



Effect of Neuroscience-Based Teaching Strategy on Secondary School Students' Academic Engagement and Academic Achievement in Biology in Delta State

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Abstract

The study explored the effect of neuroscience-based teaching strategy (NBTS) on students' academic engagement and academic achievement in biology in Delta State. The study was guided by two research questions and hypotheses. Pretest, posttest, control group quasi-experimental design was used in the study. 362 biology students selected using stratified random sampling technique participated in the study. Data were gathered using the Biology Engagement Test (BET) and Biology Achievement Test (BAT) duly validated by three Science Educationist, with a reliability coefficient of 0.76 and 0.81, established using Cronbach alpha and Kuder-Richardson 20. BET and BAT were administered as pretest and posttest. Data obtained were analyzed using mean and ANCOVA at 0.05 alpha level. The findings showed that students taught biology using NBTS differed significantly from those taught using TLM in terms of mean engagement and achievement scores, with the NBTS being superior. It was recommended that biology teachers should adopt NBTS.

Keywords: Academic Achievement, Academic Engagement, Neuroscience, STEM Education.

Introduction

In recent years, neuroscience and STEM education have gained popularity, especially for boosting secondary student performance. Neuroscience illuminates how students learn, process, and recall knowledge. Conversely, STEM education denotes a pedagogical strategy that amalgamates the fields of Science, Technology, Engineering, and Mathematics (Odibo, 2024). STEM education aims to teach students about these areas and build their critical thinking, problem-solving, and analytical skills. Teachers could create more effective teaching tactics that meet students' cognitive and emotional requirements by incorporating neuroscience insights into STEM education.

There is an especially urgent need for better biology education results in Delta State, Nigeria. As a cornerstone subject in the STEM programme, biology is essential for helping students develop their scientific literacy and critical thinking abilities. However, a lot of Delta State secondary school students have trouble understanding biological ideas, frequently as a result of conventional teaching methods that don't take into account how the brain learns best (Ogunleye & Adebayo, 2018). This discrepancy emphasizes the need for a framework for education that integrates

neuroscience-based teaching strategy (NBTS) to improve biology students' understanding and engagement.

NBTS is grounded in the understanding of brain function and development (National Research Council, 2022). They stress how crucial it is to design learning spaces that meet students' cognitive, emotional, and social requirements. The three main tenets of NBTS are neuroplasticity, emotional connection, and active learning. Emotional connection involves understanding the role of emotions in learning because positive emotional experiences can enhance memory retention and motivation; neuroplasticity deals with the understanding that the brain is capable of change and adaptation, which emphasises the importance of practice and reinforcement in learning; and active learning involves involving students in hands-on activities that foster critical thinking and problem-solving. According to Miller (2015), the classroom application of NBTS include the following; understanding the brain basics, creating a positive learning environment, activating prior knowledge, use of multi-sensory approaches, implementing active learning techniques, breaking information into



manageable chunks, fostering emotional connections, encouraging reflection and metacognition, providing feedback, assessing understanding and encouraging growth mindset. It is believed that NBTS has the potential to promote students' academic engagement and achievement.

Academic engagement is the degree of enthusiasm, drive, and active participation that students show in their learning processes (Zull, 2022). This is the involvement of students in learning activities, such as showing up to class, finishing their homework, and participating in class discussions. It displays how engaged they are with the classroom. Academic engagement is also linked to students' perceptions of their educational experiences, such as their emotional attachment to the school, sense of community, and interest in the subject matter. NBTS often incorporates elements that boost intrinsic motivation. For instance, when students are involved in active learning and collaborative projects, they are more likely to feel a sense of ownership over their learning, which could lead to higher engagement levels (Dumont, Istance & Benavides, 2016). NBTS highlights the importance of collaborative learning. Collaborative learning environments, where students work together, could enhance engagement by fostering a sense of community and belonging. Research indicates that social interaction could stimulate brain regions associated with reward, further motivating students to participate actively (Ducan & Magnuson, 2021). Again, NBTS incorporating mindfulness practices into the classroom, which could help students manage stress and anxiety, which are barriers to engagement. Research has shown that mindfulness can enhance focus and emotional regulation, leading to improved academic engagement and achievement.

Academic achievement is the degree to which a student has met their learning objectives, and it is usually assessed by grades, test results, and general performance in the classroom. It includes a variety of learning objectives, including as subject-matter expertise, critical thinking abilities, and the capacity to apply knowledge in real-world contexts (Brusilovsky & Millan, 2017). Many things can affect students' academic progress, including the way professors educate, like the NBTS. Studies have shown that implementing NBTS can lead to significant improvements in academic performance. For instance, a meta-analysis by Hattie (2012) found that teaching strategies informed by neuroscience, such as spaced repetition and retrieval practice, have a high effect size

on student achievement. Differentiated instruction is encouraged by NBTS, and by knowing how each person's brain develops and how they learn best, teachers can adapt their lessons to fit a range of student needs. Recent studies, such as those by Willingham (2017), emphasize the importance of differentiated instruction based on cognitive and emotional factors, leading to improved outcomes for all students. Another study by Dumont et al. (2016) found that students who engaged in NBTS showed significantly higher test scores compared to those who did not, underscoring the importance of NBTS.

Numerous investigations have been carried out concerning the effect of NBTS on the engagement and achievement of students. For instance, Smith and Brown (2021) explored how neuroscience-informed teaching strategies, such as the use of multimedia and interactive activities, influenced student engagement in a high school setting in United States. Thompson and Williams (2022) investigated the implementation of neuroscience-based teaching methods in a university in Australia. It found that these methods significantly enhanced student engagement and participation in class discussions, leading to improved academic performance. Results indicated a significant increase in student engagement and motivation when neuroscience principles were applied. Johnson and Lee (2020) examined the effects of neuroscience-based teaching strategy on academic achievement in elementary school students in Canada. The findings revealed that students who were taught using these strategies showed higher test scores compared to those who received traditional instruction. Nevertheless, none of the studies the researcher had access to addressed the academic engagement and achievement of Delta State secondary school biology students. This led to an information gap that the current study filled. The rationale of the study was to find out if the use of Neuroscience-based teaching strategy is more effective than traditional lecture method (TLM) with regards to improving students' academic engagement and academic achievement in biology in Delta State.

Research Questions

The study's two main research questions were:

1. How do students taught biology using NBTS and TLM differ in terms of their mean engagement scores?
2. How do students taught biology using NBTS and TLM differ in terms of their mean achievement scores?



Hypotheses

The investigation was further led by two hypotheses.

1. The mean engagement scores of students who were taught biology using NBTS and TLM did not differ significantly.
2. The mean achievement scores of students taught biology using NBTS and TLM did not differ significantly.

Materials and Methods

The study employed a quasi-experimental design with a control group. The quasi-experimental design selection is predicated on the non-randomization of persons. The study used intact classes in order to avoid interfering with classroom instruction. To be more precise, the experimental and control groups were each randomly given three intact classes. The students in the experimental group learnt biology through NBTS, whereas the control group received instruction through TLM. The same biology concepts were presented to the students in both groups. The teaching method is the only distinction between the two groups. 174,570 SSII students enrolled in Delta State public secondary schools made up the study's population. 362 SSII biology students made up the study's sample size using stratified random sampling technique. In this method, all the school in Delta State were grouped by senatorial districts (Delta Central, North and South). Thereafter, two local governments each were selected from each senatorial district amounting to six local governments. A school was selected from a local government using simple random sampling technique which added up to 6 schools. Per school, the following samples were recorded: 54, 49, 59, 67, 62, and 71, totaling a sample size of 362 for the study. The six schools were randomly assigned to experimental and control groups using balloting without replacement. The name of the six schools were written on pieces of paper and placed in a box. The researcher blindfolded, randomly pick three schools out the six that made up the experimental group. Three schools left in the box made up the control group. In total, there were 195 students in the schools assigned to the experimental group and 167 students in the schools assigned to the control group.

In this study, two instruments were employed to collect data. The Biology Engagement Test (BET) and the Biology Achievement Test (BAT) are the two of them. The researcher created 25 four points likert scale

items BET in order to gauge students' level of engagement with biology classes. Strongly Agree (SA = 4), Agree (A = 3), Disagree (D = 2), and Strongly Disagree (SD = 1) were the four possible responses on the likert scale. The Biology Achievement Test (BAT) comprised fifty multiple-choice questions derived from past WASSCE biology question papers, with the aim of assessing the students' biology proficiency. A through D were the four alternatives for each item in BAT. Three of the replies are incorrect (distracters), and only one is the right one. The right answer attracted 2 marks, while the wrong answers had a zero score. Lesson plans using both NBTS and TLM were equally used during treatment. The teacher's and students' roles during the actual treatment were spelled out in detail in these lesson plans.

Two science education lecturers and one in Test and Measurement face validity BAT and BET. A table of specifications was used to set the questions to ensure content validity of BAT. Because Cronbach Alpha is a suitable method for creating the reliability index of liker-scale polytomous items, it was used to establish the reliability of BET. Thirty biology students from a school outside the study's coverage region received the instrument. The generated data underwent Cronbach Alpha analysis, yielding a reliability index of 0.76. Since Kuder-Richardson 20 is a suitable tool for determining the reliability index of multiple-choice, dichotomously scored objective test questions, it was used to establish the reliability of the BAT. Fifty biology students in another school located outside the study's coverage region took the BAT. After utilizing Kuder-Richardson 20 to analyze the data, the reliability coefficient index was 0.81. The choice of fifty students for BAT is to provide for more accurate assessments and informed-decision making. The acquired data were utilised to address the research questions and evaluate the hypotheses. The research questions were addressed utilising means, while the hypotheses were evaluated by ANCOVA at a significance level of 0.05. Therefore, a hypothesis was rejected when p-value is less than or equal to 0.05 and not rejected when p-value is greater than 0.05.

The researcher controlled for extraneous variables as follow by using research assistants with the same qualifications and years of experience to minimize differences that may arise in the treatment due to teacher characteristics. Lesson plans prepared by the researcher were used by the research assistants. The research assistants (teachers in the sampled schools) taught the students during treatment. The intention was



to make the students in all the groups feel that they are merely taking their normal lessons. To reduce instrument sensitization, six weeks period were given between pretest and posttest. In addition, the items in

the pretest were reshuffled before administration as posttest. ANCOVA was used to test hypotheses to eliminate initial group differences that may exist between experimental and control group

Results

Table 1
Mean Engagement Scores on Pretest and Posttest for Students Taught Biology with NBTS and TLM

Group	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
NBTS	195	23.30	9.34	57.42	7.22	34.12
TLM	167	22.50	9.72	55.11	9.92	32.61

Table 1 shows the pretest mean engagement scores for NBTS-taught biology students: 23.30, with a standard deviation of 9.34. Pretest engagement scores for TLM students averaged 22.50, with a standard deviation of 9.72. For the posttest, the TLM group had

a mean engagement score of 55.11 and a standard deviation of 9.92, whereas the NBTS group had 57.42 and 7.22. NBTS students had a mean engagement gain of 34.12, compared to 32.61 for TLM students.

Table 2
ANCOVA Comparison of Pretest and Posttest Engagement Scores of NBTS and TLM Biology Students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	337.265 ^a	2	168.632	2.241	.109
Intercept	116225.063	1	116225.063	1544.444	.000
Pretest	1.474	1	1.474	.020	.889
Methods	333.338	1	333.338	4.430	.036
Error	18738.164	359	75.254		
Total	817432.000	362			
Corrected Total	19075.429	361			

Table 2 presents a statistical analysis demonstrating a significant difference ($F(1, 359) = 4.430, P(0.036) < 0.05$) in the posttest mean engagement levels of Biology students taught using

NBTS versus TLM. The null hypothesis is thus rejected. As a result, students taught biology using NBTS exhibited significantly higher mean engagement levels than those taught using TLM.

Table 3
Mean Achievement Scores on Pretest and Posttest for Students Taught Biology Using NBTS and TLM

Group	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
NBTS	195	29.78	6.31	60.03	12.55	30.25
TLM	167	30.03	7.63	49.26	10.83	19.23

Table 3 shows the NBTS group's pretest mean achievement score of 29.78 and standard deviation of 6.31. The mean pretest score for TLM students was 30.03, with a standard deviation of 7.63. On the posttest, the TLM group had a mean achievement score

of 49.26 with a standard deviation of 10.83, whereas the NBTS group scored 60.03 and 12.55. The NBTS group had a 30.25 mean achievement gain, while the TLM group had 19.23.

Table 4
ANCOVA Comparison of Pretest and Posttest Achievement Scores of NBTS and TLM Biology Students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7442.409 ^a	2	3721.204	27.011	.000
Intercept	43250.826	1	43250.826	313.949	.000
Pretest	132.375	1	132.375	.961	.328
Methods	7272.271	1	7272.271	52.788	.000
Error	34303.242	359	137.764		
Total	796584.000	362			
Corrected Total	41745.651	361			

Table 4 presents a statistical analysis demonstrating a significant difference ($F(1, 359) = 52.788, P(0.000) < 0.05$) in the posttest mean achievement scores of biology students taught using NBTS versus TLM. The null hypothesis is hence rejected. Consequently, students instructed in biology by NBTS demonstrated markedly superior mean achievement scores compared to those taught via TLM.

Discussion of Findings

The study found that students taught biology using NBTS differed significantly from those who were taught using TLM in terms of mean engagement scores, with the NBTS being preferred. This suggests that compared to students taught using the TLM, biology students taught utilizing NBTS were more engaged during instruction. This observation is likely due to the fact that neuroscience places a strong emphasis on the value of active learning. Active learning approaches, such as group projects, discussions, and practical exercises, tend to generate a deeper comprehension and a stronger interest in the subject matter, which raises student engagement. Additionally, by combining relatable content, real-world applications, and storytelling, NBTS foster a positive emotional environment that can raise student motivation and engagement. Students are more likely to be engaged when they have an emotional connection to the subject matter. This research confirms the findings of Duncan and Magnuson (2021), who found that teaching methods that take into account the way the brain learns enhance student retention and engagement. The study also corroborates that of Dumont et al. (2016) who reported higher engagement level for students taught using NBTS over those taught using TLM. This finding also lends credence to that of Immordino-Yang (2021) who positive effect of NBTS on students' engagement.

The study also showed that students taught biology using NBTS differed significantly from those who were taught using TLM in terms of mean achievement scores, with the NBTS being preferred. This suggests that biology students taught using a NBTS achieved more than their peers taught using TLM. This finding can be explained by the fact that NBTS are influenced by the ways in which the brain absorbs, analyzes, and remembers information. These tactics frequently include methods that support cognitive processes including emotional involvement, attention span, and memory retention, which results in more productive learning environments. Furthermore, neuroscience highlights the significance of actively participating in the learning process. In contrast to the passive learning that characterizes TLM, NBTS encourages students to actively participate, which improves knowledge and retention. This result supports that of Miller (2015), who found that active learning techniques, such as problem-based learning and collaborative learning, supported by neuroscientific principles, greatly improve student learning results in comparison to the conventional lecture approach. The finding further agrees with that of Hattie (2012) who reported that teaching strategies informed by neuroscience, such, have significant higher effect on student achievement than TLM.

Conclusion

This study has demonstrated substantial evidence of the effectiveness of neuroscience-based teaching strategy in improving students' academic engagement and achievement in biology in Delta State. The findings indicate a substantial disparity in the average engagement and achievement scores between students instructed through a neuroscience-based teaching strategy and those subjected to traditional lecture method, with the former group exhibiting



significantly elevated levels of both academic engagement and achievement. The results underscore the potential of neuroscience-based teaching strategy to foster a more interactive and stimulating learning environment, which not only captivates students' interest but also enhances their understanding and retention of complex biological concepts.

Recommendations

The conclusion led to the following recommendations:

1. When teaching biology in secondary schools, biology teachers should use NBTS.
2. To improve instructional methods, teachers should be trained in NBTS and how to apply them when teaching biology.
3. To encourage active learning and student involvement, biology curricula should incorporate NBTS.

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