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COMPARATIVE EFFECTS OF LABORATORY AND ALTERNATIVE TO PRACTICAL ON SSII STUDENTS' ACADEMIC PERFORMANCE IN BIOLOGY IN ZONE B OF BENUE STATE

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Abstract

This study compared effects of laboratory and alternative to practical on SSII students' academic performance in Biology in Zone B of Benue State. The researchers used quasi experimental non-equivalent pre-test post-test design. The population of this study comprised 29,571 SS II students that offer Biology in education Zone B of Benue State comprising 15,204 males and 14,367 females. A sample of 211 students comprising 113 male and 98 female SS II students was used for the study. Multi-stage sampling technique was used in the study. Biology Performance Test (BPT) constructed by the researchers was used for data collection. The test was given to three experts (lecturers), two in Science Education and one in Mathematics education in the Department of Science and Mathematics Education, all in Faculty of Education, Benue State University, Makurdi for face validation. To determine the reliability of the instrument, a trial test was conducted in a public secondary school outside the sampled schools. Thirty SSII students who offer Biology that were not part of the sampled population but within the area of the study were given the test after which they were collected the same day. Data collected were analyzed using Kuder Richardson 20 (because the item have preferred answers). The reliability of 0.81 was obtained. The researchers collected the data with the help of research assistants. Mean and Standard Deviations were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. Findings revealed a significant difference between the mean performance scores of students taught Biology using laboratory practical and those taught using alternative to practical ($F_{1,208}$= 1109.732; p = 0.000 < 0.05); there is significant difference in the mean performance ratings of male and female students taught Biology using laboratory practical learning approach ($F_{1,106}$ = 4.300; p = 0.041 < 0.05). It was recommended that Biology teachers should use laboratory practical approach to ensure effective teaching and learning so as to enhance students' performance in Biology instead of the alternative to practical.

Key words: Laboratory practical, Alternative to practical, Academic performance, Biology and Gender

Introduction

Science is a discipline with peculiar characteristics, prominent among these characteristics is the approach through which new knowledge is acquired. This approach is known as scientific method. Scientific method is a logical, rational and systematic process by which knowledge in science is acquired. Some of the steps involved in scientific method include observation, hypotheses, predictions, experimentations, conclusion (Ezeh, 2013; Ode, Akpoghol & Otor; 2020). Science is both a process (scientific method) and a product (knowledge, fact and principles) The process of science takes place practically in the laboratory and product of science are arrived at through practical experimentation in the laboratory. Science plays important roles in the society because it relates to our daily life and career. The importance of science in our society made the Federal Government of Nigeria (FGN, 2013) to introduce science subjects in the nation's secondary school curriculum and Biology is one of the subjects.

Biology is a branch of science that deals with the study of living things, which includes human-beings (Michael, 2012). Biology has many branches which include; zoology, botany, ecology, genetics, morphology, anatomy, physiology, histology, microbiology, evolution, cell Biology to mention but a few. Many societal issues are Biology-based. These include biodiversity, genetically modified organisms, reproductive technologies, prolonging of life, food production, tourism industry (biological gardens) and processing industries. All of these issues have involved improvements that meet human needs in several ways. For instance, the knowledge of Biology helps in checking environmental degradation such as desertification, erosion, land, air and water pollution.

The key objectives of Biology education are to prepare students to acquire: adequate laboratory and field skills in Biology; meaningful and relevant knowledge in Biology; ability to apply scientific knowledge to everyday life in matter of personal and community health and agriculture; lastly reasonable and functional scientific interests (FGN, 2013). Despite the importance of Biology, students' performance in the subject from West African Secondary School Certificate Examination (WASSCE) has been poor (Shana & Abulibdeh, 2014).

Available information on students' performance in Biology in School Certificate revealed inconsistent performance in the past three years in the WASSCE. The aspects of Biology which students find difficult in WASSCE are practical questions on food test, for example carbohydrates, proteins and fats/oils, this indicates that students lack basic practical principles such as observation, and interpretation of the specimens provided for the examination (WAEC Chief Examiners Report, 2019, 2020 - 2024). Many Biology teachers fail to conduct Biology practical along-side every topic treated during lessons, until a few days to examination when they will use WAEC specimens to conduct practical for their students. Eze (2015) inferred that practical work is a unique strategy of teaching and learning of Biology because it concretizes learning experiences and enables science students to observe and manipulate materials to demonstrate certain aspects of the subject matter, which have been learnt in the class through lectures, discussion and textbooks.

This study has seen the need to make teaching and learning interactive and learner-centered. According to Ode (2018), Bilya and Achor (2021), poor teaching methods such as lecture and demonstrations used by secondary school teachers without involving students have been found to contribute to

poor performance and interest in science. Akani (2015) maintained that lecture and demonstration methods are poor instructional methods to be used in Biology laboratory because they do not give room for active learning but only help intellectual passivity and weariness of the learners. This view was buttressed by Ronoh (2017) who stated that lecture method is not suitable for slow learners. The author noted that it promotes rote learning and lack of opportunity for students to: interact with one another; manipulate or handle practical materials; to reflect on the work they carried out in the laboratory and transfer the knowledge acquired during learning processes to solve daily life problems.

Practical or laboratory approach is students - centered approach of teaching and learning that allows students to find out facts themselves with the assistance of the teacher who serves as a facilitator. Inquiry learning is a form of active learning where progress is assessed by how well students develop experimental and analytical skills rather than how much knowledge they possess. According to Umoh (2021), learning becomes more effective and long lasting when learners plan their own questions, analyze and discuss their findings and finally construct their understanding. Umoh (2021) further maintained that inquiry based instruction is not only concerned with the preparation for long life learning but also extends knowledge beyond the classroom doors which enable students to experience events like real scientists. The essence of inquiry in the laboratory is to ask questions that stimulate students to think critically, construct knowledge using scientific processes such as observing, classifying, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing and experimenting which help students to build knowledge and communicate what they have learned. The practical teaching method is mostly carried out in the science laboratory where the students are guided using science equipment and materials to experiments and learn (Eriba & Samba, 2015).

Laboratory is described as a room or building or a place where experiments are carried out by science students or teachers. In the laboratory, students are engaged in providing explanations to natural phenomena in a practical way. According to Eriba and Samba (2015), a laboratory is a facility where students are provided with practical learning experiences. The authors further stressed that laboratory helps students to discover the unknown and confirm the truth of the knowledge acquired in the classrooms. Laboratories used for scientific experiments and researches take two forms such as indoor and outdoor laboratories. Indoor laboratory is a building or room furnished with different scientific equipment in various fields of science and engineering. While outdoor laboratory is one outside the confirmed building or room such as ponds, forests, riversides and botanical gardens. In the laboratory, students have the opportunity to carry out experiments and other investigative activities.

Laboratory practical are activities or investigations that are carried out in the laboratory which provide students opportunities of becoming more knowledgeable and acquiring science process skills, which includes observation, identification, classifying, hypothesizing, predicting, measuring and experimenting which could improve their interest and performance in Biology. Akusoba (2012) asserted that laboratory activities can be regarded as a strategy that could be adopted to make concepts more real to the students as opposed to abstract or theoretical

presentation of facts, principles and concepts of subject matters.

Alternative to practical refers to the practical aspect of a laboratory which may be done outside the laboratory preferably in the class room. This is carried out after taking into consideration cost, existing technology, and logistics in light of overall project purposes, and having less impact to critical areas (Umoh, 2021). On the other hand, laboratory practical involves a collection of experiments that demonstrate a wide range of physical concepts and processes. Some of the experiments can be used as starting-points for investigations or for enhancement of activities. Alternative to practical assessment is a written paper that tests the knowledge of the students in the process of conducting practical experiments in the laboratory

Laboratory activities have played a special and central role in science education for a long time, and science educators believe that engaging students in laboratory activities has many benefits: they stimulate creativity, curiosity and critical thinking, promote students' engagement with the scientific methods and encourage active learning and problem-solving approach. Laboratory activities also provide opportunities to collect and analyze data and apply mathematical knowledge to support and illustrate concepts, facts and principles (Boud, Dunn & Hegarty-Hazel, 2019).

Researchers (Akani, 2015, Ronoh, 2017 & Umoh, 2021) have found out that students encounter some problems in laboratory works, such as lack of acquisition of desirable skills (poor observation of specimens, poor identification of specimens, drawing of specimens and poor recording or reporting of practical works). These problems make it difficult for some students to understand laboratory practical work and theoretical knowledge acquired during classroom teaching and learning processes. In view of the above mentioned problems faced by students in the laboratories, if the laboratory practical are reorganized in a proper manner it will promote quality teaching and learning in the classroom or laboratory.

Group laboratory work engenders interaction among students in the laboratory, where learners work together to accomplish a certain goal. Like the cooperative learning approach, in group laboratory work, learners help one another in an academic subject, in small groups formed both in classroom and in non-classroom environments such as the laboratory to make sense of what they learn. The approach helps the learner to gain more self-confidence and develop their communication, problem- solving and critical thinking abilities and students actively participate in the learning/ teaching processes (Shana & Abdulibdeh, 2021). It could also help students to acquire practical, leadership and conflict resolution skills. When students in groups interact with one another, share ideas, and seek additional information and decisions about their findings which may enhance performance in Biology.

Academic performance refers to the ability of students to study and remember facts and being able to communicate their knowledge verbally or put down on a paper (Aduloju, 2014). According to Ode (2018), students' academic performance in school is measured mainly in terms of their ability to pass or fail test or examinations (internal and external). The author further states that academic performance of male and female students is a very vital evidence of measuring their level of knowledge, skills, ideas, values acquired in school. Academic performance is also the measure of what a student (irrespective of gender) achieved after exposure to an educational programme like Biology teaching and learning.

Gender issues remain inconclusive as findings from some studies on gender have

shown contradictory evidence in the academic performance of students. Thus, while some researchers found that male students have a higher academic performance than females, others found reverse to be the case, and yet, another group found no significant difference. For instance, while Oludipe and Oludipe (2018) and Ode, Agbike, Abah and Chia (2019) found no difference between male and female students' performance, Ezeudu and Obi (2014) found that males perform better than females. These controversial findings on students' interest and performance based on gender necessitate more research and this justifies its inclusion as a moderator variable in this study. It is against this backdrop that it became imperative to carry out a study on the effect of laboratory and alternative to practical on SSII students' academic performance in Biology in Zone B of Benue State.

Statement of Problem

In Nigeria, students' interest and performance in secondary school Biology has not been encouraging. In spite of the desire for technological development, which needs Biology education there is persistent poor academic performance of students in the subject irrespective of gender, particularly in practical Biology. So many factors can be attributed to students' poor performance in Biology practical; they include teachers' use of inappropriate instructional approaches, lack of adequate laboratory facilities, poor organization of laboratory activities, lack of commitment to laboratory work by both teachers and students, partial or total absence of laboratory, lack of qualified Biology teachers and mode of laboratory activities that are used in Biology laboratory. Studies have shown that teachers use mostly teacher-centred approaches in teaching Biology despite the fact that it is an experimental subject. The inappropriate instructional approaches used by Secondary School Biology teachers, tend to raise doubts about the possibility of realizing the objectives of Biology education in Nigerian secondary schools as stated in the National Policy on Education (FGN, 2014).

Most instructional approaches such as lecture and demonstration used in teaching Biology in the classroom or laboratory, promote rote learning and lack of opportunity for students to manipulate materials and reflect on what they do during teaching and learning processes. Students' interaction during practical activities in the laboratory could play a key role towards concretizing learning. Among all the problems that contribute to students' poor interest and performance in Biology, the researcher is interested in laboratory and alternative to practical and their effects on students' academic performance in Biology. The problem of this study stated in question forms therefore include: What is the effects of laboratory and alternative to practical on SSII students' academic performance in Biology in Zone B of Benue State? Is there any difference in academic performance of male and female students exposed laboratory practical in Biology?

Purpose of the Study

The main purpose of this study was to investigate the comparative effects of laboratory and alternative to practical on SSII students' interest and performance in Biology in Zone B of Benue State. Specifically, the study investigated:

1. the difference between the performance scores of students taught Biology using laboratory practical and those exposed to alternative to practical.

2. the difference between the performance scores of male and female students taught Biology using laboratory practical.

Research Questions

The following research questions guided this study;

1. What is the difference between the mean performance scores of students taught Biology using laboratory practical and those exposed to alternative to practical?
2. What is the difference between the mean performance scores of male and female students taught Biology using laboratory practical?

Hypotheses

The following null hypotheses were postulated to guide this study and were tested at 0.05 level
of significance;

1. There is no significant difference between the mean performance scores of students taught Biology using laboratory practical and those exposed to alternative to practical.
2. There is no significant difference between the mean performance scores of male and female students taught Biology using laboratory practical.

Method

The researchers used quasi experimental non-equivalent pre-test post-test design. The reason for the choice of quasi experimental design is because owners of schools may not want to disrupt their classes for the conduct of this study therefore, intact classes were used. Emaikwu (2015) supports the use of non-equivalent design when it may not be feasible to randomize subjects as in true experiments**.** The population of this study comprised 29,571 SS II students that offer Biology in education Zone B of Benue State comprising 15,204 males and 14,367 females (Teaching Service Board Makurdi, 2023). A sample of 211 students comprising 113 male and 98 female SS II students was used for the study. Multi-stage sampling technique was used in the study. Simple random sampling was used to select two local government areas (Makurdi and Guma) from Education Zone B of the state. This was done by numbering papers based on the number of local government areas in the Zone out of which two were randomly picked (Makurdi and Guma). Purposive sampling technique was used to select two schools each from the local government. The criteria for purposive sampling of the schools was that: the school must be a public secondary school and must have center for WAEC/NECO for at least five years. Private and mission schools were not included to ensure parity in standard; **t**he school must have a Biology teacher who holds a B.Sc. Ed or B.Sc in Biology and the school must be coeducational to take care of the gender variable in the study. Simple random sampling technique was used to assign one intact class (each) in the sampled schools to experimental group and control group.

Biology Performance Test (BPT) constructed by the researchers was used for data collection. The instrument has sections A and B. Section A elicits personal information from the respondents such as name of school and gender, while section B contains 30-multiple choice items with four options (lettered A to D) based on the topic of animal nutrition and food substances. The instrument was scored over 30; one mark for each correct answer. The test was given to three experts (lecturers), two in Science Education and one in Mathematics education in the Department of Science and Mathematics Education, all in Faculty of Education, Benue State University, Makurdi for face validation. The validators were asked to make comments in terms of the structuring of the items, clarity and the language to

strengthen the psychometric quality of the items. To determine the reliability of the instrument, a trial test was conducted in a public secondary school outside the sampled schools. Thirty SSII students who offer Biology that were not part of the sampled population but within the area of the study were given the questionnaire and the test after which they were collected the same day. Data collected were analyzed using Kuder Richardson 20 (because the item have preferred answers). The reliability of 0.81 was obtained and this value is good enough for the instruments to be used for the study (Emaikwu, 2015).

The researchers obtained official permission for collection of data in the selected schools from the school principals. After that, the researchers collected the data with the help of research assistants. The experimental treatment lasted for a period of six weeks. The first week was used for administration of pre-test, week two to five were used for treatment while week six was when post-test was administered. Treatment for the experimental group I took place twice a week: 40 minutes for theoretical lesson and 80 minutes for practical. Mean and Standard Deviations were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The choice of this statistical test is justified by the fact that the hypotheses are testing the significant effect of independent variable on the dependent variable and ANCOVA is appropriate for studies that use intact classes as it minimizes the effect of the covariates on the findings of the study (Emaikwu, 2015).

Results

Research Question One

What is the difference between the mean performance scores of students taught Biology using laboratory practical and those exposed to alternative to practical?

Table 1: Mean and Standard Deviation of Performance Test Scores of Students Taught Biology Using Laboratory Practical and Alternative to Practical.

Group	Sample (n)	Pre-test		Post-test		Mean gain
		Mean	Std. D.	Mean	Std. D.	
Practical	109	8.02	1.60	22.82	2.60	**14.8**
Alternative to Practicals	102	7.21	1.48	10.92	2.36	**3.71**
Mean Difference		**0.81**		**11.9**		**11.09**
Total	**211**					

Table 1 shows that the mean performance scores of students taught Biology using laboratory practical was 8.02 with standard deviation of 1.60 during pre-test. It also shows mean value of 22.82 with standard deviation of 2.60 in post-test. The mean performance scores of students taught Biology using alternative to practical was

7.21 with standard deviation of 1.48 during pre-test. In posttest the mean value is 10.92 with standard deviation of 2.36. Table 2 further reveals that the mean gain of students taught Biology using laboratory practical was 14.8, while those taught using alternative to practical had a mean gain of 3.71. The mean difference between the groups is 11.09 in favour of students taught using laboratory practical learning strategy.

Research Question Two

What is the difference between the mean performance ratings of male and female students taught Biology using laboratory practical?

Table 2: Mean and Standard Deviation of Performance Test Scores of Male and Female Students Taught Biology Using Laboratory Practical Approach.

Gender	Sample (n)	Pre-test		Post-test		Mean gain
		Mean	Std. D.	Mean	Std. D.	
Male	58	8.03	1.58	23.29	0.56	**15.26**
Female	51	8.00	1.64	22.27	3.70	**14.27**
Mean Difference		**0.03**		**1.02**		**0.98**
Total	109					

Data in Table 2 indicates that the performance scores of male taught Biology using laboratory practical was 8.03 with standard deviation of 1.58 at pre-test. That of posttest was 23.29 with standard deviation of 0.56. The mean performance scores of female students taught Biology using alternative to practical was 8.00 with standard deviation of 1.64 during pre-test. It also reveals mean value 22.27 with standard deviation of 3.70 in post-test. Table 4 also revealed that the mean gain of male students taught Biology using laboratory practical was 15.26, while that of female students was 14.27. The mean difference between the groups is 0.98 in favour of male students taught using laboratory practical learning strategy.

Test of Hypotheses

Hypothesis One: There is no significant difference between the mean performance scores of students taught Biology using laboratory practical and those exposed to alternative to practical.

Table 3: ANCOVA Result of the Difference in the Mean Performance Ratings of Students Taught Biology Using Laboratory Practical and Alternative to Practical**.**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7462.620[a]	2	3731.310	604.237	.000	.853
Intercept	2095.062	1	2095.062	339.268	.000	.620
Pretest	7.252	1	7.252	1.174	.280	.006
Strategy	6852.867	1	6852.867	1109.732	.000	.842
Error	1284.451	208	6.175			
Total	70203.000	211				
Corrected Total	8747.071	210				

a. R Squared = .853 (Adjusted R Squared = .852)

Table 3 reveals that F(1,208) = 1109.732; p = 0.000 < 0.05. Thus, the null hypothesis was rejected. This implies that, there is significant difference in the mean performance scores of students taught Biology using laboratory practical and those taught using alternative to practical. Thus, based on evidence from data analysis, laboratory practical significantly enhance students' performance than alternative to practical.

Hypothesis Two: There is no significant difference between the mean performance scores of male and female students taught Biology using laboratory practical.

Table 4: ANCOVA Result of the Difference in the Mean Performance Ratings of Male and Female Students Taught Biology Using Laboratory Practical Approach.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	49.318[a]	2	24.659	3.838	.025	.068
Intercept	1746.240	1	1746.240	271.803	.000	.719
Pretest	21.161	1	21.161	3.294	.072	.030
Gender	27.627	1	27.627	4.300	.041	.039
Error	681.013	106	6.425			
Total	57475.000	109				
Corrected Total	730.330	108				

a. R Squared = .068 (Adjusted R Squared = .050)

Table 4 reveals that F(1,106) = 4.300; p = 0.041 < 0.05. Since p < 0.05, the null hypothesis is therefore, rejected. It, thus implies that, there is significant difference in the mean performance ratings of male and female students taught Biology using laboratory practical learning approach. Thus, based on evidence from data analysis, academic performance of male students taught Biology using laboratory practical improved significantly more than the female counterpart.

Discussion of Findings

This study examined the comparative effects of laboratory practical and alternative to practical learning on Senior Secondary II students' academic performance in Biology in Benue State Education Zone B, Nigeria. The findings are discussed in line with the variables of the study.

Findings of this study also indicated that, there is significant difference in the mean performance scores of students taught Biology using laboratory practical and those taught using alternative to practical. This finding is in conformity with the finding of Umoh (2021) who found that students exposed to Chemistry practical performed significantly better than those taught with alternative to practical. The finding also confirms the finding of Akomaye (2021) whose findings showed significant effect of virtual laboratory simulation on SS2 students' knowledge of some science process skills in practical Chemistry in favour of practical experiences. The finding also aligns

with Ugwu, Ngwu and Eze (2020) whose results revealed that students taught Biology using group laboratory activity performed better than those taught using individual laboratory activity. Furthermore, the study agrees with The reason for the agreement in these finding could be because, laboratory practical utilizes the principles of learning science in groups in which students actively engage in learning, interact with themselves and materials and create knowledge. Furthermore, manipulating and guidance from the teacher stimulate deep thought enforcing meaningful learning and improving performance.

Findings of this study also revealed that, there is significant difference in the mean performance of male and female students taught Biology using laboratory practical learning approach. However, male students taught using laboratory practical had higher mean performance than their female counterparts. This study agrees with that of Koki (2019) who found that Male students had higher mean achievement score than their female counterparts when taught Chemistry using laboratory practical. However, the study does not concord with Usman (2018) who observed that female students under laboratory practical had higher mean performance than their male counterparts.

Conclusion

The findings of this study led to the conclusion that laboratory practical approach is capable of enhancing the performance and interest of students in Biology Furthermore, based on the findings of this study, laboratory practical learning is efficacious in eliminating gender related differences in interest in Biology learning, indicating that the approach is gender friendly. However, laboratory practical strategy was not gender friendly in closing the gap of performance in Biology.

Recommendations

Based on findings of the present study, the following recommendations are outlined:

1. Biology teachers should use laboratory practical approach to ensure effective teaching and learning so as to enhance students' performance in Biology instead of the alternative to practical.
2. Workshops should be frequently organized by educational bodies such as National Teachers Institute (NTI) to sensitise Biology teachers on the use of laboratory practical approach to enhance academic performance among senior secondary students.

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