Zamfara International Journal of Education (ZIJE)
The Official Journal of the Faculty of Education
Federal University Gusau, Zamfara State, Nigeria
Volume 6, Number 4, June, 2026
pISSN: (Hard Copy): 2814 – 1377; eISSN (Online): 2814 – 1369 www.foefugusau.com.ng
DOI: **https://doi.org/10.64348/zije.2026458**

Effects of Sequence-Chart Strategy on Retention in Nutrient-Cycling in Nature and Pollution among Secondary School Students in Nassarawa Education Zone, Kano-State, Nigeria

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Abstract

This study investigated the effect of Sequence-Chart (SQC) 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 340 SSII students were taught using SQC 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 SQC 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 Sequence-Chart teaching strategy is more effective than conventional teaching method in improving students' retention in Nutrient Cycling in Nature and Pollution. It was recommended that Biology teachers should adopt SQC strategy to enhance students' understanding and retention of complex biological concepts.

Keywords: Sequence-Chart, Retention, Biology, Graphic-Organizer, Nutrient-Cycling, Pollution

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 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

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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 Teaching Strategy (Kuthuria, 2019; Akanbi et al., 2021; Aina & Ogunkule, 2022; Velarde, 2019; Lynch, 2021).

Sequence chart is a type of graphic organizer that presents information in a logical and sequential manner, thereby helping learners to organize ideas, identify relationships among concepts, and understand step-by-step processes effectively. Graphic organizers enhance meaningful learning by connecting new information with learners' prior knowledge and improving visualization of concepts (Uba et al., 2017). Since Nutrient Cycling in Nature and Pollution involves cycles, stages, and interconnected ecological processes, the use of sequence chart may facilitate better understanding and improve students' retention of concepts. Previous studies on graphic organizers, concept maps, mind maps, and advance organizers have shown that visual instructional strategies enhance students' retention and academic performance in science subjects (Okebukola, 1990; Novak & Gowin, 1984). The theoretical foundation for the use of sequence chart 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, sequence chart teaching 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 Sequence Chart 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 sequence-chart teaching strategy on retention in Nutrient Cycling in Nature and Pollution concepts among secondary school Biology Students in Kano State, Nigeria.
2. To determine gender difference among senior secondary school Biology students' retention in Nutrient Cycling in Nature and Pollution when taught using sequence-chart teaching strategy in Kano State, Nigeria

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Research Questions

1. To what extent does the mean differ in students' retention taught nutrients cycling in nature and pollution with sequence chart 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 sequence-chart, and those taught with conventional teaching method?

Research Hypotheses

H_{01}: There is no significant mean difference in the retention of students taught nutrients cycling in nature and pollution with sequence-chart, and those taught with conventional methods of teaching.

H_{02}: There is no significant mean difference in the retention of male and female students taught nutrients cycling in nature and pollution with sequence-chart, and those taught with conventional methods of teaching

Research 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 340 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. 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.

Presentation of Results

Research Question one: To what extent does the mean differ in students' retention taught nutrients cycling in nature and pollution with sequence chart 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 a Sequence Chart	Experimental	98	21.93	2.48		Favours SQC
	Control	85	11.95	4.81	9.98	

Table 1 reveals the retention scores of students taught with the Sequence Chart and conventional method of teaching, the experimental group recorded a substantially higher mean score ($\bar{x}$ = 21.93, *SD* = 2.48) compared to the control group, which obtained a mean score of 11.95 with a standard deviation of 4.81. The mean difference of 9.98 indicates a large advantage in favor of the experimental group. This result suggests that the Sequence Chart instructional strategy significantly enhanced students' retention of learning content. By implication, the findings reveal that Sequence Chart instructional strategies was effective in improving students' retention.

H_{01}: There is no significant difference in mean retention score of students taught nutrients cycling in nature and pollution with sequence chart teaching strategies, and those taught with conventional methods of teaching.

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

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Corrected Model	4572.513[a]	2	2286.256	164.772	0.000
Intercept	939.827	1	939.827	67.734	0.000
SC_Post_test	42.759	1	42.759	3.082	0.081

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Group	2341.000	1	2341.000	168.717	0.000
Error	2497.553	180	13.875		
Total	61809.000	183			
Corrected Total	7070.066	182			

a. R Squared = .647 (Adjusted R Squared = .643), Dependent Variable: SQC_post_post_test

Table 2 presents the results of an Analysis of Covariance (ANCOVA) conducted to examine the effect of instructional group on students' retention scores, while controlling for posttest achievement (SC_Post_test). The corrected model was statistically significant, $F(2,180) = 164.77, p < 0.001$, indicating that the combined effects of the covariate and group significantly explained variance in students' retention scores. The model accounted for 64.7% of the variance in retention outcomes ($R^2 = 0.647; AdjustedR^2 = 0.643$), demonstrating a very strong explanatory power. The covariate, SC_Post_test, did not have a statistically significant effect on students' retention scores, $F(1,180) = 3.08, p = 0.081$. This result suggests that posttest achievement did not significantly influence retention after controlling for group differences. In contrast, the group effect was statistically significant, $F(1, 180) = 168.72$, $p < .001$. This finding indicates that there was a significant difference in retention scores between the experimental and control groups after adjusting for posttest achievement. Thus, instructional group had a very strong and statistically significant effect on students' retention. The intercept was also statistically significant, $F(1,180) = 67.73, p < 0.001$, indicating that the adjusted mean retention score differed significantly from zero when all predictors were held constant. In summary, the ANCOVA results reveal that although posttest achievement did not significantly predict retention, instructional group exerted a dominant and significant influence on students' retention scores. This provides strong empirical evidence that the Sequence Chart instructional strategy was highly effective in enhancing students' retention compared to the control method.

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 sequence chart teaching strategies and those taught with conventional method of teaching based on gender?

Table 3: Mean Difference between Male and Female Students' Retention taught Sequence Chart.

Gender	Group	N	$\bar{x}$	SD	M/dff	Remark
Male Retentions SC	Experimental	39	21.46	1.96		Favour male students
	Control	34	9.06	3.51	12.4	
Female Retention SC	Experimental	59	22.24	2.74		Favour female students
	Control	51	13.88	4.62	8.36	

Table 3 shows retention under the Sequence Chart, male students in the experimental group recorded a substantially higher mean retention score (M = 21.46, SD = 1.96) compared to their counterparts in the control group, who obtained a mean score of 9.06 (SD = 3.51). This result indicates a pronounced improvement in retention among male students exposed to the Sequence Chart strategy. Similarly, female students in the experimental group achieved a higher mean retention score (M = 22.24, SD = 2.74) than female students in the control group, who recorded a mean score of 13.88 (SD = 4.62). This finding demonstrates that the Sequence Chart strategy was effective in enhancing retention for female students as well. By implication, the findings indicate that the Sequence Chart instructional strategies significantly improved students' retention across gender. However, the magnitude of improvement was greater for the Additionally, female students in the experimental groups generally demonstrated slightly higher retention scores than male students, suggesting a modest gender difference in retention outcomes.

H_{02}: There is no significant difference in the mean retention score between male and female students taught nutrient cycling in nature and pollution with sequence chart teaching strategies, and those taught with conventional methods.

Table 4: ANCOVA result of male and female students using SQC and Conventional method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5032.573[a]	4	1258.143	109.914	.000
Intercept	1344.219	1	1344.219	117.434	.000
SC_Post_test	14.054	1	14.054	1.228	.269
Group	2718.624	1	2718.624	237.505	.000
Gender	347.667	1	347.667	30.373	.000
Group * Gender	191.568	1	191.568	16.736	.000
Error	2037.493	178	11.447		

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Total	61809.000	183
Corrected Total	7070.066	182

a. R Squared = .712 (Adjusted R Squared = .705); Dependent Variable: SC_post_post_test

The table four presents the ANCOVA results conducted to determine the effects of sequence chart instruction strategy and gender on students' retention scores, while controlling for posttest achievement (SC_Post_test). The corrected model was statistically significant, $F(4,178) = 109.91, p < 0.001$, indicating that the combined effects of the covariate, group, gender, and their interaction significantly explained variance in students' retention scores. The model accounted for 71.2% of the variance in retention ($R^2 = 0.712$; Adjusted $R^2 = 0.705$), demonstrating a very strong explanatory power. The covariate, SC_Post_test, did not have a statistically significant effect on retention, $F(1,178) = 1.23, p = 0.269$. This suggests that students' posttest achievement did not significantly predict their retention scores after accounting for instructional strategy (group) and gender. The main effect of the sequence chart was highly statistically significant, $F(1,178) = 237.51, p < 0.001$. This finding indicates a substantial difference in retention between the experimental and control groups after adjusting for posttest scores, showing that the Sequence Chart instructional strategy had a very strong positive influence on retention.

The main effect of gender was also statistically significant, $F(1,178) = 30.37, p < 0.001$, revealing that male and female students differed significantly in their retention performance regardless of group. Importantly, the interaction effect between group and gender was statistically significant, $F(1,178) = 16.74, p < 0.001$. This result implies that the impact of the Sequence Chart strategy on retention varied by gender; in other words, one gender benefited more from the instructional intervention than the other. The intercept was statistically significant, $F(1,178) = 117.43, p < 0.001$, indicating that the adjusted mean retention score differed significantly from zero when all predictors were held constant.

In summary, the results demonstrate that while posttest achievement did not significantly influence retention, instructional strategy and gender both had strong effects, and importantly, the effectiveness of the Sequence Chart strategy depended on gender. This suggests a differential benefit of the intervention for male and female students.

Discussion of findings

The findings of the study in table one and two revealed that students taught Nutrient Cycling in Nature and Pollution using Sequence Chart 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 Sequence Chart 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 Sequence Chart 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 Sequence Chart Teaching Strategy and those taught using the conventional lecture method was rejected. The improved retention observed among students exposed to Sequence Chart Teaching Strategy may be attributed to the visual and sequential organization of concepts provided by the strategy. Sequence charts present concepts in a logical and stepwise 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

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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 Sequence Chart 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 Sequence Chart 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 Sequence Chart 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 Sequence Chart 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 Sequence Chart 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 Sequence Chart Teaching Strategy to simplify abstract and process-oriented concepts through visual and sequential presentation of information. The strategy possibly enabled students to organize ecological concepts logically, thereby improving comprehension and long-term retention. Since Nutrient Cycling in Nature and Pollution involves interconnected processes such as nutrient movement, decomposition, and environmental interactions, the sequence chart 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 Sequence Chart 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 Sequence Chart 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 Sequence Chart 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

1. Biology teachers should adopt Sequence Chart Teaching Strategy in teaching abstract and process-oriented concepts such as Nutrient Cycling in Nature and Pollution in order to enhance students' retention and meaningful understanding of concepts.
2. Curriculum planners and educational authorities should encourage the integration of graphic organizer instructional strategies into Biology curriculum and classroom instruction at the secondary school level.
3. Teacher training institutions and professional development programmes should organize workshops, seminars, and conferences to train Biology teachers on the effective use of Sequence Chart Teaching Strategy and other learner-centered instructional approaches.

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