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Collaborative Learning Strategy and Academic Achievement of Senior Students in Ecology in Oyo, Nigeria

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Abstract
Students' performance in Biology consistently showed that biological topics like Ecology, remains suboptimal. These challenges are attributed to traditional teacher-centered instructional methods that often fail to engage students actively or foster deep understanding. This study investigated the effects of collaborative learning strategy on senior students' academic achievement in ecology. Employing a quasi-experimental research design with pretest and posttest measures, 152 Senior Secondary School II (SS2) students from 2 public schools in Oyo Central Senatorial District were assigned to experimental (67 for collaborative learning) and control (85 for conventional teaching) groups. Data were collected using the Ecology Achievement Test (EAT), and analyzed via Analysis of Covariance (ANCOVA). Results revealed: a significant effect of collaborative learning on academic achievement of students in ecology ($F_{(1;149)}$ = 101.242; P < 0.05), with students in the collaborative group outperformed those in the control group; a significant interactions effect of collaborative learning and conventional teaching method on academic achievement of students in ecology ($F_{(3;148)}$ =34.431; P<0.05), which suggested hybrid approaches to enhance improved outcomes. The study concluded that, collaborative learning fosters peer interaction and yielded improvement in students' achievement in ecology at the senior secondary school. Recommendation from the study emphasized its integration into teaching and learning of ecology to address persistent underachievement of students in the topic at the senior secondary school level.

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Introduction

Education is fundamental in cultivating critical thinking, enhancing problem-solving skills, and equipping learners with the knowledge essential for sustainable development. Within Nigeria's senior secondary school curriculum, Biology is prioritized for its relevance to life and in tackling environmental challenges and promoting sustainability. However, despite this curricular emphasis, students' achievement in Biology, especially in ecology-related concepts, has persistently remained low [1]. This persistent underachievement is primarily attributed to the continued reliance on teacher-centered instructional methods, which fail to actively involve learners or facilitate meaningful conceptual understanding [2]. A considerable number of Nigerian secondary school students experience difficulties in grasping biological concepts, often perceiving them as complex and challenging. Misconceptions are particularly prevalent in ecology, where students struggle with interpretation and articulation. Moreover, the abstract and fragmented mode of instruction commonly employed in teaching Biology further undermines students' comprehension [3].

Biology is a core subject in the Nigerian senior secondary curriculum, covering areas like cell biology, genetics, physiology, evolution, and ecology, as prescribed by the Nigerian Educational Research and Development Council [4]. It is a scientific

discipline concerned with the study of living organisms, including their structure, functions, growth, evolution, distribution, and interactions with both their environment and one another. Recognized as a core subject in the Nigerian senior secondary school curriculum, Biology covers diverse areas such as cell biology, genetics, physiology, evolution, and ecology, as prescribed by the Nigerian Educational Research and Development Council [4]. The subject is designed to equip students with the knowledge and skills necessary to comprehend life processes, cultivate scientific inquiry, and apply biological understanding to real-world challenges in health, agriculture, and environmental sustainability.

Academic achievement in Biology refers to the extent of students' mastery of the knowledge, skills, and competencies prescribed in Biology curriculum, typically evaluated through tests, examinations, and practical assessments. Within senior secondary education in Nigeria, Biology is a core science subject, with ecology as a vital component encompassing complex concepts such as ecosystems, biodiversity, food chains, and environmental interactions [5]. Academic achievement in ecology reflects students' capacity to understand these concepts, apply them to real-world contexts, and demonstrate proficiency in both internal assessments and external examinations, including the West African Senior School Certificate Examination (WASSCE). It encompasses both cognitive dimensions, such as knowledge acquisition and conceptual understanding, and practical dimensions, including laboratory skills, observation, and the application of scientific methods. Cognitively, academic achievement in Biology entails understanding core concepts such as cell theory, genetics, ecology, evolution, and physiology, alongside mastery of the scientific method, including hypothesis formulation, experimental design, data analysis, and evidence-based reasoning. Practically, it encompasses laboratory competencies such as observation, dissection, measurement, and precise data recording. Evaluation is carried out through diverse methods, including written examinations, practical tests, project work, and continuous assessment tools such as quizzes and assignments. High academic achievement signifies a student's ability not only to recall biological facts but also to apply concepts in solving real-world problems and to exhibit sound scientific reasoning [6].

Both internal factors, such as motivation, study habits, and prior knowledge, and external factors, including instructional quality, availability of learning resources, parental support, and the overall school environment are shaped by students' academic achievement in Biology. Frequently employed as a key indicator for assessing the effectiveness of instructional methods, curriculum implementation, and students' readiness for advanced study in science-related disciplines, students' academic achievement in Biology goes beyond mastery of content and scientific skills, it reflects students' capacity to engage with scientific texts, accurately use biological terminology, and establish interdisciplinary linkages with fields such as chemistry, environmental science, and health education. Academic achievement in Biology is encompassed by both lower-order cognitive skills, including recall and identification, and higher-order thinking skills, such as synthesis, evaluation, and problem-solving, in line with Bloom's taxonomy [7].

Students' achievement in Biology at the West African Senior School Certificate Examination (WASSCE) level in Nigeria has consistently been reported as fair, especially in terms of attaining the credit-level passes necessary for admission into tertiary institutions [8-12]. The West African Examinations Council (WAEC) Chief Examiners' reports on Biology have repeatedly identified numerous challenges faced by candidates, including difficulties in interpreting questions, lack of logical and coherent responses, poor drawing skills, limited expressive ability, inability to relate structure to function, frequent misspelling of biological terms, and insufficient understanding of ecological processes such as nutrient cycles and food webs. Ecology focuses on interactions between organisms and their environment, including ecosystems, biodiversity, food chains, and conservation. These recurring issues point to gaps contributing significantly to students' persistent underperformance in Biology [3, 8-12]. Despite the application of diverse instructional strategies, many students tend to either avoid ecology-related questions or respond inadequately.

A key challenge in teaching Ecology lies in its interdisciplinary nature, as it draws on principles from biology, geography, chemistry, and even economics to explain complex systems and human–environment interactions. The extensive scope of ecological concepts can pose significant challenges for students, particularly when instructional approaches lack clarity or fail to effectively bridge theoretical principles with observable phenomena. Students may encounter difficulties in grasping critical concepts such as ecological scale (population versus ecosystem dynamics), temporal processes (ecological succession), or feedback mechanisms within natural systems, all of which are essential for a comprehensive understanding of ecological stability and transformation. Furthermore, pre-existing misconceptions, such as the notion that ecosystems are static or that environmental issues can be addressed through simplistic, one-dimensional solutions, may persist if instructional strategies are not deliberately structured to challenge and reformulate these naive assumptions. Effective teaching of Ecology thus necessitates constructivist approaches that actively involve students in hypothesis testing, reflection, and practical applications, such as examining local environmental challenges or simulating ecosystem responses to disturbances [13, 14].

Moreover, the teaching of Ecology is frequently hindered by structural and institutional constraints, especially in under-resourced educational contexts. In many Nigerian secondary schools, inadequate access to laboratory facilities, field equipment, and qualified Biology teachers significantly undermines the effective delivery of ecological content. Consequently, educators often resort to didactic instruction and textbook-based explanations of ecological processes, which deprive students of the experiential learning opportunities essential for comprehending dynamic environmental systems [15, 16]. To mitigate these challenges, innovative instructional strategies such as collaborative learning and simulation-based approaches have attracted global attention. Collaborative learning, in particular, promotes peer interaction and critical thinking, allowing students to co-construct knowledge and develop a deeper understanding of ecological concepts. Within the context of this study, the integration of this strategy is anticipated to enhance students' academic achievement in ecology by addressing the shortcomings of conventional methods, which typically promote rote memorization rather than meaningful

learning [17].

Collaborative learning strategy involves students participating in structured group tasks aimed at achieving shared academic goals, thereby promoting meaningful peer interaction, effective communication, and collective problem-solving [18-20]. Rooted in social constructivist theory, this approach underscores positive interdependence, individual accountability, and the co-construction of knowledge, all of which contribute to improved academic outcomes. Empirical evidence shows that collaborative learning boosts students' motivation, critical thinking, and conceptual understanding, especially in complex areas like ecology, where peer dialogue and explanation help to demystify abstract concepts. Complementing this, the simulation strategy utilizes digital technologies or physical models to replicate ecological systems and processes, enabling learners to visualize, manipulate, and experiment with dynamic interactions in a safe environment. Through active exploration and problem-solving, simulations foster deeper cognitive engagement and effectively bridge the gap between theoretical understanding and practical application [21].

Collaborative learning is a learner-centered instructional approach where students work in small, heterogeneous groups to pursue common academic objectives, fostering meaningful interaction, cooperation, and collective problem-solving. It is grounded in the principle of positive interdependence, whereby each member's achievement is tied to the group's overall success, fostering mutual support, accountability, and shared responsibility [22]. In contrast to traditional teacher-centered methods that emphasize passive knowledge reception, collaborative learning promotes active engagement, peer dialogue, and the co-construction of knowledge through social interaction. Evidence indicates that this strategy enhances cognitive development, motivation, and conceptual mastery, particularly in science education, where complex and abstract topics like ecological relationships are better understood through diverse perspectives and cooperative analysis [23].

However, existing literature revealed that application of collaborative learning strategies has been attempted on various topics in Biology in other geographical locations. This gap is particularly pronounced in Oyo Central Senatorial District, Oyo State, Nigeria, where ecology, an integral part of environmental science, has not been sufficiently examined using collaborative learning strategies based on the available literature the current researchers are exposed to. This study therefore focused on the effect of collaborative learning on academic achievement in ecology among Senior Secondary School students in Oyo Central Senatorial District in Nigeria in order to address the gap in literature.

The objectives of this study are to (i) determine the effect of collaborative learning strategy on academic achievement of Senior Secondary School Biology students in ecology topics in Oyo Central Senatorial Districts; and (ii) determine the interaction effect of collaborative learning strategy and conventional method on academic achievement of Senior Secondary School Biology students in ecology topics in Oyo Central Senatorial Districts, Oyo State, Nigeria.

Hypotheses

The study was guided by the following null hypotheses formulated and tested at 0.05 level of significance:

H_{01}: There is no significant effect of collaborative learning strategy on Senior Secondary School Students' academic achievement in Ecology in Oyo Central Senatorial District in Nigeria.

H_{02}: There is no significant interaction effect of collaborative learning and conventional method on students' academic achievement in Ecology in Oyo Central Senatorial District in Nigeria.

Materials and Methods

This study adopted a quasi-experimental design with pretest-posttest measures using non-randomized intact groups to examine collaborative learning's effects on academic achievement in ecology. The population comprised all SS2 Biology students in public secondary schools in Oyo Central Senatorial District, spanning 11 Local Government Areas in Oyo State, Nigeria. A purposive sampling technique was employed to select two co-educational public secondary schools based on key criteria, including accessibility, and the presence of two qualified Biology teachers teaching at the SS2 classes. Two intact classes consisting of 152 students were randomly selected from the two schools drawn from two Local Government Areas in Oyo Central Senatorial District, where the study took place. Each of the two selected school was randomly assigned to collaborative learning strategy group (67 students), and the second one assigned to the control group (85 students) where the conventional teaching method to teach ecology. The instrument for data collection was a researcher-made Ecology Achievement Test (EAT) which consisted 20 multiple-choice questions on Ecology topics, validated by experts and tested for reliability using Kudar Richardson 20 (KR-20) which yielded a reliability value of 0.79. Two Lesson plans were structured for each group to guide the research assistants in each group.

Data Collection Procedure

The study was conducted over a period of eight weeks, aligned with one academic term. A pre-test using the EAT was administered to all groups to establish baseline academic achievement levels. The experimental group received instruction from their regular Biology teachers who served as research assistants and received one week of training on teaching Ecology using the collaborative learning strategy. The control group received instruction from their regular Biology teachers who served as research assistants and received no further training but used the conventional method to teach Ecology. Both experimental and control groups were provided with lesson plans aligned to their respective instructional methods; a pretest was administered before a four-week intervention, followed by a posttest in the fifth week using the same items.

The schedule of the activities for data collection are as follows: Week 1for training of the research assistants; Week 2 for administration of Pre-test; Week 3 to Week 7 for introduction of treatment (collaborative learning strategy); and Week 8 administration for Post-test.

Data Analysis

Data was analyzed using both descriptive and inferential statistics to summarize students' pre-test and post-test scores. Analysis of Covariance (ANCOVA) was employed to compare the post-test scores of the two groups, using pre-test scores as a covariate to control for initial differences. The hypotheses were tested at 0.05 significant level.

Results

H_{01}: There is no significant effect of collaborative learning strategy on Senior Secondary School Students' academic achievement in Ecology in Oyo Central Senatorial District in Nigeria.

Table1: Summary of Analysis of Covariance (ANCOVA) Test on the Effect of Collaborative Teaching Strategy on the Post-test Achievement Scores of Students in Ecology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Main effect					
Corrected Model	19512.542[a]	2	9756.271	50.629	0.000
Intercept	46142.924	1	46142.924	239.453	0.000
Collaborative	19509.478	1	19509.478	101.242	0.000
Pretest	4.094	1	4.094	0.021	0.884
Error	28712.511	149	192.701		
Total	484572.000	152			
Corrected Total	48225.053	151			
a. R Squared = 0.405 (Adjusted R Squared = 0.397)					

Source: Researchers' Fieldwork, 2025

The ANCOVA result on table 1 above revealed a significant effect of collaborative learning strategy on academic achievement of Senior Secondary School Biology students in ecology topics in Oyo Central Senatorial Districts; ($F_{(1;149)}$ = 101.242; P < 0.05). Since P < 0.05, the H_{01} is therefore rejected. This implies when students taught with the use of collaborative learning strategy outperformed their counterparts that were not exposed to the same teaching instruction.

H_{02}: There is no significant interaction effect of collaborative learning and conventional method on students' academic achievement in Ecology in Oyo Central Senatorial District in Nigeria.

Table 2: Summary of Analysis of Covariance (ANCOVA) Test on the Interaction Effect of Collaborative Learning Strategies and Conventional Method on Students' Post-test Achievement Scores in Ecology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	19822.635[a]	3	6607.545	34.431	0.000
Intercept	431974.071	1	431974.071	2250.941	0.000
Collaborative * Conventional	19822.635	3	6607.545	34.431	0.000
Error	28402.418	148	191.908		
Total	484572.000	152			
Corrected Total	48225.053	151			
a. R Squared = 0.411 (Adjusted R Squared = 0.399)					

Source: Researchers' Fieldwork, 2025

Result from table 2 above showed that there was interaction effect of Collaborative learning strategy and conventional method on academic achievement of Senior Secondary School students in ecology in Oyo Central Senatorial Districts; ($F_{(3;148)}$ =34.431; P < 0.05), the $H_0$2 is therefore rejected. This implies that students' academic performance was improved when conventional teaching method and collaborative learning strategy are used together to teach ecology. This implies that employing hybrid approaches could equally enhance improved outcomes of students in ecology when a conventional method is coupled with collaborative learning strategy in teaching ecology.

Discussion of Finding

The ANCOVA analysis indicated a significant effect of the collaborative learning strategy on students' academic achievement in ecology among Senior Secondary School II (SS2) students in Oyo Central Senatorial District. This suggests that students exposed to collaborative learning outperformed those taught using conventional method, even when controlling for pre-test scores. The finding corroborates prior empirical studies, which demonstrate the efficacy of collaborative learning in science teaching, where it was found that collaborative learning significantly improved science achievement among secondary school students in Nigeria, with enhanced peer support and critical thinking [19]. Similarly, another study conducted reported that cooperative learning strategies, such as in learning together, led to higher Biology achievement compared to conventional methods in Nigerian secondary schools [1]. These studies align with the current finding, suggesting that collaborative learning's emphasis on active engagement and peer explanation is particularly effective for conceptually dense subjects like ecology. Collaborative learning strategy promotes higher achievement and retention than individualistic or competitive methods, particularly in science teaching, due to positive interdependence and group accountability. This implies that student teams work supports and structured group work fosters both individual and collective success, which likely contributed to the observed improvement in Ecology Achievement Test (EAT).

The ANCOVA analysis in table 2 indicated a significant interaction effect between the collaborative learning strategy and the conventional method on students' academic achievement in ecology, as measured by the Ecology Achievement Test (EAT). This suggests that the combined effect of these two teaching strategies on students' performance differs significantly from the effect of a single strategy, even when controlling for pre-test scores. This finding aligns with the study's objective to determine the effect of combined teaching strategies on ecology achievement and highlights an unexpected synergy or differential effect when collaborative learning and conventional method are considered together.

The significant interaction effect can be partially explained by Social Constructivist Theory which underpins collaborative learning and emphasizes knowledge construction through social interaction and peer scaffolding within the Zone of Proximal Development (ZPD). In contrast, conventional teaching, characterized as teacher-centered and lecture-based, does not align directly with constructivist principles, as it relies on passive learning and rote memorization. The interaction effect suggests that the presence of collaborative learning may modify the impact of conventional teaching, potentially by supplementing its limitations with peer interaction and active engagement [13, 14].

For instance, the lesson plan for collaborative learning involves group discussions on ecological concepts like food chains, which encourage critical thinking and peer explanation. When paired with conventional method's structured content delivery which combination may allow students to first receive foundational knowledge (teacher's lecture method) and then deepen their understanding through collaborative activities, creating a synergistic effect. This interaction could enhance comprehension of complex ecological concepts, such as energy flow or biodiversity beyond what either strategy achieves alone.

The significant interaction effect is less commonly reported as most studies focus on comparing collaborative learning with conventional method independently. However, some empirical evidence supports the idea that combining structured instruction with active learning can enhance outcomes. For instance, a study found that integrating cooperative learning with traditional methods improved science achievement by providing a balance of direct instruction and peer interaction [23]. This aligns with the current finding, suggesting that collaborative learning may compensate for the passive nature of conventional method of teaching, enhancing engagement and retention. Furthermore, a study submitted that cooperative learning can enhance traditional instruction by fostering positive interdependence, which may explain the interaction effect. When students receive content through lectures (conventional teaching) and then process it through group discussions (collaborative learning), they may achieve deeper understanding, particularly for abstract subjects like ecology. Another study suggests that hybrid approaches combining structured instruction with active learning yield better STEM outcomes than traditional methods alone, supporting the observed interaction effect [21].

Conclusion

This study concluded that collaborative learning significantly enhances academic achievement in ecology, offering equitable benefits by synergizing with other strategies. Recommendation from the study emphasized collaborative learning strategies into teaching of ecology and other science subject to address persistent underachievement of students in the topic at the senior secondary school level; employing hybrid approaches of collaborative learning strategy and conventional method to enhance improved outcomes of students in ecology.

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