© IIJP 2026 | Volume 2, Issue 3, pp. 931-942 | ISSN: 2636-4484

EFFECT OF BRAINSTORMING INSTRUCTIONAL STRATEGY ON STUDENTS' INTEREST, PERFORMANCE AND RETENTION IN ORGANIC CHEMISTRY AMONG SENIOR SECONDARY SCHOOL STUDENTS IN PLATEAU STATE

***Shaltim Boshi Nimyel[1], Ibrahim Mohammed Danjuma[2], Olarewaju Dauda Musa[3], Sa'adatu Abubakar Mohammed[4]**

[1]Department of Chemistry, Federal University of Education, Pankshin, Plateau State, Nigeria.
[2,3,4]Department of Science Education, Abubakar Tafawa Balewa University, Bauchi, Nigeria.
****Corresponding author:** pirfashaltim@gamil.com*

ARTICLE INFO
Article No.: 0484
Accepted Date: 24/07/2026
Published Date: 10/08/2026
Type: Research

ABSTRACT
This study investigated the effect of brainstorming instructional strategy on senior secondary school students' interest, academic performance, and retention in Organic Chemistry in Plateau State, Nigeria. A quasi-experimental pre-test, post-test, post-posttest control group design was adopted. The sample comprised 91 students, with 55 assigned to the experimental group and 36 to the control group through purposive sampling. Data were collected using the Students' Interest in Chemistry Inventory Scale (SICIS) and a Chemistry Performance Test (CPT). The reliability of the SICIS was established using Cronbach's alpha, while the CPT was validated using the test–retest method. Data were analysed using mean, standard deviation, and independent samples t-test at the 0.05 level of significance. The findings revealed that students exposed to the brainstorming instructional strategy demonstrated significantly higher interest in Organic Chemistry than those taught using the lecture method ($t(89) = 2.888$, $p = .005$). Students in the brainstorming group also achieved significantly higher academic performance ($t(89) = 8.940$, $p < .001$) and better retention of Organic Chemistry concepts ($t(89) = 7.177$, $p < .001$) than their counterparts in the conventional lecture group. The study concludes that brainstorming is an effective instructional strategy for improving students' interest, achievement, and retention in Organic Chemistry. It is therefore recommended that Chemistry teachers integrate brainstorming activities into classroom instruction to promote active participation and enhance learning outcomes.

Keywords: Brainstorming instructional strategy, Organic Chemistry, students' interest, academic performance, retention.

© IIJP 2026 | Volume 2, Issue 3, pp. 931-942 | ISSN: 2636-4484

Introduction

Organic Chemistry is widely regarded as one of the most demanding areas of Chemistry taught in senior secondary schools because it involves abstract concepts, symbolic representations, reaction mechanisms, and extensive application of scientific principles. Many students experience difficulties in understanding the relationships among organic compounds, naming conventions, structural formulae, and reaction pathways, resulting in poor academic achievement and declining interest in the subject. Since Organic Chemistry constitutes a substantial component of the senior secondary Chemistry curriculum, students' understanding of its concepts is essential for success in school examinations and for pursuing science-related careers.

The persistent poor performance of students in Chemistry has remained a concern among educators, curriculum developers, and examination bodies in Nigeria. Successive West African Examinations Council (WAEC) Chief Examiners' Reports have consistently identified candidates' weaknesses in Organic Chemistry, particularly in nomenclature, reaction mechanisms, balancing chemical equations, and the application of chemical concepts to unfamiliar situations. The reports further indicate that many candidates rely on rote memorisation rather than conceptual understanding, leading to poor responses to higher-order questions. According to the West African Examinations Council (WAEC) Chief Examiners' Reports (2022, 2023, 2024), candidates continue to exhibit weaknesses in Organic Chemistry, particularly in nomenclature, reaction mechanisms, balancing chemical equations, structural formulae, and the application of chemical principles to unfamiliar situations.

One factor frequently associated with students' poor achievement in Organic Chemistry is the continued reliance on conventional lecture-based instruction. Although the lecture method enables teachers to cover large portions of the syllabus within a limited period, it often provides few opportunities for students to participate actively in the learning process. Consequently, learners tend to assume passive roles in the classroom, making it difficult for them to develop the analytical, problem-solving, and critical thinking skills required for meaningful understanding of Organic Chemistry concepts.

Recent developments in science education have emphasised learner-centred instructional strategies that encourage active participation, collaboration, and knowledge construction. Among these approaches is brainstorming, a collaborative instructional strategy that allows learners to generate ideas freely, exchange opinions, and solve problems collectively without immediate criticism. Osborne and Pimentel (2022) explained that brainstorming promotes creativity, while Liu and Li (2021) observed that it increases classroom participation and improves conceptual understanding by encouraging students to explain and defend their ideas. Similarly, Malkawi and Smadi (2018) noted that brainstorming develops creative thinking by stimulating the free flow of ideas, whereas Obafemi (2024) reported that the strategy creates an engaging learning environment capable of improving students' understanding of difficult concepts.

Students' interest in learning plays a crucial role in determining the quality of learning outcomes. Interest motivates learners to participate actively in classroom activities, sustain attention during instruction, and invest greater effort in solving academic problems. Studies have shown that active learning strategies, including brainstorming, increase students' enthusiasm for science by making lessons more interactive and engaging. When students are actively involved in classroom activities, they develop stronger intrinsic motivation and curiosity, which subsequently improve their willingness to learn difficult concepts (Chen & Yu, 2020). Zhang and Wei (2023) likewise reported that learner-centred instructional strategies significantly enhance students' engagement and participation during science instruction.

Academic performance is another important indicator of instructional effectiveness. Students who actively construct knowledge through discussion, collaboration, and idea generation often demonstrate better conceptual understanding than those who merely receive information through lectures. Research has shown that active learning strategies improve students' comprehension, analytical reasoning, and problem-solving abilities, thereby enhancing achievement in science subjects. Elma and Bostan (2021) found that inquiry-oriented instructional approaches significantly improve students' academic performance in Chemistry, while Wang and Xu (2022) concluded that active learning strategies consistently produce better learning outcomes in STEM education than traditional teaching methods.

Closely related to academic performance is retention, which refers to learners' ability to remember and apply previously acquired knowledge after instruction has been completed. Retention reflects meaningful learning because it demonstrates that students have internalised concepts rather than memorised facts temporarily for examinations. Students who achieve deeper conceptual understanding are generally more capable of recalling and applying knowledge over time. Akpan and Aminikpo (2017) explained that higher academic achievement is often associated with improved retention, while recent studies suggest that learner-centred instructional strategies facilitate deeper cognitive processing and long-term retention of scientific concepts (Elma & Bostan, 2021; Wang & Xu, 2022).

Despite growing evidence supporting the effectiveness of active learning strategies, conventional lecture-based instruction remains predominant in many Nigerian secondary schools. This continued dependence on teacher-centred methods may contribute to students' declining interest, poor academic performance, and weak retention in Organic Chemistry. It is therefore necessary to investigate whether brainstorming instructional strategy can improve students' interest, academic performance, and retention in Organic Chemistry among senior secondary school students in Plateau State. Such evidence could provide useful guidance for Chemistry teachers, curriculum planners, and educational policymakers seeking to improve science education outcomes.

Statement of the Problem

Despite the importance of Organic Chemistry in the senior secondary school curriculum, students' achievement in the subject has continued to attract concern among educators and examination bodies in Nigeria. Successive West African Examinations Council (WAEC) Chief Examiners' Reports have consistently identified candidates' weaknesses in Organic Chemistry, including poor understanding of IUPAC nomenclature, inability to write balanced chemical equations, poor knowledge of organic compounds, and difficulty applying chemical concepts to solve problems. These persistent weaknesses have contributed to the unsatisfactory performance of candidates in Chemistry examinations over the years. Furthermore, the proportion of candidates obtaining credit passes (A1–C6) in Chemistry has fluctuated considerably, with approximately 55.34% attaining credit level in the 2022 WASSCE, indicating that a substantial proportion of candidates still failed to obtain the minimum credit required for further studies in science-related disciplines.

The continued poor performance in Chemistry suggests that many students experience difficulties in understanding Organic Chemistry concepts, which may be associated with inadequate instructional approaches that encourage passive rather than active learning. In many secondary schools, including those in Plateau State, the conventional lecture method remains the dominant mode of instruction despite growing evidence supporting learner-centred strategies. This instructional practice may contribute to students' low interest, poor academic performance, and

weak retention of Organic Chemistry concepts. Although several studies have examined innovative teaching strategies in science education, there is limited empirical evidence on the effectiveness of brainstorming instructional strategy in improving students' interest, academic performance, and retention in Organic Chemistry among senior secondary school students in Plateau State. It is against this background that this study was undertaken.

Objectives of the Study

Specifically, the study intends to achieve the following objectives which include to:

1. determine the difference between the mean interest scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.
2. determine the difference between the mean performance scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.
3. determine the difference between the mean retention scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

Research Questions

The following research questions were raised to guide the study:

1 What is the difference between the mean interest scores of senior secondary school students taught Organic Chemistry using brainstorming instructional strategy and those taught using the lecture method?

2 What is the difference between the mean performance scores of senior secondary school students taught Organic Chemistry using brainstorming instructional strategy and those taught using the lecture method?

3 What is the difference between the mean retention scores of senior secondary school students taught Organic Chemistry using brainstorming instructional strategy and those taught using the lecture method?

Hypotheses

The following hypotheses were formulated to be tested at 0.05 level of significance.

H_{01}: There is no significant difference between the mean interest scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

H_{02}: There is no significant difference between the mean performance scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

H_{03}: There is no significant difference between the mean retention scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

Methodology

Research Design: This study employed a quasi-experimental pre-test, post-test, post-posttest control group design. The design was considered appropriate because the study involved intact classes in their natural school settings, making random assignment of individual students impracticable. Consequently, one intact class served as the experimental group and was taught Organic Chemistry using the brainstorming instructional strategy, while another intact class served as the control group and received instruction using the conventional lecture method.

Population and Sample: The population of the study comprised senior secondary school students offering Chemistry in Plateau State. A total of 91 students participated in the study, with 55 students in the experimental group and 36 students in the control group. Participants were selected through purposive sampling. The unequal sample sizes resulted from the use of intact classes available in the selected schools rather than assigning students randomly to treatment groups. This approach was adopted to minimise disruption to normal classroom activities while preserving the existing classroom structure required for the quasi-experimental design.

Instruments: Data were collected using the Students' Interest in Chemistry Inventory Scale (SICIS) and the Chemistry Performance Test (CPT). The SICIS is a 21-item questionnaire designed to measure students' interest in Organic Chemistry using a four-point Likert rating scale. The CPT is a 50-item multiple-choice achievement test developed to assess students' understanding of selected Organic Chemistry concepts. The SICIS was administered before and after the treatment, while the CPT served as the pre-test, post-test, and post-posttest instrument for measuring students' academic performance and retention.

Reliability of the Instruments: The instruments were pilot-tested using 80 Senior Secondary II Chemistry students selected from three senior secondary schools outside the study area but with similar characteristics to the study population. The reliability of the Chemistry Performance Test (CPT) was determined using the test–retest method to establish the stability and consistency of the instrument. The scores obtained from the two administrations were analysed using the Pearson Product Moment Correlation Coefficient, which yielded a reliability coefficient of $r = 0.74$. The reliability of the Students' Interest in Chemistry Inventory Scale (SICIS) was established using Cronbach's alpha, which produced a coefficient of $\alpha = 0.75$. These coefficients indicate that the instruments possessed satisfactory reliability for data collection, consistent with the recommendations of Cohen and Swerdlik (2018), Taber (2018), and Ekolu and Quainoo (2019), who considered reliability coefficients of 0.70 and above acceptable for educational research.

Procedure: Before the commencement of the treatment, both the experimental and control groups completed the SICIS and CPT as pre-tests to establish their baseline levels of interest and academic performance. The experimental group was then taught selected Organic Chemistry concepts using the brainstorming instructional strategy, which involved guided idea generation, collaborative discussion, and group problem-solving activities. The control group received instruction on the same content using the conventional lecture method. At the end of the treatment period, both groups completed the SICIS and CPT as post-tests. Four weeks after the post-test, the CPT was re-administered to both groups as a post-posttest to determine students' retention of the concepts taught.

Method of Data Analysis: The data collected were analysed using descriptive statistics (mean and standard deviation) and inferential statistics (independent samples *t*-test) with the aid of the Statistical Package for the Social Sciences (SPSS), Version 25. Prior to conducting the independent samples *t*-test, the assumptions of normality and homogeneity of variance were examined using the Shapiro–Wilk test and Levene's Test for Equality of Variances, respectively. All hypotheses were tested at the 0.05 level of significance.

© IIJP 2026 | Volume 2, Issue 3, pp. 931-942 | ISSN: 2636-4484

Results

Research Question One: What is the difference between the mean interest scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method?

Table 1: Summary of Descriptive Statistics showing the effect of brainstorming learning strategy on Students Interest in Organic Chemistry

Treatment	N	Pre-interest $\bar{x}$	Pre-interest SD	Post-interest $\bar{x}$	Post-interest SD	Mean Gain
Brainstorming method (BS)	55	2.86	0.35	3.07	0.33	0.21
Conventional method (CM)	36	2.87	0.25	2.92	0.35	0.05
Total	91					

The results in table 1 above reveal that the students taught organic chemistry with brainstorming instructional strategy have pre-interest mean score of 2.86 and standard deviation of 0.35, while the post-interest mean score have a valve of 3.07 with a standard deviation of 0.33. This showed a mean gain of 0.21. While the students taught with conventional methods have a mean interest score of 2.87 and standard deviation of 0.25 for pre-interest. The post-interest mean score and standard deviation have valves of 2.92 and 0.35 respectively with a mean gain of 0.05. This result revealed that students taught organic chemistry with brainstorming method developed more interest than those taught with conventional method.

Research Question Two: What is the difference between the mean performance scores of senior secondary school students taught organic chemistry using brainstorming instructional strategies and those taught using lecture method?

Table 2: Summary of Descriptive Statistics showing the effect of brainstorming strategy on academic performance

Treatment	N	Pretest $\bar{x}$	Pretest SD	Posttest $\bar{x}$	Posttest SD	Mean Gain
Brainstorming method (BS)	55	47.87	6.79	61.36	7.32	13.49
Conventional method (CM)	36	47.66	6.49	49.83	5.22	2.177
Total	91					

From table2 above, the academic performance mean scores of students taught organic Chemistry with Brainstorming instructional strategy have a pretest mean score and standard deviation of 47.87 and 6.79 respectively and the posttest mean score and standard deviation were 61.36 and 7.32 respectively, while the mean gain for Brainstorming instructional strategy was 13.49. While students taught with conventional method have pretest mean score of 47.66 and a standard deviation of 6.49, while the posttest mean score was 49.83 and a standard deviation of 5.22 with a mean gain of 2.17. This showed that the students taught with brainstorming teaching method performed better than conventional method with a mean difference of 11.32. This revealed that students taught with brainstorming instructional strategy performed better than the conventional teaching methods.

Research Question Three: What is the difference between the mean retention scores of senior secondary school students taught organic chemistry using brainstorming instructional strategies and those taught using lecture method?

Table 3: Summary of Descriptive Statistics showing the effect of brainstorming strategy on retention

Treatment	N	Pretest		Post-Posttest		Mean Gain
		$\bar{x}$	SD	$\bar{x}$	SD	
Brainstorming method (BS)	55	47.87	6.79	57.34	6.04	9.47
Conventional method (CM)	36	47.66	6.49	50.84	4.39	3.18
Total	91					

The results presented in Table 3 show that students taught Organic Chemistry using the brainstorming instructional strategy had a pre-test mean score of 47.87 with a standard deviation of 6.79, while those taught using the conventional method had a pre-test mean score of 47.66 with a standard deviation of 6.49, indicating that both groups had similar entry-level performance before the treatment. At the post-posttest, students in the brainstorming group obtained a mean score of 57.34 with a standard deviation of 6.04, whereas those in the conventional method group recorded a mean score of 50.84 with a standard deviation of 4.39. The brainstorming group also recorded a higher mean gain of 9.47 compared with the mean gain of 3.18 for the conventional method group. This indicates that students taught using the brainstorming instructional strategy retained more of the Organic Chemistry concepts than those taught using the conventional method.

Hypotheses

H_{01}: There is no significant difference between the mean interest scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

Table 4: Summary of independent sample t-test showing effect of brainstorming on students' interest in organic chemistry

Teaching Methos	N	$\bar{x}$	SD	Df	t-value	p-value	Decision
Brainstorming	55	3.08	0.33	89	2.888	0.005	Significant
Lecture method	36	2.87	0.35				
Total	91						

The table 4, above shows that the effect of brainstorming instructional strategy on students' post-interest mean score in organic chemistry was significant as p-value of 0.005 is less then 0.05, $p<0.05$. Therefore, hypothesis 1 was rejected. There was significant difference between the mean interest scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

H_{02}: There is no significant difference between the mean performance scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

Table 5: Summary of independent sample t-test showing effect of brainstorming on students' performance in organic chemistry

Teaching Methos	N	$\bar{x}$	SD	Df	t-value	p-value	Decision
Brainstorming	55	61.36	7.32	89	8.94	0.000	Significant
Lecture method	36	49.83	5.22				
Total	91						

The table 5, above shows that the effect of brainstorming instructional strategy on students' post-interest mean score in organic chemistry was significant as p-value of 0.000 is less than 0.05, $p<0.05$. Therefore, hypothesis 2 was rejected. There was significant difference between the mean performance scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

H_{01}: There is no significant difference between the mean retention scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

Table 6: Summary of independent sample t-test showing effect of brainstorming on students' retention in organic chemistry

Teaching Methos	N	$\bar{x}$	SD	Df	t-value	p-value	Decision
Brainstorming	55	57.34	6.04	89	7.177	0.000	Significant
Lecture method	36	50.84	4.39				
Total	91						

The table 6, above shows that the effect of brainstorming instructional strategy on students' post-interest mean score in organic chemistry was significant as p-value of 0.000 is less than 0.05, $p<0.05$. Therefore, hypothesis 3 was rejected. There was significant difference between the mean retention scores of senior secondary school students taught organic chemistry using brainstorming instructional strategy and those taught using lecture method.

Discussion

The findings of this study showed that students taught Organic Chemistry using the brainstorming instructional strategy developed greater interest, achieved higher academic performance, and demonstrated better retention than those taught using the conventional method. The improvement observed among students exposed to brainstorming suggests that the strategy created a more engaging learning environment in which learners actively participated in generating ideas, discussing concepts, and solving problems collaboratively. Unlike the conventional method, brainstorming encourages students to express their opinions freely, listen to alternative viewpoints, and refine their understanding through interaction with their peers. This active involvement is likely to have increased students' attention during instruction, promoted meaningful processing of

concepts, and strengthened their confidence in learning Organic Chemistry. As learners repeatedly verbalise and defend their ideas, they become more actively involved in constructing knowledge, making the learning experience more memorable than simply receiving information from the teacher.

The findings are consistent with those of Okeke et al. (2022), who reported that learner-centred instructional strategies significantly improved pupils' interest and retention in Mathematics. Similarly, Onyegbule (2024) found that brainstorming teaching strategy produced higher levels of students' interest in Biology than conventional approaches. Makinde and Oyovwi (2025) also observed that students taught through brainstorming achieved significantly higher levels of achievement and interest in Basic Science than those exposed to other instructional methods. The consistency between the present findings and earlier studies suggests that brainstorming provides opportunities for learners to interact actively with instructional content, thereby promoting deeper understanding and sustained engagement across science subjects.

The higher academic performance recorded by students taught using the brainstorming instructional strategy may be attributed to the collaborative nature of the strategy, which allows learners to analyse questions from different perspectives, exchange ideas, and receive immediate feedback from both the teacher and their peers. Such interaction may reduce misconceptions and improve conceptual understanding, enabling students to solve Chemistry problems more effectively. Rather than relying solely on memorisation, students are encouraged to organise their thoughts, justify their responses, and connect new information with prior knowledge. These learning experiences may account for the higher achievement scores obtained by the experimental group.

The findings on retention indicate that brainstorming instructional strategy supported long-term learning of Organic Chemistry concepts. Students are generally more likely to retain information when they actively participate in learning activities than when they remain passive recipients of instruction. The opportunity to discuss ideas, explain concepts, and recall information during brainstorming sessions may have strengthened memory consolidation and facilitated later retrieval of learned concepts. This finding supports the view that meaningful learning occurs when students actively construct knowledge through participation and reflection rather than through rote memorisation.

Conclusion

This study investigated the effect of brainstorming instructional strategy on students' interest, academic performance, and retention in Organic Chemistry among senior secondary school students in Plateau State. The findings established that students taught using the brainstorming instructional strategy developed greater interest in Organic Chemistry, achieved higher academic performance, and retained learned concepts better than their counterparts taught using the conventional method. The study therefore concludes that brainstorming instructional strategy is a more effective learner-centred approach for teaching Organic Chemistry than the conventional method. Its emphasis on active participation, idea generation, and collaborative learning enhances students' engagement with instructional content and promotes meaningful learning outcomes.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Chemistry teachers should adopt brainstorming instructional strategy more frequently in the teaching of Organic Chemistry and other conceptually difficult topics in order to

enhance students' interest, improve their academic performance, and promote long-term retention of scientific concepts.

2. Curriculum planners, school administrators, and educational authorities should incorporate learner-centred instructional strategies such as brainstorming into Chemistry curriculum implementation guidelines and organise regular workshops, seminars, and in-service training programmes to equip teachers with the knowledge and skills required for effective classroom application.
3. Future researchers should replicate this study using larger samples drawn from more schools across different states and, where feasible, employ random sampling or random assignment to strengthen the generalisability of the findings. Further studies may also investigate the effectiveness of brainstorming instructional strategy in other science subjects and at different levels of education.

References

Akpan, K. P. & Aminikpo, N. R. (2017). Blended learning approach on students' academic achievement and retention: A case study of Air force secondary school, Port-Harcourt, Rivers State, Nigeria. *International Journal of Multi disciplinary Research and Development 4*(12); 15-21. Retrieved from:www.allsubjectjournal.com

Chen, Z., & Yu, M. (2020). The effect of active learning strategies on studentengagement and academic performance in science education. *Journal of Educational Research*, 113(3), 215-227.

Elma, M., & Bostan, M. (2021). The impact of inquiry-based learning on student performance in chemistry education. *International Journal of Chemistry Education*, 39(4), 298-310.

Liu, X., & Li, L. (2021). Active learning and its effects on student performance in chemistry courses. *Educational Review*, 73(2), 115-132.

Makinde, O. P. & Oyovwi, E. O. (2025). Comparative analysis of guided inquiry and brainstorming teaching strategies on students' academic achievement and interest in Basic Science. *International Journal of Academic and Applied Research, 9*(9),170-178.

Malkawi, N.A.M. & Smadi, M. (2018). The Effectiveness of using Brainstorming strategy in the Development of Academic Achievement of Sixth Grade Students in English Grammar at Public Schools. *Jordan International Education Studies 11*(3), 92 – 100.

Obafemi, E.F. (2024). Enhancing pupuils performances in mathematics using brainstorming instructional strategy. *ASEAN Journal of Science and Engineering Education, 4*(2), 99-106.

Okeke, A. M., Aneshie-Otakpa, V. O., Oguguo, B. C. E., Emeji, I. E., Egara, F. O., Orga, C. A., Osakwe, J. I., Odo, I. O., Nzeadibe, A. C., Kwalat, S. K., Inweregbuh, C. O., Sunday, O., Agugoesi, O. J., Nzeakor, E., Olaniyi, O. N., Albert, L. N., Abugu, G. N., Dangbong, C. P., Matawal, D. B., Otubeje, S., Umeano, C., Biong'ahu, D., Aikoye-Enemako, J., & Obenyem, B. I. (2022). *Effect of spaced learning on primary school pupils' interest and retention in mathematics*. *Multicultural Education, 8*(3), 144–151.

Onyegbule, C. C. (2024). Effect of Crossover and Brainstorming Teaching Strategies on Senior Secondary School Students Interest in Biology in Imo State. *AJSTME 10*(5), 845-850.

Osborne, J., & Pimentel, D. (2022). Collaborative brainstorming and its impact on chemistry students' problem-solving abilities. *Journal of Science Education*, 56(2), 214 – 227.

Wagbara, O.S. (2020). Effect of brainstorming strategy on senior secondary school student academic achievement in chemistry in Rivers State Nigeria. *Middle European Scientific Bulletin, 4*(2), 77-82.

Wang, X., & Xu, S. (2022). Active learning in STEM education: A review of methods and outcomes. *STEM Education Journal*, 12(1), 45-59.

West African Examinations Council. (2022). *Chief examiners' report: West African Senior School Certificate Examination (WASSCE) for school candidates, Chemistry*. West African Examinations Council.

West African Examinations Council. (2023). *Chief examiners' report: West African Senior School Certificate Examination (WASSCE) for school candidates, Chemistry*. West African Examinations Council.

West African Examinations Council. (2024). *Chief examiners' report: West African Senior School Certificate Examination (WASSCE) for school candidates, Chemistry*. West African Examinations Council.

Zhang, X., & Wei, Y. (2023). The role of student-centered strategies in enhancing science learning: A focus on Organic Chemistry. *Journal of Science Education and Technology*, 32(5), 789-801.