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EFFECT OF ADAPTIVE TEACHING STRATEGY ON STUDENTS' ACADEMIC ACHIEVEMENT AND INTEREST IN BIOLOGY IN TUDUN WADA EDUCATIONAL ZONE, KANO STATE, NIGERIA

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Abstract
This study investigated the effect of adaptive teaching strategy on senior secondary school students' academic achievement and interest in Biology in Tudun Wada Educational Zone, Kano State, Nigeria. The study objectives are to: determine the effect of adaptive teaching strategy on students' academic achievement in Biology; examine its effect on students' interest in Biology and determine whether gender influences students' academic achievement when

taught using adaptive teaching strategy. A quasi-experimental pretest–posttest control group design was employed. The population comprised 1,114 SS II Biology students from 16 public secondary schools. A sample of 259 students was selected through stratified and simple random sampling techniques and assigned into experimental and control groups. Two instruments were used: The Biology Achievement Test (BAT), with a reliability coefficient of 0.97, and the Biology Students' Interest Questionnaire (BSIQ), with a reliability coefficient of 0.82. Data were analyzed using descriptive statistics and Z-test at 0.05significance level. Results revealed that students taught using adaptive teaching strategy achieved significantly higher scores than those taught with the conventional method. Findings also showed that students' interest in Biology increased after exposure to adaptive teaching strategy. Furthermore, female students exposed to adaptive teaching strategy performed significantly better than their male counterparts. The study concludes that adaptive teaching strategy enhances academic achievement and interest in Biology but is not gender-neutral. It recommends wider adoption of adaptive teaching strategy in Biology instruction.

Keywords: adaptive teaching strategy, academic achievement, interest, Biology education, gender differences, secondary school students

Introduction

Biology is a core science subject in secondary schools and plays a vital role in understanding living organisms, health, environment, and technological innovations. It serves as a foundation for science-based careers, including medicine, agriculture, environmental sciences, and biotechnology. However, despite its importance, students' academic performance and interest in Biology in many Nigerian schools remain low. Studies have consistently identified poor achievement and diminishing interest as persistent problems that affect students' readiness for science-related careers and national development goals (Oloruntegbe & Ogbonnaya, 2017; Ayodele & Ogunkola, 2020).

In recent decades, researchers and educators have highlighted the significance of instructional strategies in influencing student learning outcomes. Traditional teacher-centered approaches, characterized by rote memorization and passive learning, have been criticized for failing to engage learners meaningfully or address diverse learning needs (Akinsolu, 2021). In contrast, learner-centered strategies that recognize students' differences, encourage active participation, and promote critical thinking have been shown to improve academic achievement and stimulate interest in learning (Alabi & Obadire, 2018). One such approach gaining attention is Adaptive Teaching Strategy (ATS).

Adaptive Teaching Strategy refers to an educational technique in which instruction is tailored to meet the varying learning needs, abilities, interests, and pacing of individual students or groups. It involves flexible teaching methods, varied content delivery, continuous assessment, and timely feedback to optimize learning for all students (Tomlinson, 2017). In adaptive classrooms, teachers adjust instructional materials and activities based on ongoing assessment of student performance and engagement. This strategy contrasts sharply with one-size-fits-all teaching and is built on the premise that students learn best when instruction aligns with their individual profiles.

Research evidence suggests that adaptive teaching can positively influence student outcomes in science education by enhancing conceptual understanding, problem-solving skills, and classroom participation (Schmidt & Ralph, 2020).

Students exposed to adaptive instructional practices tend to demonstrate higher achievement levels because the strategy offers differentiated learning pathways, which help learners grasp complex biological concepts at their own pace (Rose & Meyer, 2018). Likewise, adaptive environments can foster greater interest in subjects by making learning experiences more relevant, accessible, and engaging, which motivates students to explore ideas deeply and persist in learning tasks (Meyer, Rose & Gordon, 2019).

In the context of Nigerian secondary schools, studies examining adaptive teaching strategies are limited despite the obvious challenges in Biology education. In Kano State—the most populous state in Northern Nigeria—issues such as class overcrowding, inadequate teaching resources, and varied student competencies often result in ineffective delivery of Biology lessons. Consequently, students' performance in Biology at both internal school examinations and external standardized tests, such as the Senior School Certificate Examination (SSCE), has frequently been below expected benchmarks (Aliyu & Mohammed, 2021). Similarly, low student interest in Biology has been linked to perceived difficulty of the subject, irrelevant teaching methods, and lack of practical engagement (Muhammad & Bello, 2022).

Tudun Wada Educational Zone, one of the educational administrative divisions in Kano State, reflects these broader systemic issues. Schools in the zone face similar constraints that impede effective Biology teaching and learning. Reports from classroom observations indicate that many teachers struggle to implement student-centered practices, often resorting to lecture-based instruction that fails to engage students meaningfully. As a result, learners exhibit low participation, superficial conceptual understanding, and diminishing interest in Biology, which threaten both individual academic success and long-term aspirations in science-related fields.

Given this backdrop, there is a compelling need to investigate whether adaptive teaching strategies can significantly improve students' academic achievement and interest in Biology in this zone. Understanding the effect of ATS is crucial because it could provide empirical evidence to inform pedagogical reforms, teacher training, and policy interventions that aim to enhance learning outcomes in Biology. Such evidence is particularly valuable for educational planners, Biology teachers, curriculum developers, and stakeholders committed to raising the standard of science education in Nigeria.

Therefore, this study seeks to bridge the gap by systematically examining the effect of Adaptive Teaching Strategy on students' academic achievement and interest in Biology in Tudun Wada Educational Zone, Kano State, Nigeria. Through this research, it is anticipated that insights will be generated on how adaptive practices can be strategically implemented to improve biological education, thereby contributing to more effective teaching and inspiring greater student enthusiasm for science.

Statement of the Problem

Biology is a core science subject in the Nigerian secondary school curriculum and serves as a foundational discipline for careers in medicine, agriculture, environmental sciences and other life-science related fields. Despite its importance, persistent poor academic achievement and declining interest in Biology among secondary school students have remained a major concern to educators, school administrators and other stakeholders in Kano State, particularly in Tudun Wada Educational Zone.

Classroom practices in many public secondary schools within the zone are still largely dominated by conventional teacher-centred instructional approaches, where learners play passive roles during teaching and learning activities. Such approaches often fail to address the wide differences in students' learning abilities, prior knowledge, learning pace and interests that characterise Biology classrooms. Consequently, many students find key biological concepts difficult, abstract and uninteresting, which contributes to low classroom participation, weak conceptual understanding and unsatisfactory performance in school and external examinations.

Although adaptive teaching strategy, which emphasizes flexible instructional methods, continuous assessment and adjustment of teaching to suit learners' diverse needs, has been widely advocated in contemporary science education, its classroom application in secondary school Biology in Tudun Wada Educational Zone appears limited. More importantly, there is insufficient empirical evidence within the local context to demonstrate whether the use of adaptive teaching strategy can significantly improve students' academic achievement and stimulate their interest in Biology.

The lack of locally generated research evidence on the effectiveness of adaptive teaching strategy in Biology classrooms has made it difficult for teachers, school administrators and curriculum planners in the zone to make informed decisions regarding instructional reforms. Without clear empirical findings, Biology teachers may continue to rely on traditional methods that do not adequately support learners with varied learning needs.

Therefore, the problem of this study is the continued low academic achievement and declining interest of secondary school students in Biology in Tudun Wada Educational Zone, Kano State, amidst the limited use and unclear effectiveness of adaptive teaching strategy in the teaching of the subject. This study is thus necessitated to determine the effect of adaptive teaching strategy on students' academic achievement and interest in Biology in the study area.

Objectives of the Study

The study sought to:

1. Determine the effect of adaptive teaching strategy on Biology students' academic achievement.
2. Examine the effect of adaptive teaching strategy on students' interest in Biology.
3. Determine whether gender influences students' achievement when taught using adaptive teaching strategy.

Research Questions

The following research questions were formulated

iv. What is the effect of adaptive teaching strategy on students' academic achievement in Biology?
v. What is the effect of adaptive teaching strategy on students' interest in Biology?
vi. Is there any difference in academic achievement between male and female Biology students exposed to adaptive teaching strategy?

Research Hypotheses

The following research Hypotheses were tested

1. Ho_1: There is no significant difference in academic achievement between students taught using adaptive teaching strategy and those taught using conventional method.

2. Ho_2: There is no significant difference in the interest of students before and after exposure to adaptive teaching strategy.
3. Ho_3: There is no significant difference in academic achievement between male and female students taught using adaptive teaching strategy.

Research Methodology

The study adopted a quasi-experimental pretest–posttest control group design involving intact classes. Two groups were used: experimental (adaptive teaching strategy) and control (conventional lecture method).

EG ⟶ O_1 ⟶ X_1 ⟶ O_2

CG ⟶ O_1 ⟶ X_2 ⟶ O_2

Figure 1: Research Design Illustration for the study.

Where: -

EG - Experimental groups

CG - Control groups

O_1 - Pre-test administration

O_2 - Post-test administration

X_1 - Teaching students' biology using Adaptive teaching strategy (treatment)

X_2 - Teaching students' biology using conventional teaching method (control)

The population comprised 1,114 SS II Biology students from 16 public secondary schools (9 boys' schools and 7 girls' schools) in Tudun Wada Educational Zone, Kano State. A sample of 259 students from four schools was selected through stratified and simple random sampling. Schools were grouped by gender, and two schools were selected from each stratum and randomly assigned to experimental or control groups.

Table 1 Sample of the Study

S/N	School Code	Group	Status	Number of Students
1	Government Secondary School FaskarMa'aji	Experimental	Male	70
2	Government Girls Secondary School Yaryasa	Experimental	Female	60
3		Control	Male	67
4	Government Secondary School Yarkawo GGTQSS Tudun Wada	Control	Femal	62
			Total	**259**

Two instruments were used: Biology Achievement Test (BAT) consisting of 40 multiple-choice items Drawn from WAEC and NECO Biology examination past papers with Reliability coefficient of 0.97 (test-retest) and Biology Students' Interest Questionnaire (BSIQ) consisting of 25 items on a 4-point Likert scale with Reliability coefficient of 0.82 (Cronbach's alpha). Experts from Aliko Dangote University of Science and Technology and an experienced Biology teacher validated

the instruments for face and content validity. A pretest was administered to both groups before the six-week intervention. The experimental group received instruction using adaptive teaching strategies, while the control group received conventional instruction. Posttests (BAT and BSIQ) were administered afterward. Descriptive statistics (mean and standard deviation) answered the research questions. Z-test was used to test hypotheses at0.05 level of significance.

Results

Research Question 1: What is the effect of adaptive teaching Strategy on Student's Academic achievement in biology in Tudun Wada Education zone?

To answer this research question, mean and standard deviation were used. The post-test mean scores of experimental and control groups were subjected to descriptive statistics. Mean and standard deviation were computed and presented in table 2.

Table 2: Mean Scores of Students Taught with Adaptive teaching strategy and Conventional Method Instructional Strategies in Biology Post-test.

GROUP	NUMBER	MEAN	STD DEV	MEAN DIFF	Decision
EXPERIMENTAL	130	26.12	9.47		
CONTROL	129	23.90	7.61	2.22	Significant.

Table 2 showed the computation of experimental and control group mean and standard deviation performance of students expose to Adaptive teaching strategy and those expose to conventional method. The table showed that the experimental group had a mean performance of 26.12, while the control group had 23.90. With a mean difference of 2.22, this shows that the experimental group had performed better as a result of exposure to Adaptive teaching strategy. However, the standard deviation for experimental and control group are 9.47and 7.61 respectively.

Null Hypothesis 1**:** There is no significant difference on Student's Academic performance when taught with Adaptive Teaching Strategy and those taught with Conventional Method.

The post test data of the experimental and control groups were generated via BAT and were subjected to Z–test statistical analysis to determine if there is any significant difference in academic achievement of students in the experimental and their counterparts in the control groups. Summary of the analysis is presented in Table 3.

Table 3: Z-Test Analysis of the Post Test Mean Scores of the Experimental Group (EG) and the Control Group (CG).

Group	N	X	SD	SE	DF	Z-crtc	p-value	Decision
Experimental	130	26.12	9.47	0.88				
					114	29.59	0.000	Significant
Control	129	23.90	7.61	0.88				

Significant at P < 0.05

From Table 3 the calculated Z-value is 29.59 with DF = 114. The results of the Z-test showed that significant difference exists between the mean scores of the

subjects in the experimental group and their counterparts in the control group. This is because the P value of 0.000 is less than 0.05 level of significant. Therefore, the null hypothesis which states that there is no significant difference in academic achievements of students taught using Adaptive teaching strategy and those taught using conventional method is there by rejected. This implies that the experimental group taught biology using Adaptive teaching strategy instruction achieved significantly higher than the control group taught same concepts using conventional method.

Research Question 2: What is the difference on the effect of Adaptive Teaching Strategy on Student's interest in biology in Tudun Wada Education zone?

To answer this research question, mean and standard deviation were used. The pre-interest questionnaire and post-interest questionnaire mean scores of experimental groups before and after the treatment were subjected to descriptive statistics. Mean and standard deviation were computed and presented in table 4.

Table 4: Mean score of Students' Interest Before and after exposure to Treatment

Group	Number	Mean	SD	Mean difference	Decision
Before	130	51.91	6.13		
After	130	56.23	4.55	4.32	Significant

Table 4 shows difference in mean scores of students before and after exposed to Adaptive teaching strategy in biology. The mean score of students before and after treatment was 51.91 and 56.23 respectively. The standard deviation of students before and after the treatment is 6.13 and 4.55 respectively. This shows an improvement of the students' achievement after exposed to Adaptive teaching strategy. To check whether differences exist or not the corresponding hypothesis was tested.

Null Hypothesis 2: There is no significant difference on Student's interest when taught with Adaptive Teaching Strategy and those taught with Conventional Method.

Table 5: Z-test Analysis of interest Mean Score of Experimental Group Before and After Experiment.

GROUP	N	X	SD	SE	DF	Z-crtc	p-value	Decision
BEFORE	130	51.91	6.13	0.71	288	6.07	0.000	Significant
AFTER	130	56.23	4.55	0.71				

Significant at P<0.05

From the data generated on Table 5 this shows that, the calculated Z-value is -6.07 with DF = 288 and p value of 0.000 which is less than 0.05 level of significant this means there is significant change in the Research Question 3: Is there any difference between the academic interest of the experimental group before and after exposure to the Adaptive teaching strategy method. Thus the null hypothesis is rejected.

achievement of male and female Biology students when taught with Adaptive

teaching Strategy in Tudun Wada Education zone.

To answer this research question, mean and standard deviation were used. The post-test mean scores of experimental group were subjected to descriptive statistics based on gender (i.e. male and female). Mean and standard deviation were computed and presented in table 6

Table 6: Experimental Groups achievement scores of male and female students on the biology post-test.

Group	Number	Mean	SD	Mean difference	Decision
Male	70	23.53	7.46		
Female	60	29.00	10.51	5.47	Significant

Table 6 shows difference in mean scores of male and female students in biology post-test. Male students score was 23.53 while that of their female counterparts was 29.00. This shows that female students generally achieved higher than the male students in the post-test. However, the standard deviations for male and female students are 7.46 and 10.51 respectively. The result shows that the females scored higher than the males after exposed to adaptive teaching strategy.

Null Hypothesis 3: There is no significant different in academic achievement of male and female students taught biology using Adaptive Teaching Strategy?

To test this hypothesis, the posttest achievement scores of the experimental group were split according to sex of the subjects in the group and compared accordingly. The mean scores of the male and female students who were exposed to the adaptive teaching strategy of instructions were subjected to Z-test statistical analysis. The results obtained are shown in Table 7.

Table 7: Z-test Analysis of post-test Mean Scores of Male and Female Students in the Experimental Groups.

GROUP	N	X	SD	SE	DF	Z-crtcl	p-value	Decision
MALE	70	23.53	7.46	1.7`				
					113	3.24	0.002	Significant
FEMALE	60	29.00	10.51	1.69				

Significant at P<0.05

From Table 7, the calculated Z-value is 3.24 with DF = 113 and P value of 0.002 which is less than 0.05 level of significant. The null hypothesis is therefore rejected. This means there is significant difference between the mean scores of the male students and their female counterparts of the experimental group exposed to adaptive teaching strategy. This implies that female student performed significantly better than male students, when exposed to adaptive teaching strategy.

Discussion

The first finding from the $RQ_1$and RHO_1results in Table 2 and 3 revealed that

there was significant difference in the academic achievement in biology concepts in favor of the experimental group. The results showed that the experimental group had a post-test means score of 26.12, while the control group had a means scores 23.90. This implies that the experimental group performed significantly better than their counterparts in the control group. This indicated that adaptive teaching strategy was a more effective instructional strategy than conventional method and can be used to improve the academic achievement of students in biology. This finding agrees with several other studies, such as that of Tshibalo (2003) and Yusuf (2011), who concluded that there was significant difference in the performance of students taught using adaptive teaching strategy and those taught using conventional instructional strategies. The finding also supports Johnson and Johnson, (1987); Slavin (2007) and Rahvard (2010) who have shown the effectiveness of adaptive learning in promoting students' learning and academic achievement.

The result of RQ_2 and RHO_2 in Table 4 and 5 shows that adaptive teaching strategy method has positive effect on interest of the students, therefore the difference in mean interest scores of the students before and after treatment are 51.91 and 56.23 respectively. Null hypothesis was tested and the result shows that there is a significant change in interest of the experimental group towards biology after being exposure to the treatment. Therefore, it can be concluded that the research hypothesis 2 is rejected. The findings are in line with Adams, (2013) and Odagboyi, (2015) who noted that adaptive learning with supportive friendship patterns enhance interest of students to better learning.

The result of RQ_3 and RHO_3 in Table 6 and 7 indicated that there was significant difference between the performance of male and female respondents after exposure to treatment. This shows that female students performed significantly better than their male counterparts, this means that adaptive teaching strategy is not gender-friendly. The results showed that the female group had a post-test means score of 29.00, while the male group had a means scores 23.53. The finding is in line with Nwagbo and Obinekwe (2010), where it was reported that the achievement and the result of learning efficiency of male and female students may be different. The findings is also line with Egbo, (2005) who shows that there is a significant deference in academic achievement between,male and their female counterparts with girls achieving higher than boys.

Conclusion

Based on the finding of this study, the following conclusions were drawn: -

1. Students exposed to adaptive teaching strategy in the present study performed much better than that taught biology by means of traditional lecture method. This means adaptive teaching strategy enhanced students' performance in learning of biology.
2. Adaptive teaching strategy improves the interest of students in learning biology concepts. Hence, adaptive teaching strategy enhanced interest of the students towards biology concept.
3. The strategy was found not to be gender-friendly as the result from the test of the Hypothesis indicated that there are differences between the performance of male and female students who learnt biology by means of adaptive teaching strategy. This means that adaptive teaching strategy enhanced female performance in learning of biology better than that of the male, since the performance of female and male was found not to be equal therefore according to the research adaptive teaching strategy was not gender friendly and the vice-versa is called the gender friendly.

Recommendations

The researchers recommend the following:

1. Biology teachers should adopt adaptive teaching strategy to enhance students' performance and interest in Biology.
2. Male students should be given targeted support to help them adapt effectively to adaptive learning approaches.
3. Curriculum planners should integrate adaptive teaching approaches into Biology instructional materials and teacher training programs.

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