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Effect of Problem-Solving and Cooperative Learning Approaches on the Academic Performance of Secondary School Biology Students in Port Harcourt Local Government Area, Rivers State, Nigeria

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Abstract
This study investigated the effects of problem-solving and cooperative learning strategies on the academic performance of secondary school Biology students in Port Harcourt Local Government Area (PHALGA), Rivers State, Nigeria. A quasi-experimental pretest–posttest non-equivalent control group design was employed to compare cooperative learning, problem-solving, and conventional lecture methods. The participants were 270 Senior Secondary Two (SS2) students (127 males and 143 females) drawn from three purposively selected public secondary schools. Data were collected using the Biology Achievement Test (BAT I & II), which was validated by experts in Science Education and demonstrated acceptable reliability (r = 0.78). Data analysis involved descriptive statistics, Analysis of Covariance (ANCOVA), and post hoc tests at a 0.05 level of significance. Findings revealed a statistically significant effect of instructional methods on students' academic performance, $F(2,263) = 280.579$, $p < 0.05$. Students exposed to cooperative learning achieved significantly higher scores than those taught using problem-solving and lecture methods, with the lecture method yielding the lowest performance. Gender and the interaction between gender and instructional methods were not statistically significant. The study concludes that cooperative learning is a more effective instructional strategy for enhancing students' achievement and engagement in Biology. It recommends the integration of cooperative and problem-solving approaches into Biology instruction to promote meaningful learning and equitable participation in secondary school science education.

Keywords: Cooperative learning, problem-solving, academic performance, Biology education, Port Harcourt, Rivers State.

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Introduction

Biology education is a cornerstone of the secondary school curriculum, playing a pivotal role in fostering scientific literacy, critical thinking, and an understanding of the natural world (Taber, 2018). It equips students with essential knowledge about living organisms and cultivates the problem-solving abilities necessary for future careers in science, technology, engineering, and mathematics (STEM) fields. In Nigeria, Biology is not only a prerequisite for many tertiary education courses but also fundamental to addressing national challenges in areas such as healthcare, agriculture, and environmental conservation. Despite its significance, the teaching and learning of Biology in Nigerian secondary schools, particularly in regions like Port Harcourt, are fraught with challenges. Traditional instructional methods, characterized by teacher-centered lectures, rote memorization, and passive student reception, continue to dominate classroom practice (Omwihiren & Ubawa, 2016). These methods, while efficient for content coverage, often fail to foster deep conceptual understanding, critical thinking, and the application of knowledge in real-world contexts (Kirschner, Sweller, & Clark, 2006). The consequence, as evidenced by consistent reports from the West African Examinations Council (WAEC), is a perennial decline in students' academic performance in Biology, highlighting a disconnect between instructional delivery and effective learning.

In response to these challenges, educational researchers and reformers have advocated for a shift towards more interactive, student-centered pedagogical approaches. Among these, problem-solving and cooperative learning have emerged as particularly promising strategies. The problem-solving approach engages students in active inquiry, presenting them with authentic scientific problems that require the application of knowledge, analytical reasoning, and systematic investigation to arrive at solutions (Adewuya, 2003). This method aligns with constructivist theories, positing that learners actively construct knowledge through experience and reflection (Piaget, 1926; Vygotsky, 1978). Recent pedagogical trends emphasize learner-centered approaches that enhance critical engagement and active participation. Among these are problem-solving and cooperative learning strategies, which align with constructivist theories of learning (Piaget, 1926; Vygotsky, 1978). Conversely, cooperative learning organizes students into small, collaborative groups where shared responsibility, peer discussion, and mutual support enhance comprehension and social skills (Johnson & Johnson, 2001).

Grounded in Bandura's (1986) social cognitive theory, which highlights observational learning and social interactions, and Vygotsky's (1978) constructivist theory, emphasizing knowledge construction through experiences, this study explores these approaches. Problem-solving enhances analytical skills via hypothesis formulation and experimentation, while cooperative learning fosters communication and collective knowledge-building. Empirical evidence supports these methods: Johnson and Johnson (2009) found cooperative learning improved Biology achievement among university students, and Springer et al. (1999) meta-analysis confirmed positive effects across subjects. Slavin et al. (2013) reported higher grades in high school Biology via group activities. Similarly, cooperative learning emphasizes collaborative social interaction, where students work in small groups to achieve shared learning goals (Johnson & Johnson, 2009). This approach is underpinned by social cognitive theory (Bandura, 1986), which highlights the importance of observational learning and social modeling. In cooperative settings, students engage in peer teaching, discussion, and collective knowledge construction, which can enhance motivation, communication skills, and academic achievement (Slavin, 2013).

While the theoretical benefits of these approaches are well-documented in international literature, their empirical validation within the specific socio-educational context of Port Harcourt, Nigeria, remains limited. This study, therefore, seeks to fill this gap by providing a rigorous, comparative investigation into the effects of problem-solving and cooperative learning approaches on the academic performance of secondary school Biology students. By doing so, it aims to inform pedagogical practices and contribute to efforts aimed at reversing the trend of poor performance in Biology.

Statement of the Problem

Despite Biology's importance to the scientific and technological development of Nigeria, performance in the subject has remained unsatisfactory. Reports from the WAEC Chief Examiners (2016–2019) consistently indicate declining student outcomes in Biology, suggesting deep-rooted instructional inadequacies. Many students exhibit difficulty understanding abstract concepts such as photosynthesis, respiration, and genetic mechanisms—often due to passive learning environments where teachers dominate the learning process (Muhammad, 2013). In Port Harcourt Local Government Area, this issue is further compounded by overcrowded classrooms and limited access to laboratory materials. Traditional lecture methods fail to accommodate the diverse learning styles and cognitive levels of students, leading to conceptual gaps and disinterest. Consequently, there is an urgent need for empirically tested pedagogical innovations capable of promoting deeper learning and improved academic performance in Biology. Problem-solving and cooperative learning strategies have shown promise in related studies (Slavin, 2013; Springer et al., 1999), yet their comparative effectiveness in the context of Nigerian secondary schools—specifically PHALGA—has not been extensively documented. This study, therefore, seeks to bridge this gap by experimentally determining whether these approaches significantly enhance Biology students' performance and whether gender mediates their effects.

Purpose of the Study

The purpose of this study was to investigate the impact of problem-solving and cooperative learning approaches on the academic performance of senior secondary school Biology students in Port Harcourt Local Government Area, Rivers State.

The specific objectives were to:

1. Examine the effect of teaching methods (problem-solving, cooperative learning, and lecture) on the academic performance of secondary school biology students.
2. Conduct a pairwise comparison of cooperative learning and lecture methods in improving students' post-test scores in biology.
3. Conduct a pairwise comparison of problem-solving and lecture methods in improving students' post-test scores in biology.
4. Conduct a pairwise comparison of cooperative learning and problem-solving methods in improving students' post-test scores in biology.
5. Examine the effect of the teaching methods on the academic performance of male and female students.
6. Assess whether the interaction between gender and teaching methods affects the academic performance of biology students.

Research Questions

The study was guided by the following research questions:

1. What is the effect of teaching methods (problem-solving, cooperative learning, and lecture) on the academic performance of secondary school biology students in Port Harcourt?
2. Is there a significant difference in the effectiveness of cooperative learning compared to the lecture method in improving students' academic performance in biology?
3. Does the problem-solving method significantly differ from the lecture method in enhancing students' academic performance?
4. How does the performance of students taught using cooperative learning compare to those taught using problem-solving?
5. Is there a significant difference in academic performance between male and female students when using these teaching methods?
6. Does the interaction between teaching methods and gender significantly influence students' academic performance?

Hypotheses

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

1. There is no significant difference in the academic performance of secondary school biology students based on the teaching method (problem-solving, cooperative learning, and lecture).
2. Cooperative learning is not significantly more effective than the lecture method in improving students' academic performance.
3. Problem-solving is not significantly different from the lecture method in enhancing students' academic performance.
4. There is no significant difference in the effectiveness of cooperative learning and problem-solving methods.
5. There is no significant difference in academic performance between male and female students in biology when using different teaching methods.
6. There is no significant interaction between teaching method and student gender in determining academic performance.

Methodology

The study employed a quasi-experimental, pretest–posttest non-equivalent control group design. This design was chosen because random assignment of subjects was not feasible due to existing class structures in the participating schools. Three intact classes were used, each receiving a distinct instructional method—cooperative learning, problem-solving, and lecture method. Pretests measured students’ prior knowledge, while posttests assessed learning outcomes following intervention.

The design is symbolically represented as:

O_1 X_1 O_2

O_1 X_2 O_2

O_1 X_3 O_2

Where: O_1 = pretest, O_2 = posttest, X_1 = cooperative learning method, X_2 = problem-solving method, X_3 = lecture method (control group). The study was conducted in Port Harcourt Local Government Area (PHALGA), Rivers State, located in Nigeria's South-South geopolitical zone. PHALGA hosts a diverse population and numerous public secondary schools managed by the Rivers State Senior Secondary Schools Board. The area provides a relevant context for exploring innovative teaching methods due to its urbanized environment and documented challenges in science education delivery. The population comprised all Senior Secondary Two (SS2) Biology students in the 17 public secondary schools within PHALGA. According to data obtained from the Planning, Research, and Statistics Department of the Rivers State Senior Secondary Schools Board (2024), the total population was 5,090 students (2,646 males and 2,444 females). A sample of 270 SS2 Biology students was selected from three purposively chosen schools. Purposive sampling ensured the inclusion of schools with comparable facilities, experienced Biology teachers, and willingness to participate. Ninety students were assigned to each instructional group: Group A: Cooperative Learning, Group B: Problem-Solving, Group C: Lecture (Control). Each intact class was exposed to its respective treatment over a three-week instructional period on the topic "Respiratory System." Two instruments were used: i. self-structured Biology Achievement Test I (BAT I) — administered as a pretest to determine baseline knowledge. ii. Biology Achievement Test II (BAT II) — administered post-intervention to measure performance gains. Each instrument consisted of 20 multiple-choice questions drawn from the Senior Secondary School Biology curriculum, focusing on topics such as respiration, excretion, and photosynthesis. Both tests were scored over 20 marks. The research instruments were subjected to face and content validation by three experts in Science Education from Rivers State University. They reviewed the test items for clarity, relevance, and alignment with curriculum objectives. Suggestions were incorporated to enhance validity and minimize ambiguity. The instruments were further subjected to item analysis to determine the item difficulty index, discrimination index, effectiveness of distracters to verify the psychometric features of each test items.

Reliability was determined using the test–retest method. The instrument was administered twice to a group of 30 students from a school not included in the main study, with a two-week interval. The scores were correlated using the Pearson Product-Moment Correlation Coefficient, yielding an $r = 0.88$, indicating satisfactory reliability. The researcher obtained approval from relevant school authorities and scheduled sessions in coordination with Biology teachers. i. Pretest Phase: All students completed BAT I to determine prior knowledge. ii. Treatment Phase: *Group A* received instruction through cooperative learning activities involving peer discussions, group tasks, and presentations. *Group B* was taught using the problem-solving method, where students identified, analyzed, and solved real-life biological problems under teacher facilitation. *Group C* (control) received the traditional lecture method, with the teacher providing verbal explanations and notes. Each treatment lasted three consecutive weeks. ii. Posttest Phase: BAT II was administered to assess achievement gains. All tests were invigilated to maintain uniformity and fairness across groups.

The data collected were analyzed using both descriptive and inferential statistics. Descriptive statistics (mean, standard deviation) were used to summarize the pre-test and post-test scores. The research hypotheses were tested using Analysis of Covariance (ANCOVA) with the pre-test scores as the covariate. This was to control for initial differences among the groups. Where the

ANCOVA showed significant effects, pairwise comparisons with a Bonferroni adjustment were conducted to pinpoint the specific differences between the teaching methods. All analyses were performed at a 0.05 significance level. This analytical procedure enabled assessment of main and interaction effects among variables, ensuring robust statistical interpretation. The descriptive statistics for the pre-test and post-test scores are presented in Table 1. The mean pre-test score for the entire sample (N=270) was 10.46 (SD=1.72), indicating a comparable baseline level of prior knowledge across the groups. After the intervention, the mean post-test score for the entire sample rose to 12.71 (SD=2.30). A breakdown by teaching method shows that the Cooperative Learning group had the highest mean post-test score (M=14.33, SD=2.15), followed by the Problem-Solving group (M=12.32, SD=1.93), and the Lecture Method group (M=11.48, SD=1.81).

Table 1: The descriptive statistics of students' pre-test and post-test scores across the three teaching methods are summarized below:

Teaching Method	N	Mean (Pre-Test)	Mean (Post-Test)	SD (Post-Test)
Cooperative Learning	90	10.42	14.33	2.15
Problem-Solving	90	10.49	12.32	1.93
Lecture (Control)	90	10.46	11.48	1.81
Total	270	10.46	12.71	2.30

Research Question 1: What is the effect of teaching methods (problem-solving, cooperative learning, and lecture) on the academic performance of secondary school biology students in Port Harcourt?

Hypothesis 1: There is no significant difference in the academic performance of secondary school biology students based on the teaching methods (problem-solving, cooperative learning, and lecture).

Table 2: ANCOVA output: Summary for Teaching Methods, Gender, and Their Interaction

Tests of Between-Subjects Effects

Dependent Variable: STUDENT'S PERFORMANCE AFTER TREATMENT (Posttest)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1245.864[a]	6	207.644	310.988	.000
Intercept	24.473	1	24.473	36.653	.000
Pretest	855.893	1	855.893	1281.868	.000
Teaching Methods	374.681	2	187.340	280.579	.000
Gender	.098	1	.098	.146	.702
Teaching Methods * Gender	.032	2	.016	.024	.976
Error	175.603	263	.668		
Total	45046.000	270			
Corrected Total	1421.467	269			

a. R Squared = .876 (Adjusted R Squared = .874)

The ANCOVA output reveals that teaching methods have a statistically significant effect on student performance ($F(2, 263) = 280.579$, $p = 0.000$). This significant F-value, coupled with the very small p-value, indicates that the type of teaching method used—whether problem-solving, cooperative learning, or lecture—significantly influences students' post-test performance. The Mean Square value for teaching methods is quite large at 187.340, emphasizing a strong effect size. Since cooperative learning and problem-solving were among the methods compared, this output confirms that at least one of these methods (or both) leads to significantly different academic outcomes compared to the traditional lecture method. The strong significance highlights the importance of teaching approach in educational outcomes, aligning with your objective to assess their effectiveness in biology education.

Research Question 2**:** Is there a significant difference in the effectiveness of cooperative learning compared to the lecture method in improving students' academic performance in biology?

Hypothesis 2**:** Cooperative learning is not significantly more effective than the lecture method in improving students' academic performance.

Table 3: Mean of Teaching Methods

Dependent Variable: STUDENT'S PERFORMANCE AFTER TREATMENT (Posttest)

Teaching Methods	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
cooperative learning	14.340[a]	.088	14.167	14.513
lecture method	11.512[a]	.086	11.343	11.682
problem-solving	12.287[a]	.086	12.118	12.457

a. Covariates appearing in the model are evaluated at the following values: PRIOR KNOWLEDGE PERFORMANCE (Pretest) = 10.46.

Table 4: Pairwise Comparisons of Teaching Methods

Pairwise Comparisons

Dependent Variable: STUDENT'S PERFORMANCE AFTER TREATMENT (Post_test)

(I) Teaching Methods	(J) Teaching Methods	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
cooperative learning	lecture method	2.828*	.123	.000	2.531	3.124
	problem-solving	2.053*	.123	.000	1.756	2.349
lecture method	cooperative learning	-2.828*	.123	.000	-3.124	-2.531
	problem-solving	-.775*	.122	.000	-1.069	-.481
problem-solving	cooperative learning	-2.053*	.123	.000	-2.349	-1.756

	lecture method	.775*	.122	.000	.481	1.069

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

The ANCOVA output shows that Teaching Methods had a significant main effect on students' post-test performance, with an F-value of 280.579 and a p-value of 0.000. This indicates that there is a statistically significant difference between the different teaching methods in terms of their effect on student performance. Specifically, the mean scores for students in the cooperative learning method (M = 14.340) were significantly higher than those for students in the lecture method (M = 11.512), as revealed by the pairwise comparison which shows a mean difference of 2.828 with a p-value of 0.000. This result suggests that cooperative learning is more effective than the lecture method in enhancing students' academic performance in biology. The significant difference ($p < 0.05$) between the two methods supports the notion that cooperative learning fosters a better learning environment by encouraging interaction, discussion, and teamwork among students, which can lead to better understanding and retention of biological concepts. These findings align with educational theories that emphasize active learning and student engagement as crucial elements in improving academic outcomes.

Research Question 3**:** Does the problem-solving method significantly differ from the lecture method in enhancing students' academic performance?
Hypothesis 3: Problem-solving is not significantly different from the lecture method in enhancing students' academic performance.

From the pairwise comparisons, the mean difference between the problem-solving method and the lecture method is 0.775, with a p-value of 0.000, indicating a significant difference between the two teaching approaches. The mean score for students in the problem-solving group was 12.287, which was significantly higher than that for the lecture group (M = 11.512). Although the problem-solving method was significantly more effective than the lecture method, the difference was smaller compared to the cooperative learning method. This suggests that while problem-solving can enhance students' academic performance compared to the more traditional lecture-based approach, it may not be as impactful as cooperative learning. Problem-solving allows students to develop critical thinking and analytical skills, which are essential for biology. However, the smaller effect size compared to cooperative learning may be due to the solitary nature of problem-solving tasks, where interaction and collaboration are limited, which are key factors in cooperative learning.

Research Question 4**:** How does the performance of students taught using cooperative learning compare to those taught using problem-solving?
Hypothesis 4**:** There is no significant difference in the effectiveness of cooperative learning and problem-solving methods.

The pairwise comparison between the cooperative learning method and the problem-solving method reveals a mean difference of 2.053 with a p-value of 0.000, indicating a significant difference between these two teaching methods. The mean score for students in the cooperative learning group (M = 14.340) was significantly higher than that of students in the problem-solving group (M = 12.287). This result suggests that cooperative learning is significantly more effective than problem-solving in enhancing students' academic performance. The collaborative nature of cooperative learning, which promotes peer interaction and the exchange of ideas, likely plays a critical role in helping students grasp complex biological concepts more effectively. On the other hand, problem-solving, while valuable in promoting independent thinking, may not provide the same level of support and scaffolding that students receive in a cooperative learning environment. Therefore, the superior performance of students in the cooperative learning group highlights the importance of collaboration in educational settings.

***Research Question 5*:** Is there a significant difference in academic performance between male and female students when using these teaching methods?

***Hypothesis 5*:** There is no significant difference in academic performance between male and female students in biology when using different teaching methods.

Table 5: Mean of Gender

Dependent Variable: STUDENT'S PERFORMANCE AFTER TREATMENT (Post_test)

SEX	Mean	**Std. Error**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Female	12.694[a]	.069	12.559	12.829
Male	12.733[a]	.073	12.589	12.876

a. Covariates appearing in the model are evaluated at the following values: PRIOR KNOWLEDGE PERFORMANCE (Pretest) = 10.46.

Table 6: Pairwise Comparisons of Gender

Pairwise Comparisons

Dependent Variable: STUDENT'S PERFORMANCE AFTER TREATMENT (Post_test)

(I) SEX	(J) SEX	**Mean Difference (I-J)**	**Std. Error**	**Sig.[a]**	**95% Confidence Interval for Difference[a]**	
					Lower Bound	**Upper Bound**
Female	Male	-.038	.100	.702	-.236	.159
Male	Female	.038	.100	.702	-.159	.236

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

In the ANCOVA table, Gender has a non-significant effect on academic performance ($F(1, 263) = 0.146$, $p = 0.702$). This means there is no statistically significant difference between male and female students' performance after controlling for pre-test scores and the teaching method used. The low F-value and high p-value (greater than the 0.05 significance level) suggest that gender does not play a notable role in influencing post-test scores in biology when accounting for the other variables. Thus, the findings suggest that gender does not significantly affect how students respond to different teaching methods, supporting the idea that male and female students have comparable academic outcomes in biology irrespective of the teaching method.

Research Question 6: Does the interaction between teaching methods and gender significantly influence students' academic performance?
Hypothesis 6: There is no significant interaction between teaching method and student gender in determining academic performance

Table 7: Interaction between teaching methods and gender

Teaching Methods * SEX Dependent Variable: STUDENT'S PERFORMANCE AFTER TREATMENT (Post_test)					
Teaching Methods	**SEX**	**Mean**	**Std. Error**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
cooperative learning	Female	14.306[a]	.111	14.087	14.525
	Male	14.375[a]	.136	14.107	14.643
lecture method	Female	11.499[a]	.122	11.259	11.739
	Male	11.526[a]	.122	11.286	11.766
problem-solving	Female	12.278[a]	.123	12.035	12.521
	Male	12.297[a]	.121	12.059	12.534

a. Covariates appearing in the model are evaluated at the following values: PRIOR KNOWLEDGE PERFORMANCE (Pre_test) = 10.46.

The interaction between Teaching Methods and Gender also shows a non-significant result ($F(2, 263) = 0.024$, $p = 0.976$). This means that the effectiveness of teaching methods does not differ significantly between male and female students. In other words, gender does not moderate the relationship between teaching method and academic performance. Both male and female students respond similarly to the problem-solving, cooperative learning, and lecture methods, and the interaction between teaching method and gender is negligible. This aligns with the previous finding that gender does not have a significant main effect on performance and supports the view that teaching methods are universally applicable across genders.

Discussion and Findings

This study provides empirical evidence that the method of instruction substantially influences the academic performance of Biology students in Port Harcourt Local Government Area. The observed significant improvement in post-test scores for cooperative learning and problem-solving groups corroborates contemporary educational theories that emphasize active engagement, social interaction, and experiential learning (Bandura, 1986; Vygotsky, 1978). The significant difference among teaching methods demonstrates that instructional strategies shape learning outcomes. Students taught through cooperative learning exhibited the highest performance. This aligns with Johnson and Johnson's (2009) social interdependence theory, which asserts that learning is optimized when students work together toward shared goals. Within the cooperative groups, learners explained concepts to peers, asked questions, and engaged in consensus-building — processes that deepen conceptual understanding (Slavin, 2013). The problem-solving approach also significantly improved performance over the lecture method. This finding agrees with Adewuya (2003) who noted that problem-solving nurtures analytical and investigative skills. Students involved in identifying and testing solutions to Biology-related problems engaged in higher-order thinking, consistent with constructivist models of learning (Piaget, 1926). Conversely, the lecture method resulted in the lowest mean performance. Its teacher-centered orientation limits opportunities for exploration and collaboration, leading to surface-level learning (Kirschner, Sweller, & Clark, 2006). This confirms previous reports that passive instruction fails to sustain student interest in science subjects (Omwihiren & Ubawa, 2016).

The large mean difference (2.828) between cooperative learning and lecture groups demonstrates the power of collaboration in enhancing learning outcomes. Students benefit from explaining ideas to peers, receiving immediate feedback, and constructing shared meaning — all of which consolidate understanding (Hattie & Timperley, 2007). The findings resonate with Springer et al. (1999), who observed that small-group cooperative instruction yielded significantly higher achievement across science domains. Furthermore, cooperative learning fosters essential soft skills such as communication, teamwork, and responsibility for collective success — competencies valuable for the 21st-century learner. Problem-solving yielded statistically higher results than lectures, reflecting its effectiveness in stimulating inquiry and application of biological principles. The approach encourages students to identify problems, hypothesize, test, and analyze results. Such cognitive engagement nurtures persistence, creativity, and understanding — critical aspects of scientific reasoning (Anderson & Krathwohl, 2001). However, its effect size was smaller than that of cooperative learning. One explanation is that problem-solving often requires individual cognitive effort and may not provide the same degree of peer support found in group collaboration.

Comparing the two active approaches, cooperative learning produced significantly higher mean scores. This suggests that learning in social contexts enhances cognitive processing. Bandura's (1986) social cognitive theory provides a theoretical lens: students model effective strategies observed in peers, thereby improving self-efficacy and performance. Similarly, Vygotsky's (1978) notion of the "zone of proximal development" underscores how interaction with more capable peers scaffolds learning. In the present study, group members likely benefited from mutual explanation and shared problem-solving, making cooperative learning a more holistic instructional method than individual problem-solving alone. No significant gender difference was found in performance across all methods. This indicates that both male and female students respond similarly to learner-centered teaching strategies. The result contrasts with some earlier studies suggesting male dominance in science achievement (Filibus, Olufunlayo, & Maey, 2016), but supports more recent findings emphasizing equal academic potential when given equitable learning opportunities. The outcome underscores the gender-neutral benefit of cooperative and problem-solving pedagogies, thereby advancing inclusivity and equality in science education. The non-significant interaction effect implies that the relative advantage of cooperative or problem-solving approaches does not depend on student gender. Both male and female learners can equally benefit from these instructional strategies. This finding strengthens the case for universal implementation of learner-centered pedagogies without fear of gender bias.

The study's findings are well-anchored in the social cognitive and constructivist theories. From Bandura's perspective, cooperative learning allows observation, imitation, and internalization of modeled behaviors, improving both cognitive and social competencies. Constructivist theory (Piaget; Vygotsky) emphasizes that learners actively build knowledge through experience and interaction. Cooperative and problem-solving methods provide such opportunities by enabling students to connect prior knowledge with new concepts through experimentation and dialogue. These theoretical underpinnings explain why both strategies yielded higher performance compared to the teacher-centered lecture method.

Conclusion

From the findings, it is clear that the choice of teaching method has a significant impact on students' academic performance in biology. Cooperative learning, which emphasizes group collaboration and active participation, emerged as the most effective method, followed by problem-solving, while the lecture method was the least effective. The lack of gender-based performance differences and interaction between teaching method and gender suggests that these instructional strategies are equally beneficial for all students, making them viable for inclusive classroom settings.

This study confirms that traditional teaching approaches such as lectures are insufficient for maximizing student achievement in biology. More dynamic, student-centered approaches like cooperative learning and problem-solving yield better academic outcomes, enhancing not only knowledge acquisition but also student engagement and motivation

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