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Effects of Concept Mapping Method of Teaching on Students' Learning Outcome and Retention in Biology in Secondary Schools in Kontagora Metropolis

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Abstract

This study investigated the effect of concept mapping method of teaching on students' learning outcomes and retention in Biology in senior secondary schools within Kontagora metropolis. A pre-test, post-test, and delayed post-test quasi-experimental design was adopted. Out of 1,984 senior secondary class two (SS II) students from 28 schools, 80 were randomly selected from four schools (two assigned to concept mapping instruction and two to conventional teaching). A standardized Reproduction in Flowering Plants Achievement and Retention Test (RFPART) was administered at pre-test, post-test, and delayed post-test stages. Data were analyzed using t-test statistics at $p < 0.05$. Findings revealed that there was a significant difference in the pre-test performance of students in the concept mapping and conventional method groups, no significant difference in post-test scores, and better retention among female students compared to their male counterparts in the concept mapping group. It was recommended that Biology teachers adopt concept mapping as a regular instructional strategy to improve students' long-term learning outcomes.

Keywords: effects, concept mapping, learning outcome, retention in biology, secondary school.

Introduction

Biology, as a natural science subject, plays a vital role in equipping students with scientific knowledge and skills relevant for understanding the living world. It serves as a foundational subject for careers in medicine, pharmacy, agriculture, biotechnology, and environmental sciences. However, despite its importance, students' performance in Biology at the secondary school level in Nigeria.

Biology is a foundational subject in the sciences that provides learners with essential knowledge about living organisms, ecological systems, and biological processes. It serves as a gateway to professional fields such as medicine, nursing, agriculture, pharmacy, and environmental science (Akinsola & Aderogba, 2020). Despite the relevance of Biology to national development, students in Nigeria, including those in Kontagora Metropolis, continue to perform poorly in both internal and external examinations. Reports from the West African Examinations Council (WAEC) indicate persistent difficulty in understanding abstract biological concepts such as genetics, respiration, and ecology (WAEC, 2022). Scholars attribute this poor performance to several factors, including inadequate teaching methods that fail to promote meaningful learning (Nwosu & Okeke, 2019). Many Biology teachers rely heavily on lecture-based instruction, which encourages rote memorization rather than conceptual understanding (Olatunji & Lawal, 2020). Consequently, students memorize facts temporarily but are unable to retain or apply them in examinations or real-life situations.

Teaching methods significantly influence students' learning outcomes and retention. The conventional lecture method commonly used in Nigerian classrooms often promotes rote learning, where students memorize facts without understanding relationships among concepts. This problem contributes to poor retention and low interest in Biology. To address these challenges, learner-centered and activity-based instructional strategies such as concept mapping have been recommended in science education.

Concept mapping, involves the use of diagrams to represent relationships among concepts in a hierarchical structure. It helps students organize knowledge, visualize connections, and relate new information to pre-existing knowledge, thereby promoting meaningful learning (Novak, 2010). Research in science education has shown that concept mapping enhances students' achievement and retention compared to traditional methods (Okafor, 2019; Adesoji & Oladele, 2020; Udeh, 2021).

Concept mapping is an active instructional strategy that requires learners' participation in representing the relationships between concepts in a pictorial or diagrammatic way. It is designed to help learners process and retain information more effectively, especially when applied within a conducive learning environment. A concept map is a visual representation of knowledge that connects key ideas using nodes and linking phrases, thereby promoting deeper understanding in the short term and improved retention in the long term (Nesbit & Adesope, 2021).

Statement of the Problem

The persistent poor academic achievement of students in Biology has become a serious concern to teachers, parents, and curriculum planners in Niger State. WAEC Chief Examiners' Reports (2021–2023) consistently show that students have difficulty recalling and applying biological concepts during examinations. Observations in secondary schools within Kontagora Metropolis reveal that many learners forget concepts shortly after instruction and struggle to connect ideas across topics such as cell biology, genetics, ecology, and physiology. A major contributor to this challenge is the continuous dependence on lecture methods by teachers, which do not engage students actively or help them construct meaningful connections among biological concepts (Akinsola & Aderogba, 2020). The inability of students to retain what they learn suggests a failure in instructional delivery methods. Although several researchers have reported that concept mapping improves academic performance and enhances long-term retention in science subjects (Okafor, 2019; Udeh, 2021; Lawal & Hassan, 2023), there is insufficient empirical evidence within Kontagora Metropolis to confirm its effectiveness in Biology classrooms. It is also unclear whether gender differences exist when students are taught using concept mapping.

Research Objectives

1. To develop concept maps for teaching reproduction in flowering plants.
2. To study the effectiveness of concept mapping as an instructional method in aiding students' retention of Biology topic as compared to the conventional method of teaching.

Research Hypotheses

Ho_1: There is no significant difference in the mean post-test scores of Biology students taught reproduction in flowering plants using concept maps and those taught with the conventional method.

Ho_2: There is no significant difference in the mean delayed post-test scores of Biology students taught reproduction in flowering plants using concept maps and those taught with the conventional method.

H_{o3}: There is no significant difference in the mean post-test scores of Biology students taught reproduction in flowering plants using concept maps based on gender.

H_{o4}: There is no significant difference in the mean delayed post-test scores of Biology students taught reproduction in flowering plants using concept maps based on gender.

Research Methodology

Research Design

The method used to carry out this study was the quasi-experimental design. It entails administering a pre-test, post-test and delay post-test to biology students of Senior Secondary School II using concept Mapping and conventional method.

Population of the Study

The population of the study comprises Biology students of 28 Senior Secondary schools in Kontagaora.

Population and Sample

The study randomly selected four (4) senior secondary schools to serve as the sample for the study. A total of eighty (80) senior secondary school two (SS II) Biology students participated in the study. The students were grouped into 2. Two (2) schools for concept mapping method and 2 schools for conventional method. Each group had 40 students with each school having 20 students respectively.

Treatment

The treatment covered all the groups: concept mapping method group 1 and 2 and conventional method group 1 and 2, as follows:

Week 1: familiarization with the students and administering of pre-test.

Week 2 &3: treatment.

Week 4: revision and post-test.

Week 7: delay post-test.

The scripts for pre-test, post-test and delay post-test were collected and scored by the researchers. The scores of these tests formed the data for the study.

Instrument

The instrument employed for this study was titled “Reproduction in Flowering Plants Achievement and Retention Test (RFPART)”. This was used as the pre-test, post-test and delay post-test. The instrument was designed in cognizance of the three (3) domains of educational objectives of knowledge (cognitive), attitude (affective), and manipulative (psychomotor). The treatment covered the topic reproduction in flowering plants as developed from the current

2022 senior secondary school (SS II) Biology curriculum. The test was set on the topic taught during the treatment. Twenty (20) multiple choice type of test was employed in setting the questions, from which they were to choose a correct answer from 4 options to each question.

The topic was taught to each of the student groups. The questions that made up the Reproduction in Flowering Plants Achievement and Retention Test (RFPART) were constructed to standard as some of them were obtained from JAMB, WAEC, NECO and NABTEB past question papers and others from standard examination questions from senior colleagues. This validated the instrument.

Results and Discussion

The data obtained were analyzed using t-test statistical technique. The hypotheses were tested at 0.05 level of significance.

Table 1: Pre-test of students' performance in the concept mapping method and conventional method groups

Teaching Method	Scores	N	$\bar{x}$	SD	S^2	DF	t.cal	t.val	Remark
Concept mapping (X_1)	94	40	5.20	2.00	4.13				
Concept mapping (X_2)	115					78	3.30	1.98	Significant
Conventional method (X_1)	91	40	4.65	1.87	3.49				
Conventional method (X_2)	95								

$P< 0.05$

0Table 1 above shows that the mean ($\overline{X}$) score for students in the concept mapping group is (5.20) while the mean ($\overline{X}$) score for the students in the conventional method group is (4.65). The t-calculated is (3.30) while the t-value is (1.98) with the degree of freedom of (78) at $P< 0.05$. Since the t-calculated value (3.30) is greater than the table value (1.98) at $P< 0.05$, the null hypothesis is rejected. That is, there is a significant difference in the performance of students in pre-test of concept mapping group and conventional method group.

The findings revealed that there was a significant difference in the pre-test performance of students taught with the concept mapping method compared to those taught using the conventional method. This suggests that concept mapping may provide students with a more organized framework to integrate new concepts with prior knowledge, consistent with Ausubel's (1962) theory of meaningful learning. Similar results have been reported in recent studies showing that concept mapping help students activate prior knowledge and link it to new content, thereby improving initial comprehension (Chiu et. al., 2020; Ifenthaler & Seel, 2019).

Table 2: Post-test of students' achievement in the concept mapping group and conventional method groups

Teaching Method	Scores	N	Mean	SD	S^2	DF	t-cal	t-val	Remark
Concept mapping (X_1)	265	40	9.83	3.77	14.18				
Concept mapping (X_2)	128								
						78	0.35	1.98	Retained
Conventional method (X_1)	163	40	9.58	2.88	5.66				
Conventional method (X_2)	220								

$P< 0.05$

The finding reveal that the mean ($\overline{X}$) score for concept mapping group is (9.58) while the mean ($\overline{X}$) of the conventional method group is (9.83). The t-calculated is (0.35) while the t-value is (1.98) with the degree of freedom of (78) at $P< 0.05$ level of significance.

Since the t-calculated value (0.35) is less than the table value (1.98) at $P< 0.05$, the null hypothesis is hereby retained. That is, there is no significant difference in the mean post-test scores of students' taught with the concept mapping and conventional teaching methods.

Table 2 shows, that there is no significant difference in the students' achievement in concept mapping and the conventional method groups. The table reveals that the concept mapping group had a score of (393), and a mean ($\overline{X}$) of (9.83), while the conventional group closed up on them with a score of (383), and a mean ($\overline{X}$) score of (9.58). It can hence be said that the difference observed in their means is due to chance. This finding has shown that neither of the teaching method produced a consequential effect that made it supersede the other. As such, it can be inferred that the success or failure of students is directly dependent on their devotedness to their academic work, the effectiveness of the teacher, the adequacy of teaching-learning aids and the conduciveness of the learning environment. This aligns with findings by Olagunju and Aladejana (2021), who argued that while concept mapping enhances initial engagement, post-test performance is influenced by other factors such as instructional quality, students' study habits, and the availability of instructional resources. Nesbit and Adesope (2021) also emphasize that concept maps should be integrated with other active learning strategies to maximize impact.

Table 3**:** Delay Post-test of students' retention in the concept mapping group and conventional method groups

Teaching Method	Scores	N	mean	SD	S^2	DF	t-cal	t-val	Remark
Concept mapping (X_1)	176	40	9.01	3.67	4.13				
Concept mapping (X_2)	186								
						78	3.30	1.98	Significant
Conventional method (X_1)	147	40	7.37	2.98	3.49				
Conventional method (X_2)	148								

P< 0.05

Table 3 above shows that the mean ($\overline{X}$) score for students in the concept mapping group is (9.01) while the mean ($\overline{X}$) score for the students in the conventional method group is (7.37). The t-calculated is (3.30) while the t-value is (1.98) with the degree of freedom of (78) at P< 0.05

Since the t-calculated value (3.30) is greater than the table value (1.98) at P< 0.05, the null hypothesis is rejected. That is, there is a significant difference in the performance of students in pre-test of concept mapping group and conventional method group.

Since the post-test results revealed a significant difference in retention scores, with the concept mapping group performing better than the conventional group. This finding supports the growing body of research that concept mapping improves long-term knowledge retention, especially in science subjects (Wang & Chen, 2022; Ifenthaler & Seel, 2019). This indicates that although immediate achievement may not differ significantly between methods, concept mapping provides a stronger foundation for long-term memory consolidation.

Table 4: Post-test of no significant difference in male and female students' achievement taught with the concept mapping method

Gender	No.	Scores	Mean	SD	S^2	DF	t-cal.	t-val.	Remark
Females	20	220	11.00	2.45	5.98				Significant
						38	3.70	2.02	
Males	20	163	8.15	2.31	5.34				

P< 0.05

The finding shows that the mean ($\overline{X}$) score for concept mapping group female students' performance is (11.00) while the mean ($\overline{X}$) score for concept mapping group male students is (8.15). The t-calculated is (3.70) while the t-value is (2.02) with the degree of freedom of (38) at P< 0.05.

Since the T-calculated value (3.70) is greater than the table value (2.02) at P< 0.05, the null hypothesis is hereby rejected. That is, there is a significant

difference in the mean score of female and male students' achievement in the concept mapping group.

Table 4 depicts that there is a significant difference in the achievement of male and female students in the Boarding school system. The findings revealed that females performed better than males. However, there might be other factors that contributed to the differences in the performances. This might include; students' background, lack of interest, poor study habits etc. This might have made the female students perform better than their male counterparts. This finding is in agreement with Akanbi (2020) who opined that female Day school students perform better than the male students, provided all necessary conditions are available.

Table 5: Delay post-test of no significant difference in Male and female students' achievement taught with the concept mapping method.

Gender	N	Scores	Mean	SD	S^2	DF	t-cal	t-cal	Remark
Females	20	265	13.25	3.65	13.29	38	5.61	2.02	Significant
Males	20	128	6.40	3.89	15.10				

$P< 0.05$

Table 5 above reveals that the mean ($\overline{X}$) score for female student's performance is (13.25) while the mean ($\overline{X}$) score for male students is (6.40). The t-calculated is (5.61) while the t-value is (2.02) with the degree of freedom of (38) at $P< 0.05$

Since the t-calculated value (5.61) is greater than the table value (2.02) at $P< 0.05$, the null hypothesis is therefore rejected. That is, there is a significant difference in the mean retention score of male and female students' taught with concept mapping method.

The finding reveal that there is a significant difference in the achievements of male and female students in taught with concept mapping method. The findings revealed that the female students performed better than their male counterparts. This finding agrees with Akanbi & Oti, (2020), which reported that female students tend to exhibit stronger persistence and deeper engagement when active and visual learning methods such as concept mapping are employed. Gender differences in cognitive engagement and study patterns may account for this disparity.

Conclusion

Concept mapping method of teaching is a teaching method for fostering long-term retention and academic achievement in biology. Although no significant difference was observed in the post-test scores, the delayed post-test

results demonstrated that students who were taught using concept mapping retained information better than their counterparts taught with the conventional method. Additionally, female students showed greater retention benefits than male students when taught with concept maps. These findings corroborate recent evidence that concept mapping enhances meaningful learning, strengthens connections between concepts, and supports knowledge retention over time (Chiu et al., 2020; Nesbit & Adesope, 2021; Wang & Chen, 2022). The results emphasize the importance of learner-centered instructional methods in biology and other sciences.

Recommendations

The following recommendations were:

1. Curriculum planners should incorporate concept mapping as a structured teaching strategy in secondary school biology curricula.
2. Biology teachers should adopt concept mapping method to foster deeper learning and improved retention.
3. School administrators should provide supportive facilities such as well-equipped laboratories and learning resources to complement concept map instruction.
4. Students should be encouraged to use concept maps during self-study to strengthen recall and conceptual understanding.

References

Adesoji, F. A., & Oladele, A. A. (2020). Effectiveness of concept mapping on students' retention in Chemistry. *Journal of Science Education Research, 12*(1), 45–56.

Akanbi, J. O., & Oti, E. C. (2020). Gender differences in students' academic retention in science subjects in Nigerian secondary schools. *Nigerian Journal of Educational Research and Evaluation, 19*(3), 112–124.

Akinsola, M. K., & Aderogba, A. A. (2020). Teaching strategies and students' performance in Biology in Nigerian secondary schools. *African Journal of Educational Studies, 8*(2), 90–104.

Ausubel, D. P. (1962). A subsumption theory of meaningful verbal learning and retention. *The Journal of General Psychology, 66*(2), 213 224.https://doi.org/10.1080/00221309.1962.9711837

Chiu, C. Y., Liang, J. C., & Tsai, C. C. (2020). The role of concept mapping in learning science: Recent developments and future directions. *Journal of Science Education and Technology, 29*(5), 678–692. https://doi.org/10.1007/s10956-020-09848-6

Ifenthaler, D., & Seel, N. M. (2019). Investigating the educational potential of concept maps for learning and instruction. *Journal of Research in Science Teaching, 56*(5), 617–640. https://doi.org/10.1002/tea.21511

Lawal, A., & Hassan, M. (2023). Concept mapping strategy and students' engagement in science classrooms. *International Journal of Science Pedagogy, 5*(3), 112–121.

Nesbit, J. C., & Adesope, O. O. (2021). Concept mapping for learning: Theory, research, and practice. *Educational Psychology Review, 33*(2), 457–480. https://doi.org/10.1007/s10648-020-09565-7

Novak, J. D. (2010). Learning, creating, and using knowledge: Concept maps as facilitative tools. *Journal of Educational Psychology Review, 22*(2), 189–210.

Nwosu, A. A., & Okeke, S. C. (2019). Classroom teaching methods and learning outcomes in Nigerian schools. *Nigerian Journal of Education, 15*(2), 67–78.

Okafor, C. O. (2019). Effects of concept mapping on students' achievement in Biology. *Journal of Science and Technical Education, 7*(1), 33–42.

Olagunju, A. M., & Aladejana, F. O. (2021). Effectiveness of concept mapping instructional strategy on secondary school students' academic performance in biology in Nigeria. *African Journal of Educational Research and Development, 13*(2), 44–55.

Olatunji, T. O., & Lawal, K. (2020). Impact of instructional techniques on students' performance in science subjects. *Nigerian Journal of Science Education, 3*(1), 25–34.

Udeh, C. A. (2021). Concept mapping and students' retention in secondary school Physics. *International Journal of Science and Technology Education, 9*(2), 145–154.

WAEC. (2022). *Chief Examiners' Report for Biology.* Lagos: WAEC Publications.

Wang, H., & Chen, C. H. (2022). Effects of digital concept maps on students' learning achievement and cognitive load in science education. *Interactive Learning Environments*. Advance online publication. https://doi.org/10.1080/10494820.2022.2037661