Effect of Project-Based Learning on Students' Problem-Solving Skills in Biology among Secondary School in Minna Metropolis, Niger State

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Abstract

The study investigated the effect of Project-Based learning on students' academic achievement, problem-solving and science process skills among secondary schools in Minna Metropolis. The study adopted quasi experimental design using pretest posttest non-equivalent group design using secondary II students from four randomly selected schools. 170 students (84 experimental and 86 control) participated in the study. Experimental group were taught Biology with PLB strategy, while the control group were taught using conventional teaching method. Four objectives, six research questions with corresponding hypotheses guided the study. The research instruments were adapted Science Process Skills Questionnaire (SPSQ), Cronbach alpha .77, Problem-Solving Skills Questionnaire (PSSQ), Cronbach alpha .75, and constructed Biology Achievement Test (BAT) with KR21 .79 respectively, which were validated by experts. Data was analyzed using descriptive statistics, mean, standard deviation and mean ranks and inferential statistics including t-test and Mann-Whitney z test. The results indicated that students taught Biology with PLB had better achievement. $t(168) = 10.315$, $p < 0.05$; problem-solving skills $z(84,86) = -10.134$, $p < 0.05$, and science process skills $z(84,86) = -9.948$, $p < 0.05$,than those taught with conventional method. It was recommended among others that biology teachers should adopt Project-based learning strategy in teaching Biology in secondary schools in Minna Metropolis

Keywords: Problem-Based Learning, teaching strategy, academic achievement, Gender

Introduction

Science and technology are foundational to national transformation because they convert empirical knowledge into socially useful innovations across health, agriculture, manufacturing, and environmental management. International policy analyses and educational strategy documents emphasize that investing in robust science education systems cultivates a skilled workforce able to design, adopt, and adapt technologies thereby enhancing competitiveness and resilience in an increasingly knowledge-driven global economy (United Nations Educational, scientific and Cultural Organization (UNESCO), 2021). By strengthening school-level science learning, countries build the pipeline of researchers, technicians, agripreneurs and clinicians who directly influence productivity and public wellbeing (UNESCO, 2021; National Universities Commission (NUC), 2019).

Contemporary science education goals extend beyond factual recall to developing transferable cognitive and metacognitive competencies such as hypothesis generation, experimental design, evidence evaluation, and interdisciplinary problem solving (Zhang and Ma, 2023). These higher-order competencies are central to addressing "wicked" societal problems climate change, emerging infectious diseases, and sustainable food systems that require cross-disciplinary

reasoning and iterative experimentation. Consequently, global reviews recommend shifting classroom practice toward student-centred, inquiry-driven approaches that enable learners to practice the habits of scientific thought (Zheng *et al.,* 2023).

Within Nigeria, policy frameworks explicitly priorities science, technology and innovation for economic transformation (NUC, 2019). Nevertheless, many systemic barriers impede the realization of policy ambitions in classrooms: inconsistent access to functioning laboratories, chronic shortages of practical consumables, outdated equipment, limited teacher professional development, and overcrowded classes that reduce opportunities for hands on learning (Olatunji, Suleiman and Okeke, 2021; Matazu, 2024). These gaps produce a dissonance between curriculum intentions emphasizing process skills and practical competence and what students actually experience in everyday lessons. National and regional examination reports routinely highlight particular weaknesses in candidates' practical reasoning and applied biology skills. Chief examiner commentaries from the West African Examinations Council (WAEC, 2021) and subsequent years indicate that many examinees perform poorly when asked to interpret experimental procedures, analyze data, or design simple investigations areas that reflect students' underdeveloped science process skills rather than a lack of memorized facts (WAEC, 2021). These observations align with classroom research showing that dominant approaches favour rote learning at the expense of inquiry-based learning

Statement of the Problem

Biology as a subject remains a significant science subject in Nigerian senior secondary schools that qualifies students to lucrative courses such as medicine, pharmacy and other biological sciences at tertiary level of education. Students' performance in WAEC has been undulating over the years. Analyses and annual comments by Chief Examiners in WAEC's subject reports (2021–2024) consistently point to recurring deficits in candidates' practical skills, application of biological principles, accuracy in diagram interpretation and labelling, weak competence in practical tasks and experimental interpretation kept reoccurring across the years. These operational criticisms are explicit in WAEC's subject pages and Chief Examiner notes, which repeatedly list failures such as illegible handwriting, poor spelling of scientific names and technical words, inability to state structure–function relationships in diagrams. Studies confirmed Project-based, inquiry-oriented methods to strengthen conceptual understanding and procedural competence in science Adeniran and Akinbola (2022)**.** Nonetheless, but the use of Project Based Learning (PBL) in Nigerian Biology classrooms and its specific effects *on* problem-solving ability remains under-researched. This study attempted to determine the effect of PLB on students' academic achievement in Biology as move towards arresting the fluctuative performance in secondary school leaving certificate examinations in Minna, Niger State.

Research study conducted by Bello and Adegoke (2021) revealed no significant gender difference in Biology achievement among students taught using PBL. On the other hand, Naidoo and Petersen (2021) reported that female students demonstrated significant achievement gains in project-based science classrooms.

Methodology

The study adopted quasi experimental design, precisely pretest-posttest non-equivalent control group design. Population of the study comprised of all the SSII students in Minna Metropolis of Niger State. A total of 170 students formed the sample size of the study (84 experimental and 86 control). This was derived from each of the intact classes of the selected schools that were used for the study. Two intact classes were randomly assigned in to the experimental group, and the

other two groups were treated as the control group. The experimental group was taught Biology using PBL strategy, while the control group were taught using the conventional teaching method.

The treatment instruments used for the study were PBL lesson plans designed to teach Biology according to the PBL. The second treatment was the conventional teaching method lesson plan. The test instrument was Biology Achievement Test (BAT) designed to assess students' achievement in cell biology. It contained 20 multiple-choice questions assessing cognitive achievement in cell, types of cell, cell organelles, functions and structures. The instruments were subjected to validation by experts thereafter, all the observations, corrections and suggestions made by the experts were used to produce the final instruments used for the study. Test instrument was pilot tested using 20 students from a school which is among the population of the study but not part of the sampled schools. Data collected from pilot test was analysed using KR20 statistical tool and reliability coefficient of 0.79 was obtained. During the treatment, the students were pretested, treated and later post tested. Data collected was analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (independent sample t-test). Statistical package for Social Sciences (SPSS version 23) was used in the analysis

Results

Demographic data.

Table 1: Gender Distribution of the Samples of the Study

Group	Gender		Total	Percentage
	M	**F**		
Experimental	38	46	84	49.41
Control	50	36	86	50.59
Total	**88**	**82**	**170**	**100**

Table 1 presents the samples of the study according to their groups and gender. The experimental group was 84(38 males, 46 females) students which represents 49.41 percent of the samples. The control group was 86 (50 males, 36 females) representing 50.59 percent of the samples. This gives the total samples of the study to become 170 (100 percent) that participated in the study

Answering Research Questions

Research Question One: What is the difference between the mean achievement scores of students taught Biology using Project-Based Learning (PBL) and those taught using the conventional teaching method? To answer this question, mean and standard deviation were used as shown in Table 2

Table 2: Mean and Standard Deviation of the Difference between Students of Experimental and Control Groups

Group	N	Pretest Mean	SD	Posttest Mean	SD	Mean gain
Experimental Group	84	6.60	2.55	16.73	2.61	10.13

Control Group	86	6.43	2.24	11.65	3.70	5.22

Table 2 revealed the difference in the pretest and posttest mean scores of the experimental and control groups, including the mean gain. The experimental group had pretest mean score of 6.60 with standard deviation of 2.55. While in the posttest they had Mean score of 16.73 and standard deviation of 2.61. The mean gain was 10.13, which indicates a substantial improvement in the performance. On the other hand, the control group had pretest mean score of 6.43, Standard deviation of 2.24, and posttest mean score of 11.65, standard deviation of 3.70. The mean gain was 5.22, which is less than that of the experimental group. Therefore, there was difference in the posttest performance mean scores of the of students taught Biology using PLB instruction and those taught with conventional teaching method.

Research Question Two: What is the difference between the performance of male and female students taught Biology using PLB instruction? To answer this question, mean and standard deviation were used as shown in Table 3

Table 3: Mean and Standard Deviation of the Performance of Male and Female Students in Experimental Group

Group	N	Posttest Mean	SD	Mean Difference
Males	38	16.47	2.023	
Female	46	16.11	2.892	0.36

Table 3 describe the gender difference in the mean performance of students taught basic science with individualized instruction. It appears that male students had posttest mean score of 16.47 standard deviation of 2.02, while the female students had mean score of 16.11, standard deviation of 2.89. The difference in the mean score of the male and female students was 0.36. This implies that there was difference in the mean scores of male and female students taught basic science and technology using individualized instruction.

Testing Hypothesis

Table 4: Pretest t-Test Results of the Difference between the experimental and control groups

Group	N	Df	Mean	SD	t	Sig.2Tailed
Experimental	84	168	6.60	2.547	.449	.654*
Control	86		6.43	2.242		

***=Not Significant at 0.05**

Table 4 presents the pretest t-test results of the difference in the performance of the experimental and control groups. From the results, $t(168) = .449$, $p > 0.05$. This implies that there was no significant difference between the mean scores of students in the experimental and control groups prior to the treatment. The groups were therefore, equivalent before the treatment.

H_o1: There is no significant difference between the mean achievement scores of students taught Biology using PBL and those taught using the conventional teaching method. To test this hypothesis, t-test was used as shown in Table 4

Table 4: Posttest T-Test Results of the PLB and Control Groups

Group	N	Df	Mean	SD	t	Sig.2tailed
Experimental	84	168	16.73	2.61	10.315	0.000*
Control	86		11.65	3.70		

***= Significant at 0.05**

Table 4 presents the Posttest t-test results of the difference in the performance of the experimental and control groups. The experimental group had mean=16.73, SD= 2.61, while the control group had mean=11.65, SD= 3.70 respectively. $t(168) = 10.315$, $p < 0.05$, hence the null hypothesis was rejected. It implies that there was significant difference between the mean scores of students taught Biology with PLB instruction and those with conventional method.

H_o2: There is a significant difference between the mean achievement scores of male and female students taught Biology using PBL. To test this hypothesis, t-test was used as shown in Table 5

Table 5: Posttest t-Test Results of the Gender Difference in Performance of the Experimental

Gender	N	Df	Mean	SD	T	Sig.2tailed
Males	38	82	16.47	2.023	2.454	0.61*
Female	46		16.11	2.892		

***= Not significant at 0.05**

Table 6 presents the Posttest t-test results of the gender difference in the performance of male and female students in the experimental group. From the results, $t(82) = 2.454$, $p > 0.05$, hence the null hypothesis was accepted. It indicates that there was no significant difference between the mean scores of male and female students taught Biology with PLB instruction.

Discussion of Findings

The study investigated the effects of problem-based learning on students' academic achievement in Biology among secondary schools in Minna Metropolis. From the analysis of the results obtained, the finding established that there was significant difference between the achievement scores of students taught Biology with PLB instruction and those taught with conventional method. This corroborates with the assertions of Hmelo-Silver *et al.,* (2021) who stated that Project based Learning is theoretically linked to improved academic achievement through its alignment with constructivist and experiential learning principles. It also translates their finding which states that PBL promotes deep cognitive processing, contextual learning, and sustained engagement factors strongly associated with achievement gains. The finding is also in line with the findings of Adeniran and Akinbola (2022) who reported that secondary school students taught Biology through PBL achieved significantly higher scores in achievement tests than those taught using lecture methods. The finding also supports that of Adeyemi and Owolabi (2022) who

examined the impact of PBL on Biology achievement among senior secondary students in southwestern Nigeria. Their finding revealed that PBL significantly enhanced students' performance in topics such as cell division, genetics, and ecological relationships. Furthermore, the finding concurs with the finding of Bello and Yusuf (2023) focused on agricultural Biology and reported that students who participated in project-based agricultural experiments achieved higher scores in both continuous assessment and terminal examinations

The findings of the study also revealed that there was no significant difference between the achievement scores of male and female students taught Biology with PLB instruction. This in support of the finding of Bello and Adegoke (2021) found no significant gender difference in Biology achievement among students taught using PBL. Contrary to this finding is the finding of Naidoo and Petersen (2021) who reported that female students demonstrated significant achievement gains in project-based science classrooms, particularly when projects emphasized communication and real-life relevance. But vast number of studies across science subjects indicated gender-friendliness of PBL as an instructional strategy in science.

In conclusion, it is evidently from the findings of this study, the authors concluded that project-based learning instructional strategy is an effective instructional strategy that improves academic achievement in biology among secondary school students. It is is also concluded that PBL is a gender friendly instructional strategy that can be adopted regardless of students' gender in secondary schools in Minna metropolis.

Recommendations

From the findings of the study, it is recommended that:

1. Project-based Learning should be adopted by biology teachers in teaching Biology among secondary schools in Minna metropolis
2. Government should finance retraining programmes for science teachers in secondary schools to update them on current instructional practices to increase productivity in schools.

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