

EFFECTS OF CONCEPT-MAPPING AND JIGSAW INSTRUCTIONAL STRATEGIES ON STUDENTS' LEARNING OUTCOMES IN BIOLOGY IN SENIOR SECONDARY SCHOOLS IN OSUN STATE

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Abstract

This study investigated the effects of concept-mapping and jigsaw instructional strategies on students' learning outcomes in biology in senior secondary schools in Osun State. The study employed the pre-test, post-test quasi-experimental design. The population for the study comprised all senior secondary school students in secondary schools in Osun State. A multistage sampling procedure was employed to select the sample for the study. From the three senatorial districts in Osun State, one senatorial district was selected using simple random sampling technique from which one Local Government Area (LGA) was chosen. Three secondary schools were selected from the chosen LGA through simple random sampling, and were randomly assigned to two experimental groups and one control group. Two research instruments were used for the data collection of this study, which are Biology Performance Test (BPT) and Biology Students' Self-Efficacy Questionnaire (BSSEQ). The data collected were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (ANCOVA). The results revealed that there was a significant effect of concept-mapping and jigsaw instructional strategies on senior secondary students' academic performance and self-efficacy in Biology. The study concluded that concept-mapping and jigsaw instructional strategies significantly improved students' learning outcomes in Biology.

Key words: *Concept-Mapping instructional strategy, Jigsaw instructional strategy, Academic performance, Self-efficacy*

Introduction

Science education is defined as the application of educational principles to the understanding, teaching and learning of science. It therefore means that science education involves the study of some science in- depth and in addition, educational disciplines that relate specially to how scientific knowledge and concepts are learnt and verified; how scientific concepts are programmed for understanding and how science curricula can be meaningfully

evaluated (Bednarowska-Michael & Uprichard, 2026). Science education can be said as an applied field which derives its authenticity from the fact that science as a field of endeavour is fundamental to human survival and hence must be seen as the right of every individual to learn. Kleickmann, et. al. (2020) outline three related strands of science education: learning science (the development of conceptual and theoretical understanding); learning about science (understanding science,

its nature, processes, and societal impacts); and doing science (science inquiry and problem-solving). All of these dimensions are essential to the advancement of society, including developing scientific literacy and equipping the next generation with the knowledge, skills and attitudes they need to survive in an increasingly complex and changing world. science education covers a range of topics including Physics, Chemistry, Earth Sciences and Biology, all of which have their own specific areas of interest that help to build a science education that is comprehensive. Biology is considered to be a basic science in relation to other disciplines on account of its study of complexity of life and its processes.

According to Honra and Monterola (2026) biology is defined as the science of life. It is an important and imperative science subject and serves as a basis for several other science courses such as medicine, pharmacy, nursing, biochemistry, genetic, agriculture etc., which are of great economic importance in a nation. Being a science of life, Biology is one of the science subjects most preferred by many students in secondary schools due to its less mathematical calculations compared to Physics and Chemistry and easier to deal with than abstract subjects (Čipkovč et al., 2019). In spite of this importance and students' interest in Biology, studies have shown erratic performance of the students in Biology at the external examinations (Chukwu & Arokoyu 2019; Yaki, 2022; Kinta & Philip 2025). This unsatisfactory and fluctuating academic achievement of students in Biology in internal and external examinations over years can be linked to the poor students' attitude, inadequate instructional materials poor teacher quality and poor instructional strategies (Olajide, et. al, 2024; Obikiezie, et. al., 2022; Adewumi, et. al., 2024). The essential criterion for good teaching and learning of Biology is the employment of suitable ways of passing on knowledge to ensure that all the important ideas are conveyed to the learner without being pushed into the background. The shortcomings of traditional teaching methods employed by teachers lead to a search for effective and reliable instructional strategy such as concept-mapping and jigsaw instructional strategies where students will be actively involved in the teaching learning process which will in turn enhance their learning outcomes in Biology

(Roeth, et. al., 2019; Maikano & Simon, 2025; Abdulrahim, et. al., 2025; Essien, et. al., 2026).

The concept map was first used in the 1960s by Joseph D. Novak, of Cornell University. Concept maps have their origin in the learning movement called constructivism. It shows how to think, how to relate ideas to knowledge. The teacher who builds concept maps for students is concerned with students' learning of relationships among facts, rather than just knowing facts. One more way is a concept map that is a graphic representation in which concepts are represented by links (points or vertices) and relationships are represented by cross links (arcs or lines). Concept maps are representations and organization of knowledge, they consist of concept which are generally represented by circles or boxes of some types and relationship between concept and preposition between two concepts. (Propositions are statement about some object or statement in the universe either naturally occurring or constructed). They have two or more ideas related by words that make a sense. According to Novak and Cacas in Schicchi *et al.* (2026), concept map is a tool that promotes meaningful learning as opposed to rote learning. A concept map is a two-dimensional, visual representation of the relationship between key ideas. It demonstrates our thinking process and introduces affinities and association that may not be apparent. According to Abdulrahim, et. al. (2026) Concept Mapping is especially useful in science learning to make a science concept that is hard to learn through the reading of books in the lecture method become easy to understand. Likewise, Essien, et. al. (2026) found that students who were instructed with Concept Mapping outscored the students who were instructed with conventional teaching. They found out that the use of Concept Mapping helps students think critically, see connections between scientific concepts, and transfer their knowledge to new contexts, all of which help enhance their academic performance. To support this, Horton et al. (2018) conducted a meta-analysis on the effectiveness of concept mapping as an instructional tool and found that Concept Mapping has positive effects on scientific knowledge comprehension, problem-solving and knowledge retention. They also commented

that concept maps can be used as diagnostic tools for students' understanding. The strategy enables students to connect and integrate disjointed bits of information into meaningful, organized, and integrated knowledge structures, thereby enhancing their conceptual understanding and academic success (Kinchin, 2020).

Likewise, the jigsaw approach has become well-known throughout the world for its ability to improve instructional techniques and raise students' academic achievement in a variety of courses and fields. The Jigsaw Instructional Strategy is a cooperative learning approach that encourages active participation, interdependence, and collaboration of learners in the learning process (Ewuola, 2025). It was initially created in the early 1970s by Aronson and his colleagues in order to decrease racial tension and promote cooperation in the classroom (Aronson et al., 1978). The strategy is to split a class into smaller groups, and give each group member a part of the learning content they will have to learn and then share with the rest of the group. All students are given an opportunity to become "experts" on a specific subtopic and then share what they know with their "home group" which means that each student will learn the entire lesson through peer instruction. Awoyale and Olajide (2025) argued that the principle of positive interdependence is the basis of the Jigsaw strategy, which means that the success of the students in the group depends on the contribution of all the students in the group. This feeling of responsibility drives pupils to work hard, achieving well and being more engaged. Obafemi, et. al. (2023) argued that Jigsaw learning not only enhances academic achievement but also fosters social and communication abilities, as students require dialogue, questioning, and explanation to ensure that the group grasps the concepts. The results of the research have been consistent in showing that the Jigsaw strategy has a positive impact on students' academic achievement. They further concluded that students who were taught using Jigsaw technique achieved higher academic outcomes and higher self-esteem than those being taught through lectures. Similarly, Slavin (2014) reported that cooperative learning techniques such as the Jigsaw method resulted in more academic success due to the increased motivation, peer assistance, and

responsibility for successful learning. Awoyale and Olajide (2025) investigated the impact of Jigsaw Instructional Strategy on the Achievement of Students in Biology in Nigeria, and they discovered that the Jigsaw Instructional Strategy outdid the traditional approach in students' performance in Biology. The researchers drew a conclusion that the part of the peer teaching of Jigsaw teaching method can help students learn by explanation, and explanation will promote the understanding and retention of students. Similarly, Ibe and Nwosu (2017) found that the use of Jigsaw technique also improved students' mastery of abstract biology concepts and the use of scientific principles when they solved problems. In addition, Achor et. al. (2019) described the Jigsaw approach as having the effect of fostering learner autonomy and responsibility, where each learner is responsible for his/her own learning but also for sharing his/her specific knowledge with other learners. This independence fosters self-motivation and self-confidence, which in turn leads to improved academic performance. The use of Instructional strategies, specifically Concept-Mapping and Jigsaw in the process of teaching and learning, not only made it easier for knowledge to be shared in class but also gave opportunities to students to be responsible for their own learning. This active engagement and reflection is important in building student's confidence and self-efficacy such that students start to feel they can contribute meaningfully and can learn new content.

Self-efficacy is the person's ability to plan and implement the necessary sequence of actions to achieve a desired result. Wang, et. al. (2024) suggested that self-efficacy is a belief that springs from thinking; and is a completely different thing from knowing what to do. Self-efficacy is one of the most important factors in motivation, learning and achievement, defined as a belief in one's ability to perform a task and achieve a goal (Zhang, et. al, 2025). It is a sense of self-efficacy in his/her abilities to achieve success and complete tasks, based on four sources of information: mastery experiences, vicarious experiences, social persuasion and emotional states (Bandura, 1997). Self-efficacy has been consistently found to be a factor that affects academic success and professional success, and there are links between self-efficacy and

overall well-being and life satisfaction. Furthermore, self-efficacy has been found to play a crucial role in motivation, learning, and achievement, and is considered a key factor in personal and professional development (Chen, et. al., 2025; Dong, 2025).

It is worth noting that the learning outcomes of students (academic achievement and self-efficacy in Biology) showed inconsistency (Achor et al., 2025). This leads to questions about the suitability of teaching and learning strategies to ensure pupils acquire the required knowledge, skills and attitudes and retain them to prepare them for success in learning biology. Some researches have been done to find appropriate teaching methods which can maximize the achievement in science subjects but some of the results were still limited. Biology as one of the broad discipline of science in the Nigerian Educational Curriculum is very important to every student irrespective of academic disposition, either science or Arts. Therefore, it is essential to create good teaching-learning processes to improve the quality of student learning so that the students can easily enter the high education institution for further study in Biology-related fields. Based on the above, the study is geared towards finding out the impact of concept mapping and Jigsaw Instructional strategies on the learning achievement of Secondary students in Senior Secondary schools in Osun State.

Experimental group I (Concept Mapping) O_1
Experimental group II (Jigsaw) O_3
Control Group (Lecture Method) O_5

O_1 , O_3 and O_5 are pre-tests observations

O_2 , O_4 and O_6 are post-tests observations

X_1 represents treatment for experimental group I

X_2 represents treatment for experimental group II

X_3 represents treatment for control group

The population of this study comprised all senior secondary school students in public secondary schools in Osun State. The target population of this study consisted of Senior Secondary School Two (SSS II) students of one Local Government Area (LGA) of the state. The sample for this study consisted of 3 intact classes of 45 Senior Secondary School Two (SSS II) Biology students, who were selected through a multistage sampling procedure. From the three senatorial districts in Osun State, one senatorial district was

Objectives of the Study

- investigate the effects of Concept Mapping and Jigsaw Instructional strategies on Senior Secondary School Students' academic performance in Biology in Osun State; and
- examine the effects of Concept-mapping and Jig-saw instructional strategies on Senior Secondary School Students' self-efficacy in Biology in the study area

Research Hypotheses

H01: There is no significant effect of concept-mapping instructional strategy and jigsaw instructional strategies on senior secondary school students' academic performance in Biology.

H02: There is no significant effect of concept-mapping instructional strategy and jigsaw instructional strategy on students' self-efficacy in Biology.

Methodology

This study adopted pre-test, post-test, quasi-experimental research design, non-equivalent control group design.

The design of the research is represented as follows:

X_1	O_2
X_2	O_4
X_3	O_6

selected using the simple random sampling technique. From the selected senatorial district, one Local Government Area (LGA) was selected using this simple random sampling technique. From the selected LGA, three secondary schools were selected through simple random sampling technique. The selected schools were randomly assigned into two experimental groups and one control group. The experimental groups were subjected to concept-mapping and jigsaw instructional strategies respectively, while the



control group was subjected to conventional method.

Two instruments were used to collect data for the study which are: Biology Achievement Test (BAT) and Biology Students' Self-Efficacy Questionnaire (BSSEQ). The BAT is a Biology test question that was developed by the researcher. The test questions were carefully selected from the past West Africa Senior School Certificate Examination (WASSCE), National Examination Council (NECO) Biology questions which the researcher is hoped to test the academic performance of the students. The test consisted of two sections; A and B. Section A contains students' personal details while section B contained a 25-item multiple-choice test developed by the researcher to measure students' achievement in Biology. The items covered the topics, Digestive System and Excretory System. Each item had four options (A-D) with one correct answer. The instrument was employed as a pre-test to ascertain the equivalence of ability of students, as post-test to determine the effect of the treatment on the students.

Likewise, the Biology Students' Self-Efficacy Questionnaire was designed by the researcher to determine students' self-efficacy towards Biology. BSSEQ consists of two sections, A to B. Section A elicited responses in demographic of students while sections B consists of 15 items designed to measure students' self-efficacy in Biology. The instrument was structured on a four-point Likert scale, which includes Strongly Agree (4), Agree (3), Disagree (2), Strongly Disagree (1).

The BAT was administered on twenty (20) SSS (II) Biology students in a school outside the study area. The data collected was subjected to item analysis and a reliability test. Items were maintained based on their difficulty index (P) and discrimination index (D). Specifically, items with a difficulty index between 0.25 and 0.75, and a discriminating index between 0.2 and 0.8 were retained. The reliability of the BAT was assessed by employing the Kuder-Richardson Formula 21 (KR-21). The KR-21 value for the BAT was 0.85.

Likewise, for the BSSEQ, the data collected from the pilot study was subjected to reliability tests. The Cronbach's Alpha

reliability estimate value of 0.81 was obtained from the result.

In this study, the researcher obtained a permission letter from the Head of Science and Technology Education department to teach senior secondary school II Biology students in three (3) different schools in the selected Local Government Area for a period of four weeks. The purpose of the research is contained in the letter. Upon approval, the researcher proceeds in the study. Each school represented a treatment group. The first school received instruction using the Concept Mapping strategy, the second school was taught using the Jigsaw strategy, while the third school served as the control group. The topics covered during the intervention were Digestive System and the Excretory System as outlined in the Senior Secondary School Biology curriculum.

In week one, prior to the commencement of instruction, the two instruments; BAT and BSSEQ were administered to all participants across the three schools as pretest to establish students' entry behavior and ensure equivalence among the groups. After the pretests, classroom instruction commenced in the three schools simultaneously. In the first school, lessons on the digestive system were introduced using concept mapping, where students were guided to brainstorm concepts, construct hierarchical concept maps, and link sub-concepts together under the teacher's supervision. In the second school, the jigsaw cooperative learning approach was used. Students were divided into expert groups to study subtopics of the digestive system, after which they returned to their home groups to teach their peers. In the third school, conventional method was employed, where the teacher explained the topic in a teacher-centered manner using chalk-and-talk and textbook references. Lessons continued throughout the first week using the respective strategies.

In week two, instruction on The Digestive System continued across the three schools using the respective teaching methods.

In Week Three, instruction on the Excretory System commenced in all three schools. The concept mapping group constructed maps showing the structure of the kidney, nephron, and processes of urine formation, refining their maps as lessons progressed. The jigsaw group was re-organized into new expert

groups to study subtopics such as kidney structure, nephron function, osmoregulation, and excretory disorders, after which they reconvened to share knowledge with their peers. The control group continued illustrations as in the previous weeks. Lessons were delivered in line with the scheme of work and at the same pace across the three schools.

In Week Four, instruction on The Digestive System and Excretory system was concluded. At the end of Week Four, immediately after the completion of instruction, the post-tests were administered to all participants in the three schools. These included the BPT (post-test) to measure students' cognitive achievement, and the Biology Students' Self-Efficacy Questionnaire (BSSEQ post-test) to assess changes in self-efficacy. All data collected from the three instruments were compiled and for analysis.

The data collected were analyzed using both descriptive and inferential statistics. Mean and

Standard Deviation were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test the null hypotheses at the 0.05 level of significance,

Results

Research Hypothesis One: There is no significant effect of concept-mapping instructional strategy, jigsaw instructional strategy on senior secondary school students' academic performance in Biology

To test this hypothesis, the post-test scores of the Biology Performance Test (BPT) for students in the Concept Mapping, Jigsaw, and Control group were compared using Analysis of Covariance (ANCOVA). The pre-test scores served as a covariate to control for any initial differences in students' prior knowledge before the treatment. Results are presented in Tables 1 and 2 below:

Table 1: Post-test Mean Scores and Standard Deviations of Students' Achievement in Biology by Group

Group	N	Mean ($\bar{x}$)	SD
Concept Mapping (Experimental I)	15	22.53	2.11
Jigsaw (Experimental II)	15	21.93	3.64
Control	15	13.73	4.47
Total	45	19.40	5.21

Source: Author's Field Survey, 2025

From the above results as shown in Table 1, the students who used the Concept Mapping strategy in teaching Biology got the highest mean score of ($M = 22.53$, $SD = 2.11$) followed by the students of Jigsaw strategy who got ($M = 21.93$, $SD = 3.64$). The students in the Control group, who were instructed through the traditional method had the lowest mean score ($M = 13.73$, $SD = 4.47$).

This result indicates that the Concept Mapping and Jigsaw strategy were significantly better than the traditional lecture

to enhance students' learning outcomes in Biology. The group with the relatively smaller standard deviation also shows that the performance of the learners in this group is uniform. The descriptive results indicate that both Concept Mapping and Jigsaw methods of conceptual visualization and collaborative learning led to better learning gains in terms of concepts comprehension and retention compared to the expository approach for Biology concepts.

Table 2: ANCOVA Summary of Students' Post-test Achievement Scores in Biology

Source	Sum of Squares	Df	Mean Square	F	p	Remark
Corrected Model	512.86	3	170.95	28.73	.000	Significant
Pre-test (Covariate)	36.52	1	36.52	6.14	.017	Significant
Group	476.34	2	238.17	39.99	.000	Significant
Error	253.91	41	6.19			
Total	15470.00	45				

Source: Author's Field Survey, 2025
S = Significant at $p < 0.05$

The results of ANCOVA in Table 2 show that the main effect of the instructional strategy is statistically significant in students' academic performance in Biology ($F = 39.99$, $p = .000$). This suggests that the type of teaching had a notable impact on students' achievement when taking into account pre-test differences. Thus, the null hypothesis was rejected. The covariate (pre-test) was also significant ($p = .017$) indicating that students' prior knowledge had a slight but meaningful effect on post-test results. The resulting mean scores after the covariate was adjusted were: Concept Mapping (22.70); Jigsaw (21.80); Expository (13.90). The results indicated that the experimental groups (Concept Mapping and Jigsaw) had higher scores than the control group, which confirmed that student-centered instruction was more effective than

traditional instruction for enhancing academic achievement.

Research Hypothesis Two: There is no significant effect of concept-mapping instructional strategy, jigsaw instructional strategy on students' self-efficacy in Biology. To test this hypothesis, data from the Biology Students' Self-Efficacy Questionnaire (BSSEQ) were analyzed. The instrument measured students' confidence, motivation, and perceived competence in learning Biology. The pre-test scores were used as a covariate to adjust for initial differences among the groups, while the post-test scores were used to determine the effect of the instructional strategies after the intervention. Results are presented in Tables 3 and 4 below:

Table 3: Post-test Mean Scores and Standard Deviations of Students' Self-Efficacy in Biology by Group

Group	N	Mean ($\bar{X}$)	SD
Concept Mapping (Experimental I)	15	47.87	3.14
Jigsaw (Experimental II)	15	46.93	3.68
Control (Expository Method)	15	38.73	4.56
Total	45	44.51	4.46

Source: Author's Field Survey, 2025

The mean score of self-efficacy of the students taught with Concept Mapping strategy was 47.87 (SD = 3.14), followed closely by the students taught with Jigsaw strategy (M = 46.93, SD = 3.68) as seen in Table 4.5. The Control group had the lowest mean self-efficacy score (M = 38.73, SD = 4.56). This indicates that students who were taught with Concept Mapping and

Jigsaw strategies were more confident, motivated, and self-efficacy in learning effectively Biology than students who were taught using Conventional teaching strategy. The results are a result of the motivating effect of participative and collaborative learning environments.

Table 4: ANCOVA Summary of Students' Post-test Self-Efficacy Scores in Biology

Source	Sum of Squares	Df	Mean Square	F	p	Remark
Corrected Model	624.74	3	208.25	25.19	.000	Significant
Pre-test (Covariate)	41.39	1	41.39	5.00	.031	Significant
Group	583.35	2	291.67	35.29	.000	Significant
Error	338.91	41	8.27			
Total	18860.00	45				

Source: Author's Field Survey, 2025

The results of the ANCOVA presented in Table 4 show that there was a significant main effect of instructional strategy on students' self-efficacy in Biology (F = 35.29, p = .000). This indicates that the type of teaching strategy applied made a significant difference in the students' confidence and motivation to learn Biology even after the pre-existence self-efficacy levels were controlled. Thus, the null hypothesis was rejected. The covariate (pre-test) was also a significant variable (p = .031), showing that the students' pre-test confidence levels did have some effect on their post-test scores.

Discussion

The study showed that students from the two groups who were taught Biology with the concept mapping and the jigsaw strategies were significantly better than the students from the conventional method group. This demonstrates that both strategies have a positive impact on students' learning outcomes. The effectiveness of concept mapping is directly related to the visual and logical organization of ideas to create meaningful learning and serve Novak's (2010) constructivist view of the integration of knowledge. Likewise, the jigsaw strategy is

effective because of the cooperative learning environment that encourages group collaboration, sharing of information and more detailed learning by interpersonal interaction. This is in line with results reported by Adeyemi and Ajibola (2021) and Ogunleye and Afolabi (2020) which reveal that cooperative learning enhances students' achievement, motivation and problem-solving skills. The results also corroborate the studies conducted by Yusuf and Aina (2019) which found that visual and interactive methods were effective in improving comprehension in science. They differ from Eze and Okoro (2018) who obtained no significant improvement which could be attributed to the poor management of the group. The current study emphasizes the need for good teacher training, class sizes of not more than twenty learners and the effective implementation of learner-centered approaches to maximize the effective teaching and learning of Biology.

It was also found that the students who were taught by Concept Mapping and Jigsaw Instructional Strategies had a significantly higher level of confidence, motivation, and self-belief to learn Biology as compared to the students who were taught conventionally.

This means that learner-centered approaches make students feel responsible for their own learning, involved in the learning process, and validate their competence in learning. The findings support the contributions of Okeke and Nwachukwu (2022) that the use of concept mapping boosts students' confidence because it helps to give students a visual representation of the scientific relationship that makes it easier to handle. In the same vein, Aliyu and Hassan (2020) concluded that cooperative learning models such as Jigsaw technique increased the students' self-efficacy and students participation in science class by encouraging students to interact with each other and problem solving together. Similarly, in another study, Egbunu and Adewale (2023) noted that students who were given interactive learning environments showed high academic confidence and motivation as compared to those who were exposed to the traditional lecture method of teaching. However, Bamidele and Olorunsola (2019) concluded that there was no significant difference between self-efficacy of students that were exposed to concept mapping and those who did not when students' prior knowledge was inadequate and they were not trained in concept mapping. Similarly, Yakubu (2021) stated that sometimes, the less vocal students in the group lose their self-confidence as a result of group dominance and unequal participation in the cooperative learning. Despite the various opinions, the present study confirms that both the Concept Mapping and Jigsaw techniques have a positive impact on students' self-efficacy in Biology through the active engagement, achievement and social reinforcement, that contribute to strengthening the students' belief in their capability to be successful in their studies.

Conclusion

It was concluded from the study that concept mapping and jigsaw teaching strategies had a significant effect on the students' learning outcomes in Biology. Both methods enhanced academic achievement, self-efficacy and science process skills. Students used concept mapping to organize ideas and create meaningful conceptual connections. Jigsaw encouraged students to work co-operatively, learn from each other and be actively involved

Recommendation

The use of concept mapping and jigsaw strategies in the classroom will enhance students' achievement and engagement in Biology. These strategies are recommended especially for abstract topics and topics that have interconnections. In addition, educational authorities should conduct workshops and seminars for the training of Biology teachers in the application of cooperative learning methods like jigsaw strategy as well as concept mapping. In addition, schools should develop facilitating contexts for group learning and collaborative inquiry, ensuring sufficient resources, space and time are available for interactive learning sessions.

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