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Effects of Two Teaching Strategies on Senior Secondary Students' Academic Achievement in Evolution in Oyo Central Senatorial District, Nigeria

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Abstract

The persistent underperformance of students in Biology, particularly in topics such as Evolution, has been linked to Conventional teaching approaches that limit learners' engagement and conceptual understanding. This study investigated the Effects of Two Teaching Strategies (Interactive 3D Modeling Software and Team-Based Learning strategies) on Senior Students' Academic Achievement in Evolution in Oyo Central Senatorial District, Nigeria. One hypothesis was formulated and tested at 0.05 level of significance using a quasi-experimental research design. The population consisted of 25,958 Senior Secondary School II Biology students in Oyo Central Senatorial District, from which 158 students were selected through intact classes from three randomly selected public secondary schools in the study location. A validated Evolution Achievement Test (EAT) (KR-20 = 0.87) was used for data collection and the collected data were analyzed using Analysis of Covariance (ANCOVA). There was a significant main effect of treatments on Senior Students' Achievement in Evolution ($F_{(2;103)} = 49.324$, $p < 0.05$, partial $\eta^2 = 0.489$). The study concluded that Interactive 3D Modeling and Team-Based Learning strategies significantly enhanced students' achievement in Evolution. It is therefore recommended that Biology teachers should adopt 3D modeling and collaborative learning strategies to promote meaningful understanding to enhance students' achievement in Evolution and related biological concepts.

Keywords: *Academic achievement, Evolution, Interactive 3D modeling, Team-based learning, Evolution, Senior School Students*

INTRODUCTION

Biology is a natural science that studies living organisms and how they interact with each other in the natural environment. Biology examines the structure, function, growth, origin, evolution, and distribution of living things. The study of living things (Biology) is very essential to human beings for many reasons. School students study Biology to obtain a certificate and to train for jobs that require the knowledge and practical skills acquired through the study of Biology. The study of Biology also helps one to live healthier and happier lives, such as by understanding the body, its systems, functions, other living organisms, and the environment. It also reveals the importance of nutrition and hygiene. High school Biology is not merely intended to increase students' knowledge but also to develop and encourage scientific attitudes. It further encourages its students to be open minded in asking questions and to be objective and accurate in interpreting results (Duschl & Rodger, 2023). The diversity of life on our planet is the result of a process called evolution, which drives organisms to change gradually over time (Paige, Rizki & Suprapto, 2024).

Evolution helps one to understand the history of life. It is the process by which modern organisms have descended from ancient ancestors. The ideal that all life on Earth shares a common ancestor is just the central idea of biological evolution. It means that all living things are distant cousins: humans and oak trees, hummingbirds and whales. There are many different species alive on earth but they all have some physical features in common, hence, the study of the physical features and structure of organisms is called morphology (Pedro, Nascimento & Soares, 2024).

Biological evolution is not simply a matter of change over time: lots of things change over time, but they are not examples of biological evolution because, they do not involve descent through genetic inheritance. In time, characteristics that allow organisms to survive and reproduce become more common and those that do not will disappear, so, the population evolves. Evolution is responsible for both

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the remarkable similarities seen across all life and the amazing diversity of those lives. Thus fundamental to the process is genetic variation upon which selective forces can act for evolution to occur. While the process of natural selection that drives evolution is happening every hour of every day, evolution of a species frequently works at a very slow pace and is usually only seen through evidence in the fossil record. Through the process of descent with modification, the common ancestor of life on Earth gave rise to the fantastic diversity that are seen documented in the fossil record around today. Both fossils from long ago and animals alive today provide evidence of evolution and help us to better understand how the process works. The fossil remains of animals and plants reveal a lot about what the world was once like. While the basic concept of organisms evolving is not a difficult one, understanding how evolution works, and how evolutionary theory was developed, is more complex.

Academic performance in evolution among Nigerian senior secondary students remains a persistent challenge, with recent empirical studies and examination analytics highlighting significant conceptual difficulties. Research consistently identifies evolution as one of the most poorly answered topics in national examinations, attributable to persistent misconceptions, abstract content, and inadequate pedagogical approaches (WAEC, 2023). Specifically, recent report from the West African Examinations Council (WAEC) Chief Examiner's Reports for Biology shows that candidates frequently confuse key concepts such as homologous and analogous structures, misinterpret natural selection as a deliberate process, and fail to articulate evidence for evolution from areas like comparative anatomy and embryology. The reports note that questions on mechanisms of evolution, such as explaining antibiotic resistance in bacteria, often yield low scores, indicating a gap between rote memorization and functional application (WAEC, 2022). Empirical studies from the last two years corroborate these findings, in a diagnostic assessment of selected SS2 students in Ogun State, found a mean achievement score of 38.7% in evolution concepts. Their study identified that 67% of students held Lamarckian misconceptions (such as inheritance of acquired characteristics) as their primary explanatory framework for adaptation, directly conflicting with the curriculums emphasis on natural selection (Okafor & Adebayo, 2023).

Emerging research points toward potential solutions. Recent interventions highlight the efficacy of technology-integrated and collaborative pedagogies. For instance, a research reported a statistically significant improvement in evolution achievement when computer simulations were used to model natural selection, as they made abstract processes like genetic variation and selection pressure visually explicit and manipulable. Furthermore, studies on collaborative learning in Nigerian classrooms suggest that peer discussion can effectively challenge and correct deeply held alternative conceptions about evolution (Nwosu, Opara & Nwachukwu, 2023).

The instructional strategies used in teaching are major factors influencing students' difficulties with evolution (Matazu & Isma'il, 2024). Conventional teaching in Nigerian classrooms is dominated by teacher-centered strategies such as lectures and rote memorization, which tend to emphasize factual recall rather than conceptual understanding (Ezurike & Feyisetan, 2020). Static two-dimensional textbook illustrations of phylogenetic trees, fossils, or homologous structures do little to help students visualize complex relationships. A phylogenetic tree, or phylogeny, maps out the evolutionary path shared by a group of species or other taxa over time. Think of it as a family tree for organisms: it's a branching diagram that reveals how different species are related to one another, based on the similarities and differences in their physical traits or genetic makeup. Consequently, many learners fail to develop deep, transferable mental models of evolutionary change. Research in Biology education suggests that when abstract biological processes are not made visible or interactive, students are more likely to cling to intuitive but scientifically inaccurate explanations (Adebayo & Yusuf, 2025; Matazu, 2025).

While the conceptual difficulties associated with evolution are universal, their manifestation and persistence are profoundly shaped by local socio-cultural and educational environments. In Nigeria, and specifically within the socio-cultural milieu of Oyo State, the challenge of teaching evolution effectively exists at a complex intersection where robust cognitive biases meet deeply ingrained religious worldviews and didactic teaching traditions. Research confirms that Nigerian students exhibit the same range of teleological, Lamarckian, and essentialist misconceptions as their global peers; however, the potency of these misconceptions is often amplified by unique contextual factors that influence knowledge reception and acceptance (Okeke & Onwu, 2021; Michaelsen & Sweet 2024).

Therefore, the case with evolution topic in Oyo Central Senatorial District is twofold. First, there are the inherent conceptual difficulties of the topic, which are universal. Second, and more specific to the context, are the potent socio-cultural filters through which the knowledge is received and the pedagogical methods that fail to mediate this process effectively. This dual challenge creates a compelling and urgent rationale for investigating innovative, student centered pedagogical interventions. Approaches such as interactive 3D modelling software, which can visualize abstract processes, and Team-Based Learning, which structures collaborative, conceptual discourse, are specifically designed to bypass the limitations of traditional methods (Maulion & Prudente, 2025). They offer a pathway to make evolution tangible and to create a classroom environment where scientific reasoning can be developed alongside, rather than in opposition to, a student's cultural identity. In the course of this research, effect of Team-based Learning Strategy and 3D Modelling Instructional Strategy on Student's Achievement in Evolution in Oyo Central Senatorial District, Oyo State, Nigeria.

Team-based Learning (TbL) represents a paradigm shift in pedagogical design, moving decisively away from the instructor-centered model of content transmission towards a structured, student centered ecosystem of accountability,

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collaboration, and applied critical thinking. Conceived by Dr. Larry Michaelsen in the late 1970s and rigorously refined over subsequent decades, TbL is a comprehensive instructional strategy with a robust evidence base across numerous disciplines, particularly in the health sciences and professional education. Its migration into secondary and undergraduate science education signals a recognition that mastering complex conceptual subjects requires more than passive reception of information; it demands active processing, discourse, and problem-solving within a social framework (Larry & Sweet, 2020). At its essence, TbL is designed to transform a cohort of students into a cohesive learning community composed of diverse, permanent teams that work together throughout an instructional unit or entire course.

The architecture of TbL is both systematic and intentional, built upon a sequence of non-negotiable core components that ensure individual preparedness and foster high quality group interaction. The process begins with Significant Student Preparation. Prior to the TbL session, students engage with carefully curated preparatory materials readings, video lectures, or interactive modules covering foundational concepts. This phase is crucial, as it shifts the initial acquisition of knowledge to the individual's time, liberating in-class hours for higher order cognitive work (Ryan, 2023). The accountability for this preparation is enforced through the Readiness Assurance Process (RAP), a two-stage testing mechanism that forms the backbone of the TbL cycle.

First, students complete an Individual Readiness Assurance Test (iRAT), a short, multiple-choice quiz focusing on core principles from the preparatory materials. This test evaluates basic comprehension and holds each learner individually responsible for the foundational knowledge. Immediately following the iRAT, the same test is taken again by students in their pre assigned, diverse teams as the Team Readiness Assurance Test (tRAT). The tRAT is where the collaborative engine of TbL ignites. Teams must discuss each question, debate possible answers, and converge on a consensus choice. The immediacy of the discussion arguing over the evidence for natural selection versus Lamarckism, or the definition of a homologous structure forces students to articulate their understanding, defend their reasoning, and confront contradictions in their thinking. A distinctive and motivating feature of the tRAT is the use of Immediate Feedback Assessment Technique (IFAT) scratch off cards or digital equivalents. Teams scratch off a coating to reveal whether their chosen answer is correct; if not, they continue discussing and scratching until they find the right answer, receiving diminishing points for subsequent attempts. This instant feedback transforms the test into a formative learning event, where the process of arguing, being wrong, and re-evaluating is as instructive as the final correct answer itself (Lantz & Bloom, 2024).

Following the RAP, the instructor conducts a Clarification Session, addressing any questions or lingering misconceptions that surfaced during the team discussions. This targeted mini lecture is highly efficient, focusing only on the concepts that proved problematic, rather than re-teaching all the material. With foundational knowledge assessed and clarified, the majority of class time is then devoted to the Application Exercises. These are the heart of TbL, where learning transitions from knowing to doing. Team-based Learning (TbL) is a highly effective pedagogical strategy that enhances student learning through structured collaboration and active participation. By organizing students into different teams, TbL creates a supportive environment where individuals can work together to have deep understanding of course materials. This approach do not only fosters teamwork but also encourages students to take ownership of their learning processes. In the field of science and medical education, TbL has been proven to significantly enhance student performance and retention rates. For example, studies have shown that TbL can improve students' grasp of complex scientific concepts and increase their engagement with the material (Shang et al, 2025). In Nigerian secondary Biology classrooms, TbL has been particularly effective in boosting academic achievement, especially in topics like ecology.

The integration of digital tools into pedagogical practice represents a significant evolution in modern education, particularly within the sciences where visual and spatial comprehension is paramount. Among these tools, three-dimensional (3D) modeling software has emerged as a transformative technology. At its core, 3D modeling software comprises a suite of computer applications engineered to facilitate the creation, manipulation, analysis, and visualization of digital objects within a simulated three-dimensional space (Sivri & Eroğlu, 2024).

These are not static images, but dynamic, interactive models that users can rotate, dissect, animate, and alter, providing a depth of engagement impossible with two dimensional textbook illustrations or even physical specimens in many cases. In the context of secondary biology education, such software transcends its origins in industrial design and animation to become a potent instrument for constructing and interrogating complex biological systems from the intricate folding of a protein polypeptide chain and the precise articulation of skeletal structures to the branching pathways of phylogenetic trees and the hypothetical reconstruction of fossilized organisms (Henderson & Kamarainen, 2023).

The application of this technology to the topic of evolution is particularly apt, given the conceptual hurdles associated with the subject. Evolution deals with changes that are often imperceptibly slow, occurring across vast geological timescales, and involving comparative anatomy across species that a student may never encounter directly. Abstract notions like common descent, homology, analogy, and adaptive radiation can remain frustratingly opaque when presented only through descriptive text and static images (Hite & Jones, 2019; Idris, 2024). 3D modeling software offers a conduit from the abstract to the concrete. For instance, instead of merely reading about homologous structures, students can access digital repositories such as the Morpho Source platform, where they can download, view, and compare 3D

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scans of a human arm, a cat forelimb, a bat wing, and a whale flipper from multiple angles.

The conventional teaching strategy, often termed the "traditional" or "transmission" model, remains a pervasive structure within many educational systems worldwide. This approach is fundamentally teacher-centred, positioning the educator as the principal authority and conduit of knowledge within the classroom. Instruction typically follows a deductive path, beginning with the presentation of abstract principles or general rules, which are subsequently illustrated through specific examples and applications (Roseanne & Graves, 2023). Within this framework, the student's role is predominantly receptive; learners are expected to absorb, replicate, and accurately recall the information presented to them.

This pedagogical model is deeply rooted in behaviourist and cognitivist theories of learning. From a behaviourist perspective, learning is shaped through structured stimulus-response mechanisms, where clear presentation, guided practice, and reinforcement are paramount (Paul & Neelen, 2020). Cognitivist influences emphasize the efficient organization and processing of information in the mind, favoring a logical, sequenced transmission of content to build structured mental schemas (Richard, 2022). Consequently, the classroom environment is carefully managed to optimize this transmission. The dominant instructional style is direct instruction, manifested through lectures, teacher-led demonstrations, and highly structured exercises. Classroom discourse flows overwhelmingly in one direction from teacher to student with limited opportunity for sustained dialogic exchange, peer-to-peer collaboration, or open-ended problem-solving (Neil & Warrick, 2021).

Statement of the Problem

Senior secondary students in Nigeria consistently demonstrate low achievement in evolution, a core yet conceptually challenging biology topic. Previous studies and national examination reports confirm persistent underperformance, marked by widespread misconceptions and a failure to grasp fundamental mechanisms like natural selection. This is largely attributed to the prevalent reliance on teacher-centered, lecture-based methods, which inadequately address the abstract nature of evolutionary concepts. Consequently, students struggle with visualizing processes and applying theoretical knowledge. While interactive 3D modelling software offers potential for enhanced visualization and team-based learning (TbL) promises improved engagement through collaboration, there is a critical lack of research on their integrated application within the Nigerian context. Another critical dimension of the problem is the low engagement of students in collaborative, inquiry-based learning environments. Evidence suggests that Team-based learning strategies enhance critical thinking, knowledge retention, and active participation in biology classes. Unfortunately, classrooms in Oyo Central Senatorial District, like in many other parts of Nigeria, still emphasize individual performance over cooperative engagement. This lack of interactive, peer-supported learning may further limit students' achievement in complex topics like evolution. Therefore, this study necessitated the need to empirically investigate the effects of these two innovative teaching strategies (Interactive 3D Modeling Software and Team-Based Learning strategies) on students' academic achievement in evolution in Oyo Central Senatorial District.

This study investigated the Effects of Two Teaching Strategies (Interactive 3D modeling software and Team-based Learning Strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial District. Specifically, the study determined the effects of Two Teaching Strategies (3D Modeling Software, Team-Based Learning (TbL) and the Conventional Lecture Method (CLM)) on Senior Students'

Hypothesis

H_0: There will be no significant effect of treatments (Interactive 3D Modeling Software, Team-Based Learning, and Conventional instructional strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial District.

Methodology

This study adopts a quasi-experimental research design. The quasi-experimental design incorporated independent variables, which are the two teaching strategies (Interactive 3-Dimentional modeling Instructional Strategy, Team-based Learning Strategy), and the Conventional Teaching Strategy and a dependent variable (Students' Academic Achievement in Evolution). The population of the study comprised all 25,958 students offering Biology in public secondary schools within the Oyo Central Senatorial District of Oyo State. The district consists of eleven Local Government Areas as at the time this research was carried out. A multi-stage sampling procedure was adopted to select the sample for the study. In the first stage, stratified sampling technique was used to stratify the eleven local government areas found in Oyo Central Senatorial Districts into three unequal strata based on their proximity. In the second stage, random sampling technique was used to select one local government area from each stratum through balloting process since they all have equal chance of selection. Similarly, same process was repeated for selection and assigning of randomly selected schools to the treatments group as follows: Group A Schools implementing 3D Modelling Instructional Package; Group B Schools implementing the Team-based Learning (TbL) Strategy; and Group C: Schools implementing the Conventional Teaching Strategy. SS II intact class was used in the three randomly selected schools to determine the sample size for this study which resulted to 107 students. The following research instruments were developed and utilized for data collection in this study; Evolution Achievement Test (EAT) and Instructional Guides. A pilot test was conducted in a school within the Oyo Central Senatorial District in Oyo State but outside the sampled senatorial district. The data collected from the pilot test was analyzed using the Kudar-Richardson Formula 20 (KR-20) for the reliability yielding 0.87. The experiment was conducted over a period of eight (8) weeks, following this sequence; Week 1: Training of the

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research assistants in all sampled schools, Week 2: Administration of the Evolution Achievement Test (EAT) as a pre-test to the selected students, Week 3-Week 7: Implementation of instructional strategies on the same evolution topics for the same duration, Week 8: Administration of post-test of Evolution Achievement Test (EAT) to all students to measure their achievement gains. The data collected was analysed using the Statistical Package for the Social Sciences (SPSS). Using Analysis of covariance (ANCOVA) at 0.05 level of significance.

Results

Hypothesis Testing

H_0: There will be no significant effect of treatments (Interactive 3D Modeling Software, Team-Based Learning, and Conventional instructional strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial District.

Table 1: Tests of Between-Subjects Effects of Treatments (Interactive 3D Modeling Software, Team-Based Learning, and Conventional instructional strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial District

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	986.068[a]	3	328.689	42.629	0.000	0.554
Intercept	712.002	1	712.002	92.343	0.000	0.473
Pretest	5.086	1	5.086	0.660	0.419	0.006
Treatments	760.620	2	380.310	49.324*	0.000	0.489
Error	794.175	103	7.710			
Total	53173.000	107				
Corrected Total	1780.243	106				

a. R Squared = 0.554 (Adjusted R Squared = 0.541)

Source: Researcher's Fieldwork, 2026

From the ANCOVA results presented in Table1, the main effect of treatments (3D Modeling Software, Team-Based, and Conventional instructional strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial District was statistically significant, $F_{(2;\ 103)} = 49.324$, $p < 0.05$, partial $\eta^2 = 0.489$. This indicates that there was a significant difference in the posttest achievement scores of students exposed to the different instructional strategies when controlling for their pretest scores. The effect size (partial $\eta^2 = 0.489$) further reveals that the instructional strategies accounted for a substantial proportion of the variance in students' achievement. Since $p < 0.05$, there was significant main effect of treatments (3D Modeling Software, Team-Based, and Conventional instructional strategies) on Senior Students' Achievement in Evolution.

Table 2: Estimated Marginal Means of Treatments (Interactive 3D Modeling Software, Team-Based Learning, and Conventional instructional strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial District

Dependent Variable: Posttest

Treatments	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Interactive 3D Modeling	24.305[a]	0.506	23.301	25.310
Team-based Learning	24.061[a]	0.474	23.120	25.001
Conventional Method	18.128[a]	0.466	17.203	19.053

a. Covariates appearing in the model are evaluated at the following values: Pretest = 12.21.

Source: Researcher's Fieldwork, 2026

Table 2 presents the estimated marginal means, which show the adjusted post-test performance of students across the three instructional strategies after controlling for their pre-test scores. With the pre-test score held constant at 12.21, students taught using Interactive 3D Modeling recorded an adjusted mean score of 24.31 (SE = 0.51, 95% CI: 23.30 to 25.31), while those exposed to Team-based Learning obtained a slightly lower adjusted mean score of 24.06 (SE = 0.47, 95% CI: 23.12 to 25.00). In contrast, students taught using the Conventional Method had a considerably lower adjusted mean score of 18.13 (SE = 0.47, 95% CI: 17.20 to 19.05).

Although both Interactive 3D Modeling and Team-based Learning strategies produced higher adjusted mean scores than the Conventional Method, the closeness of the confidence intervals between the two experimental groups suggests that their difference is minimal and not practically distinct. However, both innovative strategies clearly outperformed the Conventional Method, as reflected in the

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noticeable gap in their adjusted mean scores and non-overlapping confidence ranges. In practical terms, when prior knowledge was statistically controlled, students exposed to Interactive 3D Modeling and Team-based Learning demonstrated better achievement outcomes in Evolution compared to those taught conventionally. This pattern supports the earlier ANCOVA findings, which indicated a significant main effect of instructional strategies on students' achievement.

Discussion of Findings

There was a significant main effect of treatments (3D Modeling Software, Team-based and Conventional Instructional Strategies) on Senior Students' Achievement in Evolution in Oyo Central Senatorial Districts. The finding revealed that students exposed to Interactive 3D Modeling and Team-based Learning achieved significantly higher posttest scores than those taught through the conventional teaching method. This suggests that innovative and learner-centred instructional approaches are more effective in improving students' understanding of Evolution than the Conventional lecture-oriented approach commonly used in many secondary school classrooms. The result further implies that when students are actively engaged in learning through visualization, interaction, collaboration, and shared problem-solving, they develop stronger conceptual understanding and improved academic performance in abstract biological concepts such as Evolution.

The superior performance of students exposed to Interactive 3D Modeling Software may be attributed to the visual and immersive learning opportunities provided by digital simulations and virtual biological representations. Evolution involves several abstract concepts such as adaptation, speciation, genetic variation, and natural selection, which are often difficult for learners to conceptualize through verbal explanations alone. The use of 3D modeling tools likely enabled students to observe biological processes dynamically, manipulate variables, and visualize relationships among organisms and environments in a more concrete and meaningful manner. This finding supports the constructivist view that learners understand scientific concepts better when they actively construct knowledge through interaction and exploration rather than passive memorization. The result is consistent with previous studies which reported that virtual simulation tools such as Virtual Cell Animation, Zygote Body, Digital Microscope, and 3D Organon Anatomy significantly improved students' achievement, engagement, and retention in Biology and related science subjects (Lantz & Bloom, 2024). The finding also aligns with studies which established that immersive 3D and virtual reality environments reduce cognitive load, strengthen visual-spatial reasoning, and improve conceptual understanding in complex biological topics (Shang et al, 2025).

The finding also corroborates earlier Nigerian and African studies on the effectiveness of 3D and virtual modelling technologies in science education. Previous quasi-experimental investigations conducted in Nigerian secondary schools revealed that students taught with interactive 3D models of biological systems significantly outperformed those taught with conventional approaches in both theoretical understanding and practical application (Maulion & Prudente, 2025). Similar findings were reported in studies involving the use of 3D digestive system models and virtual biology laboratories, where learners demonstrated stronger retention ability, improved inquiry skills, and deeper understanding of structure-function relationships in Biology. Systematic reviews on augmented and virtual reality in science teaching equally concluded that students exposed to immersive digital learning environments showed higher motivation, stronger engagement, and improved academic achievement compared to learners in Conventional classrooms (Idris, 2024). The present finding therefore strengthens the growing body of evidence that interactive visualization technologies are valuable pedagogical tools for teaching difficult and abstract science concepts in contemporary classrooms.

Another important outcome of the study is the significant contribution of Team-based Learning to students' academic achievement in evolution. Students exposed to Team-based Learning performed substantially better than those in the conventional group, suggesting that collaborative learning environments enhance understanding and knowledge retention. This improvement may have resulted from the structure of Team-based Learning, which encourages students to prepare before class, engage in peer discussions, defend ideas collectively, and solve real-world biological problems cooperatively. Such collaborative interactions likely enhanced students' reasoning ability, promoted clarification of misconceptions, and deepened conceptual understanding of evolutionary processes. The result agrees with the theoretical assumptions of Vygotsky's social interactionist perspective, which maintains that learning occurs more effectively through guided interaction, shared experiences, and collaborative engagement within socially supportive environments.

The finding is further supported by empirical studies which established that Team-based Learning improves students' achievement, engagement, communication skills, and problem-solving ability across science disciplines. Previous studies reported that the readiness assurance process in Team-based Learning, involving individual preparation, team discussion, and instructor clarification, promotes accountability and meaningful cognitive engagement among learners (Adebayo & Yusuf, 2025). Similarly, recent classroom-based studies in Biology education found that Team-based Learning enhanced students' ability to apply biological concepts to unfamiliar situations, strengthened scientific argumentation, and improved higher-order thinking skills. The present finding also aligns with a recent meta-analysis which revealed that Team-based Learning produced moderate to large effects on students' academic achievement, engagement, and teamwork across science and medical education programmes (Michaelsen & Sweet 2024). This suggests that cooperative learning structures provide learners with opportunities to process information more deeply than Conventional teacher-dominated instruction.

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The comparatively low achievement recorded among students taught with the conventional teaching method further emphasizes the limitations of lecture-based instruction in teaching abstract scientific concepts such as Evolution. In many conventional classrooms, learning remains teacher-centred, with students playing largely passive roles as recipients of information. Such an approach may limit learners' opportunities to explore concepts actively, ask questions, engage in inquiry, or relate biological processes to real-life experiences. As a result, students may resort to rote memorization without achieving meaningful understanding. The significantly lower adjusted mean score obtained by the conventional group in this study therefore suggests that Conventional methods may no longer adequately address the learning needs of contemporary science students, especially in conceptually demanding topics like Evolution.

Conclusion

Based on the results, the study concluded that instructional strategy is the most significant determinant of senior secondary school students' academic achievement in Evolution in Oyo Central Senatorial District, Oyo State due to the fact that students exposed to Interactive 3D Modeling Software and Team-Based Learning achieved significantly higher posttest scores than those taught using the Conventional Method, indicating the effectiveness of learner-centred and interactive instructional approaches in improving students' understanding of Evolutionary concepts.

Recommendation

Based on the findings of this study, Biology teachers should prioritize the use of Interactive 3D Modeling Software and Team-Based Learning strategies in teaching Evolution to improve students' understanding and academic achievement in Evolution topic.

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