EFFECTS OF SPIDER AND FLOWCHART CONCEPT MAPPING INSTRUCTIONAL STRATEGIES ON STUDENTS' ATTITUDE, PERFORMANCE AND RETENTION OF ECOLOGY CONCEPTS IN SECONDARY SCHOOLS IN KATSINA STATE

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Abstract
This study investigated the effects of spider and flowchart concept mapping instructional strategies on students' attitudes, performance and retention of ecology concepts among secondary schools in Katsina state. The study adopted a quasi-experimental, non-equivalent control group design involving 185 SSII students drawn from three coeducational secondary schools in Katsina zonal education quality assurance. Participants were assigned to three groups: spider concept mapping, flowchart concept mapping, and the conventional method. Two instruments, the Ecology Performance Test (r = 0.84) and the Ecology Attitude Scale (α = 0.82), were used to collect the data. Treatment lasted ten weeks, after which post-test and retention tests were administered. Data were analyzed using descriptive statistics of mean, standard deviation and ANCOVA at a 0.05 significance level. Findings revealed significant main effects of treatments on students' attitudes, performance and retention in ecology concepts. Students taught with spider and flowchart concept mapping strategies outperformed those taught with the conventional method. The study concluded that these concept mapping strategies enhance long-term recall of ecology concepts. It is recommended that biology teachers adopt spider and flowchart concept mapping in teaching ecology; teacher-training agencies should organize capacity-building programs for effective use of these strategies; and curriculum planners should integrate concept mapping into biology instruction to improve students' cognitive and affective learning outcomes.
Keywords: Spider concept mapping, Flowchart concept mapping, Ecology, Retention.

Introduction

Biology, a major branch of the natural sciences, deals with the study of living organisms and their interactions with the environment (Odaibo, 2022 & Ajaja, 2021). Among its core areas, ecology provides essential knowledge about the interrelationships among living organisms and between organisms and their physical surroundings (Nasr, 2021). Despite its relevance to environmental sustainability and global concerns, students in Nigerian secondary schools continue to perform poorly in ecology-related concepts (Oke, 2022 & Nwosu, 2022). This persistent difficulty has been linked to abstract content delivery and the consistent use of conventional teaching methods that emphasize rote learning instead of conceptual understanding (Garba, 2022 & Adeyemi, 2021).

Research has shown that concept mapping can enhance students' meaningful learning, conceptual linkage, and retention (Baba et al., 2023 & Gana, 2023). Concept maps are graphical

tools that help learners visualize relationships among ideas, allowing them to integrate new knowledge with prior understanding (Omoniyi, 2021 & Salau, 2020). Two major types relevant to biology instruction are spider and flowchart concept maps. Spider maps arrange subtopics around a central idea, promoting visualization of relationships (Martins, 2021), while flowchart maps present processes sequentially, aiding logical and procedural reasoning (Markow, 2021). Students' attitude toward learning plays a crucial role in academic performance and retention. Positive attitudes enhance retention and understanding, while negative attitudes reduce comprehension and recall (Adesoji, 2021 & Gana, 2023). Retention is the ability to remember and apply learned concepts, is improved through strategies that encourage meaningful engagement (Baba et al., 2023). However, persistent low performance in biology suggests that such strategies are not widely applied in schools.

Statement of the Problem

Despite the centrality of ecology in the secondary school biology curriculum, students' retention of the learned concepts in this area has remained persistently low. Reports from national examinations reveal that only 26–50% of candidates obtained credit passes in Biology between 2020 and 2022, with ecology-related items ranking among the most poorly attempted sections (Adeyemi, 2022 & Nimnan et al., 2023). This recurring trend suggests deeper instructional and learning challenges that continue to undermine students' performance in the subject. Studies have identified several contributory factors, including students' negative attitudes towards ecology concepts, poor retention of learned materials, and teachers' continued use of traditional-based instructional methods that encourage rote learning rather than understanding (Garba, 2022 & Iorlaha et al., 2021). These conventional approaches do not adequately support visualization, organization of ideas, or active engagement essential elements required for comprehending abstract and interconnected ecological relationships (Nwosu, 2022 & Omoniyi, 2021). Therefore, many students struggle to integrate concepts meaningfully, leading to misconceptions, low motivation, and poor long-term retention. Although innovative instructional strategies such as concept mapping have been widely acknowledged for their effectiveness in enhancing students' attitude, performance, and retention, their utilization in secondary schools remains notably low. Within concept mapping, the spider and flowchart formats offer distinct strengths in helping learners visualize hierarchical and relational structures in ecology. However, limited empirical evidence exists on their comparative effects in improving students' learning outcomes in the subject within the local context. This creates a critical need to investigate how spider and flowchart concept mapping strategies affect students' attitude, performance, and retention of ecology concepts in secondary schools in Katsina state.

Objectives of the Study

1. Determine the main effect of the treatments (spider, flowchart, and conventional method) on the attitude of secondary school students toward ecology concepts.
2. Find out the main effect of the treatments (spider, flowchart, and conventional method) on the academic performance of secondary school students in ecology concepts.

3. Investigate the main effect of the treatments (spider, flowchart, and conventional method) on the retention ability of secondary school students of ecology concepts.

Research Questions

1. What is the main effect of the treatments (spider, flowchart, and conventional method) on the attitude of secondary school students toward ecology concepts?
2. What is the main effect of the treatments (spider, flowchart, and conventional method) on the academic performance of secondary school students in ecology concepts?
3. What is the main effect of the treatments (spider, flowchart, and conventional method) on the retention ability of secondary school students of ecology concepts?

Hypotheses

1. There is no significant main effect of the treatments (spider, flowchart, and conventional method) on the attitude of secondary school students toward ecology concepts.
2. There is no significant main effect of the treatments (spider, flowchart, and conventional method) on the academic performance of secondary school students in ecology concepts.
3. There is no significant main effect of the treatments (spider, flowchart, and conventional method) on the retention ability of secondary school students in ecology concepts.

Methodology

The study adopted a 3×2 factorial and quasi-experimental design, specifically a pretest-posttest, non-equivalent control group design involving intact classes. Intact classes were used, where participants were assigned to either an experimental group, taught using the spider concept mapping, flowchart concept mapping strategy, or a control group, which received instruction via the conventional method. All the groups were administered a pretest to determine their baseline academic performance. This enabled the researcher to check for initial group equivalence, which was statistically controlled using ANCOVA. Gender was included as a moderating variable to investigate possible interaction effects with treatment. Hence, coeducation schools were used, thereby isolating single gender schools.

The study used a sample of one hundred and eighty-five students (185) from the three selected sample schools. The researcher employed a multi-stage sampling technique of three sampling techniques used to select the participants from the list of twenty-two (22) coeducational secondary schools, thereby isolating four (04) single-gender schools. Initially, stratified sampling was used to divide the study area into three strata based on the local governments in the study area. Next, random sampling was employed using balloting to select three schools, one 1) from each local government. The first school picked was tagged as experimental group one (1), the second school picked was labeled as experimental group two (2), and the third school (3) was assigned as the control group. For this study, one intact senior secondary school II class was purposively selected from each of the three participating schools.

This study used two instruments for data collection. These include: the Ecology Performance Test and Ecology Attitude Scale. This study involved the Ecology Performance Test (EPT) as

the instrument for data collection, adapted from WAEC and NECO pass questions from 2015 to 2020. The items contained forty (30) multiple-choice questions in responses (option A-D) of which one is the correct answer, while the remaining are distractors. The Ecology Attitude Scale (EAS) was adapted from Eravwoke (2021) and administered to the respondents during the pretest, posttest, and post-test to assess students' attitude toward studying ecology concepts before and after the treatment to determine the effects of the treatment. The EAS was divided into two sections (A and B). Section A contains general information on students, and Section B collects information on their attitude toward ecology concepts. The EAS was made up of predominantly closed-ended items on a four-point Likert scale ranging from strongly agree (SA), agree (A), disagree(D), and strongly disagree (SD).

The validation exercise was conducted to determine the reliability of the Ecology Performance Test (EPT) and Ecology Attitude Scale for the study. A co-educational school not part of the main study was purposively selected for the pilot testing. In doing this, the instruments were administered to the students, and the data were collected by test-retest and analyzed using the Pearson Product-Moment Correlation Coefficient (PPMC) to determine the reliability of the items, which was found to have a value of 0.84. While Cronbach's Alpha was used for the reliability of the EAS because it is a four-point Likert scale instrument, it was found to have an R-value of 0.82.

The treatment exercise for the study commenced immediately after the pretest and concluded in 10 weeks, focusing on ecology. The instruction employed a flowchart mapping strategy, as well as the conventional teaching method. A detailed, week-by-week lesson plan for each group, experimental group (flowchart), and control group (conventional) guided the teaching procedure, covering the subtopics in ecology. Following the four-week instructional intervention, a posttest was conducted to evaluate the effects of the instructional strategies. Similarly, a post-posttest was administered two weeks later to determine the retention of the learned ecology, and the instrument was rearranged to avoid guising answers. This interval aligns with cognitive psychology literature (Bahrick & Hall, in Novac & Canas, 2008), which supports shorter retention intervals for school-based studies.

Descriptive statistics involving mean, standard deviation, and mean difference were used to answer the research questions, and an inferential statistical tool was used to test the null hypotheses formulated. All the hypotheses were tested at a 0.05 level of significance using the analysis of covariance (ANCOVA), controlling for covariate effects between pretest and posttest scores in the sampled intact classes. The data collected were subjected to normality tests. The Statistical Package for the Social Sciences (SPSS, version 25) computer analysis software was used for all data analyses in this study.

Research Question One: What is the main effect of the treatments (spider, flowchart, and conventional method) on the attitude of secondary school students toward ecology concepts?

Table 1: Mean, Std. Deviation and Mean difference of the main effect of the treatments (spider, flowchart, and conventional method) on students' attitude toward ecology concepts.

Group	N	Mean	Std. Deviation	Mean Difference
Spider Concept Mapping Strategy	**75**	**50.69**	**8.506**	**1.37**
Flowchart Concept mapping	50	49.32	7.993	
Spider Concept Mapping Strategy	**75**	**50.69**	8.506	**28.77**
Conventional method	60	21.92	3.466	
Flowchart Concept mapping	**50**	**49.32**	7.993	**27.7**
Conventional Method	60	21.92	3.466	

Table 1 presents the analysis of the main effect of treatments (spider, flowchart, and conventional method) on the attitude of secondary school students toward ecology concepts. From the results, students taught using the spider and flowchart concept mapping strategies have a mean attitude of 50.69 and 49.32, and a standard deviation of 8.506 and 7.993, while the conventional method has a mean attitude of 21.92 and a standard deviation of 3.466. However, students' attitudes in the spider and flowchart concept mapping strategies have a mean difference of 1.37; the mean difference between the spider and conventional method is 28.77, while the mean difference between the flowchart and conventional method is 27.7. This implies that students in the spider concept mapping strategy group recorded a higher mean than the flowchart concept mapping strategy and conventional method groups.

Research Question Two: What is the main effect of the treatments (spider, flowchart, and conventional method) on the performance of secondary school students in ecology concepts?

Table 2: Mean, Std Deviation, and Mean difference of the main effect of treatments (spider, flowchart, and conventional method) on the students' performance in ecology concepts

Group	N	Mean	Std. Deviation	Mean Difference
Spider Concept Mapping Strategy	**75**	**22.47**	**2.748**	**0.69**
Flowchart Concept Mapping Strategy	50	22.88	3.008	
Spider Concept Mapping Strategy	**75**	**22.47**		**4.25**
Conventional method			2.748	
	60	17.90		
			3.378	
Flowchart Concept Mapping Strategy	**50**	**22.88**		**4.94**
			3.008	
	60	17.90		
Conventional Method			3.7511	

Table 2 presents the analysis of the treatments' (spider, flowchart, and conventional method) main effect on secondary school students' performance in ecology concepts. According to the results, students taught using the spider and flowchart concept mapping strategies achieved a higher mean performance of 22.47 and 22.88, and standard deviation of 2.748 and 3.008, respectively, compared to those in the conventional method, which had a mean performance of 17.90 and a standard deviation of 3.751. However, students' performance in the spider and flowchart concept mapping strategies has a mean difference of 0.69. The mean difference between the spider and conventional method is 4.57, while the mean difference between the flowchart and conventional method is 4.95. This implies that students in the flowchart concept mapping strategy group recorded a higher mean than the spider and conventional method groups.

Research Question Three: What is the main effect of the treatments (spider, flowchart, and conventional method) on the retention ability of secondary school students in ecology concepts?

Table 3: Mean, Std. Deviation and Mean difference of students' main effect of the treatments (spider, flowchart, and conventional method) on students' retention of ecology concepts

Group	N	Mean	Std Deviation	Mean Difference
Spider Concept Mapping Strategy	**75**	**21.64**	**2.524**	**0.68**
Flowchart Concept Mapping strategy	50	22.14	2.148	
Spider Concept Mapping Strategy	**75**	**21.64**		**3.51**
Conventional method			2.524	
	60	17.92		
			3.326	
Flowchart Concept Mapping strategy	**50**	**22.14**		**4.20**
			2.148	
	60	17.92		
Conventional Method			3.326	

Table 3 presents the analysis of the main effect of treatments (spider, flowchart, and conventional method) on the retention ability of secondary school students in ecology concepts. According to the results, students taught using the spider and flowchart concept mapping strategies achieved a high mean performance score of 21.64 and 22.14, and a standard deviation of 2.4 and 2.148, respectively, compared to those in the conventional method group, which had a mean performance score of 17.92 and a standard deviation of 3.326. However, students' retention ability in the spider and flowchart concept mapping strategies has a mean difference of 0.68, the mean difference between the spider and conventional method is 3.51, while the mean difference between the flowchart and conventional method is 4.20. This implies that students in the flowchart concept mapping strategy group recorded a higher mean than the spider and conventional method groups.

Hypothesis Testing

The following null hypotheses were tested at a 0.05 level of significance

Hypothesis One: There is no significant main effect of the treatments (spider, flowchart, and conventional method) on the attitude of secondary school students toward ecology concepts

Table 4: An ANCOVA of the main effect of treatments (spider, flowchart, and conventional method) on the attitude of students toward ecology concepts

Source	Type III Sum of Squares	Df	Mean Square	F	*P*-value	Decision
Corrected Model	32412.289[a]	3	10804.096	213.961	.000	
Intercept	14258.170	1	14258.170	282.365	.000	
Pretest	53.720	1	53.720	1.064	.304	
Treatment	20564.712	2	10282.356	203.629	.000	Sig
Error	9139.690	181	50.496			
Total	352373.000	185				
Corrected Total	41551.978	184				

Significant (p< 0.05)

Table 4 presents the analysis of the main effect of the treatments (spider, flowchart, and conventional method) on students' attitudes toward ecology concepts. Results show that the [F (2, 181) = 203.629; p<0.05] indicated a significant main effect of treatment on students' attitude among the groups. To identify the group(s) causing this effect, a pairwise comparison was conducted as shown in Table 4.5

Table 5: Pairwise comparison of the main effect of the treatments (spider, flowchart, and conventional method) on the attitude of students

(I) Treatment	(J) Treatment	Mean Diff. (I-J)	Std Error	P-value	Decision
Spider	Flowchart	-.685	.514	.185	Not Sig.
Spider	Conventional	3.515	.495	.000	Sig.
Flowchart	Conventional	4.200*	.521	.000	Sig.

Table 5 showed no significant effect of the treatments (spider, flowchart, and conventional method) on the students' attitude toward ecology concepts in the experimental groups, taught using the spider and flowchart concept mapping strategies (mean difference = -0.685; p > 0.05). However, a significant difference exists between the spider and conventional groups with a mean difference of 3.515 (p<0.05), and between the flowchart and control groups (mean difference 4.200; p<0.05). This implies that the treatment significantly improved students'

attitudes toward ecology concepts compared to the conventional method. Therefore, the null hypothesis is rejected.

Hypothesis Two: There is no significant main effect of the treatments (spider, flowchart, and conventional method) on the academic performance of secondary school students in ecology concepts

Table 6: An ANCOVA of the main effect of treatments (spider, flowchart, and conventional method) on students' performance in ecology concepts

Source	Type III Sum of Squares	Df	Mean Square	F	*P*-value	Decision
Corrected Model	944.196[a]	3	314.732	34.650	.000	
Intercept	14707.817	1	14707.817	1619.240	.000	
Pretest	31.294	1	31.294	3.445	.065	
Treatment	818.324	2	409.162	45.046	.000	Sig.
Error	1644.052	181	9.083			
Total	84931.000	185				
Corrected Total	2588.249	184				

Significant (p< 0.05)

Table 6 presents the analysis of the treatments' (spider, flowchart, and conventional method) effect on students' performance in ecology concepts. Results show that the [F (2, 181) = 45.046; p<0.05] indicated a significant main effect of treatment on students' academic performance among the groups. To identify the group(s) causing this effect, a pairwise comparison was carried out as shown in Table 7

Table 7: Pairwise comparison of the main effect of the treatments (spider, flowchart, and conventional method) on students' performance in ecology concepts

(I) Treatment	(J) Treatment	Mean Diff. (I-J)	Std Error	P-value	Decision
Spider	Flowchart	.692	.570	.227	Not Sig.
Spider	Conventional	4.253	.549	.000	Sig.
Flowchart	Conventional	4.945	.577	.000	Sig.

Table 7 shows no significant main effect of the treatments (spider, flowchart, and conventional method) on the performance in ecology concepts among students in the experimental groups,

the spider, and the flowchart concept mapping strategies (mean difference = 0.692; p > 0.05). However, a significant effect exists between the spider and control groups with a mean difference of 4.253 (p<0.05), and between the flowchart and control groups (mean difference 4.945; p<0.05). This suggests that the treatment significantly improved students' performance in ecology concepts compared to the conventional method. Therefore, the null hypothesis is rejected.

Hypothesis Three: There is no significant main effect of the treatments (spider, flowchart, and conventional method) on the retention of secondary school students in ecology concepts

Table 8: An ANCOVA of the main effect of the treatments (spider, flowchart, and conventional method) on the retention of students in ecology concepts

Source	Type III Sum of Squares	Df	Mean Square	F	*P*-value	Decision
Corrected Model	645.309[a]	3	215.103	29.140	.000	
Intercept	14367.405	1	14367.405	1946.342	.000	
Pretest	13.787	1	13.787	1.868	.173	
Treatment	577.911	2	288.955	39.145	.000	Sig.
Error	1336.096	181	7.382			
Total	80241.000	185				
Corrected Total	1981.405	184				

Significant (p< 0.05)

Table 8 presents the analysis of the main effect of the treatments (spider, flowchart, and conventional method) on students' retention ability in ecology concepts. Results show that the [F (2, 181) = 39.145; p<0.05] indicated a significant main effect of treatment on students' retention ability among the groups. To identify the group(s) causing this effect, a pairwise comparison was carried out as shown in Table 9.

Table 9: Pairwise comparison of the main effect of the treatments (spider, flowchart, and conventional method) on students' retention in ecology concepts

(I) Treatment	(J) Treatment	Mean Diff. (I-J)	Std Error	P-value	Decision
Spider	Flowchart	-.692	.570	.227	Not Sig.
Spider	Conventional	4.253*	.549	.000	Sig.
Flowchart	Conventional	4.945*	.577	.000	Sig.

Table 9 shows no significant main effect of the treatments (spider, flowchart, and conventional method) on the retention of ecology concepts among the students in the experimental groups, the spider, and the flowchart concept mapping strategies (mean difference = -0.692; $p > 0.05$). However, a significant effect exists between the spider and control groups with a mean difference of 4.253 ($p<0.05$), and between the flowchart and control groups (mean difference 4.945; $p<0.05$). This indicates that the treatment significantly improved students' retention of ecology concepts compared to the conventional method. Therefore, the null hypothesis that stated no significant main effect of treatment on retention of secondary school students in ecology concepts is rejected.

Discussion of Findings

Finding one in table 1 indicated a significant main effect of treatments (spider, flowchart, and conventional method) on the attitude of students taught ecology concepts. Both the spider and flowchart concept mapping strategies significantly improved students' attitudes compared to the conventional method. Although the spider group recorded slightly higher mean scores than the flowchart group, the difference was not statistically significant. This finding aligns with Bamidele et al. (2021), Nicoll et al. (2020), and Skipper and Mintzes (2020), who reported that spider and flowchart concept mapping strategies foster positive attitudes toward learning. This result may be attributed to the interactive and learner-centered nature of the concept mapping strategy, which promotes collaboration and deeper engagement. However, it contrasts with the findings of Karakuyu (2021), who reported no significant treatment effect on students' attitudes. Previous studies (Iwan et al., 2023; Ibrahim et al., 2023; Salomi et al., 2021; Akeju, 2021) have consistently affirmed that spider and flowchart concept mapping strategies enhance students' affective outcomes by linking complex and interconnected concepts with visual representations.

Finding two in table 2 revealed a significant main effect of the treatments (spider, flowchart, and conventional method) on students' performance in ecology concepts. Students taught using the spider and flowchart strategies performed significantly better than those taught using the conventional method, with no significant difference between the two experimental groups. This finding is consistent with Nimnan et al. (2024), Kaponde and Msimuko (2023), and Gana et al. (2023), who found that concept mapping enhances students' academic achievement. It also supports the view of Udeani and Okafor (2021) and Jena (2020) that concept mapping is an activity-based strategy that promotes meaningful learning. However, the finding contradicts Wushishi et al. (2021), who reported no significant difference in performance between the experimental and control groups.

Finding three in table 3 showed a significant main effect of treatment (spider, flowchart, and conventional method) on students' retention of ecology concepts. Although retention did not differ significantly between the spider and flowchart concept mapping groups, students taught using the flowchart strategy recorded slightly higher mean retention scores. Both experimental groups, however, significantly outperformed the conventional group. This supports the findings of Nimnan et al. (2024), Adekoya and Baba (2023), and Gana (2023), who confirmed that spider and flowchart concept mapping strategies improve long-term retention. Similarly,

Baba et al. (2023) noted that the concept mapping strategy enhances students' ability to recall learned concepts better than conventional methods. This may be attributed to the structured visual representation of concepts, which strengthens memory consolidation.

Conclusion

The study concluded that:

1. The spider and flowchart concept mapping strategies significantly improved students' attitudes toward ecology concepts compared to the conventional method.
2. The use of spider and flowchart concept mapping strategies enhanced students' academic performance in ecology concepts more than the conventional method.
3. The spider and flowchart concept mapping strategies facilitated better retention of ecological concepts than the conventional method.

Recommendations

1. Biology teachers should adopt the spider and flowchart concept mapping strategies in teaching ecology concepts to improve students' attitudes, performance, and retention.
2. Both the Federal and State Government of Nigeria, through their agencies such as the Ministry of Education, Teacher Training Institutions, and professional bodies like National Teachers Institute (NTI), Nigeria Educational Research Development Council (NERDC), Science Teachers Association of Nigeria (STAN) etc., should organize workshops, seminars, and in-service training for teachers on the effective use of spider and flowchart concept mapping strategies.
3. Curriculum planners should integrate the spider and flowchart concept mapping strategies into the biology curriculum as recommended teaching approaches, especially for complex and interrelated topics such as ecology concepts.
4. Schools should be adequately equipped with instructional materials that support the use of the spider and flowchart concept mapping strategies to enhance effective teaching and learning.

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