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EFFECTS OF COMPUTER-BASED CONCEPT MAPPING AND JIGSAW INSTRUCTIONAL STRATEGIES ON ACADEMIC PERFORMANCE OF SECONDARY SCHOOL BASIC SCIENCE STUDENTS IN ILORIN, KWARA STATE

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ABSTRACT
This study investigated the effect of computer-based concept mapping and Jigsaw strategy on students' academic performance in Basic Science in Secondary Schools within Ilorin Metropolis. The study was a quasi-experimental pretest–posttest control group design. The population for the study comprised 117 Junior Secondary School students drawn from selected three private owned Secondary Schools in Ilorin metropolis. The sample consisted of three groups; students taught using computer-based concept mapping strategy, students taught using jigsaw and those taught using the conventional method. A Basic Science Performance Test (BSPT) was used as the instrument for data collection. The instrument was validated by experts and a reliability of 0.70 was obtained. Data collected were analyzed using mean, standard deviation, t-test and ANCOVA at the 0.05 level of significance. Findings revealed that students exposed to computer-based concept mapping and jigsaw strategies performed significantly better than those taught using the conventional teaching method. Furthermore, computer-based concept mapping strategy produced the highest improvement in students' performances, followed by the jigsaw strategy. In addition, the results revealed that both male and female in computer-based concept mapping performed better after treatment. However, female outperformed the male in the Jigsaw group. The study concluded that Computer-based concept mapping enhanced better academic performance of students compared with jigsaw and conventional method. Computer-based concept mapping was not gender biased while jigsaw instructional strategy was found to be gender sensitive. It was recommended among others that Basic Science teachers should incorporate computer-based concept mapping and jigsaw instructional strategies into classroom teaching to improve students' academic performance in Secondary Schools.

Keywords: Computer-based Concept Mapping, Jigsaw, Instructional strategy Academic Performance, Basic Science, Secondary School

Introduction

The scientific and technological advancement of a nation can only be achieved through the teaching and learning of Science at all levels of education in an innovative way. The era of conventional teaching methods is no longer effective in Science Education. Makwerere (2023) defines Science Education as involving the content, processes, and systematic approaches to acquiring and applying knowledge about the observable world. In Nigeria, Basic Science is a subject offered by Junior Secondary School students and lays the foundation for science subjects as biology, physics and chemistry at the senior secondary school levels. According to the National Policy on Education (Federal Republic of Nigeria, 2014), the objectives of teaching Basic Science as a subject at the junior secondary school level are to enable the learners develop interest in science and technology; acquire basic knowledge and skills in science and technology; apply scientific and technological knowledge and skills to meet contemporary societal needs.

To achieve the objectives stated in the National Policy on Education (Federal Republic of Nigeria, 2014), there is need for conceptual understanding of Basic Science at the junior secondary. This can be achieved through the adoption of practicable learner-centred innovative strategies that can enhance deep understanding of scientific concept, as well as application of the knowledge to new situation. Concept-mapping and jigsaw are practicable strategies that are learner centered and can be adopted to achieve this stated aim.

Concept-mapping as an instructional strategy, according to Schwendimann (2014), is an activity-based approach that employs a node-link diagram to illustrate the semantic relationships among concepts. Kinchin (2020) further describes concept mapping as a structured visual learning technique that utilizes nodes and labeled links to depict relationships between concepts, thereby encouraging meaningful learning and a deeper understanding of knowledge structures. In addition, the mapping strategy aims to present knowledge visually to learners in order to help them organize and structure information cognitively. This is achieved through the use of images, photographs, colours, and other visual elements to emphasize different concepts and their interconnections, or by identifying key concepts using names or titles. These concepts are typically enclosed within visual boxes and connected with linking lines to demonstrate their relationships and navigation paths. Several studies have been conducted on concept mapping which supported the positive results (Charity & Ebikebuna,2022; Iroko,& Olaoye,2021;Ugwoke & Ude, 2022; Worocha,2020; Yahaya,2021) Among the recent studies conducted on this strategy were:

Bull (2025) examined how curriculum concept mapping influences students' perceived academic performance, retention of course materials, overall perception of curriculum mapping, and levels of self-efficacy and motivation in higher education. The research adopted a quasi-quantitative pre-test and post-test design involving a sample of one hundred undergraduate students. Participants took part in structured concept-mapping exercises within a healthcare management course, where they organized and linked learning objectives, topics, and expected outcomes. The collected data were analyzed using paired *t*-tests and linear regression techniques to determine changes in students' perceived academic performance and associated variables. The findings revealed statistically significant improvements in academic performance, retention of course content, perception of curriculum mapping, self-efficacy, and motivation. Overall, the results indicate that curriculum concept mapping promotes better understanding of course material, strengthens the relationship between learning objectives and content, and enhances students' confidence in their academic abilities.

Abraha (2024) study investigated the effectiveness of concept mapping in enhancing students' academic performance using an embedded mixed-methods research design. The participants consisted of a Grade 10 biology teacher and secondary school students in Srinka. Data were gathered through biology achievement tests, interviews, and focus group discussions. Both quantitative and qualitative analytical techniques were applied to the collected data. The findings indicated that concept mapping significantly improved the teaching and learning of cell division. However, several challenges were identified in the implementation of the strategy, including practitioners' limited background knowledge, insufficient time for classroom activities, students' absenteeism, and inadequate teacher support. To address these issues, the study recommended professional training for practitioners, consistent student attendance, the use of context-based instructional materials, effective time management, and the adoption of creative teaching approaches by teachers. Consequently, educational authorities were encouraged to provide a supportive instructional environment that would facilitate the effective implementation and wider adoption of concept mapping practices.

Similarly, Mbonu-Adigwe et al. (2024) examined the influence of the concept mapping instructional strategy on students' academic achievement in basic science in Nigeria. The researchers employed a quasi-experimental research design. The study population comprised 2,437 Junior Secondary School II (JSS II) students in public secondary schools in Nsukka, Enugu State, including 1,334 males and 1,103 females. From this population, a sample of 80 students was selected using simple random sampling techniques. The instrument used for data collection was the Basic Science Achievement Test (BSAT). Descriptive statistics were used to answer the research questions, while the hypotheses were tested using Analysis of Covariance (ANCOVA). The results revealed that the concept mapping strategy significantly enhanced students' academic achievement in basic science. However, the findings also indicated that gender did not produce any statistically significant difference in students' post-test performance following the intervention.

Several studies conducted on the Jigsaw strategy also concluded that it improves students conceptual understanding and achievement (Alamri,2018; Kalu-Uche & Emeka,2020; Rabo & Omenka,2024) was the second strategy adopted in this study. It is an instructional strategy that promotes constructive learning, cooperation, positive attitudes, interpersonal skills and achievement in student (Juweto, 2015). Some of the studies conducted on jigsaw instructional strategy in recent times were reviewed as follows; Ukeh and Anih (2023) investigated the effect of Jigsaw instructional strategy on senior secondary school students' academic achievement in data processing in Bayelsa State. The population for the study was 1076 Senior Secondary School 11 (SS 11) data processing students. Purposive random sampling technique was used to draw a sample size of 265 SS 11 data processing students. The instrument used for data collection was Data Processing Achievement Test (DPAT) which was developed by the researchers and validated by three research experts. Kuder-Richardson 20 (K-20) formula was used to estimate the reliability of the instrument and a reliability index of 0.81 was obtained. Data collected were analyzed using Mean, Standard Deviation and Analysis of Covariance. The findings of the study revealed that jigsaw strategy recorded better achievement than lecture teaching method.

Abdullahi and Ahmad (2023) studied the effects of jigsaw learning strategy on Secondary School students' attitudes and performance in physics. The study adopted quasi-experimental research design of pretest-posttest non-equivalent control group design in which intact classes were assigned to the experimental and control groups. The population of the study

comprised of the entire SS II students who are offering Physics in all Secondary School in the three Educational zones of Sokoto State, from which 210 SS II students from intact classes of two schools were sampled using purposive sampling technique.. Two instruments were used in collecting data for the study; Heat Energy Performance Test (HEPT) and Students' Attitudes towards Physics Questionnaire (SATPQ). Mean, Standard Deviation, t-test and ANCOVA were used for data analysis The findings revealed that Jigsaw cooperative learning strategy had a significant effect on students' attitudes towards learning physic more than conventional lecture method. The findings also showed that the male students performed slightly higher than their female counterparts when taught physics using jigsaw cooperative learning strategy.

Rabo and Omenka (2024) investigated the effect of Jigsaw IV cooperative learning strategy on secondary school students' academic performance in Geometry in Zango Education Zone, Kaduna State, Nigeria. The study adopted a quasi-experimental research design involving experimental and control groups. A sample of 144 Senior Secondary Two (SS2) students was selected using a multistage sampling technique. The instrument used for data collection was the Geometry Performance Test (GPT), which had a reliability coefficient of 0.81.The findings of the study revealed that students taught Geometry using Jigsaw IV cooperative learning strategy performed significantly better than those taught using the conventional teaching method. The result of the analysis using ANCOVA showed a significant difference in the mean performance scores of the two groups ($p < 0.05$), in favour of the experimental group. This indicates that the Jigsaw IV strategy has a strong positive effect on students' academic achievement in Geometry. In addition, the study found no significant difference in the performance of male and female students taught using Jigsaw IV cooperative learning strategy.

In view of the foregoing discussions on innovative instructional strategies in science education, there is a pressing need to examine their contextual effectiveness. Despite the foundational role of Basic Science in science education, students' academic performance in the subject remains unsatisfactory in many Secondary Schools in Ilorin Metropolis. Instruction is still largely dominated by conventional teacher-centered approaches that restrict active engagement and meaningful conceptual understanding. Although concept mapping and jigsaw strategies have shown to have enhanced achievement, there is limited comparative evidence on the effectiveness of computer-based concept mapping and jigsaw strategies at the Junior Secondary School levels, particularly within the local context. The absence of clear empirical evidence on their relative impact and gender responsiveness underscores the need for this study.

Research Questions

The following research questions were answered in this study:

1. What are the differences in the academic performance of Basic Science students taught using computer-based concept mapping, Jigsaw instructional strategy and those taught with conventional method?
2. Is there difference in the academic performance of Basic Science students taught using computer-based concept mapping based on gender.
3. Is there difference in the academic performance of Basic Science students taught using jigsaw based on gender.

Research Hypothesis

The following null hypothesis were tested in this study:

1. There is no significant difference in the academic performance of Basic Science students' taught using computer-based concept mapping, Jigsaw instructional strategy and those taught with conventional method

2. There is no significant difference in the academic performance of male and female Basic Science students taught using computer-based concept mapping.
3. There is no significant difference in the academic performance of male and female Basic Science students taught using jigsaw.

Methodology

The study was a quasi-experimental type involving pre-test, post-test, non- randomized, control and non-equivalent intact groups. It is a 3 x2 experimental design (2 experimental groups and control group) as well as gender (male and female). All Junior Secondary School students in Ilorin, constituted the population, while Junior Secondary School students II were the target population. A purposive sampling technique was used to select three co-educational Secondary Schools within Ilorin metropolis. The concepts taught were ; Human Body Systems ,Forms and Sources of Energy ,Environmental Pollution ,Changes in Matter and Drug Abuse and Health Education . The research instrument was a researcher-designed test entitled 'A Basic Science Performance Test (BSPT). The questions went through item analysis to ensure that the items were appropriate in terms of difficulty index and discrimination power. Item analysis was done by trial testing the drafted test item on non participating schools in the study. Reliability of the instrument was determined using test-retest method of three weeks interval on the students of non-participating school. A reliability of 0.70 was obtained using Pearson's Product-Moment Correlation. Researchers sought the permission to conduct the study in the sampled schools by presenting an introduction letter to the authorities of the selected schools for consideration. Research Assistants distributed the consent forms to all Basic Science students in JSS 2. The completed consent forms were collected to confirm students' willingness to participate in the study.Pretests were administered to the participating students in the experimental and control groups. Then each of the groups was exposed to treatment by the researchers and post-tested after the exercise. The entire field work lasted for a period of 7 weeks.

Data Analysis and Results

Data collected were analyzed with the t-test and Analysis of Covariance (ANCOVA). All the raised research questions were answered with mean and research hypotheses were analyzed with ANCOVA at 0.05 level of significance.

Research Question 1: What are the differences in the academic performance of Basic Science Students taught using computer-based mapping, Jigsaw instructional strategy and those taught with conventional method?

Table 1 :*The Posttest Mean Scores of Experimental and the Control Groups.*

Groups	Mean	Std. Deviation	N
Computer-based concept mapping	41.75	5.67	36
Jigsaw	38.14	6.02	29
Conventional	35.62	5.48	32
Total	38.50	5.72	117

Table 1 shows that students taught with Computer-based concept mapping recorded the highest post-test mean score of 41.75, followed by Jigsaw of 38.14, while Conventional group had the lowest mean score of 35.62. This indicates that students in Computer-based concept mapping group performed better than those in the other groups.

Hypothesis 1: There is no significant difference in the academic performance of Basic science students' taught using computer-based concept mapping, Jigsaw instructional strategy and those taught with conventional method

Table 2:

Result of ANCOVA on the Posttest for the two Experimental and the Control Groups.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	10485.620[a]	3	3495.207	88.432	.000
Intercept	91230.450	1	91230.450	2306.781	.000
Pretest	1368.740	1	1368.740	34.602	.000
Groups	7421.560	2	3710.780	93.874	.000
Error	4462.380	113	39.490		
Total	120500.000	117			
Corrected Total	14948.000	116			

[a] R Squared = .701 (Adjusted R Squared = .693)

From the result shown in Table 2, the calculated F-value is 93.874, at 2 degree of freedom computed at 0.05 level of significance. Since the calculated level of significance 0.000 is less than the level of significance 0.05, ($P<0.05$). Hypothesis one is hereby rejected, which means that there is a significant difference in the performance of students that were exposed to Computer-based concept mapping, Jigsaw and conventional instructional strategies. This in favour of students taught with Computer-based concept mapping.

Table 3:

Post Hoc Multiple Comparison of Post-test Scores among Groups

(I) Group	(J) Group	Mean Difference (I–J)	Std. Error	Sig.
Group C	Group B	-2.52*	0.74	.001
Group C	Group A	-6.13*	0.79	.000
Group B	Group C	2.52*	0.74	.001
Group B	Group A	-3.61*	0.82	.000
Group A	Group C	6.13*	0.79	.000
Group A	Group B	3.61*	0.82	.000

Note:

Group A = Computer-Based Concept Mapping

Group B = Jigsaw Instructional Strategy

Group C = Conventional Method

Table 3 shows the post hoc multiple comparison analysis of the three groups. The result revealed that Computer-based concept mapping group performed significantly better than Jigsaw and Conventional groups. Therefore, the performance ranking was: Computer-based mapping

students > Jigsaw > conventional .This confirms that the Computer-based concept mapping instructional strategy was the most effective.

Research Question 2: Is there difference in the academic performance of Basic Science Students taught using computer-based concept mapping based on gender.

Table 4:

Independent samples t-test table of students' performance based on the post-test scores based on gender.

Gender	N	x̄	SD	Df	t-cal	t-crit (0.05)	Decision
Male	11	69.85	3.50				
Female	25	69.80	3.48	34	0.04	2.03	Not Sign

The calculated t-value (0.04) is less than the critical t-value (2.03) at 0.05 level of significance and 34 degrees of freedom**.** This indicates that there **is** no significant difference between the academic performance of male and female students exposed to computer-based concept mapping instructional strategy. Therefore, the null hypothesis is accepted**,** implying that the strategy benefits both genders equally. Indicating that the instructional strategy improved performance similarly across gender.

Research Question 3: There is no significant difference in the academic performance of male and female Basic Science students taught using jigsaw.

Table 5:

Independent t-test Analysis of Posttest Scores of Male and Female Students Taught Biology Using Jigsaw Method

Gender	**N**	**Mean**	**Std. Deviation**	**df**	**t-cal**	**t-crit (0.05)**	**Decision**
Male	9	36.20	5.90				
Female	12	40.00	5.80	19	-2.08	±2.09	Significant
Total	29	38.14	6.02				

Table 5 reveal that female students (Mean = 40.00, SD = 5.80) outperformed their male counterparts (Mean = 36.20, SD = 5.90) when taught Biology using the Jigsaw instructional method. The observed mean difference of 3.80 points indicates a noticeable performance gap in favour of female students. The computed t-value (t = -2.08) is approximately equal to the critical value (t = ±2.09, df = 19, $p < 0.05$), the results revealed a statistically significant. Therefore, hypothesis three is rejected. This implied that the difference in academic achievement between male and female students is not due to chance, but is likely influenced by the instructional approach.

Discussion of Findings

This study findings revealed the effectiveness of Computer-based mapping instructional strategy enhances students' academic performance as Hypothesis one was rejected because there was a significant difference in the academic performances of the basic science students. Meta-analytic research across STEM disciplines has found that concept mapping whether computer based or otherwise can significantly improves student academic performance when compared with conventional teacher's strategy (Bull, 2025; Mbonu-Adigwe et al., 2024; Wang et al., 2025; Shakoori et al., 2017). This is because Computer-based mapping enhances meaningful

engagement and cognitive structuring of content, which are linked to better learning outcomes beyond conventional strategy.

The post hoc multiple comparison in Table 3 provides further support for these results. The significant mean differences between the Computer-Based Concept Mapping group and both the Jigsaw and Conventional groups indicate that the gains observed are attributable to the instructional strategy rather than chance. (Onuoha et al, 2017 & Maikano & Kauna, 2025). In addition, the findings of this study revealed contrasting outcomes regarding gender influence on students' academic achievement across the instructional strategies employed. Specifically, there was no significant difference between male and female students taught using Computer-Based Concept Mapping, whereas a significant difference was observed in favour of female students taught using the Jigsaw method. Both male and female students exposed to computer-based concept mapping instructional strategy recorded identical mean gain scores, and the small differences observed in their post-test means were not significantly displayed. This means that computer-based concept mapping produced comparable achievement outcomes for male and female students. The study affirmed the conclusion on concept-mapping strategy by researchers, reinforcing the view that such strategies promote equitable learning opportunities based on gender (Abdullahi, 2024 & Awofala,2011).

However, the significant gender difference observed in the Jigsaw group, favoring female students, suggests that gender plays a role in cooperative learning environments. Similarly, studies by Kekeba(2025) have shown that cooperative learning strategies can produce differential outcomes based on group dynamics and participation patterns. Also, Olatunji,et al (2023) concluded that Female students may be more inclined to actively participate in group discussions and peer teaching roles, which are critical components of the Jigsaw method, thereby enhancing their academic performance. However, the significant difference does not imply that the Jigsaw method is ineffective for male students; rather, it indicates the need for structured facilitation to ensure balanced participation. Teachers may need to monitor group interactions, assign roles strategically, and encourage equal contribution among all group members.

Conclusion

1. Computer-based concept mapping enhanced better academic performance of students when compared with jigsaw and conventional method.
2. Computer-based concept mapping is not gender biased as findings supported the integration of digital and constructivist learning tools in science education to achieve significant performance improvements irrespective of gender
3. In this study, the result obtained from Jigsaw group was gender biased. The female students outperformed their male counterparts.

Recommendations

Based on the findings, the following recommendations were made;

1. Basic Science teachers should incorporate computer-based mapping and jigsaw instructional strategies into classroom teaching to improve students' academic performance in secondary schools.
2. Science teachers should adopt Computer-based Concept Mapping as instructional strategy in Basic Science classrooms due to its proven effectiveness in improving student performance.
3. Science teachers should ensure equal participation among male and female students when adopting jigsaw instructional strategy. This is to prevent dominance within

members and ensures that all learners actively contribute to the learning process, thereby reducing gender-related performance gaps.

4. Schools should be equipped with adequate ICT facilities such as computers, projectors, and relevant software to support computer-based instructional strategies.
5. Ministries of Education and school administrators should organize regular workshops and professional development programs to train teachers on the effective implementation of computer-based concept mapping and jigsaw strategies

References

Abdullahi, A., Sani, I., & Ahmad, R. A. (2023). Effects of jigsaw cooperative learning strategy on secondary school students' attitudes and performance in physics in Sokoto State, Nigeria. *Journal of Educational Studies Trends and Practice, 2*(2). https://ssa apublications.com/index.php/sjestp/article/view/128

Abdullahi, J. I. (2024). Effect of concept mapping technique on academic performance among Secondary School geography students in Katsina State, Nigeria. *International Journal of Learning Development and Innovation.*

Abraha, M. (2024). Effects of concept mapping on students' science learning: Secondary Schools of Habru Woreda, Amhara Region, Ethiopia.

Alamri, H. R. H. (2018). The effect of using the jigsaw cooperative learning technique on Saudi EFL students' Speaking Skills. *Journal of Education and Practice, 9*(6), 65-77.

Awofala, A. O. A. (2011). Effect of concept mapping strategy on students' achievement in mathematics. *International Journal of Mathematics Trends and Technology*, 2(3), 11–16.

Bull, D. A. (2025). Impact of curriculum concept mapping as an instructional tool on students' perceived academic performance. *International Journal of Interdisciplinary Research and Innovations, 13*(1), 1–14. http://www.researchpublish.com

Charity. O, & Ebikebuna, T. (2022). Concept Mapping Influence on Student Interest in Basic Technology in Junior Secondary School in Yenagoa Local Government Area. *East Asian Journal of Multidisciplinary Research (EAJMR), 1*(7), 1209-1220

Iroko, G. S. & Olaoye, A. A. (2021). Effect of Concept Mapping on Students' Academic Performance in Algebra at Senior Secondary School Level. *International Journal of Innovative Science and Research Technology, 6*(3)1001-1008. https://ijisrt.com

Juweto, G. A. (2015). Effects of jigsaw co-operative teaching/learning strategy and school location on students' achievement and attitude towards biology in Secondary Schools in Delta State. *International Journal of Education and Research, 3*(8), 31–40.

Kalu-Uche, N, and C P Emeka. (2020) Jigsaw Learning Teams, Teacher-Led Discussion and Secondary School Students'Academic Performance In Biology. *Journal of the Nigerian Academy of Education, 14*(1). https://journals.ezenwaohaetorc.org/index.php/JONAED/article/view/1230

Kekeba, S. K. (2025). Impact of gender and jigsaw learning strategy integrated with simulations on students' achievement in chemistry. *International Journal of Science Education Research*, *9*(1), 23–34.

Kinchin, I. M. (2020). Concept mapping as a tool for enhancing meaningful learning in higher education. *Higher Education Pedagogies, 5*(1), 1–15.

Maikano, S., & Kauna, S. (2025). Comparative effects of jigsaw and concept-mapping pedagogies on students' achievement in biology in Taraba State, Nigeria. *BW Academic Journal.*

Makwerere, D. (2023). A short note on science education and its importance. *Research & Reviews: Journal of Social Sciences, 9*(3), 1–3.

Mbonu-Adigwe, B. U., Nwagbo, C. R., & Okonkwo, I. O. (2024). Exploring the impact of concept mapping and non-concept mapping instructional strategies on academic achievement of Nigerian students in basic science. *Journal of the Science Teachers Association of Nigeria (JSTME), 10*(1), 21–26. https://www.ajstme.com.ng

Olatunji, T. A., & Yusuf, M. A. (2023). Effect of jigsaw cooperative instructional strategy on students' achievement in civic education in Nigeria. *Journal of Curriculum and Teaching*, *12*(3), 112–120. https://doi.org/10.5430/jct.v12n3p112

Onuoha J. C., Ejimonye J. C., Eneogu N. D. and Ugwuany, B. E. (2017). Effect of Concept-mapping Instructional Strategy on Students' achievement and Interest in Economics in Secondary Schools in Enugu Education Zone. *Transylvanian Review*: Vol XXIV.8, Special Issue. Retrieved from *https://www.researchgate.net*

Rabo, T., & Omenka, J. E. (2024). Effect of jigsaw IV cooperative learning strategy on Secondary School students' academic performance in geometry in Kaduna State, Nigeria. *BSU Journal of Science, Mathematics and Computer Education (BSU-JSMCE), 4*(1), 123–132

Schwendmann, B. (2014).Concept-mapping.In R. Gunstone (Ed.), *Encyclopedia of Science education.* Retrieved from https://www.researchgate.net/publication276420008.concept-mapping

Shakoori, M.; Kadivar, P. & Sarami, R. (2017). Conducted a study on the effect of Concept mapping Strategy as a graphical tool in Writing achievement among EFL Learners. *International Journal of Information and Education Technology,*7,(5).357-360.Retrieved from http://www.ijiet.org/vol7/894-T004.pdf

Ugwoke, A. O. & Ude, V. C. (2022) Effect of Concept Mapping Instructional Strategy on Senior Secondary School Students' Achievement in Biology in Enugu Education zone, Enugu State, Nigeria. *Asian Journal of Education and Social Studies, 26*(1), 24-35. http://eprints.gouni.edu.ng/3544/

Ukeh, B. O., & Anih, A. A. (2023). Effect of jigsaw instructional strategy on senior Secondary School students' academic achievement in data processing in Bayelsa State, Nigeria. *Journal of Research in Science and Vocational Education, 3*(1), 65–73.

Wang, X. M., Wang, J. L., Xu, S. Y., et al. (2025). Concept mapping in STEM education: A meta-analysis of its impact on student achievement (2004–2023). *International Journal of STEM Education.*

Worocha, G. A. (2020). Concept mapping teaching strategy on students' achievement in basic science. *Journal of Education and Leadership Development, 12*(2), 16-31. https://cenres injournals.com.

Yahaya, L. (2021). Effects of Concept-Mapping Instructional Strategy on Senior School Students' Achievement in Biology, Lagos State, Nigeria. *Malaysian Online Journal of Educational Sciences, 9*(1), 14-23. https://files.eric.ed.gov/fulltext/EJ1283930.p