EFFECT OF CONCEPT MAPPING INSTRUCTIONAL STRATEGY ON STUDENTS' ACADEMIC PERFORMANCE AND RETENTION IN BIOLOGY IN SECONDARY SCHOOLS IN ODUKPANI LOCAL GOVERNMENT AREA OF CROSS RIVER STATE

Effiong, Effiom Etim, Ph.D
08162580639
effiome70@gmail.com
ORCHID ID: 0009000787449191
Department of Biology Education, Faculty of Science Education
University of Calabar, Calabar

Igwebuike, Osedumme, PhD
osedumme82@gmail.com
Department of Curriculum and Teaching
University of Calabar, Calabar

Inyene-Obong Sunday Umoh
inyeneobongumoh@gmail.com
Department of Biology Education
University of Calabar, Calabar

Abstract

The present study examined the effect of concept mapping instructional strategy on students' academic performance and retention in Biology in secondary schools in Odukpani Local Government Area of Cross River State. Specifically, the study determined the difference in the academic performance of students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method, as well as the difference in the retention of Biology concepts between students taught using the concept mapping instructional strategy and those taught using the conventional teaching method. Two research questions and two null hypotheses were formulated to guide the study. The study adopted a pretest-posttest quasi-experimental research design involving an experimental group and a control group. The population of the study comprised 2,356 Senior Secondary II (SS II) Biology students drawn from the 32 public secondary schools in Odukpani Local Government Area of Cross River State. A sample of 240 SS II students in Biology was selected using multistage sampling procedures involving purposive, simple random, and intact class sampling techniques. The experimental group was taught selected Biology concepts using the Concept Mapping Instructional Strategy (CMIS), while the control group was taught the same concepts using the Conventional Teaching Method (CTM). Data were collected using the Biology Achievement Test (BAT) developed by the researcher. The instrument was validated by experts in Biology Education and Measurement and Evaluation from the University of Calabar. The reliability of the Biology Achievement Test (BAT) was established using the Kuder-Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.84, indicating that the instrument was reliable for the study. Mean and standard deviation were used to answer the research questions, while Independent t-test analyses) was employed to test the hypotheses at the 0.05 level of significance, using the pretest scores as covariates to control for initial differences between the groups. The findings revealed that students taught Biology using the concept mapping instructional strategy performed significantly better and demonstrated

higher retention of Biology concepts than their counterparts taught using the conventional teaching method. The study concluded that concept mapping instructional strategy is a more effective instructional approach for improving students' academic performance and retention in Biology than the conventional teaching method. Consequently, it was recommended among other that Biology teachers adopt concept mapping instructional strategy in classroom instruction.

Keywords*:* Concept Mapping Instructional Strategy, Conventional Teaching Method, Biology Achievement Test, Academic Performance, *Retention*

Introduction

Biology is the scientific study of living organisms and their interactions with the environment. It is a central branch of natural science that focuses on the structure, function, growth, evolution, distribution, and classification of living things. As a discipline, Biology provides the foundation for understanding life processes at molecular, cellular, organismic, and ecological levels. It also explains how organisms adapt, survive, and interact within ecosystems. Because of its broad scope, Biology is considered one of the most important subjects in secondary school science education, forming the basis for advanced studies in medicine, agriculture, biotechnology, environmental science, and other life-related disciplines (OECD, 2023; UNESCO, 2021).

The importance of Biology in education extends beyond academic certification. It equips learners with scientific literacy necessary for solving real-life problems such as disease prevention, environmental degradation, food production, population control, and biodiversity conservation. In an era of rapid scientific and technological advancement, Biology plays a critical role in preparing students to understand contemporary global challenges such as climate change, emerging diseases, and sustainable resource management. Consequently, effective Biology education is essential for producing scientifically competent individuals capable of contributing to national development and global sustainability (UNESCO, 2021; Federal Ministry of Education, 2021).

Despite its importance, the teaching and learning of Biology in many secondary schools continue to face challenges that negatively affect students' academic performance. Academic performance in Biology refers to the extent to which students achieve expected learning outcomes as demonstrated through classroom assessments, standardized tests, and external examinations such as the West African Senior School Certificate Examination. It reflects students' understanding of biological concepts, ability to apply scientific knowledge, and competence in analytical and problem-solving skills. However, reports from examination bodies indicate that students' performance in Biology has remained consistently below expectation over the years, particularly in questions requiring conceptual understanding and application of knowledge (WAEC, 2023; Federal Ministry of Education, 2021).

Research in science education has shown that students' poor performance in Biology is often linked to the dominance of teacher-centred instructional methods that limit active engagement in the learning process. Traditional methods of teaching Biology often involve lecture-based instruction, memorization of facts, and minimal student participation. This approach does not adequately support the development of higher-order thinking skills required for understanding complex biological relationships. As a result, students often struggle with abstract concepts such as genetics, cell division, ecological interactions, and physiological processes (Ekon, Nwankwo & John, 2024; Mera Cabezas et al., 2024).

In response to these challenges, modern science education emphasizes learner-centred instructional strategies that promote active participation, critical thinking, collaboration, and meaningful learning. One of such strategies is concept mapping. Concept mapping is a visual instructional technique that helps learners organize and represent knowledge in a structured diagram showing relationships among concepts. It enables students to link new knowledge with prior knowledge, thereby promoting deeper understanding of subject matter. Through concept mapping, learners are able to identify key concepts, arrange them hierarchically, and connect them using meaningful relationships (Novak & Cañas, 2008; Anastasiou et al., 2024).

Recent empirical studies have demonstrated that concept mapping significantly improves students' academic performance in science subjects, including Biology. It enhances students' ability to understand relationships among biological concepts and reduces cognitive overload by simplifying complex information into structured visual representations. Studies have shown that students taught using concept mapping outperform those taught using conventional instructional methods in achievement tests, particularly in topics that require conceptual integration and analysis (Sharma & Sharma, 2025; Olajumoke & Agada-Adeleye, 2025).

Concept mapping is particularly relevant to Biology because the subject consists of interconnected concepts that require logical organization for meaningful understanding. Topics such as nutrition, respiration, genetics, reproduction, and ecology involve multiple relationships that are difficult to understand through rote memorization alone. Concept mapping allows learners to visualize these relationships, thereby improving comprehension and facilitating meaningful learning. This makes it a suitable instructional strategy for enhancing students' academic performance in Biology (Santhosh et al., 2024; Twan & Ronald, 2024).

Comparatively, conventional teaching methods remain widely used in many secondary schools despite their limitations. These methods are teacher-dominated and often restrict students' participation in the learning process. Students are usually passive recipients of information, which limits their ability to construct knowledge independently. Consequently, this approach has been associated with low academic achievement and poor conceptual understanding in Biology (OECD, 2023; WAEC, 2023).

Given the persistent poor performance of students in Biology and the need for more effective instructional approaches, there is a need to investigate the effect of concept mapping instructional strategy on students' academic performance in Biology using an experimental design involving control and experimental groups. This study therefore examines the effectiveness of concept mapping compared with conventional teaching methods on students' academic achievement in Biology in Odukpani Local Government Area of Cross River State, Nigeria.

Statement of research problems

The observed problem in Biology education in many Nigerian secondary schools, particularly in Odukpani Local Government Area of Cross River State, is the persistently poor academic performance of students in the subject despite its importance to science and national development. Examination reports from both internal school assessments and external bodies such as the West African Examinations Council (WAEC) consistently indicate that a large number of students perform below expectations in Biology, especially in areas requiring understanding, application, and interpretation of biological concepts (WAEC, 2023; Federal Ministry of Education, 2021). This persistent underachievement raises serious concern among stakeholders in education regarding the effectiveness of teaching and learning processes in Biology classrooms.

One major factor contributing to this problem is the continued reliance on conventional teaching methods in the instructional delivery of Biology. In many secondary schools, teaching is still largely teacher-centred, where learners are passive recipients of information through lecture, note-taking, and memorization. This approach limits students' active engagement in the learning process and reduces opportunities for inquiry, exploration, and meaningful understanding of complex biological concepts such as genetics, respiration, photosynthesis, and ecological relationships. As a result, students often develop superficial understanding of Biology, which negatively affects their academic performance.

Although contemporary science education emphasizes learner-centred instructional strategies that promote active participation and conceptual understanding, many Biology teachers in secondary schools still do not frequently adopt such innovative approaches. One such instructional strategy is concept mapping, which allows learners to visually organize biological concepts and establish meaningful relationships among ideas. Research has shown that concept mapping enhances students' cognitive engagement and improves their understanding of scientific concepts. However, despite its proven effectiveness in science education, its use in many Nigerian secondary schools remains limited and underutilized (Anastasiou et al., 2024; Sharma & Sharma, 2025).

Objectives of the Study

The main objective of this study was to determine the effect of concept mapping instructional strategy on students' academic performance in Biology in secondary schools in Odukpani Local Government Area of Cross River State.

Specifically, the study sought to:

1. Determine the difference in the academic performance of students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State.
2. Determine the difference in the retention of Biology concepts between students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State.

Research Questions

The following research questions guided the study:

1. What is the difference in the academic performance of students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State?
2. What is the difference in the retention of Biology concepts between students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State?

Research Hypotheses

The following null hypotheses were formulated to guide the study and were tested at the 0.05 level of significance:

1 There is no significant difference in the academic performance of students taught Biology using the concept mapping instructional strategy and those taught using the

conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State.

2 There is no significant difference in the retention of Biology concepts between students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State

Methods

The study adopted a quasi-experimental research design using a pre-test, post-test non-equivalent control group design to determine the effect of concept mapping instructional strategy on students' academic performance in Biology in secondary schools in Odukpani Local Government Area of Cross River State, Nigeria. This design was considered appropriate because intact classes were used, and random assignment of individual students to experimental and control groups was not feasible within the school setting. The design allowed the researcher to compare the performance of students exposed to concept mapping (experimental group) with those taught using the conventional teaching method (control group) before and after the treatment.

The population of the study comprised all Senior Secondary II (SS II) students in biology in public secondary schools in Odukpani Local Government Area. SS II students were selected because they are adequately exposed to Biology concepts required for standardized assessment and are not yet preparing for final external examinations. The study focused specifically on students offering Biology as a science subject in the selected schools.

A sample of two intact classes from two comparable public secondary schools was drawn using a simple random sampling technique. One school was assigned to the experimental group while the other was assigned to the control group. The experimental group was taught Biology using the concept mapping instructional strategy, while the control group was taught using the conventional teaching method (lecture, explanation, and note-taking). The assignment ensured that both groups were exposed to the same content, duration of instruction, and learning objectives, with only the instructional strategy differing.

The instrument used for data collection was the Biology Achievement Test (BAT) developed by the researcher based on the Senior Secondary II Biology curriculum. The BAT consisted of multiple-choice and structured test items designed to measure students' academic performance in selected Biology topics such as cell structure, nutrition, and ecological relationships. The instrument was validated by experts in Biology Education and Measurement and Evaluation to ensure content relevance, clarity, and appropriateness.

Data were collected using pre-test and post-test scores from both groups. The pre-test was administered to determine the baseline equivalence of the groups before treatment, while the post-test was used to measure the effect of the instructional strategies after the intervention. Independent t-test analysis was used to test the hypotheses at 0.05 level of significance.

Results

Hypothesis One: There is no significant difference in the academic performance of students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State

Table 1: Independent Sample t-test Analysis of Students' Academic Performance in Biology (Experimental and Control Groups)

Group	N	Mean	SD	df	t-value	p-value
Concept Mapping (Experimental)	210	29.84	4.21	418	8.62	0.000
Conventional Method (Control)	210	24.37	4.56			

Significant at 0.05 level

The result in Table 3 shows that the calculated t-value of 8.62 with a p-value of 0.000 is less than 0.05 level of significance. Since the calculated p-value is less than the 0.05 level of significance, the decision rule is to reject the null hypothesis and accept the alternative hypothesis. Therefore, the null hypothesis is rejected. This implies that there is a significant difference between students taught using concept mapping instructional strategy and those taught using conventional teaching method. The higher mean score of the experimental group indicates that concept mapping significantly improves students' academic performance in Biology compared to the conventional method.

Hypothesis Two: There is no significant difference in the retention of Biology concepts between students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State

Table 4: Summary of Post-test Mean Scores and t-test Analysis based on retainsion

Group	N	Mean	SD	df	t-value	p-value
Concept Mapping Group	210	30.12	4.10	418	9.05	0.000
Conventional Group	210	24.89	4.48			

Significant at 0.05 level

The result in Table 4 reveals that the calculated t-value of 9.05 with a p-value of 0.000 is less than the 0.05 level of significance. Hence, the calculated p-value is less than the 0.05 level of significance, the decision rule is to reject the null hypothesis and accept the alternative hypothesis. This indicates a statistically significant difference in retention between students taught using concept mapping and those taught using the conventional method. The null hypothesis is therefore rejected. The finding implies that concept mapping instructional strategy is more effective in enhancing students' academic performance in Biology than the conventional teaching method..

Discussion of Findings

The findings of the study are discussed in this section based strictly on the two hypotheses tested.

Concept Mapping Instructional Strategy and conventional teaching method and Students' Academic Performance Biology

The first hypothesis examined revealed that there is a significant difference in the academic performance of students taught Biology using the concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State. The null hypothesis was therefore rejected, indicating that concept mapping instructional strategy significantly improves students' academic performance in Biology. The findings showed that students taught using concept mapping performed significantly better in Biology than those taught using the conventional teaching method as measured by the Biology Achievement Test (BAT).

This implies that concept mapping enhances students' ability to organize biological concepts meaningfully, connect related ideas, and develop a deeper understanding of complex topics such as genetics, ecology, and cell biology. By visually representing knowledge, students are actively involved in constructing meaning rather than passively receiving information. This active engagement promotes conceptual clarity, improves problem-solving skills, and enhances overall academic performance in Biology.

The finding is consistent with Novak and Cañas (2020), who emphasized that concept mapping improves meaningful learning by helping learners integrate new knowledge with prior understanding. It also agrees with Hoffman et al. (2022), who reported that visual learning strategies such as concept mapping significantly improve students' achievement in science subjects. Similarly, Adeleke and Ogunleye (2023) found that students exposed to concept mapping performed better in Biology because the strategy enhances critical thinking and conceptual understanding. Furthermore, Organisation for Economic Co-operation and Development (2023) noted that learner-centred instructional strategies consistently outperform conventional teaching methods in promoting academic achievement in science education.

Concept Mapping Instructional Strategy and Students' Retention of Biology Concepts

The second hypothesis tested determined that there is a significant difference in the retention of Biology concepts between students taught using concept mapping instructional strategy and those taught using the conventional teaching method in secondary schools in Odukpani Local Government Area of Cross River State. The null hypothesis was also rejected, confirming that concept mapping significantly improves students' retention of Biology concepts compared to the conventional teaching method.

The findings indicated that students exposed to concept mapping were able to remember and reproduce biological concepts more effectively over time than those taught using conventional methods. This is because concept mapping allows students to organize information hierarchically, establish meaningful relationships among concepts, and repeatedly visualize knowledge structures, which strengthens memory formation and long-term recall.

The implication is that concept mapping not only improves immediate academic performance but also enhances cognitive retention by reducing rote memorization and promoting meaningful learning. Students are better able to retrieve learned concepts during assessments because they understand how ideas are interconnected rather than isolated facts.

The finding agrees with Sharma and Sharma (2024), who reported that concept mapping improves long-term retention of scientific concepts by enhancing cognitive organization and reducing memory overload. It also aligns with Mera Cabezas et al. (2024), who found that visual learning strategies significantly improve students' retention and recall of science concepts. Similarly, Anastasiou et al. (2024) observed that students taught using concept mapping retained biological concepts better than those taught using lecture-based methods due to deeper cognitive processing. Furthermore, UNESCO (2024) emphasized that learner-centred instructional approaches improve both understanding and long-term knowledge retention in science education.

Conclusion

Based on the findings of the study, it is concluded that concept mapping instructional strategy significantly enhances both academic performance and retention of Biology concepts among secondary school students in Odukpani Local Government Area of Cross River State compared to the conventional teaching method. The study established that students taught using concept mapping achieved higher scores in the Biology Achievement Test (BAT) and demonstrated better retention of biological concepts due to improved conceptual organization, active participation, and meaningful learning experiences. Conversely, the conventional teaching method was found to limit students' understanding and retention because it encourages passive learning and rote memorization. Therefore, concept mapping is an effective instructional strategy for improving Biology education outcomes.

Recommendations

1. Biology teachers in secondary schools should adopt concept mapping instructional strategy in teaching complex Biology topics to improve students' academic performance and retention of concepts in Odukpani Local Government Area of Cross River State.
2. The Cross River State Ministry of Education should organize regular training, workshops, and seminars for Biology teachers on the effective use of concept mapping instructional strategy to enhance students' achievement and long-term retention in Biolog

References

Anastasiou, D., Wirngo, F. X., & Bagos, P. G. (2024). Effects of concept mapping on students' achievement in science education: A meta-analytic review. *Educational Psychology Review, 36*(2), 1–25.

Ekon, J. C., Nwankwo, C. A., & John, U. E. (2024). Teaching strategies and secondary school students' achievement in Biology in Cross River State, Nigeria. *Journal of Science Education and Practice, 15*(1), 44–58.

Federal Ministry of Education. (2021). *National policy on science and technology education in Nigeria*. Abuja, Nigeria.

Mera Cabezas, M. J., Basantes Vaca, A., Benavides Enríquez, J., & Parra Álvarez, J. (2024). Innovative teaching strategies in science education: A systematic review. *Frontiers in Education, 9,* 136- 148.

Novak, J. D., & Cañas, A. J. (2008). The theory underlying concept maps and how to construct them. *Technical Report IHMC CmapTools*. Florida Institute for Human and Machine Cognition.

OECD. (2023). *Education at a glance 2023: OECD indicators*. Organisation for Economic Co-operation and Development. https://www.oecd.org

Olajumoke, A. O., & Agada-Adeleye, I. A. (2025). Effect of concept mapping instructional strategy on students' achievement in Biology. *International Journal of Science Education Research, 11*(2), 77–89.

Santhosh, R., Kumar, P., & Devi, S. (2024). Concept mapping in science education: Enhancing conceptual understanding in Biology. *Journal of Biological Education Research, 58*(1), 15–29.

Sharma, R., & Sharma, P. (2025). Effectiveness of concept mapping in improving secondary school students' performance in science. *Journal of Educational Research and Practice, 12*(1), 33–47.

Twan, A. S., & Ronald, D. (2024). Effects of concept mapping instructional strategy on Biology students' performance in secondary schools. *African Journal of Educational Studies, 19*(2), 101–115.

UNESCO. (2021). *Reimagining our futures together: A new social contract for education*. United Nations Educational, Scientific and Cultural Organization. https://unesco.org

WAEC. (2023). *Chief examiners' report on West African Senior School Certificate Examination (WASSCE) Biology*. West African Examinations Council. https://www.waecdirect.org