



Relative Efficiency of Project-Based and Think-pair-Share Learning Strategies on Students' Academic Achievement in Biology

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Abstract

This study examined the relative effectiveness of project-based and think-pair-share learning strategies on senior secondary school students' academic achievement in Biology in Obollo-Afor Education Zone. A quasi-experimental, non-randomized pretest-posttest control group design was adopted for the study. The population consists of 2167 Senior Secondary One (SS1) Biology students in the zone, from which a sample of selected students was drawn using multistage sampling procedure. Data were collected using a validated Biology Achievement Test (BAT). Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the null hypotheses at the 0.05 level of significance. The findings revealed a significant difference in the mean achievement scores of students taught Biology using project-based learning strategy and those taught using think-pair-share learning strategy, with students exposed to project-based learning achieving higher mean scores. The results further indicated that gender had no significant influence on students' academic achievement in Biology. Based on the findings, the study concluded that project-based learning strategy is more effective in enhancing students' academic achievement in Biology than think-pair-share learning strategy. It was therefore recommended that Biology teachers adopt project-based learning strategy to improve students' academic achievement in secondary schools.

Keywords: Project-Based Learning, Think-Pair-Share, Academic Achievement, Biology Education, Secondary School Students, Gender

Introduction

Biology is one of the core science subjects taught at the senior secondary school level in Nigeria and plays a vital role in understanding life processes and the interaction of living organisms with their environment (Egwu, Awosika, & Osuafor, 2022). The knowledge of Biology is fundamental to the study of health-related and science-based courses such as medicine, nursing, pharmacy, agriculture, and environmental sciences (Yohana, Gresinta, & A'ini, 2022). Consequently, the Federal Ministry of Education emphasizes the teaching and learning of Biology in secondary schools as a means of developing scientifically literate individuals capable of applying scientific knowledge to everyday life.

Despite the importance of Biology, students' academic achievement in the subject has remained persistently low. Reports from the West African Examinations Council (WAEC) Chief Examiners have consistently shown poor performance of

candidates in Biology over the years. For instance, the Chief Examiners' reports from 2020 to 2023 indicated unsatisfactory performance levels, with many students demonstrating poor understanding of core biological concepts such as the cell and ecological factors. These concepts are often perceived as abstract and difficult, thereby contributing to students' low achievement in the subject.

Several factors have been identified as responsible for students' poor academic achievement in Biology. These include inadequate laboratory facilities, limited instructional resources, overcrowded classrooms, insufficient time allocation, and poor remuneration of teachers (Ibe & Abamuche, 2019). However, researchers have consistently identified the persistent use of traditional teacher-centred instructional methods, particularly the lecture method, as a major contributing factor to students' low achievement in Biology (Anih & Ukeh, 2023).



Although the lecture method allows teachers to cover a wide range of content within a limited time, it often encourages rote memorization, limits students' active participation, and does not adequately promote critical thinking and deep understanding of biological concepts (Ogbu, 2018).

In response to these challenges, educational researchers and practitioners have increasingly advocated for the adoption of innovative, student-centred learning strategies capable of improving students' academic achievement. Such strategies actively involve students in the learning process and encourage collaboration, inquiry, and problem-solving. Among these strategies are project-based learning and think-pair-share learning strategies, which have gained attention for their potential to enhance students' understanding and achievement in science subjects, including Biology.

Project-based learning is a student-centred instructional strategy that enables learners to acquire knowledge and skills through active engagement in meaningful projects over an extended period (Lemmon & Chapel, 2023). By working individually or collaboratively to investigate real-life problems, students are provided opportunities to apply theoretical knowledge in practical contexts, thereby promoting deeper understanding and improved academic achievement (Anazifa & Djukri, 2017). Previous studies have shown that project-based learning can significantly enhance students' performance and retention of scientific concepts.

Similarly, think-pair-share is a cooperative learning strategy that involves students thinking individually about a given question, discussing their ideas with a partner, and subsequently sharing their conclusions with the larger class (Carnevale, 2022; Han & Li, 2020). This structured interaction allows students to clarify their understanding, exchange ideas, and benefit from peer support (Smith & Tillema, 2021). Empirical studies have indicated that think-pair-share learning strategy can improve students' academic achievement by fostering critical thinking and encouraging active participation during lessons.

Although several studies have examined the effectiveness of project-based and think-pair-share learning strategies separately, limited empirical evidence exists comparing the relative effectiveness of these two strategies on students' academic achievement in Biology, particularly at the senior

secondary school level in Obollo-Afor Education Zone.

Gender has also been examined as a variable influencing academic achievement. While some studies report male superiority in achievement (Eseine-Aloja, 2021; Odagboyi, 2015), others suggest that cooperative instructional approaches may reduce gender disparities (Nwuba, Nwosu & Samuel, 2023). Several empirical studies (Udeobasi & Nzuruike, 2014; Ntok, 2022; Dania, 2014; Nnenna & Adukwu, 2018) found no significant gender differences in students' academic achievement, although occasional interaction effects between instructional strategies and gender were reported.

This study seeks to examine the relative effectiveness of project-based and think-pair-share learning strategies on senior secondary school students' academic achievement in Biology in Obollo-Afor Education Zone.

Statement of the Problem

Low academic achievement in secondary school biology continue to pose significant challenges in education, often attributed to the continued reliance on traditional teacher-centered instructional methods. These approaches frequently fail to stimulate students' active achievement. Biology is an important subject whose relevance cannot be overemphasized. This is because it deals with the study of life. It's teaching and learning should be interactive, student-centered and capable of fostering critical thinking and collaboration. Some researchers have suggested the use of student-centered learning strategy such as peer tutoring, computer assisted instruction, flipped classroom, scaffolding, formative assessment among others. Some reported no significant effect of those teaching strategies on academic achievement in biology, while some reported that there was significant effect on students' academic achievement in biology. These controversies necessitated the need to investigate two learners centered learning strategies that promotes collaboration and critical thinking skills to determine its effect on student achievement in biology. The need therefore arose to investigate the relative efficacy of project-based and think-pair-share learning strategies on students' academic achievement in biology.

Research Questions

The following research questions guided the study:

1. What are the mean achievement scores of students taught biology using project-based and those taught using think-pair-share learning strategies?
2. What are the mean achievement scores of male and female students in biology?
3. What is the interaction effect of learning strategies and gender on students' mean achievement score in biology?

Research Hypotheses:

The following null hypotheses was tested at 0.05 level of significance

1. There is no significant difference in the mean achievement scores of students taught biology using project-based and those taught using think-pair-share learning strategies.
2. There is no significant difference in the mean achievement scores of male and female students in biology.
3. There is no significant interaction effects of learning strategies and gender on students' achievement scores in biology.

Methods

The study adopted a quasi-experimental research design, specifically a pretest–posttest non-equivalent control group design. Intact classes were used because random assignment of individual students was not feasible within the school system. The study was conducted in Obollo-Afor Education Zone of Enugu State, Nigeria.

The population comprised all Senior Secondary School II (SS II) Biology students in public secondary schools in Obollo-Afor Education Zone. A sample of intact SS II classes drawn from selected co-educational public secondary schools in the zone was used for the study. Schools were selected using purposive sampling to ensure comparable facilities and availability of qualified Biology teachers. The

intact classes were randomly assigned to: Project-Based Learning (PBL) group and Think-Pair-Share (TPS) group.

The instrument used for data collection was the Biology Achievement Test (BAT). The BAT consisted of multiple-choice items drawn from the SS II Biology curriculum and covered the instructional units taught during the experiment. The instrument was subjected to face and content validation by experts in Science Education and Measurement and Evaluation. Reliability of the BAT was established using an appropriate reliability method (e.g., KR-20), and a satisfactory reliability coefficient was obtained, indicating that the instrument was reliable for the study.

Before treatment, the BAT was administered as a pretest to both groups to determine their equivalence. The experimental group I was taught selected Biology topics using Project-Based Learning (PBL) strategy, which involved students working on structured projects requiring investigation, collaboration, and presentation of findings. Experimental group II was taught the same topics using the Think-Pair-Share (TPS) strategy, which involved individual thinking, paired discussion, and class-wide sharing of ideas. The treatment lasted for the specified instructional period as outlined in the thesis. At the end of the treatment, the BAT was re-administered as a posttest.

The data collected for the study were analyzed using ANCOVA. This analysis was done using the Statistical Package for the Social Sciences (SPSS) version 25. The choice for ANCOVA is because this study involved pre-test score. The research questions were answered using mean and standard deviation. ANCOVA was used to test the hypotheses at 0.05 level of significance. Any p-value that is less than 0.05 was considered to be significant and therefore the hypothesis was rejected. Any p-value that is equal to or greater than 0.05 is not significant and therefore the hypothesis was not rejected.

Results

The results were presented in line with the research questions and the null hypotheses that guided the study.

Research Questions 1: What are the mean achievement scores of students taught biology using project-based and those taught using think-pair-share learning strategies?

Table 1: Mean ($\bar{X}$) and Standard Deviation (SD) achievement scores of students' taught Biology using project-based and think-pair-share learning strategies

STRATEGY	N	PRETEST		POSTTEST		ADJUSTED MEAN
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	$\bar{X}$
Project-based	50	23.24	7.15	40.96	8.57	40.892
Think-pair-share	50	25.72	8.82	50.2	4.86	49.873

Table 1 provides the descriptive statistics of biology achievement scores by learning strategy. For the project-based group, students had a pretest mean score of 23.24 and standard deviation of 7.15. After the intervention, their posttest mean increased to 40.96, with a standard deviation of 8.57. The adjusted mean achievement score for this group was 40.89. Students in the think-pair-share group recorded a higher pretest mean of 25.72 (SD = 8.82) and an even

more substantial posttest mean of 50.12 with a standard deviation of 4.86. Their adjusted mean achievement score was 49.87. These results show that students in both groups improved after instruction, but the think-pair-share strategy appears to have had a stronger impact on students' achievement, as reflected in the higher adjusted mean score (49.87 compared to 40.89).

Hypothesis 1: There is no significant difference in the mean achievement scores of students taught biology using project-based and those taught using think-pair-share learning strategies.

Table 2: Analysis of Covariance of Students' Biology Achievement scores by Strategy and Gender

SOURCES OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG	SQUARED PARTIAL ETA
Corrected Strategy	2247.347 ^a	4	561.837	11.584	0.000	0.328
Intercepts	18797.949	1	18797.949	387.587	0.000	0.803
Pre-engagement	6.580	1	6.580	1.36	0.713	0.001
Treatment	1918.416	1	1918.416	39.555	0.000	0.294
Gender	139.212	1	139.212	2.870	0.094	0.029
Treatment * Gender	2.543	1	2.543	0.052	0.819	0.001
Error	4607.493	95	48.500			
Total	214244.000	100				
Corrected Total	6854.840	99				

a. R Squared = .328 (Adjusted R Squared = .300)

The ANCOVA result in Table 2 tests this hypothesis. The main effect of treatment shows a sum of squares of 1918.416, a mean square of 1918.416, and a high F-value of 39.555. The p-value is less than 0.001, which is far below 0.05. Since the p-value is

less than 0.05, the null hypothesis is rejected. This means that there is a statistically significant difference in the achievement scores of students taught using the two learning strategies. Specifically, the think-pair-share strategy led to significantly higher achievement

scores compared to the project-based strategy. The partial eta squared for treatment is 0.294, indicates that approximately 29.4% of the variance in achievement scores is attributable to the learning strategy used

(think-pair-share). This shows a large effect size. The adjusted R-squared is 0.300, suggesting that the model explains 30% of the variation in achievement scores.

Research Question 2: What are the mean achievement scores of male and female students in biology?

Table 3: Mean ($\bar{X}$) and Standard Deviation (SD) achievement scores of students according to gender

STRATEGY	N	PRETEST		POSTTEST		ADJUSTED MEAN
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	$\bar{X}$
Male	43	24.37	8.21	43.86	8.19	43.873
Female	57	24.56	8.05	46.81	8.26	46.797

Table 3 displays achievement scores by gender. Male students (N = 43) had a pretest mean of 24.37 (SD = 8.21), and a posttest mean of 43.86 (SD = 8.19). Their adjusted mean score was 43.87. Female students (N = 57) had a pretest mean of 24.56 (SD = 8.05), and a posttest mean of 46.81 (SD = 8.26). Their adjusted mean achievement score was 46.80. This suggests that female students scored slightly higher than males on biology achievement, but the difference is not wide (46.80 vs 43.87).

Hypothesis 2: There is no significant difference in the mean achievement scores of male and female students in biology.

The ANCOVA in Table 2 shows that for gender, the sum of squares is 139.212, with a mean square of 139.212, an F-value of 2.870, and a p-value of 0.094. Since the p-value (0.094) is greater than 0.05, the null hypothesis is not rejected. This means that there is no statistically significant difference in the biology achievement scores of male and female students. Although female students had slightly higher scores, this difference is not large enough to be considered statistically significant. The partial eta squared = 0.029, meaning that only 2.9% of the variance in achievement scores is explained by gender which is a small effect size.

Research Question 3: What is the interaction effect of learning strategies and gender on students' mean achievement score in biology?

Table 4: Mean ($\bar{X}$) and standard deviation (SD) achievement scores by learning strategy and gender.

STRATEGY	PROJECT-BASED			THINK-PAIR-SHARE		
	N	$\bar{X}_1$	SD_1	N	$\bar{X}_2$	SD_2
PRE-ACHIEVEMENT						
Male	23	22.70	6.52	20	26.30	9.63
Female	27	23.70	7.74	30	25.33	8.38
Adjusted mean		23.20			25.82	
POST ACHIEVEMENT						
Male	23	39.48	7.77	20	48.90	5.33
Female	27	42.22	9.15	30	50.93	4.42
Adjusted mean		44.19			46.58	

Table 4 shows the achievement scores categorized by gender and learning strategy. For pre-

achievement, males scored 22.70 (SD = 6.52) in the project-based group and 26.30 (SD = 9.63) in the think-pair-share group. Females scored 23.70 (SD =

7.74) under project-based and 25.33 (SD = 8.38) in think-pair-share. Posttest scores showed more noticeable differences: Males: 39.48 (project-based), 48.90 (think-pair-share), Females: 42.22 (project-based), 50.93 (think-pair-share). The adjusted mean achievement scores followed a similar trend: Project-based: 44.19 and Think-pair-share: 46.58. Both males and females benefited more from the think-pair-share strategy, but the difference between the groups remained small, as seen in the profile plot (Figure 3), where the interaction lines do not cross substantially, implying little to no interaction effect.

Hypothesis 3: There is no significant interaction effects of learning strategies and gender on students' achievement scores in biology.

From Table 4, the interaction effect of learning strategy and gender on achievement yielded a sum of squares of 2.543, a mean square of 2.543, an F-value of 0.052, and a p-value of 0.819. Since the p-value is much greater than 0.05, the null hypothesis is not rejected. This shows that there is no significant interaction between gender and learning strategy in determining achievement scores in biology. The partial eta squared = 0.001, showing an almost zero practical effect.

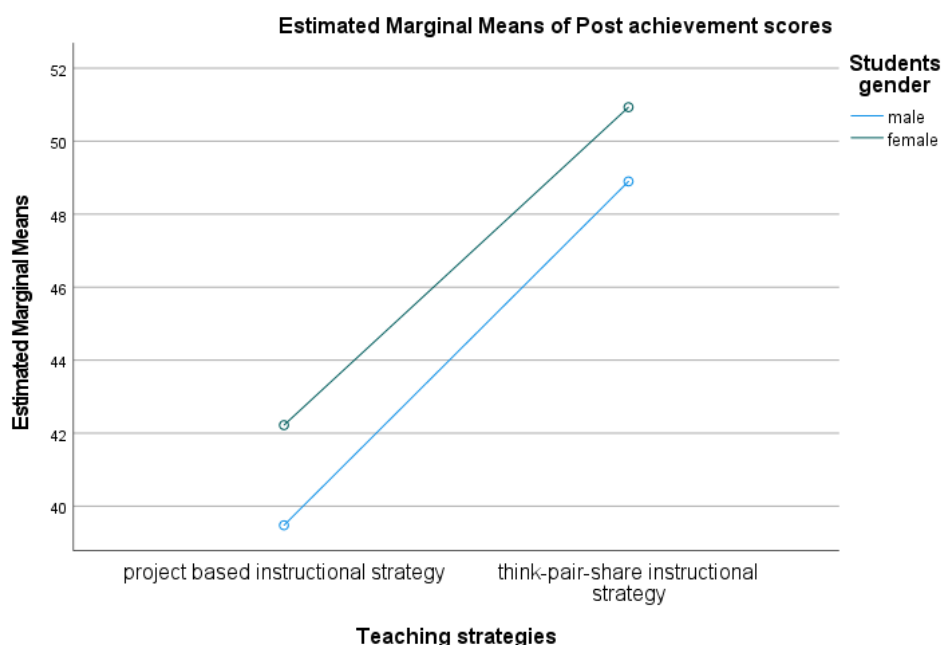


Figure 3: Profile plot showing interaction effect of project-based and think-pair-share learning strategies and gender on students' achievement in Biology.

The profile plot in figure 3 shows no meaningful interaction effect of learning strategies and gender on students' achievement in biology. Both male and female students had higher scores under the think-pair-share strategy, but the parallel lines in the plot suggest they were affected similarly by the learning strategies. The statistical result ($p = 0.819$; $\eta^2 = 0.001$) confirms that the observed differences are likely insignificant and possibly due to random variation.

Discussion of Findings

The findings revealed that students taught Biology using the think-pair-share learning strategy, performed better than students taught using project-

based learning strategy. The difference was significant. Further analysis revealed that there was a significant difference in the mean achievement scores of students taught using think-pair-share instructional strategy and those taught using project-based instructional strategy. think-pair-share strategy aims to get students' attention, encourage their thinking skills and help them access the initial knowledge they have. It also gives students the opportunity to explore and work independently in groups without direct instruction or direction from the teacher. The superior effect of think-pair-share strategy over project-based instructional strategy could be attributed to the more learner centered nature of think-pair-share strategy over project-based strategy as think-pair-share

learning strategy highlight the increasing importance of provoking students' critical thinking and collaboration. The significant effect of think-pair-share learning strategy on student achievement towards Biology could be attributed to the fact that think-pair-share strategy comprises of critical thinking, peer interaction through group discussions, which promotes social skills, learning support between individuals and a dynamic learning environment which allows for critical thinking and enhance students' achievement towards Biology.

Findings of this study corroborates with the finding of some previous researchers such as Alabi and Sanni (2021) who reported that students exposed to think-pair-share strategy enhances learning achievement by fostering classroom interaction and allowing students to express themselves freely. This study also corroborates with Ogbaga and Osuafor, (2022) who affirmed that think-pair-share learning strategy was more effective than brainstorming in terms of students' achievements.

However, they exist little or no study on the efficacy of project-based and think-pair-share learning strategies. This study contributed to knowledge by presenting findings that demonstrate that project-based and think-pair-share are efficacious for improving students' achievement in Biology, but think-pair-share proved more efficacious in that regard.

The result of this study which dwelt on the influence of gender on students' achievement in biology shows that there is no significant influence of gender in biology. The result revealed a slightly higher mean achievement score in favour of female students, though not statistically significant. The higher mean achievement scores in female students could be attributed to sampling error as studies by Njoku (2019) inferred that Biology is a gender-neutral subject and may not be influenced by students' gender. However further analysis indicated a significant gender influence on students' achievement in Biology using project-based and think-pair-share instructional strategies. The insignificant influence of gender in the use of both project-based and think-pair-share instructional strategies could be attributed to students' interaction and academic activities provided by the two strategies that influenced both male and female students' achievements equally. This shows that these strategies could bridge up gender gap and help to nullify the perceived gender bias in students' achievement.

The findings of this study agree with the studies of Nnenna and Adukwu (2018) whose study generally revealed no significant influence of gender on students' achievement. Also, Ekineh and Adolphus (2019) inferred that gender does not have significant influence on students' achievement in Biology using 7E learning cycle and collaborative learning. Atomatopha (2014) reported no significant difference between male and female achievement in basic science using instructional strategies (inquiry, demonstration, and lecture) ability level and gender on students' achievement in basic science. Mwangi, Nyagah and Mugambi (2019) opined that there is no statistically significant relationship between gender interactions and academic achievement of learners in chemistry. The insignificant influence of gender on students' achievement in biology could be attributed to the nature of biology as a natural science with less calculation. Therefore, it is not perceived to be gender bias.

Furthermore, the outcome of this study disagrees with Enebechi, (2016) who reported a significant gender influence on achievement in biology in favor of female students using two scaffolding methods of teaching which is also an activity-oriented method of teaching. The significant differences in the influence of gender on achievement in these studies could be attributed to the method of teaching employed, sampling error and age of students among others. The result of the present study, however, shows that gender is not a significant factor in determining students' achievement in Biology.

The interaction effect of instructional strategies and gender on Biology students' achievement in Biology was not significant. However female students performed better than male students irrespective of the instructional strategy. The result revealed that female student who were exposed to project-based instructional strategy performed slightly better than their male counterparts; Also, female students exposed to think-pair-share instructional strategy, performed slightly better than their male counterparts. The corresponding hypothesis proved that there was no significant interaction effect of strategies and gender on Biology students' achievement. This was revealed by mean achievement score for all the levels of gender exposed to think-pair-share learning strategy which were higher than those in project-based strategy. This therefore suggested disordinal interaction effect between the strategies and gender on students' achievement. The slight interaction could be

introduced by sampling error. The insignificant interaction effect of strategies and gender on Biology students' achievement in this study is not surprising since think-pair-share learning strategy is not gender biased.

Finding of this study corroborates with previous study by Okeye (2016) who reported that male and female cognitive styles in Biology did not differ significantly in their achievements. Similarly, the result of this study is not consistent with Olorunfemi, (2020) who reported no interaction effect of method of teaching and gender and method of teaching on primary school pupil's achievement in mathematics. This study also agrees with that of Ogbaga and Osuafor (2022) who evaluated the effects of brainstorming and think-pair-share instructional strategy on secondary school students' achievements in Biology. The variations could be due to variations that occur across disciplines.

Conclusion

Based on the findings of the study, it was concluded that think-pair-share learning strategy was found to be more effective than project-based learning strategy on students' academic achievement in Biology. The use of think-pair-share enhances students critical thinking and creates an interactive environment for students to interact with one another and learn while doing so. Gender has no effect on students' achievement in biology. The was no interaction effect of learning strategies and gender on students' achievement scores in biology, this shows that gender has no role to play when both strategies are used in enhancing academic achievement of students in biology.

Recommendations

Biology students should be actively involved in the learning process through the use of activity-oriented learning strategy of teaching such as think-pair-share learning strategy to promote students' achievement. Biology teachers should adopt the use of think-pair-share learning strategy in teaching of Biology to address the problem of students' poor achievement in Biology. Biology teachers should be encouraged to attend conferences, seminars and workshops where innovative learning strategies such as think-pair-share learning strategy are taught to update their knowledge and mastery of the strategy in order to enhance teaching and increase the academic achievement of student' in biology.

Colleges of education should regularly organize seminars, workshops and conferences on the relevance of innovative learning strategy of teaching such as the use of think-pair-share learning strategy for student teachers to update teachers' knowledge and teaching skills for better classroom performance. The curriculum planners should develop Biology curriculum to incorporate activity-oriented strategies to teaching such as think-pair-share learning strategy to promote Biology students' achievement in Biology.

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