



Effect of Main-Idea-Web Teaching Strategy on Secondary School Student Retention in Nutrient-Cycling In Nature and Pollution in Kano-State-Nigeria

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ABSTRACT

This study investigated the effect of Main-Idea-Web (MIW) teaching strategy on secondary school students' retention in Nutrient Cycling in Nature and Pollution in Kano State, Nigeria. The study adopted a quasi-experimental design involving pre-test, post-test, and post-post-test equivalent group. Population of the study consists of 11,290 SS11 students and a sample of 312 SSII students were taught using MIW strategy, while another group was taught using conventional teaching method. The instrument for data collection was a validated Nutrient Cycling in Nature and Pollution Achievement Test (NPAT). Data were analyzed using mean, standard deviation, and ANCOVA at 0.05 level of significance. Findings revealed that students taught with MIW strategy had higher mean retention scores than those taught with the conventional method. ANCOVA results showed a significant difference between the two groups in favour of the experimental group. The study also found significant effects of gender and a significant interaction effect between instructional strategy and gender. The R^2 value indicated that a substantial proportion of variation in students' retention was explained by the instructional strategy. The study concluded that Main Idea Web teaching strategy is more effective than conventional teaching method in enhancing students' retention in nutrient cycling in nature and pollution. It was recommended that Biology teachers should adopt MIW strategy to enhance students' understanding and retention of complex biological concepts.

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INTRODUCTION

Biology is one of the core science subjects taught in secondary schools and plays a significant role in national development through its contributions to health, agriculture, environmental sustainability, and technological advancement. The subject equips learners with knowledge and skills necessary for understanding living organisms and their interactions with the environment. Despite the importance of Biology, students' performance and retention of biological concepts in Nigerian secondary schools have remained a major concern to educators, curriculum planners, and examination bodies (Ogunleye, 2019; Nooraida et al., 2020). Many

students tend to forget previously learned concepts shortly after instruction, especially in topics perceived as abstract and difficult, hence affects retention.

Retention is an important aspect of learning because it determines the extent to which learners are able to store and recall learned information after a period of time. In science education, retention reflects meaningful learning and long-term understanding of concepts rather than temporary memorization for examinations (Ausubel, 1963). Retention refers to the extent to which learners preserve acquired knowledge over time after instruction. In Biology education, retention is essential because many biological

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concepts are interconnected and cumulative. Poor retention in Biology may hinder students' ability to apply scientific knowledge to real-life situations and may negatively affect their overall academic achievement (Cao, 2026; Cottone & Yoon, 2020).

Retention of concepts in biology could be seen as the ability of student to learn, understand, store, and retrieve or reproduce whatever concepts in biology that was taught even after a long period of time. Therefore Adebisi, Adeyemi and Umbugadu (2021) disclosed that retention is the process in which information and a material is encoded, stored and retrieved. For a learner to achieve maximally in biology concepts, the learner must retain the knowledge acquired during teaching and learning processes (Jena, 2019). Retention is the preservation of the mind and materials in the mind should be preserved in form of images for knowledge to develop thereby enhancing achievement. (Ahmad, Hassan & Sadoh, 2021) It is important for biology teachers to use appropriate teaching strategies to enhance students' retention in concepts such as pollution and nutrient cycling in nature

Nutrient Cycling in Nature and Pollution are Biology topics in which students often experience retention difficulties this is because it involves complex ecological processes such as carbon cycle, nitrogen cycle, oxygen cycle, decomposition, and environmental interactions that require learners to understand sequential and interconnected relationships among concepts (Ramalingam, 2018). Nutrient Cycling in Nature is the continuous circulation of nutrients such as carb on, nitrogen, oxygen, and water between living organisms and the non-living environment. These nutrients move from the soil, water, and atmosphere into plants and animals and later returned to the environment through processes such as respiration, excretion, decomposition, and decay.

Pollution, on the other hand, is explained as the contamination of the environment through the introduction of harmful substances that negatively affect organisms and ecological systems (Ramalingam, 2018). These concepts are the Biological concepts that students often find difficult, particularly the aspects concerns with

diagrammatic representation and explanation of microbial roles such as Lightening, Nitrosomonas and Azotobacter (WAEC, 2019; Abidoye et al., 2023). Due to the abstract and process-oriented nature of the topic, students frequently rely on rote memorization instead of meaningful understanding, resulting in poor retention of learned concepts.

The conventional lecture method commonly used in many secondary schools may not adequately promote meaningful learning and retention because it encourages passive learning and limits students' active participation in classroom activities. Consequently, science educators have advocated the use of learner-centered and activity-oriented instructional strategies capable of improving students' understanding and retention of concepts (Okebukola, 1990). One of such strategies are concept mapping, mind map, graphic organizer including the Sequence Chart and main-idea-web Teaching Strategy (Kuthuria, 2019; Akanbi et al., 2021; Aina & Ogunkule, 2022; Velarde, 2019; Lynch, 2021).

Main idea web is a teaching strategy that start with an overall central idea and branches into other smaller related ideas and details, as the name implies it means taking the main idea when teaching a concept in biology, the biology teacher show the student the main idea, then explain and link it with other branches or details that follows the concept being taught. In this regards, Olszak (2014) explain that main idea web can be used primarily for brainstorming and generating ideas for planning and teaching purposes. Main idea web is a handy tool that provides a structure for student to document the critical concept and information contain inside each biology concept (Lynch, 2021).

The theoretical foundation for the use of Main-Idea-Web teaching strategy is linked to Ausubel's Subsumption Theory, which emphasizes meaningful learning through proper organization of instructional materials. According to Ausubel (1963), learning becomes more meaningful and retainable when new information is systematically related to learners' existing cognitive structure. Thus, main-idea-web teaching

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strategy may improve students' retention by helping them organize and integrate biological concepts meaningfully.

Gender is another variable that has attracted considerable attention in science education research. Previous studies on gender and retention in Biology have produced inconsistent findings. While some studies reported differences between male and female students in science learning outcomes, others found no significant gender influence when innovative instructional strategies were employed (Okoronka, 2012). These inconsistent findings therefore necessitate further investigation into the influence of gender on students' retention when sequence chart teaching strategy is used.

Although studies have examined the effectiveness of graphic organizers and related instructional approaches in science education and in biology, no studies appear to have specifically investigated the effect of Teaching Strategy on secondary school students' retention in Nutrient Cycling in Nature and Pollution in Kano State, Nigeria based on the literatures available to the researcher. This gap therefore necessitated the present study.

Objectives of the Study

1. To find out the effect of main-idea-web teaching strategy on students' retention in Nutrient Cycling in Nature and Pollution of senior secondary schools.
2. To determine gender difference among senior secondary school students' retention in Nutrient Cycling in Nature and Pollution when taught with main-idea-web teaching strategy.

Research Questions

1. To what extent does the mean differ in students' retention taught nutrients cycling in nature and pollution with main-idea-web strategies, and those students taught with the conventional method of teaching?
2. What is the mean difference in gender retention of students taught nutrient cycling in nature and pollution with main-idea-web, and those taught with conventional teaching method?

Research Hypotheses

- H₀₁: There is no significant mean difference in the retention of students taught nutrients cycling in nature and pollution with main-idea-web, and those taught with conventional methods of teaching.
- H₀₂: There is no significant mean difference in the retention of male and female students taught nutrients cycling in nature and pollution with main-idea-web, and those taught with conventional methods of teaching

METHODOLOGY

The study adopted a quasi-experimental research design involving a pre-test, post-test and post –post-test equivalent control group. Quasi-experimental design was considered appropriate because it allows the researcher to determine cause-and-effect relationships between the independent and dependent variables through treatment and comparison of groups (Thomas, 2023). The population of the study comprised 11,290 SS2 students in all 28 public Senior Secondary Schools in Nassarawa Education Zone, Kano State, Nigeria. SS2 students were selected because Nutrient Cycling in Nature and Pollution are taught at this level. The students were assumed to be relatively homogeneous in age (15–17 years), exposed to the same curriculum, and learning under similar school environments.

The sample consisted of 312 SS2 students drawn from four public secondary schools using intact classes. Intact classes were used because the classes were already organized and could not be randomly restructured. The research instrument used was the Nutrient Cycling in Nature and Pollution Achievement Test (NPAT), developed from WAEC SSCE past questions (2000–2025). The instrument consisted of 30 multiple-choice items with options A–D. Section A contained demographic information such as school, age, class, and gender, while Section B contained the test items. All items were structured to reflect Bloom's taxonomy levels: knowledge, comprehension, application, analysis, synthesis, and evaluation.

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Each correct response was scored 1 mark, while incorrect responses were scored 0, giving a total maximum score of 30. The instrument was validated by experts in science education and measurement and evaluation. A split-half reliability of 0.75 was obtained using the Spearman's rank-order correlation, indicating acceptable internal consistency for research purposes (Cohen, 1988; Dancey & Reidy, 2004). Data collected were analyzed using mean,

standard deviation, and Analysis of Covariance (ANCOVA) at 0.05 level of significance.

RESULTS

Research Question one:

To what extent does the mean differ in students' retention taught nutrients cycling in nature and pollution with main-idea-web strategies, and those students taught with the conventional method of teaching?

Table 1: Mean Difference between Posttest and post-posttest

Variable	Group	N	\bar{x}	SD	M/diff	Remark
Retention of Students Taught with the Main Idea Web	Experimental	98	19.59	4.65		
	Control	85	11.95	4.81	7.64	

Table 1 presents a mean difference of students' retention scores between experimental and control groups exposed to the Main Idea Web instructional strategies. For the retention of students taught with the Main Idea Web, the experimental group achieved a higher mean score ($\bar{x} = 19.59$, $SD = 4.65$) than the control group, which recorded a mean score of 11.95, $SD = 4.81$. The mean difference of 7.64 again favors the experimental group, indicating that students exposed to the Main Idea Web strategy demonstrated better retention than those taught

using conventional methods. By implication, the findings reveal that the Main Idea Web instructional strategies were effective in improving students' retention.

H01: There is no significant difference in mean retention score of students taught nutrients cycling in nature and pollution with main-idea-web teaching strategies, and those taught with conventional methods of teaching.

Table 2: ANCOVA Result for the Students' Retention Taught Using MIW

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2830.297 ^a	2	1415.148	65.832	.000
Intercept	338.068	1	338.068	15.727	.000
MIW Post test	174.132	1	174.132	8.101	.005
Group	981.767	1	981.767	45.671	.000
Error	3869.353	180	21.496		
Total	53804.000	183			
Corrected Total	6699.650	182			

a. R Squared = .422 (Adjusted R Squared = .416), Dependent Variable: MIW post post test

Table 2 presents the results of an Analysis of Covariance (ANCOVA) conducted to examine the effect of Main-Idea-Web on students' retention scores, while controlling for students' posttest achievement. The corrected model was

statistically significant, $F(2,180) = 65.83$, $p < 0.001$, indicating that the combined effects of the covariate and Main-Idea-Web significantly explained variance in students' retention scores. The model accounted for 42.2% of the variance in

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retention achievement ($R^2 = 0.422$; $AdjustedR^2 = 0.416$), demonstrating a strong explanator.

The covariate, MIW-Post-test, had a statistically significant effect on students' retention scores, $F(1,180) = 8.10, p = .005$. This finding suggests that students' posttest achievement significantly influenced their retention performance, confirming the relevance of controlling for posttest scores in the analysis. More importantly, the group effect was statistically significant, $F(1,180) = 45.67, p < 0.001$. This result indicates that, after adjusting for posttest achievement, there was a significant difference in retention scores between the experimental and control groups. Thus, instructional strategy had a statistically significant effect on students' retention. The intercept was also statistically significant, $F(1,180) =$

15.73, $p < 0.001$, indicating that the adjusted mean retention score differed significantly from zero when the predictors were held constant.

In summary, the ANCOVA results demonstrate that while students' posttest achievement significantly influenced retention, instructional group exerted a substantial and significant effect on students' retention scores. This finding provides strong empirical evidence that Main-Idea-Web was effective in enhancing students' retention of learned material compared to the control condition.

Research Question Two:

What is the mean difference in the retention of students taught nutrients cycling in nature and pollution with main idea web and main-idea-web teaching strategies and those taught with conventional method of teaching based on gender?

Table 3: Mean Difference between Male and Female Students' Retention Exposed Main-Idea-Web.

	Group	N	\bar{x}	SD	M/diff	Remark
Male Retention MIW	Experimental	39	17.54	5.66		In favour of male students
	Control	34	9.06	3.51	8.48	
Female Retention MIW	Experimental	59	20.95	3.24		In favour of female students
	Control	50	21.46	1.96	7.07	

Table 3: presents the mean difference in students' retention scores between experimental and control groups exposed to the Main Idea Web (MIW) instructional strategies. With respect to retention of the students exposed to the Main-Idea-Web, male students in the experimental group obtained a higher mean retention score ($M = 17.54, SD = 5.66$) compared to male students in the control group, who recorded a mean score of 9.06 ($SD = 3.51$). This result indicates that the Main Idea Web strategy improved retention among male students. Likewise, female students exposed to the Main Idea Web in the experimental group recorded a mean retention score of 20.95 ($SD = 3.24$), which was higher than that of female students in the control group, who obtained a

mean score of 13.88 ($SD = 4.62$). This suggests that the Main Idea Web strategy also enhanced retention among female students. By implication, the findings indicate that Main Idea Web instructional strategies significantly improved students' retention across gender. Female students generally demonstrated slightly higher retention scores than male students, suggesting a modest gender difference in retention outcomes.

H2: There is no significant difference in the mean retention score between male and female students taught nutrient cycling in nature and pollution with main-idea-web teaching strategies, and those taught with conventional methods.

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Table 4: ANCOVA results of male and female student taught using MIW

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3412.764 ^a	4	853.191	46.204	.000
Intercept	810.035	1	810.035	43.867	.000
MIW Post test	8.830	1	8.830	.478	.490
Group	1433.097	1	1433.097	77.609	.000
Gender	581.590	1	581.590	31.496	.000
Group * Gender	26.980	1	26.980	1.461	.228
Error	3286.886	178	18.466		
Total	53804.000	183			
Corrected Total	6699.650	182			

a. R Squared = .509 (Adjusted R Squared = .498); Dependent Variable: MIW post test

Table 4 presents a two-way Analysis of Covariance (ANCOVA) conducted to determine the effects of Main-Idea-Web instruction and gender on students' retention scores, while controlling for students' posttest achievement (MIW Post test). The corrected model was statistically significant, $F(4,178) = 46.20, p < 0.001$, indicating that the combination of the covariate, group, gender, and their interaction significantly explained variation in students' retention scores. The model accounted for 50.9% of the variance in retention outcomes ($R^2 = .509$; Adjusted $R^2 = .498$), suggesting a strong explanatory power.

The covariate, MIW Post test, did not have a statistically significant effect on retention, $F(1,178) = 0.48, p = 0.490$. This implies that students' immediate posttest performance did not significantly predict their retention scores once group and gender were considered. The main effect of the Main-Idea-Web was statistically significant, $F(1,178) = 77.61, p < 0.001$. This finding shows that there was a significant difference in retention between the experimental and control groups after adjusting for posttest scores. Hence, the Main Idea Web instructional strategy had a strong influence on students' retention. The main effect of gender was also statistically significant, $F(1,178) = 31.50, p < 0.001$, indicating that male and female students differed significantly in their retention performance, irrespective of instructional group.

However, the interaction between Main-Idea-Web instructional and gender was not

statistically significant, $F(1,178) = 1.46, p = 0.228$. This suggests that the effect of the Main Idea Web strategy on retention was similar for both male and female students. The intercept was statistically significant, $F(1,178) = 43.87, p < 0.001$, indicating that the adjusted mean retention score differed significantly from zero when all predictors were held constant.

DISCUSSION OF FINDINGS

The findings of the study in table one and two revealed that students taught Nutrient Cycling in Nature and Pollution using Main-idea-web Teaching Strategy demonstrated higher retention scores than their counterparts taught using the conventional lecture method. The mean retention score of students in the experimental group was higher than that of students in the control group, indicating that the use of Main-Idea-Web Teaching Strategy enhanced students' ability to retain learned concepts over time. Furthermore, the ANCOVA result showed that there was a statistically significant difference in the mean retention scores of students taught using Main-Idea-Web Teaching Strategy and those taught using the conventional lecture method at the 0.05 level of significance. Consequently, the null hypothesis which stated that there is no significant difference in the mean retention scores of students taught Nutrient Cycling in Nature and Pollution using Main-Idea-Web Teaching Strategy and those taught using the conventional lecture method was rejected.

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The improved retention observed among students exposed to Main-Idea-Web Teaching Strategy may be attributed to the visual and detail organization of concepts provided by the strategy. Main-idea-web present concepts in a logical and detailed manner, thereby helping learners to establish meaningful relationships among concepts and processes. Since Nutrient Cycling in Nature and Pollution involves interconnected ecological processes such as carbon cycle, nitrogen cycle, decomposition, and environmental interactions, the strategy may have facilitated better understanding and long-term retention of concepts. The strategy also possibly encouraged active participation and meaningful learning by linking new knowledge with students' prior knowledge.

The finding of this study is in agreement with the theory of meaningful learning proposed by Ausubel (1963), which emphasized that learners retain information better when instructional materials are properly organized and related to existing cognitive structures. The finding also supports the studies of Uba et al. (2017) who found that graphic organizers significantly improved students' comprehension and retention of learned materials. Wallace et al. (2023) reported that graphic organizer-based instructional activities improved students' performance, engagement, and retention in Biology courses. Likewise, Kpiranyam et al. (2023) found that Graphic Advance Organizer approach significantly enhanced students' retention and performance in Biology when compared with conventional discussion method.

In the same vein, Umeana (2023) revealed that mind-mapping instructional strategy significantly improved students' retention and achievement in Biology among secondary school students. Imam and Olorundare (2023) also reported that graphic organizers improved students' learning outcomes in science subjects by enhancing meaningful learning and retention of concepts. However, the finding of the present study partly disagrees with Ollero (2023), who reported that retention in Biology concepts may not depend solely on instructional strategy but could also be influenced by factors such as

students' learning styles and individual differences. Despite this contrasting view, the current study established that Main-Idea-Web Teaching Strategy contributed significantly to improving students' retention in Nutrient Cycling in Nature and Pollution.

The findings of the study in table three and four revealed that both male and female students taught Nutrient Cycling in Nature and Pollution using Main-Idea-Web Teaching Strategy obtained higher retention scores than their counterparts taught using the conventional method. The mean retention difference for male students exposed to Sequence Chart Teaching Strategy was higher than that of male students in the control group. Similarly, female students taught using Main-Idea-Web Teaching Strategy demonstrated better retention scores than female students taught using the conventional lecture method. This indicates that the strategy enhanced retention among both male and female students.

Furthermore, the ANCOVA result revealed that there was a significant difference in the mean retention scores between male and female students taught Nutrient Cycling in Nature and Pollution using Main-Idea-Web Teaching Strategy and those taught using the conventional method. The result also showed a significant interaction effect between teaching strategy and gender on students' retention, as the probability values for gender and Group. Gender interaction were less than the 0.05 level of significance. Consequently, the null hypothesis which stated that there is no significant difference in the mean retention scores between male and female students taught Nutrient Cycling in Nature and Pollution using Main-Idea-Web Teaching Strategy and those taught using conventional teaching method was rejected.

The significant retention difference observed among male and female students may be attributed to the ability of the Main-Idea-Web Teaching Strategy to simplify abstract and process-oriented concepts through visual and detailed presentation of information. The strategy possibly enabled students to organize ecological concepts logically, thereby improving comprehension and long-term retention. Since

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Nutrient Cycling in Nature and Pollution involves interconnected processes such as nutrient movement, decomposition, and environmental interactions, the Main-Idea-Web strategy may have enhanced meaningful learning among both genders. The finding agrees with Yusuf and Afolabi (2022), who found that graphic organizers improved students' retention in Biology among male and female secondary school students. However, the present finding contrasts with studies that reported no significant gender influence on students' retention when innovative instructional strategies were used (Chukwu & Samuel, 2022; Adeyemi & Bello, 2023).

CONCLUSION

Based on the findings of the study, it was concluded that Main-Idea-Web Teaching Strategy significantly improved secondary school students' retention in Nutrient Cycling in Nature and Pollution compared with the conventional lecture method. Students exposed to the Main-Idea-Web Teaching Strategy demonstrated better retention of learned concepts due to the visual and sequential organization of information provided by the strategy. The study further revealed that both male and female students benefited from the use of the strategy, although significant differences existed in retention based on gender. The study therefore established that Main-Idea-Web Teaching Strategy is an effective learner-centered instructional approach capable of enhancing meaningful learning and long-term retention of Biology concepts among secondary school students in Kano State, Nigeria.

RECOMMENDATIONS

Biology teachers should adopt Main-Idea-Web Teaching Strategy in teaching biology. Similarly, Curriculum planners and educational authorities should encourage the integration of Main-Idea-Web instructional strategies into Biology teaching.

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