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EFFECT OF METACONCEPTUAL TEACHING APPROACH ON BIOLOGY STUDENT'S ACADEMIC PERFORMANCE, RETENTION AND INTEREST IN SECONDARY SCHOOLS IN RIVERS STATE.

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ABSTRACT
This study investigated the effect of Metaconceptual Teaching Approach on Biology Students academic performance, retention and interest. Six objectives, research questions and six hypotheses guided the study. Quasi-experimental and descriptive designs were adopted for this student. The population of the study is 31,660 biology students comprising of 16,865 female and 14,795 male in secondary school in Rivers East Senatorial District. The sample size for the study was 179 SS1 students that were purposively drawn from four selected secondary schools representing each of the clusters using multi stage sampling technique. Data was collected using Photosynthesis Performance Test, Photosynthesis Retention Test and Students Questionnaire. The instruments were validated by the research supervisor and two other experts each from the department of Science Education and Department of Educational Foundation (Measurement and Evaluation Specialist) both from Rivers State University Port Harcourt. The reliability of the instrument were ascertained using Kurder- Richardson-20 for Photosynthesis Performance Test while Cronbach-alpha was used for students Interest Questionnaire. The reliability coefficient of 0.81, 0.79 and 0.77 respectively were estimated. The research questions were analyzed using mean and standard deviation, while hypotheses were tested using ANCOVA at 0.05 level of significance with the aid of SPSS. Findings show significant statistical differences in both performance, Retention and interest of students taught photosynthesis using MTA and those taught using Lecture Method. Findings also show that student taught using MTA demonstrated a deeper understanding of the subject matter than those taught using lecture method. Based on the findings, it was recommended amongst others that secondary school biology teachers should adopt the MTA as a preferred instructional strategy when teaching topics such as photosynthesis as this will help foster deeper understanding and improve academic outcomes.

INTRODUCTION
Science education is central to preparing learners with the knowledge, skills, and attitudes required to thrive in a technologically driven society. It not only addresses the content of disciplines such as Biology, Chemistry, and Physics but also emphasizes effective teaching and learning processes (Okeke, 2024). In Nigeria, where the demand for skilled experts in science and technology is critical for socio-economic development, biology remains a core subject due to its role in health, agriculture, biotechnology, and environmental sustainability. However, traditional teaching methods often characterized by rote memorization, lectures, and limited student engagement have been criticized for failing to promote deep conceptual understanding, long-term retention, or sustained interest in biology (Bonwell & Eison, 1991; Bligh, 2020).

Emerging pedagogical strategies, such as active, collaborative, and inquiry-based learning, have demonstrated improved learning outcomes (Prince, 2004; Pedaste et al., 2015). Among these, the metaconceptual teaching approach (MTA) has attracted attention for its focus on metacognition—encouraging students to reflect on their own conceptual frameworks, confront misconceptions, and regulate their learning (Flavell, 1979; Vosniadou, 2017). By integrating reflective activities, conceptual conflict tasks, and scaffolding strategies, MTA fosters deeper understanding, enhances academic achievement, and strengthens problem-solving abilities in science education (Schraw &

Dennison, 2014; Özdemir & Demirci, 2022). Moreover, it has been linked to improved retention and increased student interest by making learning more active, contextual, and student-centered (Pintrich, 2022; Wang et al., 2021).

In the Nigerian context, particularly in Rivers East Senatorial District, biology education is hindered by inadequate facilities, high student–teacher ratios, and declining interest in science subjects (Okebukola & Jegede, 2019; Abdullahi & Sani, 2021). These challenges call for innovative approaches capable of promoting meaningful learning even under resource constraints. The MTA offers promise in this regard by fostering deeper conceptual engagement and contextualizing biological concepts in students' immediate environment (Nwofe, 2020). It is against this backdrop that the present study investigates the efficacy of the metaconceptual teaching approach in enhancing students' understanding of photosynthesis, with a focus on academic performance, retention, and interest among senior secondary school students in Rivers State.

Metacognition, first introduced by Flavell (1979), refers to "thinking about thinking" and encompasses both metacognitive knowledge (awareness of one's cognitive processes) and metacognitive regulation (planning, monitoring, and evaluating learning strategies). Scholars such as Brown and Baker (2017) and Schraw and Dennison (2014) highlight that effective metacognition requires not only knowledge of cognitive strategies but also the ability to apply and regulate them during problem-solving. In science learning, particularly biology, metacognition enables students to identify misconceptions, monitor their understanding, and refine strategies for mastering complex concepts such as photosynthesis.

Building on this foundation, the Metaconceptual Teaching Approach (MTA) applies metacognitive principles by encouraging students to reflect on their preconceptions, confront cognitive conflicts, and reconstruct their understanding through guided inquiry, dialogue, and self-assessment (Vosniadou, 2007). This approach directly aligns with Flavell's framework by fostering both awareness and regulation of learning. In the context of biology education in Rivers State, where students often struggle with abstract concepts and disengage due to rote-based teaching, MTA provides a promising strategy to enhance academic performance, retention, and interest. Therefore, this study employs Flavell's Metacognition Theory as a theoretical basis for investigating the efficacy of MTA in improving students' understanding of photosynthesis at the senior secondary level.

Cognitive Load Theory (CLT), developed by John Sweller in his seminal 1988 paper, provides critical insights into how human cognitive processes influence learning and problem-solving. The theory is grounded in the understanding that working memory has a limited capacity, typically able to process only three to seven units of information at a given time, while long-term memory provides a more stable and extensive storage system (Paas, 2020). Because of this limitation, instructional design plays a central role in ensuring that learners are not overwhelmed, but instead are supported to process and retain meaningful information effectively.

Sweller (1988) distinguished three types of cognitive load that affect learning outcomes: intrinsic, extraneous, and germane cognitive load. Intrinsic cognitive load is linked to the inherent difficulty of the subject matter, which may be high in science subjects such as biology, particularly when dealing with abstract concepts like photosynthesis. Extraneous cognitive load arises from poor instructional design, such as cluttered presentations, redundant information, or teacher-centered approaches that emphasize rote memorization. Germane cognitive load, on the other hand, refers to the mental effort invested in understanding, constructing, and integrating new knowledge into existing cognitive frameworks (Van Merriënboer & Sweller, 2015). Effective instruction seeks to manage intrinsic load, minimize extraneous load, and enhance germane load to promote deeper and more durable learning.

A number of instructional effects have been identified within CLT that further inform classroom practice. These include the worked example effect, which reduces unnecessary processing by providing learners with step-by-step solutions; the split-attention effect, which highlights the need to integrate multiple sources of information; the redundancy effect, which cautions against including unnecessary details that may overload working memory; and the modality effect, which leverages both visual and auditory channels to optimize processing capacity (Sweller et al., 1998; Tindall-Ford, Chandler, & Sweller, 2017). Together, these principles guide educators in designing instructional environments that align with the natural constraints of human cognition.

In the context of biology education, CLT is particularly relevant because students often struggle with highly abstract and interconnected concepts such as photosynthesis. When instructional strategies rely too heavily on memorization or poorly structured explanations, extraneous cognitive load increases, leaving students with little cognitive capacity to engage in meaningful processing. By applying CLT principles, teachers can restructure lessons through approaches such as segmenting complex content, eliminating redundant information, and using multimodal representations. These strategies ensure that working memory is not overloaded, thereby enhancing comprehension, retention, and the ability to apply knowledge in new contexts.

For this study, CLT provides a strong theoretical foundation for linking instructional design with student learning outcomes in biology. The Metaconceptual Teaching Approach (MTA), which emphasizes students' reflection on their pre-existing conceptions and promotes metacognitive regulation, aligns well with the principles of CLT. By engaging students in guided inquiry, concept mapping, and structured reflection, MTA helps reduce extraneous load while channeling more resources toward germane processing. In doing so, students are not only able to reconstruct misconceptions but also develop a deeper and more enduring understanding of photosynthesis. Thus, the integration of CLT with MTA is expected to enhance academic performance, retention, and interest among senior secondary school students in Rivers State.

Statement of the Problem

Biology, as a core science subject in secondary education, plays a pivotal role in preparing students for careers in medicine, agriculture, biotechnology, and other life science-related fields. Despite its importance, recent statistics from standardized tests and public examinations reveal a consistent decline in students' achievement and interest in biology in Rivers State (Rivers State Ministry of Education, 2022). This poor academic performance has raised concerns among educators and policymakers, with evidence suggesting that the continued reliance on teacher-centered methods is a major contributing factor. Such approaches emphasize rote memorization over active engagement, problem-solving, and critical thinking, thereby limiting students' comprehension and ability to apply biological knowledge in real-world contexts.

The Metaconceptual Teaching Approach (MTA), which emphasizes students' awareness of their own thinking processes and the restructuring of misconceptions into coherent conceptual frameworks, has been identified as a promising strategy for enhancing science learning outcomes (Ugochukwu, 2016; Obanya, 2014). However, despite its theoretical potential, the impact of MTA on biology education in Rivers East Senatorial District remains underexplored. This study, therefore, seeks to examine the efficacy of MTA in improving secondary school students' academic performance, retention, and interest in biology, particularly in the topic of photosynthesis. The findings are expected to provide evidence-based insights into innovative teaching practices that can strengthen biology education in Rivers State and beyond.

Purpose of the Study

The primary aim of this study is to examine the efficacy of the Metaconceptual Teaching Approach (MTA) in enhancing students' understanding of photosynthesis, with particular attention to its impact on academic performance, retention, and interest among senior secondary school students in Rivers State. The specific objectives of the study are to:

1. Examine the effect of metaconceptual teaching approach (MTA) and Lecture method on academic performance of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District.

2. Assess the effect of metaconceptual teaching approach (MTA) and Lecture method on retention of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District.
3. Investigate the effect of metaconceptual teaching approach (MTA) and Lecture method on interest of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District.

Research Questions

The following research questions guided the study:

1. What is the effect of metaconceptual teaching approach (MTA) and Lecture method on performance of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District?
2. What is the effect of metaconceptual teaching approach (MTA) and Lecture method on retention of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District?
3. What is the effect of metaconceptual teaching approach (MTA) and Lecture method on interest of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District?

Hypotheses

The following null hypotheses was tested in the study at 0.05 level of significance.

1. There is no significant difference between the mean performance scores of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught with Lecture method.
2. There is no significant difference between the mean retention score of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught with Lecture method.
3. There is no significant difference between the mean interest rating scores of students taught photosynthesis using metaconceptual teaching approach(MTA) and those taught using Lecture method.

METHODOLOGY

This study adopted a pretest-posttest quasi-experimental design alongside a descriptive design to investigate the effects of the Metaconceptual Teaching Approach (MTA) on biology students' performance, retention, and interest. The quasi-experimental design was suitable because intact classes were used without random assignment, while the descriptive aspect helped in determining students' interest. The study was conducted in Rivers East Senatorial District, one of the three senatorial districts in Rivers State, comprising eight Local Government Areas (LGAs) with both metropolitan and ethnic clusters. The area was considered appropriate because it has a diverse student population and sufficient schools for the research.

The population consisted of 31,660 senior secondary school biology students (16,865 females and 14,795 males) in Rivers East Senatorial District. Using a multi-stage sampling technique, two clusters of LGAs (metropolitan and ethnic) were identified, and one LGA was randomly selected from each cluster. From the selected LGAs, one school was randomly chosen, and in each, two intact SS1 classes were selected. One class was assigned to the experimental group and the other to the control group, giving a sample size of 179 students across four schools. SS1 was chosen because photosynthesis is included in their curriculum.

Data collection involved three research instruments: the Photosynthesis Performance Test (PPT), Photosynthesis Retention Test (PRT), and Students' Interest Questionnaire (SIQ). The PPT and PRT, each containing ten multiple-choice questions, measured students' understanding and retention, while the SIQ, consisting of 10 items on a four-point Likert scale, assessed interest. Validity of the instruments was established through expert review, and reliability was confirmed using Cronbach Alpha for SIQ (0.77) and Kuder-Richardson Formula (KR-20) for PPT (0.81) and PRT (0.79), indicating high internal consistency.

The instruments were administered with the assistance of trained biology teachers, who received orientation on both traditional lecture and metaconceptual teaching methods. The experimental group engaged in activities such as concept mapping, class discussions, journal writing, and the use of analogies and models, while the control group was taught using lecture and demonstration methods. A pretest was administered to both groups before treatment, and a posttest was given afterward. Data were analyzed using mean and standard deviation to answer research questions, while ANCOVA was employed to test hypotheses at a 0.05 significance level with the aid of SPSS Version 27.

Analysis of Data Results

Research Question 1: What is the effect of metaconceptual teaching approach (MTA) and Lecture method on performance of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District?

Table 4.1: **Mean And Standard Deviation Score of the Effect of Metaconceptual Teaching Approach (MTA) and Lecture Method on Performance of Student's Taught Photosynthesis in Senior Secondary Schools in Rivers East Senatorial District**

Groups	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Experimental (MTA)	86	58.84	17.58	91.16	15.06	32.33
Control (Lecture)	93	55.05	14.79	68.39	13.21	13.33
Total	**179**					

Table 4.1 shows the Mean and Standard Deviation Score of the effect of metaconceptual teaching approach (MTA) and Lecture method on performance of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District. The results in Table 4.1 present the comparative effect of the Metaconceptual Teaching Approach (MTA) and the Lecture Method on the academic performance of students in photosynthesis. For the experimental group (MTA), the mean pretest score was 58.84 with a standard deviation of 17.58. After the treatment, the mean post test score increased substantially to 91.16, with a slightly lower variability (SD = 15.06). This yielded a mean gain of 32.33, indicating a significant improvement in students' performance after exposure to the MTA strategy. In contrast, the control group (Lecture Method) had a pretest mean score of 55.05 (SD = 14.79) and a post test mean score of 68.39 (SD = 13.21), with a mean gain of only 13.33. This shows that while the lecture method also resulted in some improvement, the gain was much lower than that of the MTA group. A comparison of the two groups demonstrates that students taught using the Metaconceptual Teaching Approach significantly outperformed their counterparts taught through the conventional lecture method. The higher mean gain score in the experimental group (32.33 against 13.33) reveals that MTA was more effective in enhancing students' understanding and performance in photosynthesis. This finding underscores the importance of using learner-centered and conceptually driven teaching strategies over traditional teacher-centered approaches.

Research Question 2: What is the effect of metaconceptual teaching approach (MTA) and Lecture method on retention of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District?

Table 4.2: **Mean and Standard Deviation Score the effect of metaconceptual teaching approach (MTA) and Lecture method on retention of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District**

Groups	N	Posttest		Post - Posttest		Mean Gain
		Mean	SD	Mean	SD	
Experimental (MTA)	86	91.16	15.06	93.14	12.67	1.98
Control (Lecture)	93	68.39	13.39	62.04	14.33	-6.34
Total	**179**					

Table 4.2 represent the Mean and Standard Deviation Score the effect of metaconceptual teaching approach (MTA) and Lecture method on retention of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District. Table 4.2 shows the mean and standard deviation scores of students' retention in Photosynthesis after being taught using the Metaconceptual Teaching Approach (MTA) and Lecture method. The experimental group (MTA) had a mean post test score of 91.16 (SD = 15.06) and a mean post–post test score of 93.14 (SD = 12.67), yielding a positive mean gain of 1.98. In contrast, the control group (Lecture) had a mean post test score of 68.39 (SD = 13.39) and a mean post–post test score of 62.04 (SD = 14.33), producing a negative mean gain of –6.34. These results indicate that students taught with the Metaconceptual Teaching Approach (MTA) retained knowledge of Photosynthesis better than those taught with the Lecture method. While the experimental group recorded a slight positive retention gain, the control group showed a decline in performance over time. This suggests that MTA is more effective in promoting long-term retention of biological concepts compared to the Lecture method.

Research Question 3: What is the effect of metaconceptual teaching approach (MTA) and Lecture method on interest of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District?

Table 4.3: **Mean and Standard Deviation of the effect of metaconceptual teaching approach (MTA) and Lecture method on interest of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District**

Teaching Method	N	Mean	Std. Deviation
Experimental (MTA)	86	3.73	0.54
Control (Lecture)	93	2.08	1.14
Total	**179**	**2.87**	**1.22714**

Table 4.3 shows the Mean and Standard Deviation of the effect of metaconceptual teaching approach (MTA) and Lecture method on interest of student's taught Photosynthesis in senior secondary schools in Rivers East Senatorial District. Result shows that the findings reveal a substantial difference in student interest levels between the two instructional strategies. Students taught using the Lecture Method recorded a mean interest score of 2.08 (SD = 1.14), indicating relatively low to moderate interest in the subject matter. In contrast, students exposed to the Metaconceptual Teaching Approach reported a significantly higher mean interest score of 3.73 (SD = 0.54), suggesting high interest in the learning experience. The total sample mean was 2.87 (SD = 1.23),

reflecting a moderate average interest level across both groups. These results suggest that the Metaconceptual Teaching Approach is substantially more effective at stimulating student interest in photosynthesis compared to the traditional Lecture Method. The lower standard deviation in the experimental group (0.54) also indicates greater consistency in student responses, meaning that most students taught with MTA reported high levels of interest. In contrast, the control group showed a wider variability in interest (SD = 1.14), suggesting that student engagement under this method was more uneven and potentially dependent on individual motivation rather than instructional quality. Based on the findings, it can be concluded that the Metaconceptual Teaching Approach (MTA) is more effective than the Lecture Method in enhancing students' interest in learning Photosynthesis among senior secondary school students in Rivers East Senatorial District.

Test of Hypotheses

The following null hypotheses were tested at 0.05 level of significance to guide the study.

Hypothesis 1: There is no significant difference between the mean scores of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught with Lecture method.

Table 4.7: ANCOVA on Mean scores of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught with Lecture method

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	48285.456[a]	2	24142.728	415.192	.000
Intercept	12383.217	1	12383.217	212.959	.000
Performance Pretest	25107.688	1	25107.688	431.787	.000
Teaching Method	5847.211	1	5847.211	100.557	.000
Error	10234.097	176	58.148		
Total	1185000.000	179			
Corrected Total	58519.553	178			

a. R Squared = .825 (Adjusted R Squared = .823)

The ANCOVA results in table 4.7 revealed that the teaching method had a highly significant effect on students' posttest performance in photosynthesis. After adjusting for pretest differences, students taught with the Metaconceptual Teaching Approach (MTA) outperformed those taught using the lecture method, as indicated by an F-value of 100.557 and a p-value of .000. The covariate (pretest scores) also had a significant effect (F = 431.787, p = .000), confirming that students' prior knowledge influenced their posttest achievement and validating the inclusion of pretest scores in the analysis. This suggests that students with stronger baseline knowledge were more likely to achieve higher outcomes after instruction. The overall ANCOVA model was statistically significant and highly effective in explaining the variance in students' performance. The corrected model yielded an F-value of 415.192 with a p-value of .000, while the R-squared (.825) and adjusted R-squared (.823) indicated that about 82.5% of the variance in posttest scores was explained by the teaching method and pretest scores combined. Based on these findings, the null hypothesis was rejected, confirming that there was a significant difference in mean scores between students taught photosynthesis using MTA and those taught with the lecture method.

Hypothesis 2: There is no significant difference between the mean retention of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught with Lecture method.

Table 4.8: ANCOVA on Mean retention of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught with Lecture method.

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	69866.370[a]	2	34933.185	665.571	.000
Intercept	15624.178	1	15624.178	297.683	.000
Post Post-Test	29924.012	1	29924.012	570.133	.000
Teaching Method	4407.005	1	4407.005	83.965	.000
Error	9237.541	176	52.486		
Total	1112400.000	179			
Corrected Total	79103.911	178			

a. R Squared = .883 (Adjusted R Squared = .882)

The ANCOVA results in Table 4.8 revealed that the teaching method had a statistically significant effect on students' retention of photosynthesis concepts. After adjusting for differences in posttest retention scores, students taught with the Metaconceptual Teaching Approach (MTA) performed significantly better than those taught with the lecture method. This was reflected in an F-value of 83.965 with a p-value of .000, well below the 0.05 significance threshold. The covariate (posttest performance scores) also had a highly significant influence on retention (F = 570.133, p = .000), indicating that students with stronger initial performance were more likely to retain knowledge over time. The inclusion of posttest scores as a covariate strengthened the analysis by accounting for baseline differences, ensuring a more precise comparison of the two teaching methods. The overall ANCOVA model provided an excellent fit for predicting students' retention outcomes. The corrected model yielded an F-value of 665.571 with a p-value of .000, while the R-squared (.883) and adjusted R-squared (.882) values indicated that about 88.3% of the variance in retention scores was explained by the teaching method and posttest scores combined. This high level of explained variance confirms the robustness of the model and underscores the substantial impact of instructional strategies and prior knowledge on long-term learning outcomes. Based on these findings, the null hypothesis was rejected, confirming a significant difference in retention between students taught photosynthesis using MTA and those taught with the lecture method.

Hypothesis 3: There is no significant difference between the mean interest rating scores of students taught photosynthesis using metaconceptual teaching approach (MTA) and those taught using Lecture method.

Table 4.9: ANCOVA on interest rating scores of students taught photosynthesis using metaconceptual teaching approach(MTA) and those taught using Lecture method

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	122.723[a]	1	122.723	149.474	.000
Intercept	1507.147	1	1507.147	1835.683	.000
Teaching Method	122.723	1	122.723	149.474	.000
Error	145.322	177	.821		
Total	1744.000	179			
Corrected Total	268.045	178			

The ANCOVA results showed a significant difference in the mean interest rating scores of students taught photosynthesis using the Metaconceptual Teaching Approach (MTA) compared to those taught with the lecture method. The analysis reported a Type III Sum of Squares of 122.723 with 1 degree of freedom, producing a Mean Square of 122.723. This yielded an F-value of 149.474, which was highly significant at $p < .001$. These findings confirm that the observed difference in students' interest levels was not due to chance, but rather to the teaching method applied. Students exposed to MTA demonstrated a significantly higher level of interest in photosynthesis than their counterparts taught through the traditional lecture method. The large F-value and extremely low p-value provide strong evidence of the substantial effect of MTA on students' engagement. The corrected model explained a considerable portion of the variance in interest scores (Sum of Squares = 122.723 out of a total of 268.045), while error variance remained relatively small, highlighting the robustness of the result. Furthermore, the intercept was statistically significant ($F = 1835.683$, $p < .001$), reflecting the overall mean level of interest across groups. Based on these findings, the null hypothesis was rejected, leading to the conclusion that MTA is significantly more effective than the lecture method in fostering students' conceptual engagement and sustaining their interest in learning photosynthesis.

Summary of Major Findings

1. Teaching methods has significant effects on students' performance and that students taught photosynthesis using Metaconceptual teaching approach (MTA) significantly over performed those that were taught using Lecture method in senior secondary schools in Rivers East Senatorial District.
2. Teaching methods has significant effects on students' retention and that students taught photosynthesis using Metaconceptual teaching approach (MTA) retained the subject matter significantly better those that were taught using Lecture method in senior secondary schools in Rivers East Senatorial District.
3. Teaching methods has significant effects on students' interest and that students taught photosynthesis using Metaconceptual teaching approach (MTA) showed more interest in the topic than those that were taught using Lecture method in senior secondary schools in Rivers East Senatorial District.

CONCLUSION

The findings of this study reveal that the Metaconceptual Teaching Approach (MTA) significantly enhances students' academic performance, retention, and interest in biology, particularly in the topic of photosynthesis, compared to the conventional lecture method. Students exposed to MTA demonstrated a deeper understanding of the subject matter, retained information more effectively over time, and showed higher levels of engagement and enthusiasm during lessons. These results affirm the effectiveness of metaconceptual strategies in addressing students' misconceptions and promoting meaningful learning in science classrooms.

RECOMMENDATIONS

Based on the conclusion, the following recommendations were made:

1. Secondary school biology teachers should adopt the MTA as a preferred instructional strategy when teaching abstract topics such as photosynthesis as this will help foster deeper understanding and improve academic outcomes.
2. Curriculum planners and school administrators should integrate metaconceptual activities such as reflective thinking, concept mapping, and misconceptions-checking into biology teaching practices as it will promote long-term retention of key scientific concepts among students.
3. Biology teachers are encouraged to use learner-centered and reflective teaching techniques to stimulate and maintain students' curiosity and engagement.

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