International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 10 Issue 7 July - 2026, Pages: 652-658

Comparative Effects of Peer-Tutoring and Collaborative Project-Based Learning on Secondary School Students' Achievement in Biology in Delta Central Senatorial District

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Abstract: *This study investigated the comparative effects of peer-tutoring and collaborative project-based learning on secondary school students' achievement in Biology in Delta Central Senatorial District, Delta State. The study adopted a pretest-posttest quasi-experimental design involving two experimental groups. The population comprised 13,845 SSII Biology students, while a sample of 216 students selected from six public co-educational secondary schools participated in the study. Data were collected using the Biology Achievement Test (BAT), a 50-item multiple-choice instrument with a Kuder-Richardson Formula 21 reliability coefficient of 0.89. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance and independent-samples t-test were used to test the hypotheses at the 0.05 level of significance. The findings revealed that both peer-tutoring and collaborative project-based learning improved students' achievement in Biology; however, peer-tutoring was significantly more effective. The study also found no significant difference between the achievement scores of male and female students under either instructional strategy. It was concluded that peer-tutoring is a more effective learner-centred instructional strategy for improving students' achievement in Biology. The study recommended greater adoption of peer-tutoring in Biology classrooms and continuous teacher training on learner-centred instructional strategies.*

Keywords: Peer-tutoring, collaborative project-based learning, Biology achievement, sex.

Introduction

Biology occupies a strategic position in the secondary school curriculum because it provides learners with scientific knowledge and practical competencies required for understanding living systems, maintaining healthy lifestyles, conserving the environment, and pursuing careers in medicine, agriculture, biotechnology, and other science-related disciplines. As one of the core science subjects offered at the senior secondary school level, Biology also serves as a prerequisite for admission into many science and health-related programmes in tertiary institutions. Beyond its academic relevance, the subject contributes to the development of scientific literacy, critical thinking, and problem-solving abilities needed for sustainable national development. Despite this central role, achieving the desired learning outcomes in Biology continues to challenge many educational systems, particularly in developing countries where instructional practices often remain predominantly teacher-centred (Schleicher, 2019). Consequently, attention has increasingly shifted towards identifying instructional approaches capable of promoting more meaningful learning experiences and improved academic achievement (Adeyemi & Adeyinka, 2025).

Academic achievement in Biology reflects the extent to which learners acquire the knowledge, practical skills, and scientific reasoning expected from classroom instruction. It remains one of the most widely used indicators for evaluating instructional effectiveness, curriculum implementation, and educational quality. However, students' achievement is shaped by the interaction of numerous learner, teacher, and classroom factors rather than by curriculum content alone. Research has shown that classroom interaction, learners' active participation, and instructional strategies substantially influence students' understanding and retention of biological concepts (Eze & Nworgu, 2021). Similarly, learner-centred instructional approaches have been associated with improved conceptual understanding because they encourage students to construct knowledge actively instead of receiving information passively (Nworgu & Ugwuanyi, 2020). These observations underscore the need to examine instructional practices capable of transforming Biology classrooms into environments that support active engagement.

The growing emphasis on learner-centred pedagogy has stimulated considerable interest in instructional strategies that promote collaboration, interaction, and shared responsibility for learning. Such approaches are grounded in constructivist perspectives which view knowledge as actively constructed through social interaction, dialogue, and authentic learning experiences rather than transmitted directly from teacher to learner (Vygotsky, 1978). Within this perspective, students become active participants who explain ideas, negotiate meanings, solve problems collectively, and reflect on their learning processes. Evidence from science education suggests that classrooms characterised by meaningful interaction and collaborative engagement tend to produce higher levels of cognitive achievement than those dominated by traditional lecture methods (Achor & Ibrahim, 2019). Among the learner-centred approaches receiving increasing scholarly attention are peer-tutoring and collaborative project-based learning.

Peer-tutoring is an instructional strategy in which students support one another's learning by assuming complementary roles as tutors and tutees under the guidance of the classroom teacher. Rather than depending solely on teacher explanations, learners reinforce their own understanding through questioning, explaining concepts, providing feedback, and correcting misconceptions. The effectiveness of peer-tutoring has often been explained through the cognitive and metacognitive benefits associated with teaching others, as tutors consolidate existing knowledge while tutees receive personalised academic support (Roscoe & Chi, 2018). Reviews and meta-analyses have consistently reported positive effects of peer-tutoring on students' academic achievement across different educational levels and subject areas (Leung, 2021; Hidayat *et al*., 2025). In Biology education specifically, several Nigerian studies have also reported improvements in students' academic achievement following the adoption of peer-tutoring strategies (Balogun *et al*., 2023; Yusuf & Bello, 2021). While these findings are encouraging, continued investigation remains valuable because contextual variations may influence instructional effectiveness.

Alongside peer-tutoring, collaborative project-based learning has emerged as another learner-centred instructional approach that seeks to connect classroom learning with authentic scientific inquiry. In this approach, students work collaboratively to investigate problems, design solutions, complete meaningful projects, and communicate findings while assuming shared responsibility for learning. Such experiences promote sustained engagement, critical thinking, creativity, and application of scientific concepts in real-life contexts. Comprehensive reviews have indicated that project-based learning enhances students' conceptual understanding, motivation, and academic achievement when effectively implemented (Kokotsaki *et al*., 2016; Chen & Yang, 2019). More recent studies have similarly reported favourable outcomes in science classrooms where collaborative project-based learning forms an integral part of instruction (Zakiyyah *et al*., 2024; Anari *et al*., 2025). These reported benefits suggest the need to understand how the approach compares with other interactive instructional strategies in improving Biology achievement.

Although peer-tutoring and collaborative project-based learning both encourage active participation, they differ substantially in their instructional structures, patterns of interaction, and learning processes. Peer-tutoring primarily emphasises reciprocal explanation and guided academic assistance between students, whereas collaborative project-based learning focuses on collective inquiry, problem-solving, and the production of authentic learning outcomes. Consequently, differences may exist in the extent to which each strategy facilitates students' academic achievement. Comparative studies have reported varying outcomes regarding the relative effectiveness of these instructional approaches, indicating that contextual and implementation factors may influence their impact (Yusuf & Afolabi, 2022; Adeyemi & Ojo, 2024). Such variations reinforce the importance of generating additional empirical evidence across different educational settings.

Another issue that continues to attract scholarly attention concerns whether instructional strategies benefit male and female students equally. Although contemporary educational philosophy advocates equitable learning opportunities irrespective of sex, empirical findings regarding sex-related differences in Biology achievement under learner-centred instructional approaches remain inconsistent. Some investigations have reported negligible differences between male and female students when exposed to peer-mediated learning environments, suggesting that collaborative interaction may reduce traditional achievement disparities (Ibrahim *et al*., 2022). Conversely, other studies have observed variations in achievement under collaborative instructional settings depending on classroom context and instructional implementation (Adebayo & Adeyemi, 2022; Eze *et al*., 2023). These mixed findings suggest that further examination of sex differences within specific instructional approaches remains justified.

Within Delta Central Senatorial District, concerns regarding students' performance in Biology continue to stimulate interest in instructional practices capable of improving learning outcomes. While previous investigations have independently examined peer-tutoring or collaborative project-based learning in different contexts, relatively few have comparatively evaluated both strategies among secondary school Biology students within the study area while simultaneously considering possible sex-related differences in achievement. Addressing this gap provided the rationale for undertaking the present study, which investigated the comparative effects of peer-tutoring and collaborative project-based learning on secondary school students' achievement in Biology in Delta Central Senatorial District, Delta State.

Statement of the Problem

Biology is expected to equip secondary school students with scientific knowledge, practical skills, and critical thinking abilities required for further education and productive participation in a science-driven society. However, students' academic achievement in the subject has remained below expectations in many secondary schools, despite sustained efforts to improve science education through curriculum reforms and increased educational investment. One factor that has consistently been associated with this challenge is the continued reliance on teacher-centred instructional practices, which often limit students' active participation, collaborative learning, and meaningful engagement with biological concepts. Consequently, researchers and educators have increasingly advocated learner-centred instructional approaches such as peer-tutoring and collaborative project-based learning because they encourage interaction, shared responsibility, and active knowledge construction. Although previous studies have reported positive outcomes for these instructional strategies, findings have not been entirely consistent regarding their relative effectiveness, and evidence from different educational contexts suggests that instructional outcomes may vary according to classroom and contextual characteristics.

In Delta Central Senatorial District, there is limited empirical evidence directly comparing the effectiveness of peer-tutoring and collaborative project-based learning in enhancing students' achievement in Biology. Furthermore, the extent to which male and female students benefit from each instructional strategy remains insufficiently established within the study area, making it difficult

for teachers and curriculum planners to identify the most suitable learner-centred approach for improving Biology instruction. This paucity of context-specific comparative evidence creates uncertainty regarding the instructional strategy that is most effective for improving students' academic achievement in Biology. The problem of this study, therefore, was to determine the comparative effects of peer-tutoring and collaborative project-based learning on secondary school students' achievement in Biology in Delta Central Senatorial District, Delta State.

Purpose of the Study

The purpose of this study was to investigate the comparative effects of peer-tutoring and collaborative project-based learning on secondary school students' achievement in Biology in Delta Central Senatorial District, Delta State. Specifically, the study sought to:

1. determine the effect of peer-tutoring and collaborative project-based learning on students' achievement in Biology;
2. determine the difference between the achievement scores of male and female students taught Biology using the peer-tutoring strategy; and
3. determine the difference between the achievement scores of male and female students taught Biology using the collaborative project-based learning strategy.

Research Questions

The following research questions guided the study:

1. What is the effect of peer-tutoring and collaborative project-based learning on students' mean achievement scores in Biology?
2. What is the difference between the mean achievement scores of male and female students taught Biology using the peer-tutoring strategy?
3. What is the difference between the mean achievement scores of male and female students taught Biology using the collaborative project-based learning strategy?

Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

1. There is no significant effect of peer-tutoring and collaborative project-based learning on students' mean achievement scores in Biology.
2. There is no significant difference between the mean achievement scores of male and female students taught Biology using the peer-tutoring strategy.
3. There is no significant difference between the mean achievement scores of male and female students taught Biology using the collaborative project-based learning strategy.

Methodology

This study adopted a pretest–posttest quasi-experimental research design involving two experimental groups. The design was considered appropriate because intact classes were used without random assignment of individual students to treatment groups. The independent variable was instructional strategy (peer-tutoring and collaborative project-based learning), while sex (male and female) served as the moderating variable. The dependent variable for this article was students' academic achievement in Biology. Students in both groups were administered a pretest before the treatment and a posttest after the completion of the instructional intervention.

The population of the study comprised 13,845 Senior Secondary School Two (SSII) Biology students in public secondary schools in Delta Central Senatorial District, Delta State, during the 2025/2026 academic session. The sample consisted of 216 SSII Biology students (104 males and 112 females) drawn from six public co-educational secondary schools selected through purposive sampling based on the availability of functional Biology laboratories, qualified Biology teachers, and co-educational status. Intact SSII Biology classes from the selected schools were used, after which the schools were randomly assigned by balloting into two experimental groups comprising the peer-tutoring and collaborative project-based learning groups.

Data were collected using the Biology Achievement Test (BAT), a researcher-developed 50-item multiple-choice instrument adapted from past West African Senior School Certificate Examination (WASSCE) Biology questions. The instrument covered three content areas: pests and diseases of crops, reproductive system in vertebrates, and reproductive system in plants. Face and content validity were established by experts in Biology Education and Measurement and Evaluation using expert judgment and a Table of Specification. The reliability of the BAT was determined through a pilot study involving 30 SSII Biology students outside the sampled schools but within the study area. Using the Kuder–Richardson Formula 21 (KR-21), a reliability coefficient of 0.89 was obtained, indicating that the instrument possessed high internal consistency.

The treatment lasted for six weeks and was implemented by trained Biology teachers who served as research assistants. Students in one experimental group were taught using the peer-tutoring strategy, while those in the second group received instruction through collaborative project-based learning. Before the commencement of the treatment, both groups were administered the BAT as a pretest to determine their initial level of achievement. At the end of the instructional period, the same instrument was re-administered as the posttest to measure students' achievement. Standardised lesson plans, teacher training, the use of regular classroom teachers, and adequate geographical separation of participating schools were employed to control extraneous variables and ensure uniform implementation of the treatment.

Data were analysed using both descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypothesis comparing the effects of the instructional strategies on students' achievement after controlling for pretest differences. Independent-samples *t*-tests were employed to test the hypotheses on sex differences within each instructional strategy. All hypotheses were tested at the 0.05 level of significance.

Results

Table 1: Descriptive Statistics Comparing the Pretest and Posttest Mean Achievement Scores of Students Taught Biology Using Peer-tutoring and Collaborative Project-Based Learning Strategies

Strategy	Testing	N	$\bar{x}$	MD	SD
Peer-tutoring	Pretest	107	21.96	38.53	9.30
	Posttest		60.49		9.56
Collaborative	Pretest	109	21.50	30.28	8.81
	Posttest		51.78		11.40

Keys: MD = Mean Difference, SD=Standard Deviation

Table 1 shows that students taught using the peer-tutoring strategy obtained a mean gain score of 38.53, while those taught using collaborative project-based learning obtained a mean gain score of 30.28. This indicates that both instructional strategies improved students' achievement in Biology; however, peer-tutoring produced a higher improvement in achievement than collaborative project-based learning.

Table 2: ANCOVA Comparison of the Pretest and Posttest Mean Achievement Scores of Students Taught Biology Using Peer-tutoring and Collaborative Project-Based Learning Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8152.719[a]	2	4076.360	44.147	.000
Intercept	66223.837	1	66223.837	717.210	.000
pretest	4060.015	1	4060.015	43.970	.000
Strategies	3881.616	1	3881.616	42.038	.000
Error	19667.429	213	92.335		
Total	707438.000	216			
Corrected Total	27820.148	215			

Table 2 indicates that instructional strategy had a significant effect on students' achievement in Biology ($F = 42.038$, $p < .05$). Since the probability value (.000) is less than the 0.05 level of significance, the null hypothesis was rejected. Therefore, there was a significant effect of peer-tutoring and collaborative project-based learning on students' achievement in Biology.

Table 3: Descriptive Statistics Comparing the Posttest Mean Achievement Scores of Male and Female Students Taught Biology Using Peer-Tutoring Strategy

Sex	N	$\bar{x}$	MD	SD
Male	51	60.53	0.08	9.62
Female	56	60.45		9.59

Table 3 shows that male students had a mean score of 60.53, while female students had a mean score of 60.45, with a mean difference of 0.08. This indicates that there was only a negligible difference in the achievement of male and female students taught using the peer-tutoring strategy.

Table 4: Independent Samples t-test Comparison of the Posttest Mean Achievement Scores of Students Taught Biology Using Peer-tutoring Strategy

Method	N	$\bar{x}$	MD	SD	df	t_{cal}	Sig.(2-tailed)	Remark
Male	51	60.53	0.08	9.62	105	0.807	0.964	HO_3 is not rejected
Female	56	60.45		9.59				

Table 4 shows that the probability value of 0.964 is greater than the 0.05 level of significance. Therefore, the null hypothesis was not rejected. This implies that there was no significant difference between the achievement scores of male and female students taught using the peer-tutoring strategy.

Table 5: Descriptive Statistics Comparing the Posttest Mean Achievement Scores of Male and Female Students Taught Biology Using Collaborative Project-Based Learning Strategy

Sex	N	$\bar{x}$	MD	SD

Male	53	49.81	3.83	10.11
Female	56	53.64		12.31

Table 5 shows that female students obtained a higher mean score (53.64) than male students (49.81), with a mean difference of 3.83. This indicates that female students performed slightly better than their male counterparts when taught using collaborative project-based learning.

Table 6: Independent Samples t-test Comparison of the Posttest Mean Achievement Scores of Students Taught Biology Using Collaborative Project-Based Learning Strategy

Method	N	$\bar{x}$	MD	SD	df	t_{cal}	Sig.(2-tailed)
Male	53	49.81	3.83	10.11	107	1.771	0.079
Female	56	53.64		12.31			

Table 6 shows that the probability value of 0.079 is greater than the 0.05 level of significance. Therefore, the null hypothesis was not rejected. This implies that there was no significant difference between the achievement scores of male and female students taught using collaborative project-based learning.

Discussion

The findings of the study revealed that both peer-tutoring and collaborative project-based learning enhanced students' achievement in Biology. However, students exposed to the peer-tutoring strategy obtained a higher mean gain score than those taught using collaborative project-based learning. Furthermore, the ANCOVA result showed that the difference in achievement between the two instructional strategies was statistically significant. This finding suggests that although both strategies are learner-centred and promote active participation, peer-tutoring provides greater opportunities for immediate feedback, peer explanation, and reinforcement of learning, thereby facilitating better understanding of Biology concepts. The finding is consistent with those of Adeyemi and Ojo (2024), Abdulrahman (2024), Balogun (2025), and Yusuf and Afolabi (2022), who reported that peer-tutoring significantly improved students' academic achievement in Biology compared with other learner-centred instructional approaches. The finding also corroborates the meta-analytic evidence reported by Leung (2021) and Hidayat *et al.* (2025), which concluded that peer-tutoring has a positive and significant effect on students' academic achievement across disciplines.

The study also found that there was no significant difference between the achievement scores of male and female students taught Biology using the peer-tutoring strategy. Although male students obtained a marginally higher mean score than female students, the observed difference was not statistically significant. This finding indicates that peer-tutoring provides comparable learning opportunities for both sexes and supports equitable participation in classroom learning. The result agrees with the findings of Ibrahim *et al.* (2022), Okeke and Nwoye (2020), and Ogunleye and Adebayo (2021), who similarly found that sex did not significantly influence students' achievement when Biology was taught using peer-tutoring strategies.

Similarly, the findings showed that male and female students taught Biology using collaborative project-based learning did not differ significantly in their academic achievement. Although female students recorded a slightly higher mean score than their male counterparts, the difference was not statistically significant. This suggests that collaborative project-based learning benefits both male and female students almost equally when implemented appropriately. The finding is in agreement with Adebayo and Adeyemi (2022), Yusuf and Afolabi (2024), and Okafor and Nwankwo (2021), who reported that collaborative project-based learning promotes comparable academic outcomes for both sexes in Biology and other science subjects.

Conclusion

Based on the findings of this study, it was concluded that both peer-tutoring and collaborative project-based learning are effective learner-centred instructional strategies for improving students' achievement in Biology. However, peer-tutoring was found to be significantly more effective than collaborative project-based learning in enhancing students' academic achievement. The study also concluded that sex did not significantly influence students' achievement under either instructional strategy, indicating that both approaches provide equitable learning opportunities for male and female students. Therefore, peer-tutoring may be considered a more effective instructional strategy for improving Biology achievement among secondary school students in Delta Central Senatorial District.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Biology teachers should adopt peer-tutoring more frequently during classroom instruction because it was found to be more effective than collaborative project-based learning in improving students' academic achievement.
2. School administrators and curriculum planners should encourage the integration of learner-centred instructional strategies, particularly peer-tutoring and collaborative project-based learning, into Biology teaching through regular teacher training and professional development programmes.
3. Teachers should provide equal opportunities for male and female students to participate actively in peer-tutoring and collaborative project-based learning activities since both instructional strategies were found to be equally beneficial irrespective of sex.

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