

Comparative Effect of Flipped Classroom, Problem-Based and Lecture Teaching Methods on Students' Academic Achievement and Interest in Agricultural Mathematics in Colleges of Education, Northwest Nigeria

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Abstract

This study determined the Comparative Effects of Flipped Classroom (FC), Problem-based (PB) and Lecture teaching methods on students' academic achievement and interest in Agricultural Mathematics in Colleges of Education in Northwest Nigeria. The researcher developed three research objectives, formulated three research questions and three null hypotheses that guided the study. The study adopted a quasi-experimental pre-test post-test non-equivalent group design, using three intact classes across three public Colleges of Education. The population for the study was 771 (466 males and 305 females) NCE 1 students in Department of Agricultural Education in 12 Colleges of Education in Northwest Nigeria. 131 NCE I Agricultural Education students made up of 80 males and 51 females participated in the study. Two instruments, the Agricultural Mathematics Achievement Test (AMAT) and the Agricultural Mathematics Interest Inventory Questionnaire (AMIIQ), were developed, validated by experts, and trial-tested. The experimental procedure began with the preparation of a standardized lesson plan by the researcher, designed for use by regular agricultural mathematics lecturers during their normal class schedules. Participants were divided into three groups: Experimental Group I (flipped classroom method), Experimental Group II (problem-based method), and a control group (traditional lecture method). A pre-test was administered a week before the experiment to determine baseline knowledge. The experiment lasted nine weeks. Several measures were taken to control extraneous variables and initial group differences were adjusted using ANCOVA. Data collection involved administering the Agricultural Mathematics Achievement Test (AMAT) and the Agricultural Mathematics Interest Inventory Questionnaire (AMIIQ) before and after the experiment. Data were analyzed using ANCOVA, Mean and Standard Deviation. Findings revealed that gender had no significant effect on achievement or retention, though male students showed slightly greater gains under FC and PB, and females performed marginally better with lecture method. A small but significant difference was found between gender and teaching methods in relation to interest. The study concluded that FC and PB can substantially improve academic achievement and knowledge retention in Agricultural Mathematics in teacher training institutions regardless of gender, among others. It recommends that professional development for educators, the inclusion of Flipped Classroom and Problem-based teaching methods to accommodate gender-based learning preferences, and investment in technological infrastructure to support the effective implementation of modern teaching methods.

Keywords: Flipped Classroom, Problem-based, Teaching methods, Gender, retention, Academic achievement

Introduction

Agricultural mathematics simply means mathematical principles use for solving agricultural problems such as crop yield prediction, animal production, pest management, irrigation scheduling, and farm economics. It is a core course for agricultural education students in Nigerian Colleges of Education. The National Commission for Colleges of Education (NCCE, 2021) emphasized active student engagement and effective instructional support in the teaching of agricultural courses. However, students' difficulties in learning complex concepts often lead to negative attitudes toward the course (Uzoma & Amadi, 2018). Efe (2017) attributed the poor academic achievement of Colleges of Education students in agricultural mathematics to the predominant use of lecture-based teaching methods.

The lecture method primarily takes place in a traditional classroom setting, where instructors deliver information and provide direct instructions to students through lectures. Lecture method of teaching which is also referred to as lecturer centered method, simply means that students get information from the lecturer without building their engagement level with the subject being taught (Wabwoba, et al, 2017). The approach is least practical, more theoretical and memorizing (Wabwoba, et al, 2017). The lecture method, which is teacher-centered, limits students' active participation and initiative, positioning them as passive recipients of knowledge (Mohammad, Bala, & Ladu, 2016). In response, the NCCE (2021) advocated a shift from teacher-centered to learner-centered instructional approaches, redefining the lecturer's role from content transmitter to learning facilitator. This shift supports the transformation of students into active constructors of knowledge (Muianga et al., 2018) and has increased the adoption of learner-centered teaching methods such as the flipped classroom.

The flipped classroom integrates digital technologies and online resources to deliver instructional content outside the classroom, allowing class time to be used for interactive activities, discussions, and collaborative learning. Studies have shown that this approach enhances students' preparedness, flexibility, and engagement compared to traditional lecture-based instruction (Ağırman & Ercoşkun, 2022). Flipped classroom traces its roots in active learning, a process that utilizes various activities which engage the learners at both individual and collaborative levels, transferring the learning responsibility to their own ability and pace (Camiling, 2017). In this study, the flipped classroom involves students' engagement with video lectures prior to class and participation in collaborative learning activities during class time. Problem-based learning is another learner-centered teaching method that similarly promotes collaboration and critical thinking.

Problem-based learning (PBL) is a student-centered instructional approach that engages learners in exploring real-world problems and constructing knowledge through active problem-solving (Johnson, et al. 2019). It involves extended student investigation, interdisciplinary inquiry, open-ended questioning, collaborative group work, and self-directed learning, allowing students to take responsibility for their own learning. In a PBL environment, students work together to identify problems, gather and analyze information, and propose solutions, applying critical thinking and collaborative skills. In this study, PBL is defined as a method that fosters active learning, critical thinking, and practical application of agricultural mathematics concepts. By working in groups to solve real-world agricultural problems, learners develop relevant skills such as research, problem-solving, and document analysis. When lecturers implement PBL, students' engagement, interest, and academic achievement in agricultural mathematics are enhanced through active participation.

Interest plays a central role in learning, as it motivates students to engage with and persist in academic tasks. It is a positive emotional response that draws individuals toward exploration and engagement (Harackiewicz & Hulleman, 2019). Wigfield and Eccles (2021) define interest as an enduring affective-motivational state reflected in heightened attention, positive emotions, and a desire to engage with a specific object or activity. Similarly, Krapp, Hidi, and Renninger (2016) describe interest as an affective-motivational state that energizes and directs behavior, distinguishing between "individual interest" and "situational interest." In agricultural mathematics, cultivating student interest is essential for sustained engagement, deeper learning, and improved academic performance.

Academic achievement refers to the level of success a student attains in their studies, typically measured by grades, test scores, or academic awards. It reflects students' ability to meet the expectations

of instructors and the standards of their academic programs (Yousef & Dahmani, 2020). In this study, academic achievement in agricultural mathematics is defined as the knowledge, skills, and competencies students acquire, measured through grades, test performance, and the application of mathematical concepts to real-world agricultural problems. While students often focus on passing examinations, meaningful learning requires knowledge retention and the ability to apply learning beyond the classroom. Deslauriers and Wieman, cited in Chinwendu and Olele (2020), note that education should emphasize knowledge that can be retained and applied weeks, months, or years after instruction.

Retention, the process of storing and recalling learned information, is crucial for long-term learning. It involves transferring knowledge from short-term to long-term memory (Chinwendu & Olele, 2020) and is essential for students to apply mathematical concepts in practical agricultural contexts. Retention is influenced by factors such as instructional methods and gender, which can affect students' ability to learn and apply knowledge effectively. Gender, a social construct encompassing roles, behaviors, and cultural norms (Joseph et al., 2015), can influence academic outcomes in agricultural mathematics.

A significant challenge in Nigerian Colleges of Education is the continued reliance on lecture-based, teacher-centered instruction, which promotes passive learning. Students who are motivated and actively engaged tend to perform better, whereas those who are not are likely to struggle. Poor instructional approaches contribute to low participation, math anxiety, reduced interest, and ultimately poor academic achievement in agricultural mathematics. For example, a review of students' performance in Kaduna State College of Education between 2015 and 2020 revealed consistently low pass rates: only 34.7% passed in 2015/2016, 25.19% in 2016/2017 and 2017/2018, 70.21% in 2018/2019, and 24.28% in 2019/2020. These outcomes underscore the limitations of lecture-based teaching in promoting student engagement, understanding, and retention.

In light of these issues, there is a need to determine whether flipped classroom and problem-based teaching methods can enhance students' interest, academic achievement, and retention in agricultural mathematics. This study, therefore, aims to determine the effects of these methods on student interest, academic achievement, and retention in agricultural mathematics in Colleges of Education in Northwest Nigeria.

Problem Statement

Agricultural Mathematics, a core component of the Agricultural Education curriculum in Nigerian Colleges of Education, is essential for equipping students with the quantitative skills needed to address real-world agricultural challenges, including crop yield estimation, farm management, irrigation planning, and pest control. Despite its central importance, students' academic performance in this course has remained consistently poor. This persistent underachievement is largely linked to the continued reliance on the lecture method, which positions learners as passive recipients of information and offers limited opportunities for critical thinking, active engagement, or practical application.

Empirical evidence from Kaduna State College of Education between 2015 and 2020 underscores the severity of the problem, with high failure rates recorded year after year. Unfortunately, Efe (2017), attributed the poor academic achievement of college of education students in agricultural mathematics to teaching methods used by lecturers which is predominantly lecture method. Lecture method does not apply activity-based learning to encourage students to learn real life problems based on applied knowledge, since the lecturer controls the transmission and sharing of knowledge, the lecturer may attempt to maximize the delivery of information while minimizing time and effort (Wabwoba, et al, 2017). These outcomes reflect not only inadequacies in instructional methods but also associated challenges such as students' mathematics anxiety, low motivation, weak study habits, and declining interest, all factors that impede meaningful learning and knowledge retention. The implications extend beyond classroom performance. Students' inability to acquire and apply essential mathematical skills undermines their capacity to contribute effectively to agricultural development, with broader consequences for national food security and sustainable agricultural productivity. Furthermore, persistent poor achievement negatively impacts lecturer morale, further diminishing the quality of teaching and learning.

In response to these challenges, there is a pressing need to examine and implement innovative instructional methods that alleviate mathematics anxiety, foster active participation, stimulate student interest, and improve both academic achievement and knowledge retention. This study, therefore, investigates the effects of flipped classroom and problem-based teaching methods on students' interest and academic achievement in Agricultural Mathematics in Colleges of Education in Northwest Nigeria.

Objectives of the Study

The major purpose of the study was to determine the comparative effect of flipped classroom, problem-based and lecture methods on students' academic achievement and interest in agricultural mathematics, Northwest Nigeria. Specifically, the study:

1. compared the effect of flipped classroom, problem-based and lecture teaching methods on the academic achievement of male and female students in Agricultural Mathematics.
2. compared the effect of flipped classroom, problem-based and lecture teaching methods on the interest of male and female students in Agricultural Mathematics.
3. compared the effect of flipped classroom, problem-based and lecture teaching methods on the academic retention ability of male and female students in Agricultural Mathematics.

Research Questions

The following research questions guided the study:

1. What is the comparative effect of flipped classroom, problem-based and lecture teaching methods on the academic achievement of male and female students in Agricultural Mathematics?
2. What is the comparative effect of flipped classroom, problem-based and lecture teaching methods on the interest of male and female students in Agricultural Mathematics?
3. What is the comparative effect of flipped classroom, problem-based and lecture teaching methods on the academic retention ability of male and female students in Agricultural Mathematics?

Null Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

1. There is no significant effect of flipped classroom, problem-based and lecture teaching methods on male and female students' academic achievement in agricultural mathematics in colleges of education.
2. There is no significant effect of flipped classroom, problem-based and lecture teaching methods on male and female students' interest in agricultural mathematics in colleges of education.
3. There is no significant effect of flipped classroom, problem-based and lecture teaching methods on male and female students' academic retention in agricultural mathematics in colleges of education.

Methodology

This study adopted a quasi-experimental design, specifically a pre-test–post-test non-equivalent group design. According to Capili and Anastasi (2024), this design compares the performance of two or more groups that have not been randomly assigned by measuring the dependent variable before and after an intervention. Since random assignment of students was not feasible, intact classes were used as experimental groups. This approach allows for the assessment of the effects of the intervention while accounting for potential differences between groups at the outset (Hargreaves et al., 2017).

The population for this study comprised 703 Nigerian Certificate in Education (NCE) 1 students in 2023/2024 session (406 males and 297 females) enrolled in the Department of Agricultural Education across 12 public Colleges of Education in Northwest Nigeria. A purposive sampling technique was used to select 131 NCE 1 students from three Colleges of Education, chosen due to proximity and security considerations in Northwest Nigeria. Kaduna State College of Education, Gidan Waya (80 students) as Group A, and Federal College of Education, Bichi, Kano State (31 students) as Group B, were assigned as experimental groups, while Federal College of Education, Katsina (20 students) served as the control group (Group C). Intact classes were used to maintain normal classroom settings and minimize disruption to students' learning routines.

Data were collected using two researcher-developed instruments: the Agricultural Mathematics Achievement Test (AMAT) and the Agricultural Mathematics Interest Inventory Questionnaire (AMIIQ). The AMAT comprised 36 multiple-choice items, each with four options (A–D), covering topics such as triangles and rectangles, circles and squares, trapeziums and parallelograms, bar charts, histograms, and pie charts. The AMIIQ was a 20-item questionnaire measuring students' interest in Agricultural Mathematics on a 5-point rating scale (Very interested (5), Interested (4) Neutral (3) Not very interested (2) Not interested at all (1)). Both instruments were administered as pre-tests and post-tests with a 60-minute time allocation.

Face and content validation were conducted by three experts—two from the Department of Agricultural Education, University of Nigeria, Nsukka, and one from the Agricultural Education Unit, Vocational and Technical Education Department, Ahmadu Bello University, Zaria. Experts reviewed the instruments and lesson plans for clarity, relevance, and suitability, with their suggestions incorporated into the final versions. Content validation utilized the table of specification to ensure alignment with the curriculum and consistency across test items.

Experimental Procedure

The experiment ran for eleven weeks. Week 1 was for the pre-test, Weeks 2–7 covered the instructional intervention, Week 8 was used for revision, and Week 9 was for the post-test. A retention test was then administered two weeks after the post-test

One week instructional programme was organized for the course lecturers that were used as research assistants for the study. The instruction was based on the purpose of the study, the topics to be taught, the use of lesson plan, the application of flipped classroom and problem-based as teaching methods and the general conduct. The lecturers and the researcher jointly administered the pre-test before instruction began, with several measures implemented to control extraneous variables. Standardized lesson plans, instructions to research assistants, and supervised trial-teaching sessions ensured uniform delivery of the six-week instructional programme. Test materials were securely held by the researcher to avoid bias, and pre-test sensitization was reduced by reshuffling test items before the post-test. The same instruments were used for both assessments to maintain consistency. Because the study used a non-equivalent group, pre-test–post-test design, ANCOVA was applied to control for initial group differences. Each treatment group was placed in a different college to prevent interaction, and regular lecturers taught the classes without informing students of the research to minimize the Hawthorne effect.

Data collection was conducted by the researcher and three trained assistants. The AMAT and AMIIQ instruments were administered as both pre- and post-tests in the Agricultural Education classes of the selected colleges. All scripts were retrieved and scored according to a predetermined marking scheme. For data analysis, descriptive statistics (mean and standard deviation) were used to answer the research questions. The treatment group with the highest mean score was interpreted as having a greater effect. To test the null hypotheses, ANCOVA was employed at a 0.05 level of significance. This method accounted for the non-random assignment of participants and initial group differences. A hypothesis was rejected if the p-value was less than 0.05; otherwise, it was retained.

Results Presentation

Research Question 1 (1): What is the comparative effect of flipped classroom, problem-based and lecture methods on the academic achievement of male and female students in Agricultural Mathematics?

Table 1: Pretest and posttest mean academic achievement scores of male and female students in Agricultural Mathematics taught using flipped classroom, problem-based and lecture teaching methods in Colleges of Education

Teaching methods	Gender	N	Pretest		Posttest		Mean Difference
			\bar{X}	SD	\bar{X}	SD	
Flipped classroom	Male	50	31.21	8.91	57.28	6.99	26.07
	Female	30	30.40	9.58	56.75	5.95	26.35
Problem-based	Male	12	29.00	7.74	59.35	5.96	30.35
	Female	08	28.82	9.67	56.94	5.73	28.12
Lecture	Male	18	24.60	7.19	45.00	7.08	20.40
	Female	13	25.06	6.38	45.57	5.96	20.51

Note: N = Number of Respondents, \bar{X} = Mean, SD = Standard deviation

Result in Table 1 in all shows the pretests and post-tests mean academic achievement scores in Agricultural Mathematics achievement ratings for male and female students taught using Flipped Classroom (*male*; \bar{X} = 57.28, *female*; \bar{X} = 56.75), problem-based (*male*; \bar{X} = 59.35, *female*; \bar{X} = 56.94), and the lecture teaching method (*male*; \bar{X} = 45.00, *female*; \bar{X} = 45.57). A closer look at this result shows that male students had a better enhancement of their achievement in Agricultural Mathematics than their female counterparts when taught using Flipped classroom and Problem-based while the female students had a better enhancement of their achievement when taught using lecture method.

Hypothesis 1

HO₁: There is no significant effect of flipped classroom, problem-based and lecture teaching methods on male and female students' academic achievement in agricultural mathematics in colleges of education.

Table 2: Analysis of covariance (ANCOVA) of the difference in the mean academic achievement scores of students in Agricultural Mathematics in Colleges of Education taught using flipped classroom, problem-based and lecture methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared (η^2_p)	Dec.
Corrected Model	29162.542 ^a	6	3193.757	412.652	.000	.906	
Intercept	3567.194	1	3567.194	460.902	.000	.643	
Pretest OPA	3042.790	1	3042.790	393.146	.000	.606	
Teaching Methods	10471.057	2	5235.528	665.532	.000	.732	S
Gender	172.881	1	172.881	22.337	.152	.080	NS
Methods * Gender	130.550	2	65.275	8.434	.056	.062	NS
Error	1981.336	256	7.740				
Total	168532.000	263					
Corrected Total	21143.878	257					

Note: df= Degree of Freedom, f= f-ratio, Sig.= Significant/probability value, Dec.= Decision, S = Significant

The Analysis of Covariance (ANCOVA) result in Table 2 also revealed that the academic achievement scores of male and female students taught mathematics using Flipped classroom, problem-based and lecture teaching methods in Colleges of Education in Northwest Nigeria did not differ significantly ($f(1, 257) = 22.337, p = .152; \eta^2_p = .080$). This is given the fact that the associated probability (Sig.) value of 0.152 is more than 0.05 level of significance at which the result was being tested. On this note, the null hypothesis one (HO₁) was accepted, and inference drawn was that the academic achievement scores of male and female students in Agricultural Mathematics when taught using Flipped Classroom, problem-based and lecture teaching methods in Colleges of Education did not differ significantly. Furthermore, the interaction between

teaching methods and gender was marginally significant, $f(2, 256) = 8.434$, $p = .056$, $\eta^2_p = 0.062$. About 6.2% of the variance in students' academic achievement can be attributed to this interaction, suggesting that the effectiveness of teaching methods does not differ meaningfully between male and female students. The plotted graph below further explained the result.

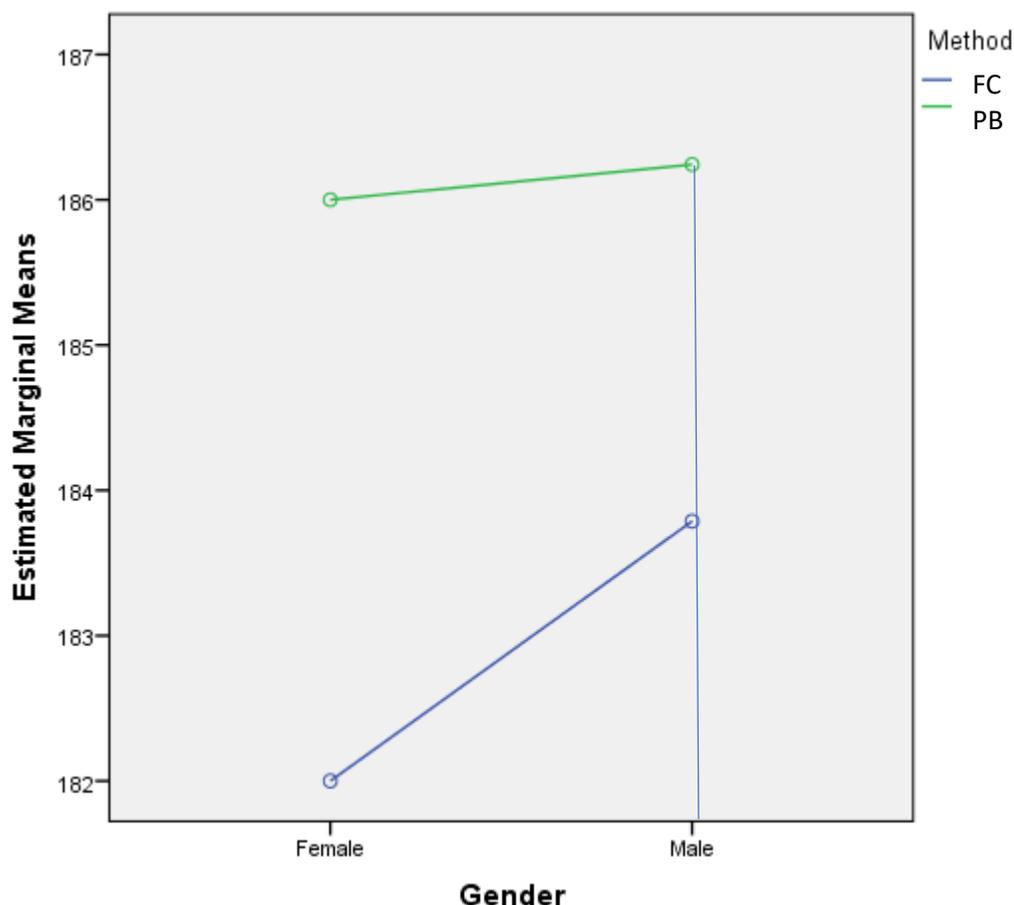


Figure one (1): Profile plot for the effect of teaching methods and gender on students' academic achievement in mathematics. Key – FC (Flipped Classroom) PB – (Problem Based)

The profile plot above (Figure 1) shows that there is no significant effect of teaching methods and gender on students' academic achievement in Mathematics. This is obvious as the teaching methods lines drawn against the students' gender in the graph intercepted between the teaching methods to produce no considerable interaction effect on their Mathematics achievement. Hence, there is a no significant effect of teaching methods and gender on students' academic achievement in Mathematics.

Research Question Two (2): There is no significant effect of flipped classroom, problem-based and lecture methods on male and female students' interest in agricultural mathematics in colleges of education.

Table 3: Pretest and posttest mean difference in the mean interest rating of male and female students in Agricultural Mathematics in Colleges of Education.

Teaching methods	Gender	N	Pretest		Posttest		Mean Difference
			\bar{X}	SD	\bar{X}	SD	
Flipped classroom	Male	50	14.86	5.01	30.93	6.25	16.07
	Female	30	13.92	4.04	27.17	4.78	13.25
Problem-based	Male	12	14.43	3.99	32.54	4.41	18.11
	Female	08	14.32	4.41	29.97	4.32	15.65
Lecture	Male	18	10.71	3.18	12.66	3.12	1.95
	Female	13	12.65	3.69	14.63	3.69	1.98

Note: N = Number of Respondents, \bar{X} = Mean, SD = Standard deviation

Result in Table 3 shows the pretests and post-tests mean differences in the Mathematics interest scores for male and female students taught using Flipped Classroom (*male; pretest = \bar{X} = 14.86, posttest = 30.93, female; pretest = \bar{X} = 13.92 posttest = 27.17*), problem-based (*male; pretest = \bar{X} = 14.43, posttest = 32.54 female; pretest = \bar{X} = 14.32, posttest = 29.97*), and the lecture teaching method (*male; pretest = \bar{X} = 10.7145, posttest = 12.66, female; pretest = \bar{X} = 12.65, posttest = 14.63*). A critical look at this result show that male students had a slightly better improvement in their Agricultural Mathematics interest than their female colleagues when taught using Flipped Classroom and problem-based teaching methods while the female students were slightly better when taught using the Lecture teaching method.

Hypothesis Two

HO₂: There is no significant effect of flipped classroom, problem-based and lecture teaching methods on male and female students' interest in agricultural mathematics in colleges of education.

Table 4: Analysis of covariance (ANCOVA) of the difference in the mean interest rating of students' interest in Agricultural Mathematics in Colleges of Education

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	114.128 ^a	4	28.532	3.603	0.010	0.186	
Intercept	715.132	1	715.132	90.313	0.000	0.589	
AI_ Pretest	4.718	1	4.718	0.596	0.543	0.009	
Methods	20.894	2	20.894	2.639	0.109	0.040	NS
Gender	2.268	1	2.268	0.286	0.604	0.005	NS
Methods * Gender	1.444	1	1.444	6.809	.0000	.07145	S
Error	498.858	634	7.918				
Total	2327543.000	682					
Corrected Total	612.985	676					

Note: df= Degree of Freedom, f= f-ratio, Sig.= Significant/probability value, Dec.= Decision, S = Significant

The Analysis of Covariance (ANCOVA) result in Table 4 also revealed that the interest rating of male and female students in Mathematics taught using flipped classroom, problem-based and lecture teaching methods in agricultural mathematics in colleges of education did not differ significantly, $f(1, 634) = 0.286$, $p = 0.604$, $\eta^2_p = 0.005$, indicating male and female students showed similar levels of interest after controlling for pretest scores. This is due to the fact that the associated probability (Sig.) value of 0.604 is more than 0.05 level of significance at which the result was being tested. Thus, the null hypothesis five (HO₂) was accepted, and the conclusion drawn was that male and female students did not differ significantly in their Mathematics interest when taught using Flipped classroom, problem-based and lecture teaching methods in Colleges of education in Northwest, Nigeria.

Research Question Three (3): What is the comparative effect of flipped classroom, problem-based and lecture methods on the academic retention ability of male and female students in Agricultural Mathematics?

Table 5: Pretest and posttest mean academic retention scores of male and female students in Agricultural Mathematics taught using flipped classroom, problem-based and lecture methods in colleges of Education

Teaching methods	Gender	N	Posttest		Retention test		Mean Difference
			\bar{X}	SD	\bar{X}	SD	
Flipped Classroom	Male	50	28.99	6.25	28.93	5.17	-0.06
	Female	30	28.54	4.78	27.17	4.79	-1.37
Problem-based	Male	12	31.98	4.41	31.54	3.90	-0.44
	Female	08	31.97	4.32	29.97	3.75	-2.00
Lecture	Male	18	12.71	3.12	10.66	3.18	-2.05
	Female	13	14.65	3.69	14.63	3.69	-0.02

Note: N = Number of Respondents, \bar{X} = Mean, SD = Standard deviation

The result in Table 5 The post-test and retention scores of male and female students in Agricultural Mathematics. For Flipped Classroom, males had a post-test \bar{X} = 28.99, SD = 6.25, and a retention \bar{X} = 28.93, SD = 5.17, resulting in a difference of -0.06, while females had a post-test \bar{X} = 28.54, SD = 4.78, and a retention \bar{X} = 27.17, SD = 4.79, with a difference of -1.37. For the Problem-Based method, males post-test \bar{X} = 31.98, SD = 4.41, and a retention \bar{X} = 31.54, SD = 3.90, giving a difference of -0.44, whereas females had a post-test \bar{X} = 31.97, SD = 4.32, and a retention \bar{X} = 29.97, SD = 3.75, resulting in a difference of -2.00. In the Lecture Method, males achieved a post-test \bar{X} = 12.71, SD = 3.12, and a retention \bar{X} = 10.66, SD = 3.18, with a difference of -2.05, while females had a post-test \bar{X} = 14.65, SD = 3.69, and a retention \bar{X} = 14.63, SD = 3.69, giving a difference of -0.02. Overall, students taught with Flipped Classroom and Problem-Based methods retained most of what they learned, with only minor declines. Males in the Flipped Classroom group showed almost perfect retention, while females showed a minor decline. In the Problem-Based method, males had a very small decline, and females had a slightly larger decline. In contrast, the Lecture Method produced lower post-test scores and weaker retention, particularly for males, although females maintained higher retention. The slight decreases in SDs from post-test to retention suggest more consistent performance over time. To test for the effect of teaching methods and gender on students' retention in Agricultural Mathematics, hypothesis six explained more.

Hypothesis Three

HO₃: There is no significant effect of flipped classroom, problem-based and lecture methods on male and female students' academic retention in agricultural mathematics in colleges of education.

Table 6: Analysis of covariance (ANCOVA) of the difference in the mean academic retention scores of students in Agricultural Mathematics using flipped classroom, problem – based and lecture teaching methods in Colleges of Education

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	1385.474 ^a	4	346.369	7.737	0.000	0.329	
Intercept	7891.331	1	7891.331	176.270	0.000	0.737	
SR_Pretest	1143.531	1	1143.531	25.543	0.000	0.288	S
Methods	12.327	2	12.327	138	0.000	0.303	S
Gender	77.505	1	77.505	1.731	0.193	0.027	NS

Methods *	296.415	1	296.415	6.621	0.012	0.095	S
Gender							
Error	2820.408	634	44.768				
Total	1578928.000	688					
Corrected Total	4205.882	674					

Note: df= Degree of Freedom, f= f-ratio, Sig.= Significant/probability value, Dec.= Decision, S = Significant

The Analysis of Covariance (ANCOVA) result in Table 6 also revealed that the effect of teaching methods on male and female students on academic retention in Agricultural Mathematics is not statistically significant, ($f(1, 674) = 1.731, p = 0.193, \eta^2_p = .027$). This is because the associated probability (Sig.) value of 0.193 is more than 0.05 level of significance at which the result was being tested. Hence, the null hypothesis six (H_{03}) was accepted and the conclusion drawn was that there is no significant effect of teaching methods and gender on students' academic retention in Agricultural Mathematics.

Findings of the Study

1. Male and female students in Agricultural Mathematics class showed the highest academic achievement gains with Problem-Based (males: 30.35; females: 28.12) and Flipped Classroom methods (males: 26.07; females: 26.35), while the Lecture method produced lower gains (males: 20.40; females: 20.51), with minimal gender differences overall. ANCOVA showed no significant gender difference, $f(2,257) = 22.337, p = .150, \eta^2_p = .080$, and the interaction between teaching method and gender was marginal, $f(2,256) = 8.434, p = .050, \eta^2_p = .062$, indicating minimal gender influence.
2. Males students taught using Flipped Classroom (pretest $\bar{X} = 14.86$, posttest $\bar{X} = 30.93$) and Problem-Based (pretest $\bar{X} = 14.43$, posttest $M = 32.54$) showed slightly higher gains than females (Flipped Classroom: pretest $\bar{X} = 13.92$, posttest $\bar{X} = 27.17$; Problem-Based: pretest $\bar{X} = 14.32$, posttest $\bar{X} = 29.97$), whereas females improved slightly more in Lecture (pretest $\bar{X} = 12.65$, posttest $\bar{X} = 14.63$ vs. males 10.71, posttest 12.66). ANCOVA showed no significant difference, $f(2,637) = 0.286, p = .604, \eta^2_p = .005$.
3. Males students taught using Flipped Classroom (post-test $\bar{X} = 28.99$, retention $\bar{X} = 28.93$) and Problem-Based (males post-test $\bar{X} = 31.98$, retention $\bar{X} = 31.54$), retained slightly better than females (post-test $\bar{X} = 28.54$, retention $\bar{X} = 27.17$), females (post-test $\bar{X} = 31.97$, retention $\bar{X} = 29.97$), while females had slightly higher retention in Lecture (post-test $\bar{X} = 14.65$, retention $\bar{X} = 14.63$ vs. males post-test $\bar{X} = 12.71$, retention $\bar{X} = 10.66$). ANCOVA showed no significant difference in retention between genders, ($f(1, 674) = 1.731, p = 0.193, \eta^2_p = .027$).

Discussion of Findings

The findings of this study were discussed based on the subheadings below:

Effect of flipped classroom, problem-based and Lecture Teaching Methods on the academic achievement of male and female students in Agricultural Mathematics

Table 1 and 2 revealed that both male and female students benefited from flipped and Problem-based methods, though males showed slightly higher achievement gains overall. However, there was no statistically significant effect on gender, ($f(1, 257) = 22.337, p = .152; \eta^2_p = .080$). This suggests that both male and female students improved similarly under active learning methods. The findings are consistent with Alviar & Solon (2023), who found no significant gender divide in mathematics achievement after a flipped intervention in high school. Also, Aduloju & Adodo (2024) reported that flipped learning improved achievement but did not show marked performance differences between male and female students. In a similar vein, Lee & Wang (2022) and Johnson et al. (2019), found that flipped and Problem-based methods reduce achievement disparities but may still require gender-responsive supports to ensure equitable outcomes (Ikwuka & Okoye, 2022). In a similar study, Abolarinwa (2020) found out that gender is not a

vital factor in the mean achievement scores of students taught Physics using flipped classroom in collaborative learning. Whereas, a study conducted by Baeppler et al. (2016) found that the flipped classroom approach improved student learning outcomes in STEM subjects, particularly for female and underrepresented minority students. also, a study by Ambrose et al. (2019) also found that the flipped classroom approach had a positive impact on student performance in a biology course, with female students outperforming male students.

Effect of flipped classroom, problem-based and Lecture Teaching Methods on the interest of male and female students in Agricultural Mathematics

From Table 2 and 4, males showed slightly greater gains in interest when taught using flipped classroom and Problem-based methods, whereas females recorded marginally higher interest under the lecture method. ANCOVA showed no significant difference, $f(2,637) = 0.286$, $p = .604$, $\eta^2_p = .005$. , though the profile plot suggested a small, non-crossover interaction. These results reflect gender differences in engagement patterns. Research by Liu et al. (2023) suggests flipped classrooms may appeal more to males due to their structure and use of technology, while Niazi et al. (2025) found that some females may prefer more structured, teacher-led environments. Also, Bedemo (2020) found out that problem-based learning approach improved 8.76% of students' academic achievement and 3.56% of attitude towards Mechanics. Students developed positive attitude towards problem-based learning, their academic achievement and attitude towards mechanics were positively correlated.

Effect of flipped classroom, problem-based and Lecture Teaching Methods on the academic retention ability of male and female students in Agricultural Mathematics

Table 5 and 6 showed that Males students taught using Flipped Classroom and Problem-Based retained slightly better than females while females had slightly higher retention in Lecture. ANCOVA showed no significant difference in retention between genders, $(f(1, 674) = 1.731, p = 0.193, \eta^2_p = .027)$. This is aligned with Martinez & Clark (2023), who suggested females may retain conceptual knowledge longer, possibly due to different study strategies. These findings highlight the equitable potential of active learning methods across genders (Ajayi & Oladele, 2024; Liu et al., 2023). Also, Parajuli, & Thapa (2017) found a significant difference in academic performance in Basic science. The female students were found outperforming their male counterparts. On the other hand Ani et al. (2020) in the study conducted, observed that male students performed better than their female counterparts when taught Basic Science. Most male students out-performed female students in science related subjects due to the psychological ability of the male students to with stand difficult tasks compared to their female counterparts who go for easy ways of life or less boredom tasks (Ani et al. 2021).

Conclusions

The Flipped Classroom method is the most effective instructional method for improving students' academic achievement, interest, and retention in Agricultural Mathematics, followed by the Problem-Based method, while the Lecture method consistently produced the weakest outcomes. Gender differences in achievement, interest, and retention were minimal across all teaching methods. Although males showed slightly higher gains under the Flipped Classroom and Problem-Based methods and females performed marginally better under the Lecture method, these differences were not statistically significant. The absence of meaningful gender effects indicates that both male and female students benefit equally from learner-centered instructional methods, reinforcing their suitability for diverse classrooms. It was concluded that both Flipped Classroom and Problem-Based methods are effective in enhancing students' interest, academic achievement, and retention in Agricultural Mathematics, regardless of gender.

Recommendations

Based on the findings the following recommendations were made:

1. Head of department, Course coordinators and lecturers should ensure both male and female students participate fully in Flipped Classroom and Problem-Based sessions to promote equitable academic achievement.
2. Lecturers teaching Agricultural mathematics should use inclusive teaching methods within Flipped Classroom, Problem-Based, and Lecture methods to accommodate diverse learning preferences and maintain student interest.
3. Lecturers teaching Agricultural mathematics should continue to use Flipped Classroom and Problem-Based methods, as these methods have been shown to improve students' academic retention of Agricultural Mathematics knowledge.

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