Effect of Advance Organizer Strategy on Students' Academic Achievement and Retention in Biology among Senior Secondary School Students in Girei Local Government Area of Adamawa State, Nigeria

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Abstract

This study investigated the effect of Advance Organizer Strategy on students' academic achievement and retention in Biology among Senior Secondary School students in Girei Local Government Area of Adamawa State, Nigeria. The study was motivated by persistent challenges associated with students' poor understanding, achievement, and retention of biological concepts, which have been linked to the dominance of teacher-centred instructional approaches. The study was anchored on Ausubel's Theory of Meaningful Learning, which emphasizes that learning becomes more effective when new knowledge is connected with learners' existing cognitive structures. A quasi-experimental pre-test, post-test non-equivalent control group design was adopted for the study. The population comprised all Senior Secondary School II Biology students in public secondary schools in Girei Local Government Area. A sample of 145 students was selected from four public secondary schools using purposive and simple random sampling techniques. Data were collected using the Biology Achievement Test (BAT), which consisted of 50 multiple-choice items adapted from the Biology curriculum and past examination questions. The instrument was validated by experts in Biology Education and Measurement and Evaluation, and a reliability coefficient of 0.83 was obtained using the KR-20 method. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at 0.05 level of significance. The study found that students taught Biology using the Advance Organizer Strategy achieved higher academic performance and demonstrated better retention of Biology concepts than those taught using the conventional method. The findings also revealed that the strategy was equally effective for both male and female students, as gender did not significantly influence students' academic performance when exposed to the strategy. The study concludes that the Advance Organizer Strategy is an effective learner-centred approach for improving Biology achievement and retention. It is therefore recommended that Biology teachers integrate advance organizers into classroom instruction to promote meaningful learning and improved students' outcomes.

Keywords: Advance Organizer Strategy; Academic Achievement; Retention; Biology Education.

Introduction

Education plays a significant role in national development by promoting scientific literacy, innovation, and human capital development. Science education is particularly important because it equips learners with critical thinking, problem-solving skills, and the ability to address contemporary challenges (OECD, 2023; UNESCO, 2024). Among science subjects taught in secondary schools, Biology occupies a central position because of its relevance to health, agriculture, environmental sustainability, biotechnology, and several professional disciplines such as Medicine, Nursing, Pharmacy, and Microbiology (UNESCO, 2024; Wilton et al., 2021).

Despite the importance of Biology, students' achievement and retention of biological concepts remain a concern. Many students experience difficulties understanding abstract and interconnected concepts, resulting in poor academic performance and weak retention of knowledge (Adonu et al., 2021; Yilmaz & Yilmaz, 2023). Academic achievement reflects students' attainment of instructional objectives, while retention indicates their ability to preserve and recall learned concepts over time. Both are essential indicators of effective learning, particularly in Biology where new concepts build upon previously acquired knowledge (Karpicke & Grimaldi, 2022).

One major factor contributing to poor learning outcomes in Biology is the dominance of teacher-centred instructional approaches. Conventional lecture methods often emphasize memorization rather than meaningful understanding and active participation, limiting students' ability to develop deep conceptual knowledge (Bransford et al., 2000; Mayer, 2021). Therefore, educational researchers have advocated learner-centred strategies that promote meaningful learning and improve students' engagement.

The Advance Organizer Strategy, developed from Ausubel's Theory of Meaningful Learning, provides learners with structured materials such as concept maps, diagrams, charts, analogies, and summaries before instruction. These materials enable students to connect new information with existing knowledge, thereby improving understanding, achievement, and retention (Ausubel, 1968; McLeod, 2024). Previous studies have demonstrated that advance organizers enhance students' achievement and retention in science subjects (Omondi et al., 2018; Komenda et al., 2020; Awodun & Boris, 2021). Although previous studies have established the benefits of advance organizers, limited evidence exists regarding their effectiveness among senior secondary school students in Girei Local Government Area of Adamawa State. Therefore, this study examines the effect of the Advance Organizer Strategy on students' academic achievement and retention in Biology.

Statement of the Problem

Biology is an important science subject that provides foundational knowledge for several scientific and professional fields. However, students' performance in Biology at the secondary school level remains unsatisfactory due to difficulties in understanding and retaining biological concepts. Reports from educational stakeholders and examination bodies indicate persistent challenges in students' ability to comprehend and apply Biology knowledge (WAEC, 2023).

The continued reliance on conventional lecture methods may contribute to these challenges because such approaches often encourage passive learning and memorization rather than conceptual understanding. Although the Advance Organizer Strategy has been found effective in improving learning outcomes in other contexts (Omondi et al., 2018; Komenda et al., 2020), its effectiveness among senior secondary school Biology students in Girei Local Government Area has not been sufficiently established. This study therefore investigates whether the Advance Organizer Strategy can improve students' academic achievement and retention in Biology.

Objectives of the Study

The main objective of this study was to determine the effect of the Advance Organizer Strategy on students' academic achievement and retention in Biology among senior secondary school students in Girei Local Government Area of Adamawa State.

Specifically, the study sought to:

1. Determine the effect of the Advance Organizer Strategy on students' academic performance in Biology.
2. Determine the effect of the Advance Organizer Strategy on students' retention of Biology concepts.
3. Determine the difference in academic performance between male and female students taught Biology using the Advance Organizer Strategy.

Research Questions

The following research questions guided the study:

1. What is the difference between the pre-test and post-test mean academic performance scores of students taught Biology using the Advance Organizer Strategy and those taught using the conventional method?
2. What is the difference between retention and post-test mean scores of students taught Biology using the Advance Organizer Strategy and those taught using the conventional method?

3. What are the pre-test and post-test mean scores of male and female students taught Biology using the Advance Organizer Strategy?

Hypotheses

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

HO1: There is no significant effect of the Advance Organizer Strategy on students' academic performance in Biology.

HO2: There is no significant effect of the Advance Organizer Strategy on students' retention in Biology.

HO3: There is no significant difference in the academic performance of male and female students when taught Biology using the Advance Organizer Strategy.

Literature Review

The theoretical foundation of this study is based on **Ausubel's Theory of Meaningful Learning**. Ausubel (1968) proposed that learning becomes meaningful when new information is connected with learners' existing cognitive structures. Unlike rote learning, meaningful learning enables students to organize, relate, and apply new knowledge effectively. Advance organizers support this process by providing conceptual frameworks before instruction, allowing learners to connect new ideas with prior knowledge.

The theory is particularly relevant to Biology learning because many biological concepts are abstract and interconnected. By presenting students with structured materials before lessons, advance organizers reduce cognitive difficulties and enhance understanding, retention, and academic achievement (Ausubel, 1968; Mayer, 2021).

Empirical studies have consistently demonstrated the effectiveness of advance organizers in improving students' academic outcomes. Omondi et al. (2018) and Komenda et al. (2020) found that students taught Biology using advance organizers performed significantly better than those taught using conventional approaches. The researchers attributed the improvement to the ability of advance organizers to help learners connect new information with prior knowledge.

Similarly, Awodun and Boris (2021) reported that students taught using advance organizer strategies achieved higher academic scores than those taught using traditional methods. Gambari et al. (2014) also found that multimedia-based advance organizers improved students' achievement and retention in science subjects.

The effect of advance organizers on retention has also been established. Komenda et al. (2020) reported that students exposed to advance organizer instruction retained Biology concepts better than students taught using conventional methods. Omondi et al. (2018) similarly found that advance organizers improved students' ability to recall biological concepts during subsequent assessments.

Research has also shown that instructional strategies based on meaningful learning principles benefit both male and female students. Hattie (2023) and Karpicke and Grimaldi (2022) noted that strategies promoting meaningful learning and retrieval processes improve learning outcomes regardless of gender. Wilton et al. (2021) and Yilmaz and Yilmaz (2023) further reported that instructional approaches that enhance conceptual understanding support achievement among diverse groups of learners.

Methodology

The study adopted a quasi-experimental pre-test, post-test non-equivalent control group design. The study was conducted among Senior Secondary School II Biology students in Girei Local Government Area of Adamawa State, Nigeria. The population comprised all SS II Biology students in public secondary schools in the study area. A sample of 145 students, consisting of 75 males and 70 females, was selected from four public secondary schools using purposive and simple random sampling techniques. Intact classes were used to preserve normal classroom arrangements, with selected schools assigned to experimental and control groups. Data were collected using the Biology Achievement Test (BAT), which consisted of 50 multiple-choice questions adapted from the WAEC Biology syllabus and past examination questions. The instrument was validated by experts in Biology Education and Measurement and Evaluation. A reliability coefficient of 0.83 was obtained using the KR-20 method, indicating that the instrument was reliable. The study lasted for eight weeks. A pre-test was administered to both groups before instruction. The experimental group was taught selected Biology topics using the Advance Organizer Strategy, while the control group was taught using the conventional lecture method. After six weeks of instruction, a post-test was administered, followed by a retention test two weeks later. Data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

Research Question 1

What is the difference between the pre-test and post-test mean academic performance scores of students when taught biology using advanced organizer model and those taught with conventional method?

Table 1: Mean and Standard Deviation of Pretest and Post-test Mean Academic Performance Scores of Students in taught Biology using Advanced Organizer Model and those taught using Lecture Method

Teaching Methods	n	Pre-Test		Post-Test		Mean Gain
		Mean	S. D	Mean	S. D	
Advanced Organizer (Experimental Group)	72	33.93	2.61	44.38	2.49	10.45
Conventional method (Control Group)	73	33.44	3.06	39.71	3.03	6.27
Mean difference				4.67		

Table 1 presents the mean and standard deviation of the pre-test and post-test academic performance scores of students taught Biology using the Advanced Organizer Model and those taught using the Conventional Method. The result shows that students in the Advanced Organizer Model (experimental group) had a pre-test mean score of 33.93 with a standard deviation of 2.61, while their post-test mean score increased to 44.38 with a standard deviation of 2.49. The group recorded a mean gain score of 10.45, indicating a substantial improvement in students' academic performance after exposure to the Advanced Organizer Model.

Similarly, students taught Biology using the Conventional Method (control group) recorded a pre-test mean score of 33.44 with a standard deviation of 3.06 and a post-test mean score of 39.71 with a standard deviation of 3.03. The group achieved a mean gain score of 6.27, showing that students taught using the conventional method also improved in academic performance after instruction.

Comparatively, students taught using the Advanced Organizer Model achieved a higher mean gain score (10.45) than those taught using the Conventional Method (6.27). The difference in mean gain scores between the two groups was 4.67 in favour of the Advanced Organizer Model. This indicates that students exposed to the Advanced Organizer Model demonstrated greater improvement in Biology academic performance than students taught using the conventional method.

Research Question 2

What is the difference between retention and post-test mean scores of students when taught biology using advanced organizer model and those taught with conventional method?

Table 2: Mean and Standard Deviation of Retention and Post-test Mean Scores of Students in taught Biology using Advanced Organizer Model and those taught using Lecture Method

Teaching Methods	n	Retention		Post-Test		Difference between retention and post test
		Mean	S. D	Mean	S. D	
Advanced Organizer (Experimental Group)	72	40.83	2.55	44.38	2.49	3.55
Conventional method (Control Group)	73	36.86	2.59	39.71	3.03	2.85

Table 2 presents the difference between retention and post-test mean scores of students taught Biology using the Advanced Organizer Model and those taught using the Conventional Method. The findings show that students in the Advanced Organizer Model group obtained a retention mean score of 40.83 with a standard deviation of 2.55, compared with their post-test mean score of 44.38 and standard deviation of 2.49. The difference between the retention and post-test mean scores was 3.55, indicating that students retained a considerable proportion of the knowledge acquired after instruction.

For students taught using the Conventional Method, the retention mean score was 36.86 with a standard deviation of 2.59, while the post-test mean score was 39.71 with a standard deviation of 3.03. The difference between the retention and post-test mean scores was 2.85, suggesting a decline in performance after the post-test, although students retained some of the knowledge gained during instruction.

A comparison of both groups reveals that students taught using the Advanced Organizer Model recorded a higher retention mean score (40.83) than those taught using the Conventional Method (36.86). Furthermore, the difference between post-test and retention scores was slightly higher for the Advanced Organizer Model group (3.55) compared with the Conventional Method group (2.85). This suggests that the Advanced Organizer Model enhanced students' ability to retain Biology concepts better than the conventional teaching approach.

Research Question 3

What are the pre-test and post-test mean scores of males and females students when taught biology using advance organizer model?

Table 3: Mean and Standard Deviation of Pretest and Post-test Mean Academic Performance Scores of Male and Female Students in taught Biology using Advanced Organizer Model

Gender	n	Pre-Test	Post-Test	Mean Gain

		Mean	S. D	Mean	S. D	
Male	38	34.00	2.87	44.53	2.26	10.53
Female	34	33.85	2.34	44.21	2.74	10.36
Mean difference				0.32		

Table 3 presents the pre-test and post-test mean academic performance scores of male and female students taught Biology using the Advanced Organizer Model. The results indicate that male students had a pre-test mean score of 34.00 with a standard deviation of 2.87, while their post-test mean score increased to 44.53 with a standard deviation of 2.26. The male students recorded a mean gain score of 10.53, indicating improvement in their academic performance after exposure to the Advanced Organizer Model. Similarly, female students recorded a pre-test mean score of 33.85 with a standard deviation of 2.34, while their post-test mean score increased to 44.21 with a standard deviation of 2.74. The female students obtained a mean gain score of 10.36, showing that they also benefited from the instructional strategy.

The comparison between male and female students shows that male students recorded a slightly higher post-test mean score (44.53) compared with female students (44.21). Likewise, male students had a slightly higher mean gain score (10.53) than female students (10.36), with a mean difference of 0.32. However, the difference between the performance gains of male and female students was very small, suggesting that the Advanced Organizer Model improved the academic performance of both male and female students almost equally.

HO_1: There is no significant effect of advance organizer model on students' academic performance in biology.

Table 4: Summary of ANCOVA of Effect of Advanced Organizer Model on Students' Academic Performance in Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	807.983[a]	2	403.992	53.122	.000	.428
Intercept	1438.287	1	1438.287	189.125	.000	.571
Pretest	19.928	1	19.928	2.620	.108	.018
Teaching methods	760.650	1	760.650	100.020	.000	.413
Error	1079.906	142	7.605			

Total	258004.000	145
Corrected Total	1887.890	144

a. R Squared = .428 (Adjusted R Squared = .420)

Table 4 presents the ANCOVA results on the effect of the Advance Organizer Model on students' academic performance in Biology after controlling for pretest scores. The result revealed that the effect of teaching method was statistically significant, $F(1,142) = 100.020$, $p < .05$, with a partial eta squared of .413. This indicates that the teaching method accounted for approximately 41.3% of the variance in students' academic performance, representing a large effect size. The pretest covariate was not statistically significant, $F(1,142) = 2.620$, $p = .108$, indicating that students' initial differences in achievement did not significantly influence the posttest scores after adjustment.

Furthermore, the corrected model was significant, $F(2,142) = 53.122$, $p < .05$, with $R^2 = .428$ (Adjusted $R^2 = .420$), implying that the model explained about 42.8% of the variation in students' academic performance. Since the probability value associated with teaching method ($p = .000$) is less than the alpha level of 0.05, the null hypothesis was rejected. Therefore, there is a significant effect of the Advance Organizer Model on students' academic performance in Biology.

HO_2: There is no significant effect of advance organizer model on students' retention in biology.

Table 5: Summary of ANCOVA of Effect of Advanced Organizer Model on Students' Retention in Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	701.475[a]	2	350.737	61.144	.000	.463
Intercept	772.143	1	772.143	134.607	.000	.487
Pretest	130.078	1	130.078	22.676	.000	.138
Teaching methods	521.011	1	521.011	90.827	.000	.390
Error	814.553	142	5.736			
Total	220193.000	145				
Corrected Total	1516.028	144				

a. R Squared = .463 (Adjusted R Squared = .455)

Table 5 shows the ANCOVA results on the effect of the Advance Organizer Model on students' retention in Biology while controlling for pretest scores. The result revealed that teaching method significantly influenced students' retention, $F(1,142) = 90.827$, $p < .05$, with a partial eta squared of .390. This indicates that approximately 39.0% of the variance in retention scores was attributable to the teaching method, which is considered a large effect size.

The pretest covariate was also significant, $F(1,142) = 22.676$, $p < .05$, with a partial eta squared of .138, indicating that students' prior knowledge contributed significantly to their retention performance.

The corrected model was statistically significant, $F(2,142) = 61.144$, $p < .05$, with $R^2 = .463$ (Adjusted $R^2 = .455$). This means that the model explained 46.3% of the variance in students' retention scores. Since the significance value for teaching method ($p = .000$) is less than 0.05, the null hypothesis was rejected. Therefore, there is a significant effect of the Advance Organizer Model on students' retention in Biology.

HO_3: There is no significant difference in the academic performance of male and female students when taught biology using advance organizer model.

Table 6: Summary of ANCOVA of Effect of Advanced Organizer Model on Students' Academic Performance in Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.979[a]	2	2.489	.396	.675	.011
Intercept	927.771	1	927.771	147.538	.000	.681
Pretest	3.136	1	3.136	.499	.482	.007
Gender	1.980	1	1.980	.315	.577	.005
Error	433.896	69	6.288			
Total	142217.000	72				
Corrected Total	438.875	71				

a. R Squared = .011 (Adjusted R Squared = -.017)

Table 6 presents the ANCOVA results examining the influence of gender on students' academic performance when taught Biology using the Advance Organizer Model. The result showed that gender had no significant effect on students' academic performance, $F(1,69) = 0.315$, $p = .577$, with a partial eta squared of .005. This indicates that gender accounted for only 0.5% of the variance in academic performance, which is a negligible effect size.

Similarly, the pretest covariate was not statistically significant, $F(1,69) = 0.499$, $p = .482$, indicating that initial differences in students' achievement did not significantly affect their posttest performance.

The corrected model was not significant, $F(2,69) = 0.396$, $p = .675$, with $R^2 = .011$ (Adjusted $R^2 = –.017$), suggesting that only 1.1% of the variance in academic performance was explained by the model.

Since the significance value for gender ($p = .577$) is greater than the alpha level of 0.05, the null hypothesis was not rejected. Therefore, there is no significant difference in the academic performance of male and female students taught Biology using the Advance Organizer Model. This implies that the model was equally effective for both male and female students.

Discussion of Findings

The finding of the study reveals that the Advanced Organizer Model significantly improved students' academic performance in Biology. This finding agrees with Omondi et al. (2018), Komenda et al. (2020), and Awodun and Boris (2021), who reported that students taught using advance organizers achieved higher performance than those taught using conventional methods because the strategy promotes meaningful learning by linking new knowledge with prior experiences.

The finding of the study reveals that the Advanced Organizer Model significantly enhanced students' retention of Biology concepts. This supports Komenda et al. (2020), Omondi et al. (2018), and Gambari et al. (2014), who found that advance organizers improve retention by helping learners organize and integrate information into existing cognitive structures.

The finding of the study reveals that the Advanced Organizer Model was equally effective for male and female students, as gender did not significantly influence academic performance. This agrees with studies indicating that meaningful learning strategies benefit learners irrespective of gender because they focus on knowledge organization and cognitive processing rather than gender differences.

Conclusion

The study concludes that the Advanced Organizer Model significantly improves students' academic performance and retention in Biology compared with the conventional teaching method. The model was found to be effective for both male and female students, indicating that it provides an inclusive approach for enhancing Biology learning outcomes.

Recommendations

The following recommendations were made based on the findings.

1. Biology teachers should adopt and integrate the Advanced Organizer Model into classroom instruction to enhance students' understanding and achievement.
2. Teachers should use advance organizers such as concept maps, diagrams, and summaries before introducing new topics to promote meaningful learning and long-term retention.

3. Biology teachers should apply the model as an inclusive instructional strategy to provide equal learning opportunities for all students regardless of gender.

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