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Effect of Concept Mapping Instructional Strategy on Senior Secondary School Students' Scoring Levels in Biology in Kwara State

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ABSTRACT

The study examined the effect of concept mapping instructional strategy on senior secondary school students' scoring levels in biology in Kwara State. A quasi-experimental research design of pretest, posttest, and control group was used. The target population was 852 Secondary School Students (SSS II) from two selected public senior secondary schools in Ilorin, Kwara State. The sample consisted of 80 Senior Secondary School II Biology students purposively selected from two Public Secondary Schools in Ilorin, Kwara State, Nigeria. The adapted Biology Concept Map Instructional Strategy for Teaching Cell Division (BCMISTCD) and Scores from the Biology Performance Test (BPT) were used for data collection. The instruments were duly validated by experts. The reliability of the Biology Performance Test (BPT) instrument was .83. Frequency count, percentage, mean and standard deviation to answer the research questions (1-2). Analysis of Covariance (ANCOVA) and T-test were used to test the null hypotheses 1-2 at 0.05 level of significance. Results show that there is a significant difference in the scoring levels of Biology students when concept mapping instructional strategy is used to teach Cell Division (p.<0.05). The study also indicates that there is a significant difference in the male and female students scoring levels when concept mapping instructional strategy is used to teach Cell Division (p.<0.05). Based on the results, the study concludes that there is a significant difference in the post-test and post-posttest scoring levels of the students when concept mapping instructional strategy is used to teach them. The study also concludes that male students' scoring level is higher than that of female students when concept mapping instructional strategy is used to teach Cell Division. The study recommends that Biology teachers should teach female students who have low-scoring levels in Biology by using concept concept-mapping instructional strategy. This would further improve the female students' scoring levels in the Cell Division. The study recommends that Biology teachers should focus more on female students when concept mapping is used to teach Cell Division.

Keywords: *concept mapping, scoring levels, cell division, biology students, gender*

INTRODUCTION

Biology as part of science education is a branch of natural science that deals with the study of living organisms, including their structures, functions, evolution, distribution, origin and growth (Bagley, 2017). The goals of Science Education according to Ada (2016) are; the acquisition of knowledge, skills, inquiry and a rational mind to conduct of good life, to produce scientists for national development, to service studies in technology and the cause technology advancement and provide knowledge and understanding of the complexity of the physical world, the forms and conduct of life.

In pursuit of these objectives, educational planners advocated for the inclusion of science disciplines, such as Biology, across all levels of the educational system in Nigeria. Biology holds a

distinctive position in the secondary school curriculum due to its significance as the study of life. It serves as a foundational science subject that underpins various other disciplines including Medicine, Pharmacy, Nursing, Biochemistry, Genetics, and Agriculture. The popularity of Biology among students is attributed to its close connection to life itself.

Concept maps also referred to as cognitive maps or organizers, semantic networks, or visual organizers, utilize diagrams, lines, arrows, and spatial arrangements to illustrate the organization and relationships of content ideas and concepts (Appaw et al., 2021). The process of creating concept maps involves visually representing the logical connections among concepts in a structured, sequential, or hierarchical manner, with broader or more general concepts positioned at the top and more specific ones at the bottom of the map. These maps consist of nodes, each denoting a concept, interconnected by directional lines with labels. The arrangement of concept nodes follows a hierarchical structure from general to specific concepts (Zeilik, 2020). Concept maps aid students in organizing concepts into sub-concepts, synthesizing information, gaining a holistic view, and developing higher-order thinking skills and strategies, ultimately leading to improved academic performance (Lee et al., 2013).

It is observed by the researcher that students' performance in biology external examinations has been dwindling steadily. Besides, the WAEC Chief Examiner's Reports showed that students' weakness areas include poor labelling, poor organization and linking of concepts in Biology (Chinyere & Isaiah, 2019). The major weakness areas among Biology students in WASSCE conducted in Nigeria include poor and untitled diagrams, rough labelling, brokenness at some points and shady drawings (WAEC, Chief Examiners' Report, 2021). Bichi et al. (2019) showed that in Nigeria, Biology students performed below average with a mean score of 47.02. These problems keep reoccurring every year among Biology students and require urgent solutions to remediate them. Researchers like Eze and Madu (2022), Eric and Edioga (2022) and others concluded that concept mapping improved students' retention in other related Science Education (Physics, Basic Science, Economics, Mathematics and Geometry subjects. The study investigated the effect of concept mapping instructional strategy on senior secondary school students' scoring levels in biology in Kwara State.

The research on the effect of concept mapping instructional strategy on senior secondary school students' biology scores has revealed a significant achievement gap. The study categorizes performance levels into low (0-39%), average (40-59%), and high (60-100%), identifying where students stand in their understanding of biology. The WAEC Chief Examiner's Reports revealed persistent weaknesses among students, such as poor labelling and organization of concepts in biology. These weaknesses are recurrent, suggesting that traditional teaching methods have not effectively addressed these issues. The research employs the Concept Mapping Instructional Strategy (CMIS) to address these gaps. Previous studies have shown that concept mapping can improve retention and understanding in various subjects, suggesting a potential solution. The study's methodology includes a quasi-experimental design, allowing for a comparison between students taught with CMIS and those taught through conventional methods. The results indicate a significant difference in performance levels between male and female students when using CMIS, with males achieving higher scores. This highlights a gap in the effectiveness of the instructional strategy across genders, suggesting further research is needed to understand and address these disparities.

The purpose of this study is to investigate the effectiveness of the Concept Mapping Instructional Strategy (CMIS) in teaching Biology, specifically by examining two key aspects. First, the study aims to determine whether there is a difference in the scoring levels of students at the post-test and post-posttest stages after being taught using CMIS. Second, it seeks to explore whether there are differences in scoring levels between male and female Biology students taught

with this instructional strategy. To address these objectives, the study is guided by two research questions. The first question focuses on identifying the difference in post-test and post-posttest scoring levels of Biology students who were taught using CMIS. This aims to evaluate the impact of the instructional strategy on students' knowledge retention and long-term learning outcomes. The second research question investigates the difference in scoring levels between male and female students, providing insights into whether gender plays a role in the effectiveness of CMIS as a teaching approach. Based on these questions, the study formulates two null hypotheses to test statistically. The first hypothesis (Ho_1) states that there is no significant difference in the post-test and post-posttest scoring levels of Biology students taught using CMIS. This hypothesis tests the effectiveness of CMIS over time. The second hypothesis (Ho_2) asserts that there is no significant difference in the scoring levels of male and female students when taught using CMIS, examining the potential influence of gender on learning outcomes. By addressing these hypotheses, the study aims to contribute valuable findings on the application of CMIS in Biology education and its implications for teaching strategies and gender inclusivity.

Cognitive learning theory, developed by Piaget in the 1930s, centres on the internal processes related to information processing and memory. It elucidates how both internal and external factors impact an individual's cognitive functions in the context of learning. Challenges and impediments in the learning process arise when cognitive processes are disrupted. These processes encompass attention, observation, retrieval from long-term memory, and categorization, shedding light on the intricate workings of the human mind during learning. Piaget posits that a schema serves as the fundamental unit of knowledge, with schemata accumulating over a person's lifespan. Cognitive learning represents an engaging approach to learning that aims to empower learners to optimize their brain's capacity. By facilitating connections between new information and existing knowledge, cognitive learning enhances memory and retention capabilities. Retention, which involves the brain's capacity to absorb and store information through experiences, senses, and thoughts, is a key component of cognition.

The significance of cognitive learning theory in the context of this study lies in the concept of learners' cognitive development stages. When devising lesson plans, educators must consider learners' developmental stages, particularly in the context of the concept mapping instructional strategy, which underscores the importance of presenting topics from simple to complex (hierarchical). Considering learners' prior knowledge and experiences when designing instructional content is crucial. Furthermore, the social learning theory underscores the collaborative aspect of learning, emphasizing how knowledge emerges from interactions among individuals, their cultural backgrounds, and society. Through concept mapping, students engage in collaborative learning, fostering the exchange of ideas and sharing knowledge on specific biology topics, such as Cell Division.

Simpson (2021) studied ways to improve Georgia's end-of-course Biology assessment scores. Students felt there were too many tests throughout the year. Various assessments were used, and students agreed that teachers prepared them well. The low passing rate in 2018-2019 was due to test anxiety. Interviews and surveys were conducted to design a solution. Interventions include restructuring the schedule, smaller classes, and tutorials, and focusing on priority domains. Instructional interventions support student progress. Similarly, Appaw, et al (2021) conducted a study comparing the effectiveness of a constructivist concept mapping approach to traditional teaching methods in Senior High Schools. Two intact classes were randomly selected from five Co-educational Senior High Schools in the New Juaben Municipality. The experimental group received instruction through concept mapping, while the control group received traditional instruction. Both groups were taught the same content, focusing on photosynthesis and internal respiration. Statistical tools like means, standard deviations, frequencies, Mann Whitney U, independent sample t-test, and paired sample t-test

were used to analyze the data. The findings showed that concept mapping outperformed traditional methods.

Cheema and Mirza's (2013) study investigated the impact of concept mapping, a constructivism-based learning strategy, on the academic performance of 7th-grade students in general science. The study involved 167 students from two single-sex schools and used a developed achievement test as both a pretest and posttest. After a five-month treatment period, students were trained to create concept maps for three weeks. After sharing these maps, they received feedback from teachers for corrections and improvements. The data on gain achievement scores was analyzed through 2-way ANOVA. Results showed that both male and female students taught through concept mapping performed better than those taught through traditional methods, with male students showing significantly better performance compared to female students.

Ebuoh and Ezeudu's (2015) study examined the impact of scoring by section, independent scorers, and conventional patterns on scorer reliability in Biology essay tests. The study involved 42 Biology teachers from 23 secondary schools in Enugu Education zone, divided into three groups: experimental group I (scoring by section), experimental group II (scoring by independent scorers), and group III (conventional pattern of scoring all items). The 13-day treatment involved calculating mean scores and Kendal's coefficient of concordance, and hypotheses were tested using a t-test. The results showed that independent scorers were most effective, followed by section scoring, while the conventional pattern showed no significant impact.

Adebisi et al. (2021) conducted a study in Lagos State, Nigeria, to examine the impact of concept mapping instructional strategy on Senior Secondary School Students' Biology achievement. The study used a quasi-experimental design and included two intact classes of SS 2 students. Data was collected using the Biology Achievement Test (BAT) and Concept Mapping Based Lesson Plan (CMLP). The results showed that concept mapping positively influences students' retention, outperforming the control group. The study replicated a previous one conducted in Ilorin, Kwara State. Also, Aslami et al. (2021) conducted a study on the impact of concept mapping on Computer Technological Skills (CTS) of medical students. The study involved 100 second-year medical students in an anatomy course, who were randomly assigned to a control group and an intervention group. The California Critical Thinking Skills Test was used to assess CT levels.

METHODOLOGY

A quasi-experimental research design involving pretest, posttest, and a control group was utilized in this study. The focus was on 852 Secondary School Students in SSS II from two public senior secondary schools in Ilorin, Kwara State. Specifically, the sample comprised 80 Senior Secondary School II Biology students who were purposively chosen from these schools in Nigeria. The selection process was based on a tally card method. The rationale behind selecting SS II students was the timing of the Cell Division topic being taught at this class level. The students were categorized into high, average, and low scoring and retention levels based on their scores from the Biology Performance Test (BPT). To gather data, two instruments were employed. The first instrument was an adapted Biology Concept Map Instructional Strategy for Teaching Cell Division (BCMISTCD) developed by Opinado, Yuri, Mikhail, and Ayinla. The instruments were validated by experts from Al-Hikmah University, Ilorin.

The reliability of the instruments was tested through a pilot study involving 30 Senior Secondary School Students from a different school. The Biology Performance Test (BPT) instrument showed a reliability coefficient of .83. Data analysis involved the use of frequency count, percentage, mean, and standard deviation to address research questions 1-2. Furthermore,

Analysis of Covariance (ANCOVA) and T-test were conducted to test the null hypotheses at a 0.05 level of significance. Students' performance levels were categorized as low, average, and high based on their scores on the Biology Performance Test (BPT). Low performance was defined as scores between 0-39%, average performance fell between 40-59%, and high performance was considered for scores between 60-100%. IBM Statistical Package for Social Science (SPSS) version 25 was employed for data analysis. The results of the analysis will provide valuable insights into the impact of this instructional strategy on student performance in the subject. The study does not specify the exact number of male and female participants, but the analysis reveals significant differences in performance between male and female students. The students were chosen based on their enrollment in SSS II and the timing of the Cell Division topic being taught. The selection criteria were based on curriculum requirements and previous scores from the Biology Performance Test (BPT), allowing for a comprehensive analysis of the instructional strategy's effectiveness across different performance levels.

RESULT AND DISCUSSION

One of the key research questions explored in this study is the difference in post-test and post-posttest scoring levels of Biology students when the Concept Mapping Instructional Strategy (CMIS) was employed to teach the topic of cell division. The findings related to this question are presented in Table 1, which summarizes the scoring levels of students at the two assessment stages.

Table 1. Post-Test and Post-Posttest Scores Using CMIS

Scoring Levels	Posttest	Post-posttest
Lowest Mark	60.00	50.00
Highest Mark	99.00	99.00
Mean	73.5375	72.3875
Std. Deviation	11.50448	11.16334

Note: Low Performance (0-49%), Average Performance (50-65%), High Performance (66-100%)

Table 1 shows that the lowest mark that students got from the Biology Performance test (BPT) was 50% and the highest mark was 99%. The expected highest mark was 100% while the lowest mark score was 0%. The mean score on the post-test was (M=73.54; SD=11.50) while the mean score on the post-posttest was (M=72.39; SD=11.16) respectively. This indicates there were differences in the scoring level of the biology students.

Another important research question examined in this study is the difference in scoring levels between male and female Biology students when taught using the Concept Mapping Instructional Strategy (CMIS). This analysis aims to determine whether gender influences the effectiveness of CMIS in improving students' understanding of cell division. The data related to this question are presented in Table 2 below.

Table 2. Gender-Based Score Differences Using CMIS

Academic Performance		
	Male	Female
Lowest Score	47.00	45.00
Highest Score	99.00	99.00
Mean	68.5250	64.9500
Std. Deviation	9.32802	9.68478

Note: Performance was rated low (0-49%), Average Performance (50-65%), High Performance (66-100%).

Table 2 shows that the minimum performance score is 45% and the maximum score is 99%. The expected maximum score was 100% while the minimum performance score was 0%. The mean score of males was (M= 68.53; SD=9.33) and the mean score performance of females was (M=64.95; SD=9.68) respectively. This indicates that gender had some influence on the student's performance when Concept Mapping Instructional Strategy was used to teach them Cell Division. The result shows that this positive influence was in favour of male students.

The first hypothesis (Ho1) states that there is no significant difference in the post-test and post-posttest scoring levels of Biology students when the Concept Mapping Instructional Strategy (CMIS) is used. To test this hypothesis, an Analysis of Covariance (ANCOVA) was conducted, and the results are presented in Table 3 below.

Table 3. ANCOVA Results for Post-Test and Post-Posttest Scores Using CMIS

Dependent Variable: Academic Performance					
Source of Variation	Sum of Squares	Df	Mean Square	F	Sig.
Covariates	4368.952[a]	7	56.012	1	.
		8		.655	561
Main Effects	118.810	1	118.810	3	.
				.510	312
Posttest	302.168	8	33.574	.	.
				992	658
Post-posttest	752.332	1	62.694	1	.
		1		.852	523
Residual	33.848	1	33.848		
Explained	4402.800	7			
		6			
Total	335162.000	7			
		7			

a. R Squared = .992 (Adjusted R Squared = .393)

Results in Table 3, indicate that the F (11)-calculated value for scoring levels is 1.86, and the critical table value is 1.97 at 5% level of significance. The F (11) calculated of 1.86 is greater than the critical table value of 3.97 at 5% (F_{cal}=3.51 < $F_{0.05,1,176}$=3.97). Therefore, hypothesis one is accepted**.** This implies that there is a significant difference in the posttest and post-posttest scoring levels of the students when concept mapping instructional strategy is used to teach them.

The second hypothesis (Ho_2) posits that there is no significant difference in the scoring levels of male and female Biology students taught using the Concept Mapping Instructional Strategy (CMIS). To test this hypothesis, a T-test was conducted, and the results are presented in Table 4 below.

Table 4. T-Test Results for Gender Differences in Scoring Levels Using CMIS

One-Sample Test

Test Value = 0.5

	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Male	21.546	53	.000	44.198	40.08	48.31
Female	14.267	26	.000	50.389	43.13	57.65

Results in Table 4, indicate that the t-calculated value for male scoring levels is 21.55, and 14.28 for females. The significance level is .000 at 5% level of significance. The significant level is less than 5% (p.<0.5). Therefore, hypothesis two is rejected**.** This implies that there is a significant difference in the scoring level of male and female students when concept mapping instructional strategy is used to teach them.

The research demonstrates a substantial disparity in the post-test and post-posttest scores of students when the concept mapping instructional strategy is employed. Specifically, the study indicates a notable contrast in the post-test and post-posttest scores of Biology Students when the concept mapping instructional strategy is utilized to teach Cell Division. This suggests that the average scores of participants at the post-test (M= 302.17) and post-posttest (M=752.33) exhibit a significant difference due to the implementation of the concept mapping instructional strategy. Notably, this variance favoured the experimental group participants who achieved higher scores compared to those in the control group. The findings reveal that the concept mapping instructional strategy positively impacted the scores of participants in the experimental group in contrast to those in the control group. These results align with previous studies conducted by Adebisi et al. (2021), Aslami et al. (2021), Appaw et al. (2021), Simpson (2021), Nuru et al. (2020), Ebuoh and Ezeudu (2015), which all underscored that students exposed to the concept mapping instructional strategy achieved higher scores than those taught through conventional methods. This indicates that the utilization of concept mapping assisted experimental group participants in organizing, linking, and comprehending the interconnectedness of concepts in Cell Division compared to those in the control group, thereby contributing to their higher scores.

Furthermore, the research also concludes that a significant discrepancy exists in the scoring levels of students when the concept mapping instructional strategy is employed, particularly favouring male participants. The data suggests that the average scores of male and female participants exhibit a significant difference when the concept mapping instructional strategy is applied, with male participants achieving higher scores than their female counterparts. The results demonstrate that the concept mapping instructional strategy positively impacted the scoring levels of male participants compared to females, aligning with the findings of Toheed et al. (2017), Adeniran et al. (2018) and Martins-Omole et al. (2016), all which indicated that students taught using the concept mapping instructional strategy experienced significant improvements in their retention scores. Male students displayed better retention levels than their female counterparts, indicating that the use of concept mapping facilitated male participants in organizing, linking, and comprehending the interconnected concepts in Cell Division more effectively than their female counterparts, leading to higher retention levels among male participants. Thus, it can be inferred that the exposure to the concept mapping instructional strategy enhanced the retention levels of male participants compared to females. In conclusion, the implementation of the concept mapping instructional strategy yielded positive outcomes in terms of students' performance and retention, particularly benefiting male participants in understanding and retaining the concepts related to Cell Division.

CONCLUSION

Based on the findings, the study concludes that a notable disparity exists in the post-test and post-posttest performance levels of students when the concept mapping instructional approach is employed. Moreover, the study concludes that male students attain higher performance levels compared to their female counterparts when the concept mapping instructional strategy is utilized to teach Cell Division.

Based on the findings of this study, several recommendations can be made for improving teaching practices in biology. First, it is recommended that science education teachers, particularly in the field of biology, utilize the concept mapping instructional strategy (cmis) when teaching students who demonstrate lower performance levels. This instructional approach has been shown to enhance students' understanding and performance, particularly in complex topics such as cell division. By incorporating cmis, educators can help these students improve their comprehension and academic outcomes. Second, the study highlights the importance of paying

particular attention to female students when employing concept mapping techniques. It is suggested that biology instructors tailor their approach to ensure that female students benefit equally from the strategy, ensuring that both male and female students achieve optimal learning outcomes in topics like cell division.

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