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EFFECTS OF FLIPPED CLASSROOM AND CANVAS STRATEGIES ON STUDENTS' ACHIEVEMENT IN PHOTOSYNTHESIS IN SOUTH SENATORIAL DISTRICT, GOMBE STATE, NIGERIA

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Abstract

This study determined the effects of Flipped Classroom and CANVAS Learning Management System strategies on students' achievement in photosynthesis in senior secondary schools in the South Senatorial District of Gombe State, Nigeria. Three research questions guided the study, and three null hypotheses were tested at the 0.05 level of significance. A quasi-experimental pre-test, post-test, and post-post-test non-randomized, non-equivalent control group design was adopted. The population comprised 10,605 Senior Secondary One (SS1) students (6,201 males and 4,404 females) in 91 public secondary schools. The sample consisted of 156 SS1 students (89 males and 67 females) drawn from three purposively selected co-educational schools with functional ICT facilities. The Photosynthesis Achievement Test (PAT) was used for data collection. Reliability indices of 0.81 for PAT was obtained using Kuder–Richardson 21. Data were analyzed using mean and standard deviation, while ANCOVA was employed for hypothesis testing. The results revealed that Flipped Classroom and CANVAS LMS strategies significantly enhanced students' achievement and retention in photosynthesis compared to the conventional method, and that no significant gender difference existed among students taught using the two innovative strategies. The study recommended the integration of technology-supported strategies into Biology instruction and curriculum planning.

Keywords: Flipped Classroom; CANVAS Learning Management System; Photosynthesis; Students' Achievement; Retention; Gender Difference.

Introduction

Scientific knowledge and technological innovation constitute fundamental drivers of national development, as they advance understanding of both living and non-living systems and provide the foundation for sustained societal progress (Ilorah & Adenji, 2018). Consistent with this view, Oyovwi (2022) explains that the Nigerian Senior

Secondary School Biology Curriculum is designed to equip students with essential biological knowledge that promotes deep conceptual understanding and fosters an informed appreciation of the natural environment. Similarly, Ibukun (2022) asserts that the senior secondary school Biology curriculum emphasizes the development of functional scientific attitudes, equipping learners with the capacity for critical thinking and the practical application of scientific principles to real-world situations.

The Federal Republic of Nigeria (FRN, 2013) in National Policy on Education, further underscores the expectation that Biology education should facilitate the effective application of scientific knowledge and processes while cultivating learners' abilities to engage in independent inquiry, solve real-life problems, and communicate scientific ideas clearly. Collectively, these curricular objectives highlight the central role of Biology education in the development of scientifically literate citizens capable of contributing meaningfully to national development. Within this context, photosynthesis occupies a pivotal position in the Biology curriculum, as it exemplifies the integration of conceptual understanding and practical application by providing a foundational framework for understanding plant nutrition, energy transformation, and ecological interactions.

Photosynthesis is widely recognized as one of the most important metabolic processes and has long been a core component of the secondary school Biology curriculum worldwide, playing a central role in understanding energy flow within organisms and ecosystems (Jancarikova & Jancarik, 2022). However, several physiological, anatomical, and biochemical aspects of photosynthesis present significant learning challenges for students. Ojo, Oluwasola, Omosholape, and Olurunleke (2024) identify students' difficulty in visualizing the stages and experimental procedures of photosynthesis as a key barrier to comprehension, while Eziyi et al. (2016, in Bizimana, Mutangana, & Mwesigye, 2024) note the abstract nature of the topic due to its bio-physical and biological complexity.

The importance of photosynthesis extends beyond classroom learning; it provides critical insights into the sustainability of life, human health, evolutionary processes, bioengineering, and agricultural innovation. Despite a well-structured Biology curriculum aimed at fostering deep understanding, students often avoid questions on photosynthesis in examinations or answer them incorrectly, highlighting persistent gaps in achievement and comprehension. Given that photosynthesis is

foundational to plant biology, ecology, and applied scientific fields, ensuring students acquire a thorough understanding of the concept is essential for advancing scientific literacy and supporting innovations in sustainable agriculture and bioengineering.

Table 1: Summary of Achievement of Students in Biology Gombe State

Academic Session	School A (%)	School B (%)	School C (%)
2020/2021	58	52	57
2021/2022	61	60	50
2022/2023	55	48	43
2023/2024	46	44	49

Sources: Annual School Census, Education Management and Information System, Ministry of Education Gombe State.

Table 1 shows that the percentage performance in the concept of biology over the four academic sessions revealed a persistent underachievement across the three senatorial districts. The trend varied over the years, these fluctuations in variation according to ministry of education is attributed to either improved instructional methods and or targeted interventions in some schools. The persistent poor performance of students in photosynthesis, despite its fundamental importance in Biology, has been largely attributed to ineffective teaching strategies and suboptimal learning practices. Okoli and Okoli (2014, in Ojo, Oluwasola, Onosholape, & Olurunleke, 2024) and Raiyegbemi et al. (2020) identified teaching strategies, students' attitudes, learning habits, and inadequate learning resources as key factors influencing low achievement in Biology. Similarly, Abdullahi and Zyum (2018, in Abdullahi, Jibril, Dauda, & Danjuma, 2021) highlighted students' limited ability to recall complex concepts as a major contributor to poor performance. The West African Examination Council (WAEC) Chief Examiner's Report (2016, in Joda, 2019) also emphasized that substandard instructional delivery is a significant factor underlying low achievement in Biology.

In Nigerian secondary schools, Biology and other sciences are still predominantly taught through conventional, teacher-centered methods, characterized by passive listening, rote memorization, and limited student engagement. Saheed, Shivoga, and Nzabalirwa (2021) observed that academic achievement in science subjects is strongly influenced by the instructional strategies adopted, yet traditional approaches often neglect individual learners' needs and fail to

promote active participation. Egbes and Ajaja (2021) further noted that reliance on teacher-led instruction diminishes opportunities for students to leverage prior knowledge, explore personal abilities, and construct meaningful understanding, thereby weakening concept acquisition. Consequently, poor performance in photosynthesis is frequently linked to inadequate teaching strategies, suboptimal student learning habits, and insufficient instructional resources.

The integration of digital devices into instruction has been identified as a strategy to overcome the limitations of conventional methods. Akinbadewa (2020) emphasized that visualizing abstract concepts through computer-supported multimedia significantly enhances students' understanding. Advances in educational technology, including widespread access to the internet, computers, smartphones, and multimedia applications, have facilitated a shift toward interactive and student-centered teaching (Elkhidir, 2020). Studies indicate that integrating Information and Communication Technology (ICT) in science education promotes active learning and positively influences learning outcomes (Adonu, Nwagbo, Ugwuanyi, & Okeke, 2021). Zainuddin and Halili (2016) further noted that technology transforms education by shifting from traditional teacher-centered approaches to dynamic, technology-driven learning environments, where teachers act as facilitators of critical thinking and problem-solving.

In this context, the flipped classroom and CANVAS Learning Management System (LMS) have emerged as effective instructional strategies for teaching complex concepts such as photosynthesis. The flipped classroom, introduced by Bergmann and Sams (2017), reverses traditional learning by delivering instructional content online outside the classroom, allowing class time to be devoted to interactive activities such as discussions, exercises, and collaborative problem-solving (Mobolaji & Ogunyebi, 2019; Femi, 2021). This approach enables students to engage with content at their own pace, facilitates differentiated instruction, and supports active learning (Birgili et al., 2021; Goedhart et al., 2019). Similarly, CANVAS LMS provides a flexible online platform for teacher-student interaction, monitoring of learning progress, and personalized support (Shi & Zhang, 2023). Both approaches enhance students' engagement, foster positive learning attitudes, support modern pedagogical practices, and improve the quality and efficiency of classroom instruction.

Globally, academic achievement has often been examined in relation to gender, which refers to the social and biological identity of individuals as male or female. The influence of gender on students' academic performance

has increasingly attracted the attention of researchers and psychologists. However, there remains no consensus on the nature or extent of this influence, with studies producing mixed findings (Etobro, 2017; Kalu, 2019; Gambari, 2016). Gender-related issues have long been the subject of debate, particularly regarding their potential impact on students' achievement across different fields of study.

Some studies suggest that gender does not exert a significant influence on academic performance. For instance, Ojo, Oluwasola, Omosholape, and Olurunleke (2024) reported that gender had no significant effect on students' achievement. Similarly, Ibe and Abamuche (2019) found that although Information and Communication Technology (ICT) significantly affected learning outcomes, there was no significant main effect of gender on students' performance in Biology. These findings indicate that instructional strategies, rather than gender, may play a more decisive role in determining academic achievement. It is against this background that this study investigated the effect of flipped classroom and canvas strategies on students' achievement in photosynthesis in south senatorial district, Gombe State, Nigeria.

Statement of the Problem

The teaching and learning of Biology at the secondary school level are intended to foster a clear understanding of fundamental scientific concepts and enhance students' academic achievement. The extent to which these objectives are achieved is largely influenced by the instructional strategies employed by Biology teachers. However, in many Nigerian secondary schools, Biology instruction remains dominated by traditional, teacher-centred approaches such as demonstration, controlled questioning, dictation, board writing, and oral exposition. These methods often provide limited opportunities for active student engagement, critical thinking, and independent learning.

Photosynthesis is a foundational topic in the secondary school Biology curriculum and serves as a basis for understanding several other biological processes. Despite its significance, students' achievement in photosynthesis has continued to be unsatisfactory, with many learners exhibiting inadequate conceptual understanding. This persistent challenge has adversely affected students' overall performance in Biology and other related science subjects. Although various instructional strategies, including cooperative learning, peer tutoring, and other innovative approaches, have been investigated in previous studies, students' poor achievement in photosynthesis remains

a recurring concern, indicating the need for more effective and sustainable instructional interventions.

Advancements in educational technology and changes in students' learning preferences have created opportunities for the adoption of digital and student-centred instructional strategies. Many students now demonstrate greater engagement with multimedia resources, such as instructional videos and online learning platforms, than with conventional text-based materials. Instructional approaches such as the flipped classroom and the CANVAS Learning Management System offer structured environments that support active learning, flexible access to instructional content, and continuous interaction between teachers and students.

Despite the growing emphasis on technology-enhanced learning, empirical evidence on the effectiveness of flipped classroom and CANVAS instructional strategies in improving students' achievement in photosynthesis at the secondary school level remains limited, particularly in the South Senatorial District of Gombe State, Nigeria. This lack of context-specific evidence constitutes a significant gap in the literature. Therefore, this study seeks to investigate the effects of flipped classroom and CANVAS strategies on students' achievement in photosynthesis in the South Senatorial District of Gombe State, Nigeria.

Research Objectives

The aim of this study was to determine the effect of flipped classroom and canvas strategies on students' achievement in photosynthesis in south senatorial district, Gombe State, Nigeria. Specifically, the objectives of this study were to:

1. ascertain the effect of Flipped classroom and CANVAS LMS strategies on students' achievement in photosynthesis.
2. ascertain the effect of Flipped classroom strategy on male and female students' achievement in photosynthesis.
3. find out the effect of CANVAS LMS on male and female students' achievement in photosynthesis.

Research Question

The following research questions were asked to guide the study:

1. What are the mean achievement scores of students taught photosynthesis using Flipped classroom, CANVAS LMS and conventional strategies?
2. What are the mean achievement scores of male and female students' taught photosynthesis using Flipped classroom strategy?

3. What are the mean achievement scores of male and female students' taught photosynthesis using CANVAS LMS strategy?

Research Hypotheses

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

H_{O1}: There is no significant difference in the mean achievement scores of students taught photosynthesis using Flipped classroom, CANVAS LMS and conventional strategies.

Ho_2: There is no significant difference in the mean achievement scores of male and female students taught photosynthesis using Flipped classroom strategy.

Ho_3: There is no significant difference in the mean achievement scores of male and female students taught photosynthesis using CANVAS LMS strategy.

Methodology

The research design of this study was quasi-experimental, pre-test, post-test and post-posttest, non-equivalent, non- randomized control design. According to White and Sabarwal (2014), this design is often used when it is not possible to randomize individuals or groups to treatment and control groups. The targeted population for this study was 10,605 senior secondary one (SS1) student 6,201 (males) and 4,404 (females) in 91 public schools in South Senatorial District of Gombe State Nigeria for 2024/2025 session. The choice of male and female students was gender moderating variable of the study. The sample for this study was 156 students (89 male and 67 female) from three co-education senior secondary one (SS1) students. The sampling technique employed was a combination of purposive sampling and intact class sampling. Purposive sampling was used to select three secondary schools from different senatorial districts within the study area. These schools were selected based on availability of functional ICT infrastructure, exposure to digital learning tools and willingness to participate.

The research instruments used for data collection in this study was Photosynthesis Achievement Tests (PAT). The PAT is divided into two sections (A and B) Section A contained items on students' personal data respondents while section B had 30 items of multiple choice. The Photosynthesis Achievement Test was used for pre-test, post –test to obtain data on students achievement. The Photosynthesis Achievement Test (PAT) was validated by three experts in Department of Science, Technology and Mathematics Education, Faculty of Education Nasarawa State University, Keffi. The experts subjected the instrument to face and content validity. The comments, suggestions and criticism made by validators were incorporated to produce the final instrument. In the respective ratings of the instrument by

the experts, the validity index of PAT was 0.82. The Photosynthesis Achievement Test (PAT) was subjected to trial test to ascertain the reliability of the instruments; it was administered to a sample of 30 students outside the main sample. The reliability of PAT was determined using Kuder Richardson formular (KR-21) The reliability coefficient of 0.85 was obtained for PAT. The scores obtained from pre-test and post-test were analyzed using descriptive statistics of mean and standard deviation for the research questions. Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance.

Results

The data are analysed according to the research questions asked and hypotheses formulated for the study.

Research Question One

What are the mean achievement scores of students' taught photosynthesis using Flipped classroom, CANVAS LMS and conventional methods?

Table 1: Mean and Standard Deviation of Students' Taught Photosynthesis Using Flipped Classroom , CANVAS LMS and Conventional Method

Group		Pre-test		Post- test	
	N	Mean	S.D	Mean	S.D
Flipped Classroom	48	16.00	3.039	23.46	2.526
CANVAS LMS	49	16.18	3.784	24.69	1.949
Conventional Method	59	16.07	3.755	16.07	3.174

Table 1 presents the pre-test and post-test mean achievement scores and standard deviations of students taught photosynthesis using Flipped Classroom, CANVAS LMS, and Conventional methods. For the Flipped Classroom group, the pre-test mean and standard deviation were 16.00 and 3.039 respectively, while the post-test mean and standard deviation are 23.46 and 2.526 respectively. Similarly, students in the CANVAS LMS group had a pre-test mean and standard deviation of 16.18 and 3.784, which improved to 24.69 and 1.949 in the post-test. In contrast, the Conventional method group recorded a pre-test mean and standard deviation of 16.07 and 3.755, with a modest increase in the post-test mean and standard deviation to 18.78 and 3.174 respectively.

Null Hypothesis One

There is no significant difference in the mean achievement scores of students taught photosynthesis using Flipped classroom, CANVAS LMS and conventional methods.

The test for hypothesis one is presented in Table 2.

Table 2: Results of ANCOVA on Achievement Scores of Students' Taught Photosynthesis Using Flipped Classroom, CANVAS LMS and those Taught Using Conventional Methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1081.759[a]	3	360.586	52.035	0.000	0.507
Intercept	3148.782	1	3148.782	454.388	0.000	0.749
Pretest	13.142	1	13.142	1.897	0.170	0.012
Method	**1066.861**	**2**	**533.431**	**76.977**	**0.000**	**0.503**
Error	1053.318	152	6.930			
Total	78168.000	156				
Corrected Total	2135.077	155				

a. R Squared = 0.507 (Adjusted R Squared = 0.497)

Table 2 reveals that, there is a significant difference in the mean achievement scores of students exposed to Flipped Classroom, CANVAS LMS and Conventional Methods. The value of $F_{(2, 252)} = 76.977$ is obtained with associated exact probability value of 0.000. Since the associated probability value was 0.000 is less than 0.05 level of significance, the null hypothesis one is rejected. The results implied that, the flipped classroom and CANVAS LMS methods produce a significant effect on the post-test achievement scores of students when covariate effect (pre-test) is controlled. Hence, there is a significance difference among the three groups.

Based on the established difference in the Mean achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis are presented in Table 3.

Table 3: Results of Bonferroni Multiple Comparisons on Mean Achievement Scores of Students' Exposed to Flipped Classroom, CANVAS LMS and Conventional Methods

(I) Methods	(J) Methods	Mean Difference (I-J)	Std. Error	Sig. [a]	95% Confidence Interval for Difference	
					Lower Bound	UpperBound
FC	CLms	-1.220	0.535	0.072	-2.515	0.074
	CM	4.684*	0.512	0.000	3.446	5.923
CLms	FC	1.220	0.535	0.072	-0.074	2.515
	CM	5.905*	0.509	0.000	4.673	7.136
CM	FC	-4.684*	0.512	0.000	-5.923	-3.446
	CLms	-5.905*	0.509	0.000	-7.136	-4.673

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 3 indicates that, there is no significant difference in the mean achievement scores of students exposed to Flipped classroom and CANVAS LMS methods ($p=0.072 > \alpha=0.05$). There is significant difference in the mean achievement scores of students exposed to flipped classroom and Conventional methods($p=0.000 < \alpha=0.05$). in favor of Flipped Classroom method. Similarly, there is significant difference in the mean achievement scores of students exposed to CANVAS LMS and Conventional Methods ($p=0.000 < \alpha=0.05$). in favor of CANVAS LMS method.

Research Question Two

What are the mean achievement scores of male and female students' taught photosynthesis using Flipped classroom method?

Table 4. Mean and Standard Deviation on Achievement Scores of Male and Female Students' Taught Photosynthesis Using Flipped Classroom Method

Gender	N	Pre-test		Post-test	
		Mean	S.D	Mean	S.D
Male	30	16.27	3.194	23. 67	2.294
Female	18	15.56	2.791	23.11	2.908

Table 4 shows the results of pre-test and post-test mean achievement scores and standard deviation of male students' taught photosynthesis using flipped classroom

method as (16.27, 3.194) and (23.6, 2.29), while pre-test and post-test mean achievement scores and standard deviation of female students' taught photosynthesis using flipped classroom method are (15.56, 2.79) and (23.11, 2.91) respectively.

Null Hypothesis Two

There is no significant difference in the mean achievement scores of male and female students taught photosynthesis using Flipped Classroom method.

The test for hypothesis two is presented in Table 5.

Table 5: Results of ANCOVA on Achievement Scores of Male and Female Students' Taught Photosynthesis Using Flipped Classroom Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.784[a]	2	1.892	0.288	0.752	0.013
Intercept	859.526	1	859.526	130.613	0.000	0.744
Pretest	0.312	1	.312	0.047	0.829	0.001
GenderFC	**3.194**	**1**	**3.194**	**0.485**	**0.490**	**0.011**
Error	296.133	45	6.581			
Total	26714.000	48				
Corrected Total	299.917	47				

a. R Squared = 0.013 (Adjusted R Squared = -0.031)

Table 5 reveals that, there is no significant difference in the mean achievement scores of male and female students taught photosynthesis using Flipped Classroom Method. The value of $F_{(1, 45)} = 0.485$ was obtained with associated exact probability value of 0.490. Since the associated probability of 0.490 was greater than 0.05 level of significance, the null hypothesis two not rejected. The results implied that, there is no gender difference in students' achievement in photosynthesis when they are taught using flipped classroom method.

Research Question Three

What are the mean achievement scores of male and female students' taught photosynthesis using CANVAS LMS method?

Table 6: Mean and Standard Deviation on Achievement Scores of Male and Female Students' Taught Photosynthesis Using CANVAS LMS Method

Gender	N	Pre-test		Post-test	
		Mean	S.D	Mean	S.D
Male	27	15.74	4.320	24.44	1.867
Female	22	16.73	3.011	25.00	2.047

Table 6 shows the results of pre-test and post-test on mean achievement scores and standard deviation of male students' taught Photosynthesis using CANVAS LMS Method as (15.74, 4.32) and (24.44, 1.87), while pre-test and post-test mean achievement scores and standard deviation of female students' taught Photosynthesis using CANVAS LMS method are (16.73, 3.011) and (25.00, 2.047) respectively.

Null Hypothesis Three

There is no significant difference in mean achievement scores of male and female students taught photosynthesis using CANVAS LMS method.

The test for this hypothesis is presented in Table 7.

Table 7: Results of ANCOVA on Achievement Scores of Male and Female Students' Taught Photosynthesis Using CANVAS LMS Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.282[a]	2	2.141	0.553	0.579	0.023
Intercept	1433.247	1	1433.247	370.128	0.000	0.889
Pretest	0.541	1	0.541	0.140	0.710	0.003
GenderCLms	**3.317**	**1**	**3.317**	**0.857**	**0.360**	**0.018**
Error	178.126	46	3.872			
Total	30062.000	49				
Corrected Total	182.408	48				

a. R Squared = 0.023 (Adjusted R Squared = -0.019)

Table 7 reveals that, there is no significant difference in the mean achievement scores of male and female students exposed to CANVAS LMS Method. The value of $F_{(1, 46)}$ = 0.857 was obtained with associated exact probability value of 0.360. Since the associated probability 0.360 is greater than 0.05 level of significance, the null hypothesis

three not rejected. The results implied that, there is no gender difference in achievement scores of students in Photosynthesis when they are taught using CANVAS LMS Method.

Discussion

The findings revealed a significant difference in the achievement scores of students taught using Flipped Classroom, CANVAS LMS, and Conventional Methods. This indicates that students exposed to Flipped Classroom and CANVAS LMS strategies performed better in photosynthesis compared to their peers taught using the conventional method. This outcome supports the findings of Adonu, Nwagbo, Ugwuanyi, and Okeke (2021), Gambari, Agboola, and Adeoye (2016), and Femi (2021), who reported that flipped classroom strategies significantly enhance students' achievement in biology concepts. Similarly, studies by Ahmed and Lawal (2020) and Bizimana, Mutangana, and Mweseigye (2024) found that cooperative and interactive learning approaches improve students' understanding and retention of scientific concepts, which aligns with the effectiveness of the CANVAS LMS strategy observed in this study. The enhanced achievement among students exposed to Flipped Classroom and CANVAS LMS can be attributed to active engagement, self-paced learning, and accessibility to multimedia resources. Flipped Classroom allows students to interact with instructional materials before class, enhancing understanding during classroom activities, while CANVAS LMS provides an online platform for continuous interaction, discussion, and assessment. These strategies encourage students to construct knowledge actively, collaborate with peers, and receive immediate feedback, resulting in higher levels of academic achievement.

The findings revealed that there is no significant difference in the achievement scores of male and female students taught photosynthesis using the Flipped Classroom method. This indicates that both male and female students performed equally well when exposed to this student-centered instructional strategy. This outcome aligns with the findings of Gambari, Agboola, and Adeoye (2016), Adonu, Nwagbo, Ugwuanyi, and Okeke (2021), and Femi (2021), who reported that gender did not significantly influence students' performance in biology concepts when taught using flipped classroom strategies. Similarly, Ahmed and Lawal (2020) found that cooperative and interactive learning approaches promoted equitable achievement among male and female students. The lack of gender

difference can be attributed to the interactive and engaging nature of the Flipped Classroom. By allowing students to access instructional materials before class and participate actively in learning activities, the method provides equal opportunities for all students to understand and apply concepts. The strategy encourages collaboration, discussion, and self-paced learning, which minimizes gender-related disparities in achievement.

The findings revealed that there is no significant difference in the achievement scores of male and female students exposed to the CANVAS LMS method. This indicates that both male and female students benefited equally from the use of the online learning platform in learning photosynthesis. This outcome is consistent with the findings of Garcia et al. (2020), Kalaw (2022), and Gunarathna, Dayananda, and Ransara (2023), who reported that the use of Learning Management Systems, such as CANVAS, promotes equitable learning outcomes among students regardless of gender. Similarly, Yaprak (2022) and Santiana, Silvani, and Ruslan (2021) found that students' interaction with LMS platforms enhances learning and engagement for all learners, minimizing gender disparities in performance. The equal achievement of male and female students can be attributed to the interactive and accessible nature of CANVAS LMS. The platform allows students to engage with learning materials at their own pace, participate in online discussions, and receive timely feedback. These features create a learning environment where all students have equal opportunities to understand and apply concepts, reducing potential gender-based differences in achievement.

Conclusion

Based on the findings of this study, the flipped classroom and CANVAS Learning Management System (LMS) strategies were found to be more effective than the conventional teaching method in enhancing students' achievement in photosynthesis in secondary schools in the South Senatorial District of Gombe State, Nigeria. Students exposed to the flipped classroom and CANVAS instructional strategies demonstrated improved understanding of photosynthesis as a result of increased active engagement, self-paced learning, and access to diverse instructional resources.

The study also revealed that the flipped classroom and CANVAS LMS strategies were gender-friendly, as no significant difference was observed in the achievement of male and female students taught using these methods. This indicates that both instructional strategies provided equal learning opportunities and benefits for all learners, regardless of gender. Consequently,

the adoption of flipped classroom and CANVAS instructional strategies can be considered effective and inclusive approaches for improving students' achievement in photosynthesis at the secondary school level.

Recommendations

1. Biology teachers in secondary schools should be encouraged to adopt flipped classroom and CANVAS Learning Management System (LMS) strategies in the teaching of photosynthesis.
2. Education policymakers and curriculum planners should integrate flipped classroom and CANVAS LMS strategies into the Biology curriculum, particularly for abstract and concept-intensive topics such as photosynthesis.
3. School administrators, teacher training institutions, and professional development bodies should organize regular workshops, seminars, and in-service training programmes for Biology teachers in the use of CANVAS LMS.

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