EFFECT OF CONCEPT MAPPING STRATEGY ON BIOLOGY STUDENTS ACHIEVEMENT AND RETENTION IN SENIOR SECONDARY SCHOOLS IN ADAMAWA STATE, NIGERIA

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Abstract
The study examined the effect of concept mapping as an instructional strategy on the achievement and retention of senior secondary II Biology students in Adamawa state, Nigeria. The study adopts a quasi-experimental design involving a pre-test, post-test, non-equivalent control group design. The researchers sampled 119 students from two intact classes in Yola zone out of a population of over 49,000 students. The data were collected using Biology Performance Test (BPT) and its reliability coefficient was found to be 0.82 using KR-20. Data collected were analyzed with descriptive statistics (mean and standard deviation) as well as inferential statistics (ANCOVA and MANCOVA). The findings showed that students taught Biology using the concept mapping strategy achieved significantly higher scores than those taught with the traditional lecture method. This difference in achievement was also significant when school location was considered. In addition, students exposed to concept mapping demonstrated significantly better retention than those taught through lectures. However, no significant difference in retention was found based on school location. The study concludes that concept mapping is a more effective instructional strategy than the lecture method for improving Biology students' achievement and retention at the senior secondary school level. As a result, it recommends that Biology teachers be trained and encouraged to adopt concept mapping as a regular teaching strategy to enhance students' learning outcomes.
Key words: Concept Mapping Strategy, Biology, Achievement, Retention.

Introduction
Concept mapping is a student-centered instructional strategy that visually represents the relationships among concepts using circles, boxes, and arrows with linking phrases (Mogbo, 2023). It emphasizes learners' active engagement by enabling them to construct knowledge through meaningful connections between new and prior information. As a learner-centered approach, it bridges the gap between how knowledge is acquired and how it is meaningfully applied (Yunus in Awodun, 2017). Peñalosa, et, al., (2025) note that concept mapping clarifies key ideas for both teachers and learners by breaking complex tasks into smaller, manageable units that connect to major concepts in a subject. This visual externalization supports learners' understanding by making their prior knowledge explicit and connecting it with new concepts.

According to Choudhary and Bano (2022), concept mapping is especially effective in teaching Biology topics such as nutrient cycles and conservation of natural resources, improving comprehension and performance. Concept maps provide a schematic or flow-chart-like structure that concretizes abstract ideas and highlights relationships between concepts and facts Exter, et, al., (2020) and enhance meaningful learning in science (Dhull & Verma, 2020).

By organizing information hierarchically, they allow learners to see the structure of knowledge clearly communicate relationships visually (Huseynli, 2024). This technique promotes collaboration and shared understanding among learners. In addition, (Ullah , 2020) defines concept maps as graphical tools for organizing and representing knowledge through linked concepts enclosed in shapes. The linking words describe relationships, promoting logical thinking and study skills. However, it encourages learners to actively build and take responsibility for their knowledge. It has proven to enhance understanding in science education, warranting continued investigation into its effects on students' performance in Biology. Novak and Gowin (1998, cited in Torre, et, al., 2023) emphasized that concept mapping supports meaningful learning by helping students assimilate new information into existing cognitive structures.

School location refers to the geographical and environmental context of a school, urban or rural, along with available infrastructure, community resources, and accessibility (Bæck, 2015). Urban schools often have superior facilities, qualified teachers, and more learning opportunities, while rural schools may provide quieter but resource-limited environments. The socioeconomic status of a school's community influences students' academic support and access to enrichment activities like museum visits and field trips that enhance understanding (Ekpenyong, 2017). As a moderator variable, school location can influence how interventions like concept mapping impact learning outcomes (Kweona et al., 2017). Considering location helps tailor educational strategies to diverse settings, improve policy development, and address disparities in educational achievement.

Retention refers to a learner's ability to recall and reproduce learned concepts when needed (Holschuh & Nist, 2000; Caldwell & Stewart, 2023). It signifies the preservation and recall of knowledge, indicating that true learning has occurred (Radvansky et al., 2022). Retention is crucial in Biology, as recalling past concepts enhances ongoing performance (McDaniel, et,al., 2022). (Maceiras, et, al., 2025), also asserts that retention depends heavily on effective, participatory teaching strategies. Active engagement in learning enhances long-term retention, emphasizing the need for interactive instructional techniques like concept mapping over traditional lecture methods in science education.

Statement of the Problem

Over the years, studies in science education have consistently shown poor student performance in Biology in Nigeria's public examinations. Statistics from the West African Examinations Council (WAEC) between 2010 and 2020 reveal persistently low and fluctuating results in the subject. However, (Junco, and Nabua, 2023) attribute this to teachers' lack of professional skills for handling complex biological concepts and the continued reliance on traditional lecture methods. Similarly, Ndayambaje, et, al., (2021) identify students' lack of interest and inability to retain learned concepts as major factors contributing to poor achievement. Teaching Biology poses challenges due to the abstract nature of many concepts, the scarcity of instructional aids, and the complexity of certain topics (Mogbo, 2023). Consequently, there is a growing need for alternative instructional strategies that promote meaningful learning. Buzan (2024) identifies concept mapping as an effective,

student-centered method that graphically organizes and presents information, thereby enhancing understanding and long-term retention. This study, therefore, seeks to investigate the effect of concept mapping on achievement and retention in Biology among senior secondary school students in Adamawa State, Nigeria.

Objectives of the Study

The objective of the study is intended to determine the:

1. Effect of concept mapping strategy on achievement of senior secondary school biology students in Adamawa state.
2. Effect of concept mapping strategy on retention of senior secondary school biology students in Adamawa state.
3. Effect of concept mapping strategy on retention of senior secondary school biology students in Adamawa state by school location.

Research Questions

The following research questions were posed to guide the study:

1. What are the pre-test and post-test mean difference of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state?
2. What are the post-test and retention test mean difference of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state?
3. What are the pre -test and post-test mean difference of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state by school location (Urban and rural)?

Hypotheses

The following null hypothesis were formulated:

Ho_1: There is no significant difference in achievement scores of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state.

Ho_2: There is no significant difference in retention scores of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state.

Ho_3: There is no significant difference in retention scores of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state by school location.

Methodology

This study employed a quasi-experimental pretest–posttest non-equivalent, non-randomized control group design. This design was chosen because the subjects could not be randomly assigned to groups, as is required in a true experimental setup. According to Cohen, Manion, and Morrison (2007), quasi-experimental designs are suitable when randomization is impossible or impractical, as they allow researchers to work with naturally existing groups. The study was conducted in Adamawa state, Nigeria. The population of the study included all

senior secondary school two (SS II) Biology students in Adamawa state, totaling 49,253 students. The sample consisted of 119 SS II Biology students drawn from four senior secondary schools in one educational zone of the state. A multistage sampling technique was employed: In stage one, one education zone was randomly selected. Stage two used purposive sampling to select four co-educational, government-funded schools with Biology laboratories, representing both urban and rural areas. In stage three, intact classes from each school were randomly assigned as experimental or control groups. One Biology teacher per school was also randomly chosen as a research assistant and trained in concept mapping instruction.

The instrument for data collection was the Biology Performance Test (BPT), comprising 50 multiple-choice questions adapted from WAEC past papers (2020–2024) on nutrient cycles and conservation of natural resources. Data from the trial test were analyzed using the Kuder-Richardson Formula 20 (KR-20), suitable for dichotomously scored items. The BPT achieved a reliability coefficient of 0.82, indicating that the instrument was highly reliable for data collection. Data analysis employed descriptive statistics (mean and standard deviation) to answer research questions, while Two-Way Analysis of Covariance (ANCOVA) tested hypotheses at the 0.05 significance level. ANCOVA adjusted for initial group differences using pre-test scores as covariates.

Results

Research Question 1: What are the pre-test and post-test mean difference of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state?

Table 1: Mean and Standard Deviation of Pre – test and Post test Scores of Students in the Experimental and Control Groups

Group	N	Pre-test		Post-test		Mean Difference
		Mean	S.D	Mean	S.D	
Experimental Group	61	10.90	4.53	27.64	7.34	16.74
Control Group	58	10.60	3.83	20.59	5.51	9.99

The results in table 1 show that both the experimental (concept mapping) and control (lecture method) groups began with nearly equal pre-test mean scores of10.90 and 10.60, respectively indicating that students had similar prior knowledge in Biology before the treatment. After the intervention, both groups improved, but the experimental group's post-test mean score increased substantially to 27.64, while the control group's mean rose to 20.59. This represents a greater mean gain of 16.74 for the experimental group compared to the control. The mean difference of 7.05 points between the two groups' post-test results demonstrates that students taught with the concept mapping strategy performed significantly better than those taught through the traditional lecture method.

Research Question 2: What are the post-test and retention mean difference of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state by school location?

Table 2: Mean and Standard Deviation of Post-test Retention Scores of Students in the Experimental and Control Groups based on School Location

Group	School Location	Post-test Mean	S.D	N	Retention Mean	S.D	Mean difference
Experimental Group	Urban	25.91	6.29	33	31.21	5.99	5.30
	Rural	29.68	8.05	28	37.86	8.78	8.18
Control Group	Urban	19.00	5.13	30	21.43	5.93	2.43
	Rural	22.29	5.49	28	27.04	3.16	4.75

Table 2 shows that both urban and rural students in the experimental group exhibited improvement from post-test to retention scores. Notably, rural students had a higher retention mean (37.86) than urban students (31.21), reflecting a mean retention difference of 5.0 and 8.18 for rural and urban students respectively. A similar pattern was observed in the control group, where rural students retained more (mean = 27.04) than urban students (mean = 21.43), with a retention gain of 2.43 and 4.75 for urban and rural students respectively. This again emphasizes that rural students benefited more in terms of knowledge retention, particularly under the concept mapping strategy. These results suggest that the learning environment in rural schools may support better consolidation of knowledge when interactive and visual learning strategies like concept mapping are employed.

Research Question 3: What are the pretests and post-test mean difference of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state by school location?

Table 3: Mean and Standard Deviation of Pre-test and Post-test Mean Difference of Students in the Experimental and Control Groups based on School Location

Group	School Location	N	Pre-test Mean	S.D	Post-test Mean	S.D	Mean difference
Experimental Group	Urban	33	8.97	3.4	25.91	6.29	16.94
	Rural	28	13.18	4.67	29.68	8.05	16.5
Control Group	Urban	30	10.13	4.40	19.00	5.13	9.13
	Rural	28	11.11	3.11	22.29	5.49	11.18

Table 3 reveals variations in students' performance based on school location. In the experimental (concept mapping) group, rural students scored higher than urban students in both the pre-test (13.18 vs. 8.97) and post-test (29.68 vs. 25.91). The mean gain was 16.5 for rural and 16.94 for urban students, indicating substantial improvement in both groups. In the control group, a similar pattern emerged, with rural students achieving a higher post-test mean (22.29)

than urban students (19.00), and mean gains of 11.18 and 9.13 respectively. Overall, the results show that concept mapping improved Biology performance among students in both rural and urban schools. However, while rural students consistently recorded slightly higher raw scores, urban students appeared to benefit more proportionally from the concept mapping intervention possibly due to better classroom engagement and fewer environmental distractions.

Hypothesis Testing

Ho_1: There is no significant difference in achievement scores of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state.

Table 4: Summary of ANCOVA of Difference in Achievement Scores of Senior Secondary School Students taught Biology with Concept Mapping Strategy and those Taught with Lecture Method in Adamawa State

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1708.206[a]	2	854.103	20.933	.000	.265
Intercept	6552.963	1	6552.963	160.607	.000	.581
Post-test	229.181	1	229.181	5.617	.019	.046
Teaching methods	1435.842	1	1435.842	35.191	.000	.233
Error	4732.954	116	40.801			
Total	76142.000	119				
Corrected Total	6441.160	118				

a. R Squared = .265 (Adjusted R Squared = .253)

Table 4 presents the results of an Analysis of Covariance (ANCOVA), which was conducted to determine whether the teaching method had a significant effect on students' achievement in Biology after controlling for pre-test scores. The result shows that the effect of teaching method is statistically significant, $F(1, 119) = 35.191$, $p < .05$, with a partial eta squared of .233. This indicates a large effect size, suggesting that the teaching method accounted for approximately 23.3% of the variance in students' post-test scores. Since the p-value is less than 0.05, the null hypothesis is rejected. Therefore, it is concluded that there is a significant difference in the achievement of students taught with concept mapping strategy compared to those taught with the lecture method, favoring the concept mapping approach.

Ho_2: There is no significant difference in retention scores of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state.

Table 5: Summary of ANCOVA of Difference in Retention Scores of Senior Secondary School Students taught Biology with Concept Mapping Strategy and those Taught with Lecture Method in Adamawa State by School Location

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4173.377[a]	4	1043.344	26.310	.000	.480

Intercept	11932.068	1	11932.068	300.886	.000	.725
Retention Test	2.434	1	2.434	.061	.805	.001
Teaching methods	3141.458	1	3141.458	79.217	.000	.410
Error	4520.841	114	39.656			
Total	111048.000	119				
Corrected Total	8694.218	118				

a. R Squared = .480 (Adjusted R Squared = .462)

The results presented in table 5 show the outcome of the ANCOVA conducted to test Ho_2, which stated that there is no significant difference in the retention scores of senior secondary school students taught Biology using the concept mapping strategy and those taught using the lecture method in Adamawa state, controlling for school location. The analysis indicates that the overall model was statistically significant, $F(4, 114) = 26.31$, $p < .05$, with an R^2 value of .480. This implies that approximately 48% of the variance in students' retention scores was explained by the combined effects of the independent variables in the model, demonstrating a strong explanatory power.

Specifically, the main effect of teaching method on retention was found to be statistically significant, $F (1, 114) = 79.22$, $p < .05$, with a large effect size (partial eta squared = .410). This result indicates that students taught Biology using the concept mapping strategy retained significantly more content than those taught with the lecture method. The large effect size further suggests that the teaching method had a substantial influence on students' retention of Biology concepts.

$H0_3$: There is no significant difference in retention of senior secondary school students taught Biology with concept mapping strategy and those taught with lecture method in Adamawa state by school location.

Table 6: Summary of ANCOVA of Difference in Retention Scores of Senior Secondary School Students taught Biology with Concept Mapping Strategy and those Taught with Lecture Method in Adamawa State by School Location

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4173.377[a]	4	1043.344	26.310	.000	.480
Intercept	11932.068	1	11932.068	300.886	.000	.725
Retention Test	2.434	1	2.434	.061	.805	.001
Teaching methods	3141.458	1	3141.458	79.217	.000	.410
School location	1030.723	1	1030.723	25.991	.000	.186
Teaching methods * school location	9.583	1	9.583	.242	.624	.002
Error	4520.841	114	39.656			
Total	111048.000	119				
Corrected Total	8694.218	118				

a. R Squared = .480 (Adjusted R Squared = .462)

In table 6, ANCOVA was used to assess whether both teaching method and school location significantly influence retention scores. The results show significant main effects for both teaching method, $F(1, 119) = 79.217$, $p = .000$, partial eta squared = .410, and school location, $F(1, 119) = 25.991$, $p < .05$, partial eta squared = .186. These findings indicate that both variables independently had a strong impact on students' retention of Biology concepts. However, the interaction between teaching method and school location is not significant, $F(1, 114) = 0.242$, $p > .05$, partial eta squared = .002. This suggests that the superiority of the concept mapping strategy in enhancing retention is consistent across different school locations (urban and rural).

Discussions of Finding

The findings of the current study align with a substantial body of previous research indicating the effectiveness of concept mapping strategies over traditional lecture methods in enhancing achievement in Biology. Specifically, the study found a significant difference in achievement between students taught with concept mapping and those taught with the lecture method in Adamawa State. This agrees with the findings of (Magaji, et, al., 2024; Silva, et, al., 2022 & Ahmed et al., 2021) all of whom reported that concept mapping significantly enhanced students' academic achievement in science-related subjects, especially Biology and Chemistry. These studies affirm the cognitive benefits of concept mapping, which facilitates meaningful learning by helping students, organize and relate new information to existing knowledge structures.

However, the present study contradicts the findings of (Shi, et, al., 2023 & Joda, 2018) who found no significant difference in academic achievement between students taught using concept mapping and those exposed to other strategies such as inquiry and expository methods. A likely reason for these differences could be the variation in subject matter, sample size, instructional duration, or teacher familiarity with the concept mapping technique. Additionally, while Shi, study involved a comparison between two active learning strategies (concept mapping and inquiry), the current study compares an active strategy (concept mapping) with a more passive approach (lecture), which might explain the observed contrast in outcomes. However, this finding differs slightly from Becker et al. (2021), found no significant difference in content-related learning success when comparing different concept map strategies (retrieval vs. elaboration), although they acknowledged the value of concept mapping for methodological skill development. A likely reason for this difference could be methodological: while Becker et al. focused on different uses of concept mapping rather than comparing it directly to lecture methods, the current study compares concept mapping with a more passive strategy. Also, differences in sample populations, subject areas, and instructional duration may have influenced these outcomes.

Conclusion

The study concludes that concept mapping is an effective instructional strategy for improving the achievement of senior secondary school Biology students in Adamawa state. While

students' achievement differed significantly between rural and urban schools, their retention of Biology concepts did not. This indicates that concept mapping supports long-term retention equally across school locations, making it a valuable and effective teaching strategy for Biology instruction.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Biology teachers in Adamawa state senior secondary schools should be encouraged and trained to adopt the concept mapping strategy as a regular instructional method to enhance students' achievement.
2. Educational stakeholders should consider providing targeted support and resources tailored to specific school locations to maximize the effectiveness of concept mapping strategies based on contextual needs.
3. Since retention benefits are consistent across locations, concept mapping should be uniformly implemented across all school locations in the state without concern for variation in effectiveness.

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