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Effect of Concept Mapping on Federal Colleges of Education Students Academic Achievement in Cell Biology in Southwest Nigeria

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Abstract

This study investigates the effect of concept mapping on the academic achievement of 100-level Biology students in Cell Biology at Federal Colleges of Education in Southwest Nigeria. A 3x1x1 factorial quasi-experimental design was used, involving pre-tests and post-tests with both treatment and control groups. The treatment groups were taught using concept mapping strategies, while the control group received conventional teaching methods. The sample comprised 240 Biology students from two colleges, selected through a multi-stage sampling technique. The study's instruments included the Biology Achievement Test (BAT) and tailored lesson plans for both concept mapping and conventional methods. Hypothesis testing using ANCOVA revealed significant main effects of concept mapping and gender on academic achievement, as well as a significant interaction between the two. Concept mapping significantly improved students' academic performance ($p<0.05$), with a 22.2%

contribution to the variance in achievement. Gender also played a significant role, with females outperforming males. The interactive effect demonstrated that concept mapping positively influenced both genders, but more so for males. The study recommends incorporating concept mapping into the Biology curriculum and tailoring teaching strategies to address gender-specific learning needs.

Introduction

The swiftly changing environment of education highlights the essential requirement to investigate creative teaching methods that enhance student engagement, critical thinking, and a profound comprehension of the subject matter. In recent years, there has been a growing emphasis on enhancing educational quality through the implementation of innovative and effective teaching strategies aimed at fostering learning. Among these strategies, concept mapping have emerged as promising tools to enhance student learning outcomes. For students focussing on Biology, establishing a robust understanding of the subject is crucial, as they hold the important role of influencing the scientific literacy of future generations. Utilising concept mapping can significantly enhance students' understanding and achievement in Biology. This strategy promotes active engagement among learners, foster collaboration, enhance critical thinking, and facilitate the development of advanced cognitive skills.

The importance of receiving a quality education in Biology cannot be overestimated since it is the cornerstone of establishing scientific literacy and gaining a grasp of significant ecological, health, and environmental concerns. On the other hand, conventional methods of education would not always thrive in complete engagement of learner in class activities foster understanding and information retention. Educators and researchers have turned their focus to concept mapping and cooperative learning as a means of unraveling students potentials as means of fostering active learning, critical thinking, and collaborative abilities among Biology students.

The academic achievement of students in cell biology significantly impacts the quality of instruction they deliver in the classroom. To enhance effective scientific teaching in educational institutions, it is crucial to guarantee that future educators

in Biology possess a strong grasp of the subject matter. However, the use of instructional methods such as concept mapping approach by educators at colleges of education in the context of teaching Biology enhances the academic achievement of students (Kodri & Ong, 2023). According to Melike (2020), students at the Federal College of Education denote persons who are undergoing preparation to get licensure as teachers or educators but have not yet commenced their professional teaching careers. These individuals are generally enrolled in teacher training programs at colleges, universities, or other educational institutions. Programs at the Federal College of Education are structured to provide prospective educators with the essential information, skills, and competencies required for effective teaching in diverse educational environments.

Tsevreni, (2021) affirmed that the pursuit of knowledge in biological science is crucial for improving quality of life, as it provides insights into living organisms and their complex interactions with the environment. The pursuit of knowledge and skill development in Biology enhances scientific literacy and aids in understanding our environment. Moreover, these competencies offer substantial advantages to both individuals and society, as they actively contribute to the promotion of the nation's socio-economic progress. Despite the significance of Biology, there has been a notable decline in student's achievement specifically in the field of Cell Biology within various colleges of education in the Southwestern region of Nigeria. For instance, the proportion of students who successfully passed Cell Biology in these colleges appears to be considerably lower when compared with the overall student's population. The current scenario is disheartening and, if left unattended to, could yield significant effect on the entire educational system (Bizimana, Mutangana & Mwesigye, 2022).

Multiple studies by Bizimana, Mutangana & Mwesigye, (2021), have demonstrated that students possess a considerable number of misconceptions regarding many topics within the field of Biology, such as photosynthesis, ecology, genetics, evolution, and Cell Biology, among others. Cell Biology, a fundamental discipline within the study of Biology that investigates the interconnectedness of living organisms, has witnessed significant advancements in the last two decades due to the progress made in several scientific domains such as electron microscopy, biochemistry, and immunology. The course Cell Biology offered in colleges of education covers the following topics: Cell theory, the structure of plant and animal cells, and their comparison. It offers numerous advantages to students in comprehending Biology as a comprehensive discipline, as it serves as the

fundamental basis for the biological sciences and aids in addressing diverse societal issues (Rahma, Moncef, Boujemaa, Nadia, Anouar & Lhoussaine, 2022).

According to Goryachev, (2021), Cell Biology is the scientific discipline that focuses on examining the structure and functioning of cells, which are the fundamental unit of life. The objectives of the Cell Biology course include gaining a comprehensive understanding of cell and cell theory, exploring the historical background of cell research, and conducting a comparative analysis of animal and plant cells based on their contents, among other topics. One of the goals of Cell Biology is to explore new fields of study, such as microbiology, forensic science, biotechnology, medicine, biomedical engineering, cytology, and biochemistry. Forensic medicine employs the fields of Cell Biology and DNA fingerprinting to aid in the resolution of homicides and physical attacks. Both the judicial system and the offenders cannot evade the significance of Cell Biology, (Christian, 2023).

Hence, it is imperative that the field of Cell Biology be incorporated into the fundamental scientific education of all individuals in the 21st century. The idea of cell poses significant challenges and learning barriers for undergraduate students. The definition of the science of Cell Biology has challenges, mostly due to the abstract nature of cell as a fundamental entity in terms of structure and function. Cell is seen as a metaphysical idea, lacking tangibility and visibility, and its study relies heavily on microscopic observation. This difficulty will undoubtedly create in the learners a false understanding of the basic concepts of Cell Biology and will emerge false ideas, erroneous conceptions, and unsurpassable misconceptions that block good learning in Biology (Raj, 2023). However, several studies that have focused on the teaching of Cell Biology and educational innovations have shown that this discipline generates learning difficulties for Biology students, which will constitute potential obstacles to the assimilation and understanding of concepts of other biological disciplines. As a result, the underachievement of students may be associated with the inappropriate, insufficient, and exclusive teaching strategies and methods employed by Biology educators (Terhemba, Okwara & Jirgba, 2021).

To tackle this challenge, it is advisable for Biology educators to utilise teaching methods that foster active participation among students, especially when covering intricate and abstract subjects like Cell Biology. Among the methodologies that can be employed and extensively studied in recent times is Concept Mapping (CM). This methodology have demonstrated significant efficacy and widespread adoption which is why this present study deem it fit to consider it as proactive measures to

teaching of Cell Biology to pre-service Biology teachers (Terhemba, Okwara & Jirgba, 2021).

According to Emmanuel, (2022), concept mapping serves as a cognitive learning strategy that enables individuals to visually articulate and structure their knowledge in a hierarchical manner. When learners deconstruct extensive information into digestible segments of concepts and connections, they enhance their capacity to comprehend and remember the material. Students in biological sciences could gain advantages from concept mapping as it promotes reflective thinking, thereby aiding them in linking theoretical concepts to practical applications in the real world.

Appaw, Owusu, Frimpong & Adjibolosoo, (2021), also agreed that Concept mapping serves as a meta-cognitive learning technique that evaluates how an individual organises and structures their knowledge within a specific domain. The terms "cognition about cognition," "knowing about knowing," and "thinking about thinking" all refer to the concept of meta-cognition. Concept mapping serves as a technique for illustrating the relationships among concepts within a two-dimensional framework. A concept map illustrates a collection of interconnected concepts, highlighting the relationships between pairs of concepts through the links that bind them. A valuable technique for demonstrating ideas within a topic or unit and their interrelations in a two-dimensional format is concept mapping. The map serves as a tool for both the instructor and the students to illustrate their perspectives on a range of topics and the relationships between them, (Agustin, 2022).

Additionally, Goryachev (2021) affirmed that concept mapping offers students with a visual depiction of a certain subject area, which may help them make more effective use of the resources that are at their disposal. When looking at the map, he or she might be able to identify the primary ideas, sort them in descending order from more broad to more detailed, and establish meaningful connections between the various ideas. Therefore, concept mapping is an effective yet straightforward method of utilizing diagrams to display information in the same manner that one thinks about it. Through the use of concept mapping, difficult material may be easily comprehended, remembered, and communicated. The position of the teacher in his environment has evolved from that of a knowledge-transmitter to that of a facilitator.

Moreover, Immelman, (2020), confirmed that concept mapping promotes collaborative learning, which can further enhance academic achievement. When

students work together to create concept maps, they engage in discussions, share perspectives, and challenge each other's understanding. This collaborative process not only reinforces their individual learning but also builds communication and teamwork skills. As a result, students are more likely to develop a comprehensive and nuanced understanding of cell biology, which translates into improved performance in assessments and a stronger foundation for future scientific studies. In addition to fostering deeper comprehension and critical thinking, concept mapping significantly aids in reducing cognitive overload, especially in subjects like cell biology that are laden with complex information. The visual nature of concept maps allows students to break down and organize vast amounts of data into manageable chunks. This process helps in clarifying abstract concepts and reducing the mental strain often associated with learning dense scientific material, (Mo, 2019).

A separate investigation examined the effects of various instructional strategies, including concept mapping on Biology students' comprehension of biological concepts. The findings from the study indicated that when students were instructed using a blend of these strategies, they demonstrated improved retention of knowledge, enhanced critical thinking skills, and a greater ability to apply biological concepts to real-world situations. Furthermore, the reports from students indicating a rise in their interest and enjoyment in academic pursuits are quite promising, (Aliu, & Raheem (2023)). A study was carried out to assess the impact of concept mapping on the academic performance of Biology students and their attitudes towards the subject. The results indicated that the approach positively impacted students' academic performance and fostered a more positive attitude towards Biology, (Anthony & Chinonyelum, (2022).

Long-standing observations have highlighted the existence of gender disparities in science education, particularly in the field of Biology, and these issues persist in the present day, (Stevenson, Szczytko, Carrier, & Peterson, 2021). A recent review indicates that disparities in student achievement based on sex persist, largely due to the teaching strategies employed by educators, (Uchegbue & Amalu, 2020). Considering these variations and the differences in students' learning approaches to Biology, it is essential for educators in this field to recognise and address these factors effectively.

The recent studies emphasise the advantages of implementing concept mapping and cooperative learning strategies in the teaching of Biology for students in Federal Colleges of Education in Southwest Nigeria. The integration of these

teaching strategies seems to improve students' grasp of concepts, foster critical thinking abilities, boost motivation, and positively influence their attitudes towards the subject. Given the positive outcomes demonstrated by these studies, it is logical to contemplate the implementation of such strategies in teacher training programs to enhance the preparation of future educators in the field of Biology. This study aims to explore the impact of concept mapping strategy on the academic achievement of Federal Colleges of Education students in Cell Biology within Southwest Nigeria.

Statement of the Problem

The education system plays a crucial role in shaping the knowledge and skills of future educators, particularly those specializing in Biology. In Southwest Nigeria, there has been growing concern about the academic achievement of students in Cell Biology due to various challenges. Traditional teaching methods currently employed often fail to adequately engage students or address their specific learning needs, leading to suboptimal educational outcomes. Many Biology students perceive the subject as demanding extensive memorization, which can be overwhelming and discouraging. Additional factors, such as limited student engagement, insufficient and poor-quality practical laboratory sessions, overcrowded classrooms, an unconducive learning environment, and ineffective teaching methodologies, further exacerbate the issue. These challenges hinder students' comprehension and retention of key biological concepts, potentially impairing their ability to apply this knowledge in their future teaching careers. Without effective instructional strategies, the quality of Biology education could decline, affecting the preparation of future educators. This study seeks to investigate the effect of concept mapping on the academic achievement of Federal Colleges of Education students in Cell Biology in Southwest Nigeria. By examining this innovative teaching approach, the research aims to identify its potential to enhance student understanding and improve academic outcomes in this critical area of science education.

Aim and Objectives of the Study

The study aimed to investigate the effectiveness of concept mapping and cooperative learning strategies on Federal Colleges of Education students Academic Achievement in Cell Biology in Southwest Nigeria**.** The objectives of the study are to:

i. examine the main effect of concept mapping on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria;
ii. evaluate the main effect of gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria; and
iii. ascertain the interactive effect of concept mapping and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest Nigeria;

Hypotheses

The following hypothesis were tested in the study at 0.05 level of significant

$H_{o}1$: There will be no significant main effect of concept mapping on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria.

$H_{o}2$: There will be no significant main effect of gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria.

$H_{o}3$: There will be no significant interactive effect of concept mapping and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest Nigeria.

Methodology

Research Design

The study employed a 3x1x1 factorial quasi-experimental design, incorporating pre-test and post-test measures, along with non-randomized control and non-equivalent intact groups. The study emphasises concept mapping strategies, and conventional methods across three levels, including two treatment groups and a control group. Concept mapping strategies functioned as independent variable serving as the treatment group for the experimental group, while the conventional teaching method was employed for the control group. The dependent variable was the achievement of pre-service teachers, categorised into two levels: high achievers and low achievers. Gender served as the moderating variable, also divided into two levels: male and female.

Population of the Study

The population for the study comprises of all the 100 Level Biology students in Federal Colleges of Education Southwest Nigeria which include Federal College of

Education (Special) Oyo, Oyo State, and Federal College of Education Iwo, Osun State. The population of 100 level Biology students in Federal College of Education (Special) Oyo is one hundred and seventeen (117) Students and the total population of Biology students at Federal College of Education Iwo was one hundred and twenty three (123). The total target population for the study is two hundred and forty (240) Biology students of the schools in consideration as at the time of conducting this study.

Sample and Sampling Techniques

A multi-stage sampling technique was utilised to select the participants for the study. The initial phase entails employing a simple random sampling technique to select two (2) Federal Colleges of Education that fulfil the criteria of possessing qualified lecturers and accessible digital teaching and learning facilities relevant to the topic at hand. Secondly, the study comprises three intact classes of 100 level Biology students, which will be randomly selected from three different schools according to the established selection criteria. One school was designated as the control group, while the second school was assigned as experimental groups. The experimental group underwent concept mapping, while the control group, experienced the conventional method of teaching.

Research Instruments

This study utilised three research instruments, including the Biology Achievement Test (BAT) and a lesson plan format for concept mapping for the experimental group, and a lesson plan format for the conventional method for the second experimental group. These tools were designed to facilitate the teaching of Cell Biology, which is central to the study.

Description of Research Instruments

Biology Achievement test (BAT)

Biology Achievement test (BAT). The achievement test was developed by the research in order to assess the level of achievement in Cell concepts. It covered the main topic of Biology taught in NCE 1. It initially consists of 50 items multiple choice questions with five (5) options A to E and based on six cognitive levels, Knowledge, comprehension, Application, Analysis, Synthesis and Evaluation. Biology Achievement Test (BAT) answered by the Biology students it has two (2) sections. Sections A consist of demographic Data which include Gender, Level,

Name of the institution, Age. while section B initially comprises of fifty (50) multiple choice questions with option A-E which was self-structured to test the students achievement in cell topics in Biology.

Validity of Research Instrument

The validation of the research instruments was conducted by the supervisor and three lecturers from the Department of Science Education at Lead City University, Ibadan, Nigeria. The BAT was initially constructed with fifty (50) objective questions and underwent expert review to ensure its legitimacy regarding face, content, and construct validity. All corrections and suggestions were implemented prior to the production of the final draft.

Reliability of Research Instrument

A preliminary study was carried out to assess the reliability of the primary research tool, the Biology Achievement Test (BAT). The research tools were applied to a subset of the population that was not involved in the primary study. The reliability value of the instruments was determined using the Kuder Richardson (KR-20) formula. The result obtained was 0.75.

Method of Data Collection

Prior to administering the instruments to the chosen students, a letter of introduction was secured from the Head of Department (HOD), Science Education, Lead City University Ibadan, and sent to the Heads of the selected schools. The approval of the Lecturer and the collaboration of the chosen students were also being requested prior to the implementation of the instruments. The study was conducted over duration of ten weeks, with the initial week dedicated to visiting schools. One week was allocated for the training of research assistants who supported the study. The pre-test was administered to all groups over a period of two weeks, followed by a six-week treatment phase for the treatment group, and finally, the post-test was conducted in the last week. The team and the assistants waited for all the participating students to complete the achievement test before collecting the instrument.

Method of Data Analysis

The hypotheses formulated for the study were tested using analysis of covariance (ANCOVA) at 0.05 level of significance.

Result

Test of Hypotheses

This section answer the test of hypothesis

$H_{o}1$: There will be no significant main effect of concept mapping on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria.

Table 1: Shows the analysis of covariance of main effect of concept mapping on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4561.001[a]	2	2280.500	33.884	.000	.222
Intercept	1932.749	1	1932.749	28.717	.000	.108
Pre-Test	341.127	1	341.127	5.068	.025	.021
Concept Mapping	1984.441	1	1984.441	29.485	.000	.111
Error	15950.983	237	67.304			
Total	126436.000	240				
Corrected Total	20511.983	239				
a. R Squared = .222 (Adjusted R Squared = .216)						

Source: Field Survey, 2024

Table 1 shows that there is a significant main effect of concept mapping on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria($F_{(1,\ 237)}$=29.485 with associated probability (p=0.000) whereby the probability value of 0.000 is less than 0.05 (p<0.05) level of significant. While Partial Eta Squared value of 0.222 (η^2=0.222) shows the contributing effect size of 22.2%. The null hypothesis is therefore rejected. This implies that the introduction of concept mapping as a method significantly affects the academic achievement of Biology students when taught Cell Biology at Federal College of Education in Southwest Nigeria.

Table 2: Estimated Marginal Means of Concept Mapping on Biology students' academic achievement when taught Cell Biology

Control	17.670[a]	.811	16.071	19.268
Concept Mapping	24.518[a]	.836	22.872	26.164

Source: Field Survey, 2024

Table 2 shows that participants exposed to concept mapping (treatment group 1) had higher posttest mean ($\bar{x}$) score of 24.518 on Biology students' academic achievement when taught Cell Biology, than other participants in the control group with posttest mean ($\bar{x}$) score of 17.670. This means that participants exposed to Concept Mapping method of teaching (treatment group) performed better than those in the control group, the difference is sufficient to justify the effectiveness of concept mapping over conventional method of teaching cell Biology in South west Nigeria.

H_{02}: There will be no significant main effect of gender on biology students' academic achievement when taught cell biology at federal college of education in southwest Nigeria.

Table 3: Analysis of covariance of main effect of Gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3542.314[a]	2	1771.157	33.384	.000	.159
Intercept	1663.152	1	1663.152	31.348	.000	.082
Pre_Test	2825.557	1	2825.557	53.257	.000	.131
Gender	367.977	1	367.977	6.936	.009	.019
Error	18675.280	352	53.055			
Total	197709.000	355				
Corrected Total	22217.594	354				
a. R Squared = .159 (Adjusted R Squared = .155)						

Source: Field Survey, 2024

Table 3 indicate that there is a significant difference on the main effect of Gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria ($F_{(1,352)}$=6.936 with associated probability (p=0.000) whereby the probability value of 0.000 is less than 0.05 (p<0.05) level of significant while Partial Eta Squared value of 0.159 (η^2=0.159) shows the contributing effect size of only 15.9%. Therefore the null hypothesis is rejected. This implies that gender as a factor affect the academic achievement of Biology students when taught Cell Biology at Federal College of Education in Southwest Nigeria.

Table 4: Estimated Marginal Means of Gender on Biology students' academic achievement when taught Cell Biology

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Female	23.408[a]	.590	22.247	24.569
Male	21.334[a]	.516	20.319	22.349

Source: Field Survey, 2024

Table 4 indicate that the female participants had higher posttest mean ($\bar{x}$) score of 23.408 than that of their male counterparts had posttest mean ($\bar{x}$) score of 21.334. This means females have higher mean average score than the males after considering other factors, gender is also a key factor that significantly affects the academic achievement of biology students taught cell Biology at Federal College of Education in Southwest Nigeria.

H_03: There will be no significant interactive effect of concept mapping and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest Nigeria.

Table 5 Analysis of covariance of interactive effect of concept mapping and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest Nigeria.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5784.362[a]	4	1446.090	23.074	.000	.282
Intercept	2576.894	1	2576.894	41.118	.000	.149
Pre-Test	97.970	1	97.970	1.563	.212	.007
Gender	552.324	1	552.324	8.813	.003	.036
Concept Mapping	2080.674	1	2080.674	33.200	.000	.124
Gender * Concept Mapping	673.304	1	673.304	10.744	.001	.044
Error	14727.621	235	62.671			
Total	126436.000	240				
Corrected Total	20511.983	239				
a. R Squared = .282 (Adjusted R Squared = .270)						

Source: Field Survey, 2024

Table 5 shows that there is a significant interactive effect of main effect of gender and concept mapping on Biology students' academic achievement when taught Cell

Biology at Federal College of Education in Southwest Nigeria ($F_{(1, 235)}$=10.744 with associated probability (p=0.001) whereby the probability value of 0.001 is less than 0.05 (p<0.05) level of significant while Partial Eta Squared value of 0.282 (η^2=0.282) shows the contributing effect size of only 28.2%. The null hypothesis was therefore rejected. This implies that the introduction of concept mapping with great consideration of the students' gender significantly affect the academic achievement of Biology students when taught Cell Biology at Federal College of Education in Southwest Nigeria.

Table 6: Estimated Marginal Means of concept mapping and gender on Biology students' academic achievement when taught Cell Biology

Gender	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Female	Control	21.056[a]	1.096	18.897	23.214
	Concept Mapping	24.732[a]	1.179	22.410	27.055
Male	Control	14.517[a]	1.062	12.425	16.609
	Concept Mapping	24.981[a]	1.023	22.967	26.996

Source: Field Survey, 2024

Table 6 shows that for the female participants there is a little difference in the average mean ($\bar{x}$) score between control group ($\bar{x}$) = 21.056 and Concept Mapping (treatment 1) group ($\bar{x}$) = 24.981 while the male participants had a clear average mean difference between the control group ($\bar{x}$) = 14.360 and Concept Mapping (treatment 1) group ($\bar{x}$) = 24.981.Although, the effect of concept mapping was evident on both gender, it is obvious that concept mapping had a clear influence/effect on the males as there is an obvious difference between the control group and treatment group of concept mapping. Hence, it could be deduced that concept mapping had a great effect/impact on the males than on the females' academic achievement of Biology students taught cell Biology at Federal College of Education in Southwest Nigeria.

Discussion of Findings

According to the initial hypothesis, the results indicate that the introduction of concept mapping as a method significantly affect the academic achievement of Biology students when taught Cell Biology at Federal College of Education in

Southwest Nigeria because the p value of 0.000 is less than 0.05 (p<0.05) level of significant which means that the null hypothesis is rejected. Also the Estimated Marginal Mean shows that participants exposed to Concept Mapping method of teaching (treatment group) performed better than those in the control group. The finding aligns with a previous study conducted by Anthony & Chinonyelum, (2022) in Enugu Education Zone using a multistage selection approach. The outcome of the study indicated that Students who were instructed in Biology through the utilization of concept mapping exhibited superior achievement compared to their peers who were taught utilizing the lecture technique. Also, study by Aliu, & Raheem (2023) investigates the impact of concept maps on the academic achievement of higher secondary level school Students in the field of Biology in Colleges from Gadhinglaj Taluka shows that the concept map technique employed for teaching Biology proved to be helpful for Students at the higher secondary level. Furthermore findings from hypothesis two indicate that there is a significant difference on the main effect of Gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria whereby the p value of 0.000 is less than 0.05 (p<0.05) level of significant. The null hypothesis there will be no significant main effect of gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria was rejected, while the estimated marginal mean indicate that the female participants had higher posttest mean ($\bar{x}$) score of 23.408 than that of their male counterparts had posttest mean ($\bar{x}$) score of 21.334. This means females have higher mean average score than the males taught Cell Biology at Federal College of Education in Southwest Nigeria. The findings is not in line with study carried out by Uchegbue & Amalu, (2020) in two senior secondary schools in Adamawa state that shows no notable disparity observed between male and female students in the experimental group.

The result from the findings in hypothesis three indicates that there is a significant interactive effect of concept mapping and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest Nigeria whereby the p value of 0.001 is less than 0.05 (p<0.05) level of significant. The null hypothesis there will be no significant interactive effect of concept mapping and gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria was rejected, while estimated marginal mean shows that for the female participants there is a little difference in the average mean ($\bar{x}$) score between control group ($\bar{x}$

) = 21.056 and Concept Mapping (treatment) group ($\bar{x}$) = 24.981 while the male participants had a clear average mean difference between the control group ($\bar{x}$) = 14.360 and Concept Mapping (treatment) group ($\bar{x}$) = 24.981.Although, the effect of concept mapping was evident on both gender. The present study is in line with the previous study which shows no notable disparity observed between male and female students in the experimental group. Also in line with a study carried out by Immelman, (2020), in Ika South Local Government Area, Delta State shows that inequality was observed in the achievement of male and female students who were instructed using the concept learning approach, with female students exhibiting superior outcomes.

Conclusion

Based on the findings, the study's findings indicate that concept mapping strategy have a significant positive impact on the academic achievement of Biology students in cell biology at Federal Colleges of Education in Southwest Nigeria. The strategy demonstrated beneficial impacts on students' comprehension, with concept mapping contributing 22.2% of the variance in achievement. Furthermore, gender served as a moderating factor affecting academic results, as male and female students exhibited different responses to the instructional methods employed. The results suggest that employing alternative teaching strategy like concept mapping can lead to improved learning outcomes in comparison to traditional methods.

Recommendations

Based on the study's findings and objectives, the following recommendations are proposed:

1. Lecturers in Federal Colleges of Education in Southwest Nigeria should incorporate concept mapping strategies into their cell biology curriculum to enhance students' academic achievement. This approach can support students' comprehension and retention of complex biological concepts, as shown by its significant effect on learning outcomes.
2. Educators should be mindful of gender-specific learning needs and preferences when selecting instructional strategies. Given that gender has a significant effect on students' academic achievement, personalized approaches that accommodate gender differences can further improve learning outcomes.
3. Given the interactive effect of concept mapping and gender, teachers should consider tailored applications of concept mapping that address the unique

needs of male and female students. This customization can further maximize the effectiveness of concept mapping for diverse student groups.

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