories of students in senior secondary classes.

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The seventy-six students (76) used for the study were drawn from SS 1 students offering Biology in Ijebu-North Local Government Area of Ogun State. The two schools where the students were drawn were purposively selected on the basis of the following criteria:

a. The schools must be offering Biology at the senior secondary school level.

b. The schools must have educationally qualified Biology teachers possessing B. Sc. (Ed.) Biology, B. Ed. Biology or B. Sc. and Postgraduate Diploma in Education

c. The schools should not be very close to each other to prevent subject interaction effect that could affect internal validity of the study.

One intact class in each of the selected schools was randomly chosen and used for the study. A sample of seventy-six students from two intact classes of SS1 students offering Biology was used. While the experimental group consisted of thirty-one (31) students, the control group consisted of forty-five (45) students.

3 Instrumentation

3.1. Biology Achievement Test (BAT)

Biology Achievement Test (BAT) was a researcher-developed instrument to measure students' achievement in Biology. It had sections A and B with the section A eliciting learners' demographic details while section B consisted of 30 multiple choice test items on the Ecological Management and Micro-organism. The 30 items were decided upon after careful analysis of the initial one hundred and ten items. The test covered three levels of Bloom's taxonomy of educational objectives - that is, knowledge, understanding, and application. These levels were used on account of the duration of study and the level of study of the subjects.

The instrument was validated with the help of two experienced Biology teachers in secondary schools and two experts in test construction from the Faculty of Education, Olabisi Onabanjo University, Ago-Iwoye, Nigeria. The suggestions and comments of the experts were used to modify the test items before the final production. The reliability of Biology Achievement Test (BAT) was determined after being administered twice on a sample of 26 Secondary School 1 (SS 1) students offering Biology at a school that was not part of the study but which has similar characteristics as the schools selected for the study. The test re-test reliability method was used to analyse the students' responses obtained twice within the interval of two weeks and it yielded a co-efficient of 0.78.

4 Method for Data Collection

The researchers took permission from the authorities of the selected schools and thereafter approached the teachers and the students to solicit for their support. The study participants agreed to participate in the experiment after the assurance of being ethical in the use of the data collected for research purposes only.

Prior to the commencement of the teaching activities, both the teacher and the students in the experimental group were trained on the use of generative learning strategy to learn Biological concepts. The teacher in the control group employed the usual method of teaching which did not involve generative learning method. Thereafter, BAT was administered as pre-test to the students in both experimental and control groups. The study lasted for eight weeks but six weeks were used for intensive teaching and learning processes in both groups. The training and administration of pre-test took place in the first week while the administration of post-test took place in the eighth week. The topics learned were Ecological Management and Micro-organisms around us. The topics were chosen based on the

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scheme of work approved by the Ogun State Government, Nigeria so as not to disrupt the academic calendar.

In the experimental group, students were taught the topics highlighted for the study using the following generative learning strategy steps:

Step 1: Attention Component

The teacher directed the student's attention to the topic and objective of the lesson. The students became actively involved in the process of learning by focusing on the topic and contents of the lesson.

Step 2: Motivation Component

The teacher encouraged the students to give meaning to the topic, lesson contents by representing the content using their own understanding. The teacher reinforced learning using positive feedback. The students were given the opportunities to control the learning process

Step 3: Knowledge Component

The teacher gave the details of the new contents and the students were able to connect the respective topics with what they have learned and relate them to their immediate environment.

Step 4: Generation Component

The teacher further engaged the students by asking them for explanations and made clarifications where necessary, and then drew inferences. The students were also allowed to ask questions from classmates while generating meaning of biological concepts. The two-way communication was to aid the deeper understanding of the subject. Then, the teacher asked questions from both male and female in equal proportion about the learnt materials to evaluate the students' level of mastery. This was to ensure that both male and female learners take equal part in the learning process.

Step 5: Metacognitive Component

The teacher guided the students towards areas where the new knowledge can be useful and applied, either personally or collectively. The students learnt to organise their thoughts, thereby applying the new knowledge and demonstrate its usefulness.

Step 6: Assignment

The teacher gave the students take-home assignment. The students copied the take-home tasks.

5 Method of Data Analysis

The data analysis involved the use of descriptive and inferential statistics. The descriptive statistics used frequency counts and simple percentages while the inferential statistics involved the use of simple regression and Analysis of Covariance (ANCOVA) with pre-test scores as covariates to determine the effects of the strategy and gender as well as the interplay of gender and strategy on the dependent variable. The hypotheses generated were tested at 0.05 level of significance.

5.1. Descriptive Analysis

This section describes the data about the sample selected for the study from both experimental and the control groups.

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Table 2. Descriptive analysis of the respondents by Strategy and Gender

Strategy	Gender composition		Total (%)
	Male (%)	Female (%)	
Generative learning	12 (15.8)	19 (25)	31(40.8)
Control	23 (30.3)	22 (28.9)	45 (59.2)
Total	35 (46.1)	41(53.9)	76 (100)

Source: Field survey, 2018

It can be seen from Table 2 that the experimental group contained 31 students representing 40.8% of the study participants while the control group had 45 students representing 59.2% of the study participants. Also, the table reveals that the female students have the higher percentage participant distribution of 53.9% (41) compared to males' 46.1% (35). This means that female students outnumbered their male counterparts.

5.2. Testing of hypotheses on the relative effect of generative learning strategy

$H_0$1: There is no significant effect of strategy (generative learning strategy and conventional method) on students' academic achievements in secondary school Biology.

Table 3. Summary of Analysis of Covariance of Students' Achievement Scores According to Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1202.595[a]	4	300.649	6.948	0.000
Intercept	2725.292	1	2725.292	62.980	0.000
Pretest	541.867	1	541.867	12.522	0.001
Strategy	194.393	1	194.393	4.492	0.038
Gender	56.543	1	56.543	1.307	0.257
Strategy * Gender	3.476	1	3.476	0.080	0.778
Error	3072.353	71	43.273		
Total	403460.000	76			
Corrected Total	4274.947	75			
R Squared = 0.281, Adjusted R Squared = 0.241					

Table 3 reveals a significant main effect of the strategy, $F_{(1, 71)} = 4.492$, $p = 0.038 < 0.05$) on students' academic achievement in senior secondary school Biology. Therefore, the null hypothesis which states that there is no significant main effect of strategy on academic achievement of secondary school students in Biology is rejected.

In order to determine which of the strategies produced the higher post-test mean achievement scores, simple effect analysis was conducted using SPSS syntax which produced the results shown in table 4:

Table 4. Analysis of effect produced across the strategy

Teaching Strategy	Mean	Std. Error
Generative Learning Strategy	74.423[a]	1.240
conventional method	70.971[a]	1.004

Covariates appearing in the model are evaluated at the following values: Covariate = 55.75

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Table 4 indicates that the students exposed to the GLS achieved higher adjusted post-test mean achievement score, mean = 74.423 compared to their counterparts exposed to the conventional method with post-test mean achievement score of 70.971

$H_0$2: There is no significant main effect of gender on the academic achievement of senior secondary school students in Biology.

The results in table 3 prove convincingly that there is non-significant main effect of gender on students' academic achievement in Biology, $F_{(1,71)} = 1.307$, $p = 0.257 > 0.05$. This means that the post-test mean achievement scores of students in Biology across gender is not significantly different. Therefore, the null hypothesis that no significant main effect of gender on the academic achievement of senior secondary school students in Biology is retained.

Table 5. Analysis of effect produced across the gender

Gender	Mean	Std. Error
Male	71.805	1.172
Female	73.589	1.030

Covariates appearing in the model are evaluated at the following values: Covariate = 55.75

Table 5 illustrates that the students exposed to the male achieved higher adjusted post-test mean achievement score, mean = 71.805 compared to their counterparts exposed to the conventional method with adjusted post-test mean achievement score of 73.589

$H_0$3: There is no significant interaction effect of strategy and gender on the academic achievement of senior secondary school students in Biology.

Disclosed in table 3 is the presence of non-significant interaction effects of strategy and gender on students' academic achievements in Biology, $F_{(1,71)} = 0.080$, $p = 0.778 > 0.05$. This implies that the effect of the strategy on students' academic achievement in Biology did not differ significantly across the levels of gender. Therefore, the null hypothesis which states that there is no significant interaction effect of strategy and gender on the academic achievement of senior secondary school students in Biology is provisionally retained.

6 Discussion

The results obtained reveal that more female students are offering Biology than their male counterparts. This may be due to their appreciation of application of Biology in solving the environmental problems confronting the nation and more importantly as the basis for survival of humankind. This finding negates the report of Arizona State University (2014) that STEM subjects are traditionally heavily male-dominated. In addition, the finding revealed that there is significant main effect of strategy on academic achievement in Biology in favor of the students exposed to the generative learning strategy. This may be the attributed to the nature of generative learning strategy which involve active participation of the students in the teaching learning process. Students were able to generate the meaning on the biological concepts on their own with teacher acting as the facilitator. The implication of this finding is that the generative learning strategy has the power to lay the foundation for proper understanding of Biology at the senior secondary school level. This finding corroborates that of Adeyemi and Awolere (2016); Bot (2018) who reported efficacy of generative learning strategy on Biology and Mathematics respectively.

Furthermore, the final outcomes of the present study reveal no significant main effect of gender on the academic achievements of the senior secondary school students in Biology. This may be attributed to the ability of the generative learning strategy to allow individual students to construct useful knowledge irrespective of their gender. It may also be due to the teacher's ability to give students,

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regardless of their gender, opportunities to ask questions and make clarifications while reinforcing the knowledge constructed by the learners during the GLS. Female learners might also want to weaken the belief that science subjects are male-dominated and therefore work harder to show that their genetic make-up as female cannot hinder their academic achievements. This finding lends credence to the findings of Ariyo and Gabriel (2018); Abakpa, Achor and Odoh (2016) which revealed no significant gender gap in the students' performance in Biology.

Moreover, the finding indicates no significant interaction effect of strategy and gender on the academic achievement of senior secondary school students in Biology. This may be attributed to the ability of generative learning strategy to allow learners regardless of gender to construct the knowledge of the materials learnt in suitable ways and thus, improving their academic achievement in Biology. Meanwhile, post hoc analysis made it known that female students achieved higher adjusted post-test mean achievement scores than their male counterparts when exposed to generative learning strategy. This means that the strategy meets the specific needs of the female learners. Such a finding aligns with the suggestion of Accenture (2016) that it is important to advance the strategy that will meet the specific needs of female learners to change the myth that science subjects are male-dominated.

7 Conclusion

The study investigates the effect of generative learning strategy on students' academic achievement in senior secondary school Biology. The study reaches the conclusion that generative learning strategy is effective in solving the problems of students' unstable academic achievement in senior school Biology. The study also infers that there is no significant main effect of gender on the students' academic achievements in Biology. Furthermore, the study agrees that there is no significant interaction effect of strategy and gender on the students' academic achievements.

Consequent upon the findings, the study recommends that teachers should adopt the use of generative learning strategy to assist students in improving the quality of their learning in Biology. To this end, governments at all levels should sponsor workshops where teachers and other stakeholders could be trained on how to use the strategy. The strategy should also be integrated into the teacher education programmes to allow prospective teachers to have proper grasp of its application.

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