

## BIOLOGY ACHIEVEMENT AND RETENTION: A COMPARATIVE INVESTIGATION OF CONCEPT MAPPING AND TRADITIONAL TEACHING TECHNIQUES, BY EXAMINING INFLUENCE OF GENDER AND SCHOOL LOCATION ON STUDENT OUTCOMES IN CROSS RIVER STATE

**Ekon, Esther Etop**

Department of Science Education, University of Calabar, Calabar  
estheretopy@gmail.com

&

**Nwankwo, Yvonne Ebere**

Department of Science Education University of Calabar, Calabar  
nwankwoyvonnemaria@gmail.com

### Abstract

*The study focused on biology achievement and retention: A comparative investigation of concept mapping and traditional teaching techniques in Calabar Education Zone, Cross River State, Nigeria. To achieve the purpose of this study, four research hypotheses were formulated. Literatures were reviewed according to the variables of the study. Multistage sampling technique involving simple random, stratified and purposive sampling techniques were used to select 264 subjects for the study. Biology Achievement Test (BAT) and Biology Retention Test (BRT) were the instruments used for data collection. The instruments were subjected to face and content validation. Analysis of Covariance (ANCOVA) was employed to test the hypotheses at .05 level of significance. The result of the analysis revealed a significant effect of school location on secondary school students academic achievement in biology in Calabar Education Zone, Cross River State. It was recommended among others that posting of teachers and distribution of educational facilities in the urban and rural secondary schools should be done in an even manner to avoid clustering of best qualified biology instructors and educational facilities together in a particular setting.*

**Keywords:** School location, academic achievement, retention, biology, Cross River State

### Introduction

Biology is a key science subject that deals with the study of plants and animals. The major branches of Biology are Botany and Zoology. Biology concepts according to Urry, Cain, Wasserman, Minorsky, Reece and Campbell (2017) is the scientific study of life and the processes that occur within living organisms. It is a vast and fascinating field that seeks to understand the structure, function, growth, evolution, distribution, and taxonomy of all living things, from the simplest bacteria to complex ecosystems. This subject is offered in all senior secondary schools. It attracts the greatest number of both science-oriented and arts-based students. Most of the students choose Biology because it is considered as the easiest science subject when compared with Chemistry and Physics (Njoku, 2015).

Teaching biology through concept mapping is a revolutionary approach that diverges from the traditional methods of conveying complex biological concepts. Unlike conventional teaching, which often relies on lectures and textbooks to transmit information, concept mapping encourages active learning, critical thinking, and problem-solving (Novak & Cañas, 2020; Adie, Okri and Anditung, 2019). By visually representing relationships between ideas, concepts, and processes, students develop a deeper, more holistic understanding of biology.

In a concept mapping classroom, students are empowered to take ownership of their learning, making connections and adjustments as they navigate the intricate web of biological concepts. This flexible and adaptive approach fosters a dynamic learning environment, where students can explore, question, and discover the intricacies of life. Research has shown that concept mapping can significantly improve student outcomes, including increased retention and understanding of biological concepts (Adie, Inah, Ibu, Anditung & Igyo, 2022; Kinchin, Streatfield & Hay., 2019)

Biology, a fundamental science subject, plays a crucial role in understanding the intricacies of life and the natural world. However, students' achievement and retention in Biology have remained a concern for educators and researchers alike. The quest for effective teaching methods and strategies to enhance student outcomes has led to the exploration of innovative approaches, such as concept mapping, alongside traditional teaching techniques. This study aims to investigate the comparative impact of concept mapping and traditional teaching methods on Biology achievement and retention among secondary school students in Cross River State, Nigeria. Furthermore, it seeks to examine the influence of gender and school location on student outcomes, addressing the lingering questions: Do concept mapping and traditional teaching methods yield different results in Biology achievement and retention? How do gender and school location intersect to affect student performance in Biology? By exploring these questions, this research endeavors to contribute meaningfully to the existing body of knowledge, providing insights that can inform evidence-based instructional strategies to improve Biology education in Cross River State and beyond.

The relationship between gender using concept mapping and students' academic performance in biology is complex and multifaceted. While some studies suggest that there are no significant differences in biology achievement between males and females, others reveal subtle disparities. For instance, males may excel in certain areas like ecology and evolution, while females may outshine their peers in botany and zoology. Recent research has shown that gender differences in biology achievement can be attributed to factors such as teacher-student interactions and classroom environment (Kahle et al., 2020). Moreover, studies have also highlighted the importance of addressing gender stereotypes and biases in biology education to promote equity and inclusivity (Shapiro & Williams, 2022).

School location refers to the place where school is situated whether in urban or rural area. Urban schools are those schools in the municipalities or schools found within the towns of Calabar and rural schools are those located in the villages or semi-urban areas, that is, schools at the out-sketch of Calabar; the location of a school determines to a large extent the level of students' achievement viewed school location as one of the major factors that influence students academic achievement in some subject areas. Location of schools could be a factor that affects the performance of students in science subjects. Also, lack of concentration, or poor "on-task behaviour," is a core indicator of low motivation and disengagement in students. However, when school facilities provide intellectual support and stimulation, all students can develop academically as they explore their own intellectual abilities. Providing laptops and other social amenities for urban adolescents, for example, has increased achievement and on-task engagement among students

The concept of gender and its intersection with students' academic achievement in Biology is a complex and multifaceted phenomenon. For decades, researchers and educators have sought to understand the dynamics at play, revealing a nuanced landscape of influences and outcomes. On one hand, gender has been shown to shape students' attitudes, interests, and motivations towards Biology, with males often exhibiting greater confidence and enthusiasm for the subject (Kahle, Meece & Scantlebury, 2020). Conversely, females may face subtle barriers and biases, including stereotyping and teacher-student interactions, which can impact their performance and persistence in Biology. Gambari and Yusuf (2015). noted that males show no

superiority in Science, Statistics and Accounting as compared to females. The author further noted that a well applied teaching strategy would produce the same effects on the students' achievement in Science concepts irrespective of Gender. Research has highlighted the importance of addressing gender stereotypes and biases in Biology education to promote equity and inclusivity (Shapiro & Williams, 2022). By recognizing and addressing the complex relationships between gender and academic achievement in Biology, we can unlock the full potential of our students and cultivate a more diverse and talented pool of future biologists and scientists.

The concept of gender and its impact on students' academic retention in Biology is a pressing concern in education. Research has shown that gender plays a significant role in shaping students' experiences, motivations, and ultimately, their decision to persist or withdraw from Biology courses. Female students, in particular, face unique challenges that can lead to decreased retention rates in Biology, including stereotyping, lack of role models, and gender bias in the classroom (Shapiro & Williams, 2022).

Moreover, the learning environment and pedagogical approaches can either reinforce or challenge these gender dynamics, influencing students' opportunities to succeed in Biology. Studies have highlighted the importance of creating an inclusive and supportive learning environment to promote gender equity and retention in Biology (Nwoyem, Okeke & Nwosu, 2020; Adie, Obi, Okri and Ogbe, 2020). By acknowledging and addressing the complex relationships between gender and academic retention in Biology, educators can develop targeted strategies to foster a more inclusive and engaging learning environment, ultimately promoting greater retention and success for all students. The location of a school can influence the quality of education, resources, and opportunities available to students, ultimately affecting their performance in Biology. Schools in urban areas may have better access to resources, technology, and experienced teachers, while rural schools may face challenges such as limited funding, outdated textbooks, and high teacher turnover rate

Recent studies have highlighted the disparities in Biology education due to school location. For instance, research has shown that students from urban schools tend to outperform their rural counterparts in Biology, attributed to better access to resources and opportunities (Yang & Lou, 2020). R). Furthermore, schools in disadvantaged areas may lack the infrastructure and support systems to foster a conducive learning environment, exacerbating the achievement gap in Biology (Zhang, 2022)

The concept of school location and its impact on students' academic retention in Biology is a critical factor in understanding the complexities of science education. Research has shown that students from urban schools tend to have higher retention rates in Biology compared to their rural counterparts, attributed to better access to resources, technology, and experienced teachers (Tao et al., 2022). Conversely, rural schools often face challenges such as limited funding, outdated textbooks, and high teacher turnover rates, which can lead to decreased student engagement and motivation in Biology.

Furthermore, the school location can also influence the availability of advanced courses, mentorship opportunities, and hands-on experiences in Biology, ultimately affecting students' decisions to pursue further education in the field. A study by Wang et al. (2022) found that students from urban schools were more likely to enroll in advanced Biology courses and pursue science-related careers compared to students from rural schools. By acknowledging the impact of school location on academic retention in Biology, educators and policymakers can develop targeted strategies to address these disparities and promote greater equity in science education

### **Statement of the problem**

The pursuit of excellence in science education, particularly in Biology, is a pressing concern in secondary schools within the Calabar Education Zone, Cross River State. Despite its

significance, students' academic achievement and retention rates in Biology remain disappointingly low. A critical examination of this trend reveals a complex web of factors, with gender and school location emerging as potential influencers. However, the extent to which these factors impact students' performance in Biology is unclear, with some studies suggesting that gender disparities and urban-rural differences may contribute to the observed trends.

In this context, the Calabar Education Zone presents a unique scenario, with its diverse student population and varied school settings. Yet, empirical research investigating the comparative impact of gender and school location on achievement and retention in Biology among secondary school students in this region is scarce. This knowledge gap necessitates a comprehensive study to unravel the relationships between these variables, ultimately informing evidence-based strategies to enhance student performance and retention in Biology.

This research aims to address the lingering questions: How do gender and school location influence students' academic achievement and retention in Biology? Do gender disparities and urban-rural differences significantly impact students' performance in the subject? By exploring these questions, this study seeks to contribute meaningfully to the existing body of knowledge, providing insights that can inform targeted interventions to improve science education outcomes in the Calabar Education Zone.

### **Objective of the study**

The aim of the study was to examine the influence of gender and school location using concept mapping teaching technique as treatment on secondary school students' academic achievement and retention in biology in Calabar Education Zone, Cross River State, Nigeria

Specifically, the study seeks to;

1. Ascertain the effect of gender using concept mapping (treatment) on students' academic achievement in Biology
2. Find out main effect of gender using concept mapping (treatment) on students' retention of concepts in Biology
3. Find out the main effect of school location concept mapping (treatment) on students' academic achievement in Biology
4. Find out the main effect of school location concept mapping (treatment) on students' retention of concepts in Biology

### **Research questions**

The following research questions were posed to guide the study;

1. What is the main effect of gender using concept mapping (treatment) on students' academic achievement in Biology?
2. What is the main effect of gender using concept mapping (treatment) on students' retention of concepts in Biology?
3. What is the main effect of school location using concept mapping (treatment) on students' academic achievement in Biology?
4. What is the main effect of school location using concept mapping (treatment) on students' retention of concepts in Biology?

### **Statement of hypotheses**

The following hypotheses were formulated to guide the study:

1. There is no significant main effect of gender using concept mapping (treatment) on students' academic achievement in Biology in Calabar Education Zone, Cross River State
2. There is no significant main effect of gender using concept mapping (treatment) on students' retention of concepts in Biology in Calabar Education Zone, Cross River State

3. There is no significant main effect of school location using concept mapping (treatment) on students' academic achievement in Biology in Calabar Education Zone, Cross River Stat
4. There is no significant main effect of school location using concept mapping (treatment) on students retention of concepts in Biology in Calabar Education Zone, Cross River State

### Methodology

The research design adopted for this work was quasi-experimental design this was as adopted for the study because the intact classes and the rigid school timetable would not allow for randomization of subjects. However, the research subjects were randomly assigned to experimental and control group based on their intact classes. The population of the study comprised three thousand and eighty-four (3,084) senior secondary two (SSII) Biology students of 2018/2019 session in eighty-four (84) public secondary schools in Calabar Education Zone of Cross River State. This population was considered most appropriate for the study because the students must have acquired some prerequisite knowledge about ecology, the Biology unit selected for this study; the students were considered mature enough to comprehend the experimental treatment and the test instrument given to them; and the students have chosen biology as one of the subjects they will offer for the Senior School Certificate Examination (SSCE). The sample for the study was made up of 264 Senior Secondary School two (SSS II) biology students from six intact classes selected from six co-educational public secondary schools of Calabar Education Zone. The sample represents 14.6 percent of the entire population. A breakdown of this figure gave 178 subjects in the experimental groups and 86 subjects in the control group. The disparity in class size was due to the intact class situation. The instruments used for the study include Biology Achievement Test (BAT) and Biology Retention Test (BRT). The BAT and BRT were constructed by the researcher for the purpose of data collection. The BAT was used for both pre-test and post-test. The instruments consisted of a forty (40), four options multiple choice objective test items selected from ecology of population covering succession, overcrowding, food shortage and balance in nature

### Results

The data collected were analysed using 3 – way Analysis of Covariance (ANCOVA) with IBM Statistical Packages for the Social Sciences (SPSS) version 20. The results of data analyses are presented and interpreted hypothesis-by hypothesis. The hypotheses were tested at .05 significance level..

**Hypothesis one:** There is no significant effect of gender using concept mapping (treatment) on students' academic achievement in Biology. The hypothesis was tested with ANCOVA. The results are presented in table 1.

**Table 1:** Summary of 3 – way ANCOVA of effect of treatment, gender, school location on students' academic achievement in Biology.

Source	SS	Df	Mean Square	F	Sig.
Model	129908.852	13	9992.989	769.128	0.000
Pretest	1460.788	1	1460.788	112.432*	0.000
Gender	10.342	1	10.342	0.796	0.373
SchoolLocation (SchLoc)	21.007	1	21.007		
Gender * SchLoc	2.856	1	2.856	2.877	0.058
Error	3261.148	251	12.993	.831	0.437
Total	133170.000	264			

\*p.05

As shown in table 1, the calculated F value for gender is .796 and it is not statistically significant ( $p = .373$ ) at .05 significance level and (1, 251) degrees of freedom. That means that there is no significant main effect of gender on students' academic achievement in Biology. The null hypothesis is retained. In other words, male and female students do not significantly differ in their academic achievement in Biology when taught using concept mapping

**Hypothesis two:** There is no significant main effect of gender using concept mapping (treatment) on students' retention of concepts in Biology. The hypothesis was tested with ANCOVA.

**Table 2:** Summary of three-way ANCOVA of the effect of treatment, gender and school location on students' retention of concepts in Biology.

Source of Variation	SS	Df	Mean Square	F-value	Sig.
Model	135133.072	13	10394.852	629.622	.000
Pre-test	1368.845	1	1368.845	82.912*	.000
Treatment	1836.316	2	918.158	55.613*	.000
Gender	5.782	1	5.782	.350	.555
School location	34.281	1	34.281	2.076	.151
Gender * Sch location	24.103	1	24.103	1.460	.228
Error	4143.928	251	16.510		
Total	139277.000	264			

\*P.05

As shown in table 2, the calculated F value for gender is .350 and the significance level of .555 is greater than .05 significance level at (1, 251) degrees of freedom. That means the calculated F value is not statistically significant. In other words, male and female students do not significantly differ in their mean retention score of concepts in Biology. That is, there is no significant main effect of gender using concept mapping on students' retention of concepts in Biology. Thus, the null hypothesis is retained

**Hypothesis three:** There is no significant main effect of school location using concept mapping (treatment) on students' academic achievement in Biology. (see table 3)

**Table 3:** Summary of 3 – way ANCOVA of effect of treatment, gender, school location on students' academic achievement in Biology.

Source	SS	Df	Mean Square	F	Sig.
Model	129908.852	13	9992.989	769.128	0.000
Pretest	1460.788	1	1460.788	112.432*	0.000
Gender	10.342	1	10.342	0.796	0.373
SchoolLocation (SchLoc)	21.007	1	21.007	1.617	.205
Gender * SchLoc	2.856	1	2.856	2.877	0.058
Error	3261.148	251	12.993	.831	0.437
Total	133170.000	264			

\*p.05

As shown in table 3, the calculated F value for School location which is 1.617 is not statistically significant since the significance level of the calculated F value, .205 is greater than .05 significance level at (1, 251) degrees of freedom

That means that there is no significant main effect of school location using concept mapping on students' academic achievement in Biology. In other words, urban and rural school students do not differ significantly in their mean academic achievement in Biology. The null hypothesis is therefore upheld.

**Hypothesis four:** There is no significant main effect of school location using concept mapping (treatment) on students' retention of concepts in Biology. The result of analysis is presented in table 4

**Table 4:** Summary of three-way ANCOVA of the effect of treatment, gender and school location on students' retention of concepts in Biology.

Source of Variation	SS	Df	Mean Square	F-value	Sig.
Model	135133.072	13	10394.852	629.622	.000
Pre-test	1368.845	1	1368.845	82.912*	.000
Treatment	1836.316	2	918.158	55.613*	.000
Gender	5.782	1	5.782	.350	.555
School location	34.281	1	34.281	2.076	.151
Gender * Sch location	24.103	1	24.103	1.460	.228
Error	4143.928	251	16.510		
Total	139277.000	264			

\*P.05

The results in table 4 indicate that the calculated F value for School location is 2.076. The value is not statistically significant since the significance level of the calculated F value, .151, is greater than .05 significance level at (1, 251) degrees of freedom. That means that there is no significant main effect of school location on students' retention of concepts in Biology. The null hypothesis is therefore upheld. In other words, urban and rural school students do not differ significantly in their mean retention of concepts in Biology.

### Discussion of findings

The result of testing this hypothesis one indicates that there is no significant effect treatment and gender on the academic achievement of students in Biology. This result is in line with the study of Gambari and Yusuf (2015). who noted that males show no superiority in Science, Statistics and Accounting as compared to females. The author further noted that a well applied teaching strategy would produce the same effects on the students' achievement in Science concepts irrespective of sex. However the finding is challenged by the study of Shapiro and Williams (2022) that stated that the classroom environment and pedagogical approaches such as concept mapping can either reinforce or challenge these gender dynamics, influencing students' opportunities to learn and succeed in Biology. Research has highlighted the importance of addressing gender stereotypes and biases in Biology education to promote equity and inclusivity. By recognizing and addressing the complex relationships between gender and academic achievement in Biology, we can unlock the full potential of our students and cultivate a more diverse and talented pool of future biologists and scientists

The result of testing this hypothesis two indicates that there is no significant effect of gender taught using concept mapping on retention of students in Biology. The, result of this study conflicts with that of Nwoyem, Okeke and Nwosu (2020) that sated that the learning environment and pedagogical approaches can either reinforce or challenge these gender dynamics, influencing students' opportunities to succeed in Biology. Studies have highlighted the importance of creating an inclusive and supportive learning environment to promote gender equity and retention in Biology. Als Shapiro and Williams (2022) stated that the concept of gender and its impact on students' academic retention in Biology is a pressing concern in education. Research has shown that gender plays a significant role in shaping students' experiences, motivations, and ultimately, their decision to persist or withdraw from Biology courses. Female students, in particular, face unique challenges that can lead to decreased retention rates in Biology, including stereotyping, lack of role models, and gender bias in the classroom

The result of the analysis in hypothesis three revealed that there is no significant main effect of school location using concept mapping on students' academic achievement and retention in Biology. The experimental treatment is the variable that resulted in deep understanding of Biology and consequently greater retention of the concepts learnt. This implies that school location does not affect students' retention of concepts but the method used by the teacher. The findings of this study support Penuel's (2006) cited in Wang, Zhang and Liu (2022) stating that when school facilities are available to provide intellectual support and stimulation, all students could benefit academically as they explore according to their own intellectual abilities and not because of location .

The result of the analysis in hypothesis four revealed there is no significant main effect of school location using concept mapping (treatment) on students' retention of concepts in Biology. The findings of this study contradicts the study of Tao et al. (2022) stating that research has shown that students from urban schools tend to have higher retention rates in Biology compared to their rural counterparts, attributed to better access to resources, technology, and experienced teachers. The location of school may have no effect on students' retention as students in both urban and rural locations in the experimental groups retained most of what were taught due to the instructional strategy employed in presenting the lesson. The students in control group could not retain much of what was learnt irrespective of the school location, as the method used by the teacher did not promote meaningful learning of Biology since the learners were passive and did not participate actively during the lesson.

## **Conclusion**

Based on the findings from the study, it is evident that gender and school location (with treatment) of school does not influence students' academic achievement and retention of concepts in Biology. Therefore, Biology being such an important subject for knowledge of physiological function of the human body and for socio economic development deserves some good attention through the use of appropriate instructional pedagogy for teaching the subject. The nations socio- economic and industrial development hinges on scientific status of the nation.

## **Recommendations**

1. Posting of teachers and distribution of educational facilities in the urban and rural secondary schools should be done in an even manner to avoid clustering of best qualified Biology instructors and educational facilities together in a particular setting.
2. Co-education school at the secondary level should be encouraged by the government since gender by this study, does not significantly influence academic achievement and retention in Biology. An admixture of male-female students would rather encourage academic competition between the two sexes.



3. Professional Associations like Science Teachers Association of Nigeria (STAN) should popularize the use of concept mapping in teaching difficult Biology concepts through seminars and workshops.
4. Government and stakeholders in education should regularly organize workshops and seminars for teachers practice of the rudiments and ultimate familiarity in the use of cooperative and concept mapping instructional strategies in secondary school Biology learning.

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