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Effect of Flipped Classroom Model on Upper Basic Students' Achievement and Retention in Basic Science and Technology in Benue State, Nigeria

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ABSTRACT

This study investigated the effect of flipped classroom model on the academic achievement and retention of upper basic learners in Basic Science and Technology (BST) in Benue State, with a focus on gender variable. Four research questions and four hypotheses guided the study. A pretest post-test control group, non-equivalent quasi-experimental design was used for the study. The sample of 120 learners was drawn from the population of 3,767 Basic 8 (JSS 2) learners from Makurdi Local Government. Intact classes were randomly selected and assigned to experimental and control groups. Basic Science and Technology Achievement Test (BSTAT) and the Basic Science and Technology Retention Test (BSTRT) researcher-design instrument were used for data collection. The BSTAT items of the instrument were subjected to face and content validation. The reliability of the instrument was established using Kudar-Richarson formula 20 (K-R20). The reliability coefficient of the instrument was found to be 0.78. A flipped classroom model lesson plan was used for classroom instruction in the experimental group while the control group used lesson plan on lecture method for instruction. The research questions were answered using mean and standard deviation, while the hypotheses were tested at 0.05 alpha level of significance using Analysis of Covariance (ANCOVA). The findings from the study revealed that learners taught using the flipped classroom model significantly outperformed those in the control group in both academic achievement and retention of BST concepts. Furthermore, while both male and female learners in the experimental group showed improved performance, no statistically significant gender differences were observed in the outcomes, suggesting that the flipped classroom benefitted learners regardless of gender. The findings underscored the effectiveness of the flipped classroom model in promoting deeper understanding and long-term retention of scientific concepts in BST. The study recommends that educators adopt flipped learning strategies in science instruction and provides evidence that gender does not moderate the positive effects of this pedagogical approach.

KEYWORDS: Flipped classroom, academic achievement, retention, Basic Science and Technology, gender, upper basic education.

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INTRODUCTION

Education plays a critical role in shaping the intellectual and socioeconomic development of individuals and societies. In Nigeria, Basic Science and Technology (BST) serves as a basis in fostering scientific literacy, critical thinking, and innovation among learners at the upper basic level (Federal Ministry of Education [FME], 2014). These skills are essential for preparing learners for future careers in Science, Technology, Engineering, and Mathematics (STEM) fields (Aina, 2017). Despite the emphasis on science education, learners' achievement and retention in BST have remained unsatisfactory, posing threat to the advancement of science and technology in country (Achor, Njoku, Nwankwo, 2020).

The persistent underachievement and poor retention rate among Basic Science and Technology learners have been linked to traditional teaching methods that are often teacher-centered and fail to engage learners effectively (Adegoke, 2020, Yusuf, Adewale, Okeke, 2022). The traditional classroom characterized by the teacher lecture method while learners passively receive information, which does not adequately engage learners, leading to a lack of deep understanding and retention of scientific concepts (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt & Wenderoth, 2014). This challenge calls for the adoption of innovative teaching strategies, such as the flipped classroom model, to improve learning outcomes.

The flipped classroom model is a pedagogical approach that inverts traditional teaching methods. The flipped classroom modifies instruction outside the classroom, allowing learners to engage with lecture content though videos or reading materials before class. Classroom time is then used for interactive activities such as problem-solving, discussion, and hands-on exercises (Bishop & Verleger, 2013). The strategy leverages technology to shift the focus from passive learning where learners receive knowledge from the teacher to active learning, where learners actively engage with the material. The strategy has the potentials to promote active learning, enhance critical thinking and improve retention and achievement in various sciences subjects including Basic Science and Technology (Zainuddin & Attaran, 2016).

Several studies have highlighted the effectiveness of the flipped classroom model in improving academic achievement and retention across various subjects, including science and technology. For example, a study by Lage, Platt and Treglia (2021) found that learners in a flipped classroom environment demonstrated higher levels of understanding and retention compared to those in traditional lecture-based classes. Similarly, O'Flaherty and Phillips (2022) reported that the flipped classroom approach significantly improved students' long-term retention of scientific concepts, as they were more engaged in the learning process and had more opportunities to apply their knowledge. These findings suggest that the flipped classroom model could be particularly beneficial for teaching Basic Science and Technology in Nigerian schools, where student engagement and performance have been major concerns.

Achievement and retention are critical indicators of effective learning. Achievement is the learners' ability to comprehend and apply knowledge. Similarly, Achievement refers to the extent to which learners meet specific learning objectives, typically measured through tests or assessments (Okonkwo & Ezeh, 2022). It also, indicates the extent of learners' retention of BST content taught over a period time.

Retention reflects the ability to recall and apply learned concepts over time (Eze, 2020). It is an indicator of effective learning as it reveals the depth of understanding and the capacity to transfer knowledge to new contexts. Various factors influence achievement and retention including the nature of the instructional strategy used, the complexity of the content, student motivation and gender

Gender is a significant factor in educational research as it influences learning preferences, participation and outcome. Gender is the social meaning associated with being a male or a female, including the construction of identities, expectations, behaviors, power, and relationships that are derived from social interactions (Ezechi & Adukwu, 2018). Some studies suggest that societal expectations and stereotypes contribute to differences in achievement levels, with males often perceived as more inclined toward science subjects (Eze, 2023). Meanwhile, female learners face challenges such as limited encouragement and fewer role models in science fields (Nwafor & Akinpelu, 2023). However, evidence also points to equal capabilities between genders when provided with equitable learning opportunities.

Furthermore, studies related to gender revealed that male and female learners respond differently to instructional strategies, with variation in cognitive and social engagement (Okeke & Ofoegbu, 2022). For instance, females are often found to excel in environments that promote collaboration and discussion, while males may prefer more hands-on experimental activities (Adamu, 2022). However, collaborative learning strategies like flipped classroom may bridge these gaps by fostering inclusive participation and mutual support among learners (Kagan, 2021). Understand the role of gender in learning outcomes can help educators design more inclusive and effective teaching strategies that will address the diverse needs of learners. Therefore, this study seeks to investigate the effect of the flipped classroom on upper basic students' academic achievement and retention in Basic Science and Technology, while considering gender differences.

Statement of the Problem

Basic Science and Technology is a core subject for developing learners' scientific and technological literacy, yet learners' achievement in the subject has been unsatisfactory (Achor, Njoku, Nwankwo, 2020). One of the contributing factors to this underachievement may be the continued reliance on lecture-based teaching methods, which do not actively engage learners or promote deep learning and retention. The flipped classroom model has been shown to enhance learners' engagement, achievement, and retention in various educational contexts. However, gender differences in learning preferences, academic achievement, and retention rates remain an important factor that has not been adequately addressed in the literature on flipped classrooms, particularly in Makurdi, Benue State. Research suggests that male and female students may respond differently to flipped learning environments due to variations in cognitive styles, learning preferences, and socio-cultural influences. Given these gender differences, it is important to investigate how the flipped classroom model affects both male and female learners' academic achievement and retention in BST. Therefore, this study seeks to address this gap by examining the effect of the flipped classroom on upper basic learners' academic achievement and retention in Basic Science and Technology, while controlling for gender variable.

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Objective of the Study

The objective of the study is to determine the effect of flipped classroom model on upper basic learners' academic achievement and retention in Basic Science and Technology in Benue State, Nigeria. Specifically, the objective of the study is to:

i. determine the effect of flipped classroom model on learners achievement in Basic Science and Technology with those taught with lecture method
ii. examine the effect of flipped classroom model on learners retention in Basic Science and Technology with those taught with lecture method
iii. determine the effect of flipped classroom model on male and female learners achievement in Basic Science and Technology
iv. examine the effect of flipped classroom model on male and female learners retention in Basic Science and Technology

Research Questions

i. What is the effect in the mean achievement scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method?
ii. What is the effect in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method?
iii. What is the effect in the mean achievement scores of male and female learners taught Basic Science and Technology with flipped classroom model?
iv. What is the effect in the mean retention scores of male and female learners taught Basic Science and Technology with flipped classroom model?

Hypotheses

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

$H0_1$: There is no significant effect in the mean achievement scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method.

$H0_2$: There is no significant effect in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method

$H0_3$: There is no significant effect in the mean achievement scores of male and female learners taught Basic Science and Technology with flipped classroom model.

$H0_4$: There is no significant effect in the mean retention scores of male and female learners taught Basic Science and Technology with flipped classroom model.

METHODOLOGY

The study adopted a quasi-experimental design of non-equivalent group. Specifically, the study used a non-randomized pre-test, posttest control group design. This design was used because it is not possible for the study to randomly sample and assign subjects to groups as this will disrupt the normal classroom organization of the school. Therefore, intact classes

were randomly assigned to the experimental and control group. The population was 3,767 Basic 8 learners offering Basic Science and Technology in public schools in Makurdi local government area of Benue State. Purposive sampling technique was used to select four co-educational public Secondary Schools in Makurdi local government. The choice of co-educational schools was because gender was a moderating factor in this study. The sample of size 120 consisting of 60 males and 60 female Basic 8 learners was randomly drawn from four schools in Makurdi local government area. Two schools were randomly assigned to experimental group while the other two were assigned to the control group through a simple random sampling technique of toss of a coin. The instruments for data collection were Basic Science and Technology Achievement Test (BSTAT) and Basic Science and Technology Retention Test (BSTRT) which was developed by the researcher. The BSTAT was made up of section A and B. Section A sought information on demographic data of the learners such as gender, section B of the instruments contains items designed to determine learners' achievement in Basic Science and Technology. The BSTAT contains 30 multiple choice items drawn from Basic Science and Technology of UBE II curriculum. The Basic Science and Technology Retention Test (BSTRT) is the same as the Basic Science and Technology Achievement Test (BSTAT) except that, the items in the BSTAT was reshuffled. The instruments was validated by three experts, one expert from Test, Measurement and Evaluation, another expert from Integrated Science Education Department both from Joseph Sarwan Tarka University, Makurdi and an experienced Basic Science and Technology teacher in secondary school. The instrument was trial tested and the reliability coefficient of BSTAT was found to be 0.78, using Kuder-Richardson formula 20 ($K\text{-}R_{20}$). The values showed a positive relationship within the test items which means the instruments was both internally consistent and reliable. Research assistants were used in order to eliminate bias. Pre-test was administered to experimental and control groups to ascertain the level of achievement of learners before the treatment. The experimental group was taught using Flipped Classroom model (that is treatment) while the control group was taught using lecture method (that is no treatment). A post-test (Achievement Test), which was an equivalent form of the pre-test, was administered to determine the level of achievement after the treatment meanwhile a post-posttest (Retention test) was administered to learners after two weeks of treatment to determine the level of retention. Mean and standard deviation were used to answer the research questions while null hypotheses were tested at 0.05 alpha level of significance using Analysis of Covariance (ANCOVA).

Results

Research Question 1

What is the effect in the mean achievement scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method?

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Table 1: Mean Achievement Scores and Standard Deviation of Learners taught Basic Science and Technology in Experimental and Control Groups

Groups	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Experimental	60	13.75	3.01	23.83	3.18	10.08
Control	60	13.85	3.17	18.48	3.14	4.63
Mean Difference		00.10		5.35		5.45
Total	120					

Table 1 showed that in pre-test, the experimental group had a mean achievement score of 13.75 with a standard deviation of 3.01, while the control group had a mean achievement score of 13.85 with a Standard deviation of 3.17. The Table also revealed that in the post-test, experimental group had a mean achievement score of 23.83 with a standard deviation of 3.18, while the control group had a mean achievement score of 18.48 with a standard deviation of 3.14. From the pre-test and post-test scores, the mean gain for the experimental group was found to be 10.08 while the mean gain for the control group was 4.63. The mean difference between the mean achievement gain scores of the experimental and control group was 5.45. This indicated that the experimental group gained more in achievement compared to the control group.

Research Hypothesis 1

There is no significant effect in the mean achievement scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method.

Table 2: Summary of Analysis of Covariance (ANCOVA) of Experimental and Control Groups' Achievement Scores in Basic Science and Technology

Source of Variance	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	866.16[a]	2	433.08	43.31	.00
Intercept	2182.76	1	2182.76	218.37	.00
Posttest	7.48	1	7.48	.75	.39
Group	**863.07**	**1**	**863.07**	**86.32**	**.00**
Error	1169.84	117	9.99		
Total	55757.00	120			
Corrected Total	2035.99	**119**			

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Table 2 revealed the ANCOVA analysis of the achievement scores of learners taught Basic Science and Technology using flipped classroom model and those taught using lecture method. From the analysis, $F(1,117) = 86.32$, $p<0.05$. Hence, the null hypothesis was rejected. This means that there was a statistically significant difference in mean achievement scores between learners taught Basic Science and Technology using flipped classroom model and those taught using lecture method. This further indicated that there was higher improvement in the mean achievement scores of learners in the experimental (Flipped Classroom Model) group than those in the control group.

Research Question 2

What is the effect in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method?

Table 3: Mean Retention Scores and Standard Deviation of Learners taught Basic Science and Technology in Experimental and Control Groups

Groups	N	Posttest		Retention		Mean Gain
		Mean	SD	Mean	SD	
Experimental	60	23.83	3.18	25.12	2.99	1.29
Control	60	18.48	3.14	18.93	4.55	0.45
Mean Difference		5.35		6.19		0.84
Total	120					

Table 3 indicated that in posttest, the experimental group had a mean posttest score of 23.83 with a standard deviation of 3.18, while the control group had a mean posttest score of 18.48 with a Standard deviation of 3.14. The Table also showed that in the retention test, experimental group had a mean retention score of 25.12 with a standard deviation of 2.99, while the control group had a mean retention score of 18.93 with a standard deviation of 4.55. From the posttest and retention scores, the mean retention gain for the experimental group was found to be 1.29 while the mean retention gain for the control group was 0.45. The mean difference between the mean retention gain scores of the experimental and control group was 0.84. This shows that the experimental group retained more knowledge than their counterpart in the control group.

Research Hypothesis 2

There is no significant effect in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method.

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Table 4: Summary of Analysis of Covariance (ANCOVA) of Experimental and Control Groups' Retention Scores in Basic Science and Technology

Source of Variance	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	1320.62[a]	2	660.31	49.07	.00
Intercept	497.22	1	497.22	36.95	.00
Posttest	173.61	1	173.61	12.90	.00
Group	**295.74**	**1**	**295.74**	**21.98**	**.00**
Error	1574.31	117	13.46		
Total	61107.00	120			
Corrected Total	2894.93	**119**			

Table 4 showed the ANCOVA analysis of the retention scores of learners taught Basic Science and Technology using flipped classroom model and those taught using lecture method. From the analysis, $F(1,119) = 21.98$, $p<0.05$. Hence, the null hypothesis which states that there is no significant difference in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method was rejected. This means that there was a statistically significant difference in mean retention scores between learners taught Basic Science and Technology using flipped Classroom model and those taught using lecture method. This further indicated that learners in experimental group retained more knowledge than their counterpart in the control group.

Research Question 3

There is no significant effect in the mean achievement scores of male and female learners taught Basic Science and Technology with flipped classroom model.

Table 5: Mean Achievement and Standard Deviation of Male and Female Learners taught Basic Science and Technology in Experimental Group

Groups	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Experimental	30	13.70	2.85	24.07	3.03	10.37
Control	30	13.60	2.94	23.60	3.36	10.00
Mean Difference		0.10		0.47		0.37
Total	60					

Table 5 revealed that in pre-test, the male learners had a mean achievement score of 13.70 with a standard deviation of 2.85, while the female learners had a mean achievement score of 13.60 with a Standard deviation of 2.94. The Table also indicated that in the post-test, male learners had a mean achievement score of 24.07 with a standard deviation of 3.03, while the female learners had a mean achievement score of 23.60 with a standard deviation of 3.36. From the pre-test and post-test scores, the mean gain for the male learners was found to be 10.37 while the mean gain for the female learners was 10.00. The mean difference between the mean achievement gain scores of the male learners and female was 0.37. This shows that the male learners achieved more than the female learners.

Research Hypothesis 3

There is no significant effect in the mean achievement scores of male and female learners taught Basic Science and Technology with flipped classroom model.

Table 6: Summary of Analysis of Covariance (ANCOVA) of Male and Female Learners Achievement Scores in Basic Science and Technology

Source of Variance	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	4.085[a]	2	2.43	.23	.79
Intercept	1332.60	1	1332.60	128.42	.00
Posttest	1.59	1	1.59	.15	.69
Group	**3.186**	**1**	**3.19**	**.31**	**.58**
Error	591.48	57	10.38		
Total	34678.00	60			
Corrected Total	596.33	**59**			

Table 6 showed the ANCOVA analysis of the achievement scores of male and female learners taught Basic Science and Technology using Flipped Classroom Model. From the analysis, $F(1,59) = 0.58$, $p>0.05$. Hence, the null hypothesis which states that there is no significant difference in the mean achievement scores of male and female learners taught Basic Science and Technology with flipped classroom model was accepted. This means that there was no statistically significant difference in mean achievement scores between male and female learners taught Basic Science and Technology using flipped classroom model. This further indicated that both the male and female learners improved almost equal in the mean achievement when exposed to flipped classroom model

Research Question 4

What is the effect in the mean retention scores of male and female learners taught Basic Science and Technology with flipped classroom model?

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Table 7: Mean Retention Scores and Standard Deviation of Male and Female Learners taught Basic Science and Technology

Groups	N	Posttest		Retention		Mean Gain
		Mean	SD	Mean	SD	
Experimental	30	24.07	3.03	25.43	2.40	1.36
Control	30	23.60	3.36	24.80	3.49	1.20
Mean Difference		0.47		0.63		0.16
Total	60					

Table7 indicated that in posttest, the male learners had a mean posttest score of 24.07 with a standard deviation of 3.03, while the female learners had a mean posttest score of 23.60 with a Standard deviation of 3.36. The Table also showed that in the retention test, male learners had a mean retention score of 25.45 with a standard deviation of 2.40, while the female learners had a mean retention score of 24.80 with a standard deviation of 3.49. From the posttest and retention scores, the mean retention gain for the male learners was found to be 1.36 while the mean retention gain for the female learners was 1.20. The mean difference between the mean retention gain scores of the male and female learners was 0.16. This revealed that the male learners retained more knowledge than their female counterpart.

Research Hypothesis 4

There is no significant effect in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model and those taught with lecture method.

Table 8: Summary of Analysis of Covariance (ANCOVA) of Male and Female Learners Retention Scores in Experimental Groups in Basic Science and Technology

Source of Variance	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	12.65[a]	2	6.32	.69	.50
Intercept	523.95	1	523.95	57.93	.00
Posttest	6.64	1	6.67	.73	.39
Group	**5.09**	**1**	**5.09**	**.56**	**.46**
Error	151.53	57	9.04		
Total	38379.00	60			
Corrected Total	528.18	**59**			

Table 8 revealed the ANCOVA analysis of the retention scores of male and female learners taught Basic Science and Technology using flipped classroom model. From the analysis, F (1,59) = 0.56, p>0.05. Hence, the null hypothesis was which states that there is no significant difference in the mean retention scores of learners taught Basic Science and Technology with flipped classroom model was accepted. This implies that there was no statistically significant difference in mean retention scores between male and female learners taught Basic Science and Technology using flipped classroom model. This further means that the male and the female learners both benefitted from the flipped classroom model almost equally.

Discussion of Findings

The findings of this study support the effectiveness of the flipped classroom model in improving learners' academic achievement and retention in Basic Science and Technology. Learners in the flipped classroom showed significantly higher achievement and retention compared to those in the traditional lecture-based instruction group. These findings are consistent with previous research (Bishop & Verleger, 2013) that highlights the benefits of active learning environments, such as flipped classrooms, in enhancing learners understanding and engagement. The findings of the study also align with Lage, Platt and Treglia (2021) revealed that learners in flipped classroom environment demonstrated higher levels of understanding and retention. Meanwhile,

Interestingly, the study found no significant gender differences in the effectiveness of the flipped classroom model, suggesting that both male and female learners benefit equally from this instructional strategy. This aligns with research by kagan (2021), which suggests that gender, does not play a significant role in the effectiveness of flipped classrooms, as the model promotes collaborative and active learning regardless of gender.

Summary, Conclusion, and Recommendations

This study investigated the effect of the flipped classroom model on upper basic students' academic achievement and retention in Basic Science and Technology in Makurdi Local Government. It also examined the role of gender as an extraneous variable in influencing the outcomes. Using a quasi-experimental design, 120 students were used in experimental and control groups via intact classes. The experimental group was taught using the flipped classroom model, while the control group received traditional lecture-based instruction. Data were collected using the Basic Science and Technology Achievement Test (BSTAT) and the Basic Science and Technology Retention Test (BSTRT).

The results revealed that:

1. The flipped classroom model significantly improved learners' academic achievement compared to traditional teaching methods.
2. Learners in the flipped classroom also showed significantly higher retention of BST concepts.
3. Gender did not significantly influence the effectiveness of the flipped classroom model on learners' academic achievement.

Conclusion

The flipped classroom model is an effective instructional strategy for enhancing academic achievement and retention in Basic Science and Technology among upper basic learners. The findings suggest that this model promotes a deeper understanding of scientific concepts and supports long-term retention by providing learners with opportunities for active, in-class engagement. The lack of significant gender differences indicates that both male and female learners benefit equally from the flipped classroom approach.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Schools and educators should consider adopting the flipped classroom model in teaching Basic Science and Technology. This approach has been shown to enhance both academic achievement and retention.

2. Teachers should be provided with professional development opportunities to learn how to effectively implement flipped classrooms. Training should focus on creating engaging pre-class materials and facilitating active learning during in-class sessions.

3. Further research should be conducted to explore the impact of flipped classrooms across other subjects and educational levels. Longitudinal studies may also provide insights into the long-term benefits of this instructional strategy.

4. Schools should ensure that learners have access to the necessary technology for flipped classrooms, including devices for viewing pre-class materials and reliable internet access.

Contributions to Knowledge

This study contributes to the growing body of research on the flipped classroom model, particularly in the context of Nigerian education. It provides empirical evidence on the effectiveness of the model in improving academic achievement and retention in Basic Science and Technology and highlights the role of gender in this instructional approach

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