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Effects of Flipped Classroom and Laboratory Teaching Methods on Secondary School Students' Achievement in Physics in Abak Education Zone of Akwa Ibom State, Nigeria

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Abstract
This study aimed to investigate the effects of flipped classroom and laboratory teaching methods on the academic achievement of secondary school students in Physics in the Abak Education Zone of Akwa Ibom State, Nigeria. A quasi-experimental design was employed, involving pre-test and post-test measures across three groups: one using the Flipped Classroom Method (FCM), another using the Laboratory Teaching Method (LTM), and a control group utilizing the Lecture Method (LM).The population consisted of 13,730 Senior Secondary Two (SS2) students from 63 public secondary schools, with a purposive sample of 168 students selected from three schools. Physics Achievement Test (PAT) validated by experts and showing reliability coefficients of 0.87 using Kuder-Richardson 20 (KR-20). Data analysis was conducted using mean, standard deviation, and Analysis of Covariance (ANCOVA). Results indicated that students taught with the flipped classroom method had significantly higher mean scores compared to those in the other groups. While male students showed higher gains, no significant gender differences were found across teaching methods. In conclusion, the flipped classroom method significantly enhances academic achievement in Physics without gender bias. Recommendations include adopting the flipped classroom approach in teaching Physics and providing necessary resources for its effective implementation in public secondary schools.

Keywords: Achievement, Classroom, Flipped, Laboratory, Method

Introduction

Physics is a crucial component of the science curriculum in Nigerian secondary schools, essential for technological advancement (Ebong, 2016). Defined as the study of matter and energy, Physics encompasses key topics such as mechanics, heat, light, sound, electricity, and magnetism. The Federal and State Governments of Nigeria have recognized its importance, leading to its inclusion in the Senior Secondary Schools Curriculum for science-oriented students (Federal Republic of Nigeria, FRN, 2013). The relevance of Physics extends beyond academia, impacting various sectors, including technology and healthcare, through applications like electromagnetism and nuclear sciences.

Despite its significance, students' performance in Physics, particularly in the Senior Secondary School Certificate Examinations (SSSCE), has been disappointing. Reports from the West African Examinations Council (WAEC) indicate that from 2014 to 2018, less than 50% of students achieved credit levels in Physics, with specific concepts like friction, tension, and molecular properties identified as particularly challenging (WAEC Chief Examiners Reports, 2014-2018). The consistent poor performance has been attributed to traditional teaching methods, which often rely on rote learning and limit students' engagement and comprehension.

Teaching methods are categorized into three main types: teacher-centred, student-centred, and interactive methods (Eze, Ezenwafor, & Molokwu, 2015). Teacher-centred methods dominate many classrooms, characterized by the teacher's control over knowledge transmission, which can hinder students' active participation and critical thinking. In contrast, student-centred methods encourage active learning and have been shown to enhance academic achievement. Among these is the flipped classroom model, where students first access learning materials outside the classroom and engage in hands-on activities during class time (Leo & Puzio, 2016). This approach fosters deeper understanding, encourages collaboration, and allows for personalized instruction, addressing the limitations of traditional teaching methods.

Laboratory teaching methods also play a significant role in Physics education. Defined as experimental and observational activities, laboratory teaching enhances students' practical skills and understanding of complex concepts (Dienye & Gbamanja, 2010). It allows students to engage in scientific inquiry, developing critical thinking and problem-solving skills essential for success in the sciences.

Academic achievement in Physics is measured through test scores, reflecting students' acquired knowledge and skills (Udoudo, 2011; Aditi, 2017). Poor academic performance is often linked to students' attitudes towards the subject, which can be shaped by teaching methods. Negative attitudes may arise from experiences of difficulty and frustration in learning Physics, often exacerbated by the traditional lecture method, where information is delivered in a rigid format without opportunities for student engagement.

Gender differences in academic achievement are also a contentious topic. While some studies indicate that male students may outperform females in Physics, others suggest that girls excel in certain interactive learning contexts (Kost, Pollock, & Finkelstein, 2009; Anagbogu & Ezeliora, 2007). This inconsistency highlights the need for further investigation into how gender influences students' attitudes and performance in Physics.

The rapid advancement of technology has shifted societal expectations of education, emphasizing the need for schools to equip students with skills like critical thinking and effective information use (Gerstein, 2014). Traditional teaching methods, which often focus on passive learning, are becoming less relevant in this context. The flipped classroom and laboratory methods represent innovative approaches that align more closely with contemporary educational needs, fostering deeper engagement and better learning outcomes.

Given the current challenges in Physics education in Nigeria, particularly in the Abak Education Zone, there is a pressing need to explore the comparative effects of flipped classroom and laboratory teaching methods on students' academic achievement and attitudes towards Physics. This study aims to address the gap in empirical research regarding these innovative teaching strategies and their potential to enhance student outcomes in the subject. Ultimately, understanding the effectiveness of these methods could inform educational practices and contribute to improving Physics education in Nigeria.

Literature Review

Academic achievement refers to a student's achievement in meeting the short or long term goals of education. According to Aditi (2017), academic achievement is defined as knowledge or skill developed in the school usually measured by the means of test scores or by marks given by the teacher according to the students' performance. It is commonly measured by the means of examination scores on continuous assessment. Ahmad, as cited in Gambari, Bello, Agboola, and Adeoye (2016), found that the flipped classroom approach significantly improved the listening comprehension skills of Egyptian students learning English as a Foreign Language (EFL).

Similarly, Odo and Eze (2017) examined the impact of the flipped classroom method on students' academic achievement in Computer Science in tertiary institutions in Enugu State, Nigeria. Using a quasi-experimental design and a sample of 152 students, their study employed an achievement test with a reliability coefficient of 0.89. Data analysis using mean, standard deviation, and ANCOVA revealed that students taught using the flipped method outperformed those taught with traditional methods, affirming the effectiveness of flipped instruction in enhancing academic outcomes.

In contrast, Dusenbury and Olson (2019) studied the effect of flipped learning on aviation students' academic performance and perceptions in a human factors course at a

Midwestern university. A total of 81 students participated, and the researchers used various statistical analyses including paired sample t-tests, independent sample t-tests, and MANCOVA. The findings indicated no significant academic performance advantage for the flipped classroom group over the traditional lecture group. Additionally, students in the lecture group reported higher satisfaction levels, suggesting that student familiarity with conventional teaching methods might affect the reception of flipped learning, and that adjusting to new methods may require time and support.

Chibabi, Umoru, Onah, and Itodo (2018) conducted a study on the effectiveness of the laboratory teaching method on Biology achievement and retention among senior secondary students in Kogi East, Nigeria, also examining gender differences. Adopting a quasi-experimental design, they sampled 365 SSII students using a validated and reliable (0.87) achievement test (SBAT). Over a three-week period, the experimental group received instruction via the laboratory method, while the control group was taught using traditional methods. Analysis through mean, standard deviation, and ANCOVA revealed that the laboratory method significantly enhanced students' academic achievement and retention, with a notable interaction between gender and teaching method. The study concluded that laboratory-based instruction is a powerful strategy for improving Biology learning at the senior secondary level.

Statement of the Problem

In Nigeria, particularly in the Abak Education Zone of Akwa Ibom State, students' achievement in secondary school Physics has been declining, largely due to the prevalent use of teacher-centred instructional methods such as lectures and demonstrations. Research indicates that these approaches foster rote learning and contribute to the perception that Physics is a difficult subject, negatively impacting students' attitudes and academic performance. Studies suggest that adopting student-centred methods, like flipped classrooms and laboratory methods could improve achievement towards Physics. However, these innovative teaching methods are not commonly employed by Physics teachers in the region, and there is a lack of empirical research on their comparative effects on students' academic outcomes. Consequently, this study seeks to investigate the effects of flipped classroom and laboratory methods on students' academic achievement in Physics in the Abak Education Zone Zone of Akwa Ibom State.

Purpose of the Study

The general purpose of this study was to ascertain the effects of flipped classroom and laboratory teaching method on secondary school students' achievement in Physics in Abak Educational zone of Akwa Ibom State. Specifically, the study tended to ascertain the:

1. Mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods.

2. Mean achievement scores of male and female students taught Physics using flipped classroom, laboratory teaching and lecture methods.

Research Questions

The following research questions were posed to guide the study:

1. What are the mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods?
2. What are the mean achievement scores of male and female students taught Physics using flipped classroom, laboratory and lecture teaching methods?

Research Hypotheses

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

Ho_1: There is no significant difference among the mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods.

Ho_2: There is no significant difference between the mean achievement scores of male and female students taught Physics using flipped classroom and laboratory teaching methods.

Methodology

The study utilized a quasi-experimental design, specifically a non-equivalent control group approach, involving pre-test, treatment, and post-test measures. This design was chosen to establish a cause-effect relationship between the independent variables (teaching methods) and the dependent variables (students' achievement and attitude towards Physics). Intact classes were used, by comparing pretest and posttest scores, the study aimed to mitigate threats to internal validity such as history and maturation while ensuring that the groups remained comparable.

The research was conducted in the Abak Education Zone of Akwa Ibom State, Nigeria, focusing on Senior Secondary Two (SS2) Physics students across 63 public secondary schools. The total population was 13,730 students, from which a sample of 168 students was purposively selected.. The sample included students from three schools equipped with Wi-Fi and digital devices, with one serving as a control group and the other two as experimental groups. Data collection instruments was Physics Achievement Test (PAT) validated by experts and tested for reliability, yielding coefficients of 0.87.

Data collection involved administering the PAT as a pre-test, followed by three weeks of treatment where each group was taught their respective topics and then the post-test was administered. Data analysis employed mean and standard deviation for research questions, while Analysis of Covariance (ANCOVA) was used to test null hypotheses at a 0.05 significance level. Measures were taken to control extraneous variables, including training for teachers, engaging with students to minimize anxiety, and ensuring homogeneity among the selected schools.

Results

Research Question 1: What are the mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods?

Table 1: Mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods

S/N	Group/ Method	n	Pretest		Post-test		Mean Gain	Rank
			$\bar{X}$	SD	$\bar{X}$	SD		
1	Flipped Classroom	57	30.86	4.78	35.61	3.82	4.75	1
2	Laboratory teaching	53	29.68	3.77	33.30	3.33	3.62	2
3	Lecture Method	58	29.86	5.44	32.50	3.74	2.64	3

The data in Table 1 is a summary of the mean pre-test and post test scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods. The result shows that the mean pre-test and post-test scores of students who were taught using flipped classroom are 30.86 and 35.61 respectively with standard deviation of 4.78 and 3.82. The corresponding figures for those students who were taught using laboratory are 29.68 and 33.30 respectively with standard deviation of 3.77 and 3.33 respectively. Table 1 further shows that the mean pre-test and post-test scores of students who were taught using lecture method are 29.86 and 32.50 respectively with standard deviation of 5.44 and 3.74 respectively. It could be observed that students who were taught using flipped classroom had the highest mean gain of 4.75 as against 3.62 and 2.64 obtained by those who were taught using laboratory and lecture method respectively. This result suggests that teaching Physics using flipped classroom enhances students' academic achievement than using laboratory and lecture methods.

Research Question 2: What are the mean achievement scores of male and female students taught Physics using flipped classroom, laboratory and lecture teaching methods?

Table 2: Mean achievement scores of male and female students taught Physics using flipped classroom, laboratory and lecture teaching methods

S/N	Group/ Method	Gender	N	Pretest		Post-test		Gain	Rank
				$\bar{X}$	SD	$\bar{X}$	SD		
1	Flipped classroom	Male	23	33.30	1.89	38.70	1.33	5.40	1
		Female	34	29.21	5.43	33.53	3.53	4.32	2
2	Laboratory	Male	25	31.84	2.80	35.56	2.95	3.72	3
		Female	28	27.75	3.50	31.29	2.17	3.54	4
3	Lecture method	Male	23	29.70	3.20	32.57	2.84	2.87	5
		Female	35	29.97	6.56	32.46	4.27	2.49	6

The data in Table 2 is a summary of the mean pre-test and post test scores of male and female students taught Physics using flipped classroom, laboratory and lecture teaching methods. The result shows that male students taught using flipped classroom obtained a mean

pre-test and mean post-test scores of 33.30 and 38.70 respectively while the corresponding figures for female students in the same group are 29.21 and 33.53 respectively. The mean pre-test and post-test scores of male students who were taught using laboratory are 31.84 and 35.56 respectively while their female counterparts obtained 27.75 and 31.29 respectively as their mean pre-test and mean post-test scores. Table 2 further shows that the mean pre-test and mean post-test scores of male students who were taught using lecture method are 29.70 and 32.57 respectively while their female counterparts obtained 29.97 and 32.46 respectively as their mean pre-test and mean post-test scores. It could be observed that male students who were taught using flipped classroom had the highest mean gain of 5.14 followed by female students who were taught using flipped classroom (Mean gain = 4.32). Also, male students who were taught using laboratory came third with a mean gain of 3.72 followed by the female students in the same group (Mean gain = 3.54). Their male colleagues who were taught using lecture method took the fourth position (Mean gain = 2.87) while their female counterparts came last with the least mean difference of 2.49. This result suggests that teaching Physics using flipped classroom enhances male students' academic achievement than their female counterparts. Also, teaching Physics using laboratory enhances male students' academic achievement than their female counterparts while the same also apply to the use of lecture method. Generally, the three methods favour male students than the female students as they enhance male students' academic achievement than their female counterparts.

Research Hypothesis 1: There is no significant difference in the mean achievement scores of students taught physics using flipped classroom, laboratory and lecture teaching methods

Table 3: Analysis of Covariance of the mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods

Source	Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	621.17	3	207.06	18.17	0.00	
Intercept	2473.11	1	2473.11	217.04	0.00	
PRETEST	322.44	1	322.44	28.30	0.00	
GROUP	236.86	2	118.43	10.39	0.00	S
Error	1868.74	164	11.40			
Total	194528.00	168				
Corrected Total	2489.91	167				

S = Significant at 0.05 level of significance

Table 3 shows the result of the Analysis of Covariance (ANCOVA) conducted to test for significant difference in the mean post test scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods with pre-test used as

covariates.The students were divided into three groups by teaching methods namely flipped classroom, laboratory and lecture teaching methods. The f-value for teaching method or group is 10.39 with p-value (level of significance) being 0.00. Since the obtained p-value is less than the stipulated probability level of 0.05, it implies that the value of f is significant at 0.05 level of significance. On this basis, the null hypothesis is rejected implying that there is significant difference in the mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods. A post hoc test was conducted to determine where the significant difference lies.

Table 4: Summary of Post-hoc Pairwise comparison of the mean post test scores of students in the three groups

Groups	Mean difference	Standard Error	Sig
1 Vs 2 [35.61- 33.30]	2.31	0.596	0.00*
1 Vs 3 [35.61- 32.50]	3.11	0.583	0.00*
2 Vs 3 [33.30-32.50]	0.80	0.59	0.179

*The mean difference is significant at the .05 level.

The summary of the post hoc pairwise comparison in Table 4 shows that the mean difference between group 1(flipped classroom) and group 2 (laboratory) was 2.31 which was significant at 0.05 level of significance. Table 4 also reveal that the mean difference between group 1 (flipped classroom) and group 3 (lecture method) was 3.11 in favour of group 1 and this difference was found to be significant at 0.05 level of significance. There was no significant difference between the mean of group 2 and group 3. This result implies that the mean achievement of students in the two experimental groups (flipped classroom and laboratory) was significantly better than those in the control group (lecture method). However, the achievement of students in group 1 is significantly better than those in the other two groups. This is evident in the mean post-test achievement scores of the three groups (flipped classroom, laboratory and lecture method) which are 35.61, 33.30 and 32.50 respectively as presented in Table 1. The significant difference was therefore caused by group 1 (flipped classroom) which recorded the highest mean post- test score.

Research Hypothesis 2: There is no significant difference in the mean achievement scores of male and female students taught Physics using flipped classroom, laboratory and lecture teaching methods

Table 5: Summary of Analysis of Covariance of the mean achievement scores of male and female students taught physics using flipped classroom, laboratory and lecture teaching methods

Source	Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	1006.96	6	167.83	18.22	0.00	
Intercept	2854.93	1	2854.93	309.95	0.00	
PRETEST	100.61	1	100.61	10.92	0.01	
GROUP	323.04	2	161.52	17.54	0.00	
GENDER	277.35	1	277.35	30.11	0.13	NS
GROUP * GENDER	134.29	2	67.15	7.29	0.01	
Error	1482.94	161	9.21			
Total	194528.00	168				
Corrected Total	2489.91	167				

NS = Not Significant at 0.05 level of significance

The data in Table 5 is a summary of the Analysis of Covariance (ANCOVA) conducted to test for significant difference in the mean achievement scores of male and female students taught Physics using flipped classroom, laboratory and lecture teaching methods. The f- value for gender is 30.11 with p-value (level of significance) being 0.13. Since the obtained p-value is greater than the stipulated probability level of 0.05, it implies that the value of f is not significant at 0.05 level of significance. On this basis, the null hypothesis is retained implying that there is no significant difference in the mean achievement scores of male and female students taught physics using flipped classroom, laboratory and lecture teaching methods.

Discussion of Findings

The study found that students who were taught Physics using flipped classroom had the highest mean gain in the post-test than those who were taught using laboratory and lecture methods. Testing of the corresponding hypothesis confirmed that there was significant difference in the mean achievement scores of students taught Physics using flipped classroom, laboratory and lecture teaching methods. The significant difference was in favour of those who were taught using flipped classroom method. The superior performance of students taught using flipped classroom over the other two methods could be attributed to the fact that the flipped classroom method provide enriched teaching and learning experiences and at the same time motivate and encourage the students to learn more complex concepts in Physics. Also, in comparison with other instructional methods, the flipped classroom method offer many advantages which are not obtainable with laboratory teaching and lecture methods. For instance, the flipped classroom method uses technology and provide opportunities for students to work on a task, exchange their ideas, opinions and experiences and also discuss and negotiate strategies, actions and results. Also, the method enhance students' motivation to learn, provides increased transfer of learning, enhance a variety of

skills, including problem solving and higher-order thinking skills. These advantages obviously accounts for the superior performance of students taught Physics using flipped classroom method.

The superiority in performance between students taught using laboratory over those taught with lecture method could be attributed to the fact that laboratory teaching is student-centred, interactive, and encourages collaborative learning. In addition, the method stimulate creativity, curiosity, critical thinking, promote students involvement with the scientific methods and encourage active learning and problem solving skills. These advantages which are not obtainable through lecture method accounts for the superior performance of students taught Physics using laboratory teaching over those taught with lecture method.

The study that found a significant difference in Physics achievement scores favoring students taught with the flipped classroom method, aligns with previous research by Gambari et al. (2016) and Odo and Eze (2017), who reported similar outcomes in Biology and Computer Science. However, this contradicts Dusenbury and Olson (2019), who found no significant differences when comparing flipped classroom and lecture methods. Additionally, the study indicated that laboratory teaching was more effective than the lecture method, consistent with findings by Chibabi et al. (2018). While male students showed higher mean gains in the post-test when taught with the flipped classroom, no significant gender differences were found in achievement scores across teaching methods, supporting the results of Gambari et al. (2016) and others.

Conclusion

Based on the findings of the study, it could be concluded that the use of flipped classroom method enhance students' academic achievement in Physics than using laboratory teaching and lecture methods. Also, the three teaching methods (flipped classroom, laboratory and lecture teaching methods) are not gender biased with respect to students' academic achievement in Physics.

Recommendations

Based on the findings and conclusion of the study, the researcher made the following recommendations:

1. Physics teachers in all public Secondary Schools in Akwa Ibom State should henceforth adopt the flipped classroom teaching method in order to improve students' academic achievement in Physics.
2. Physics teachers in public SecondarySchoolsin Akwa Ibom State should not discriminate between male and female students in their classes since the use of flipped classroom, laboratory and lecture methods does not favour one gender than the other in terms of achievement.

3. The Akwa Ibom State Ministry of Education should recommend and enforce the use of flipped classroom method in the teaching of Physics in all public SecondarySchoolsin the state.
4. The Ministry of Education should supply computers and other necessary facilities and resources required for effective application of the flipped classroom method to all public SecondarySchoolsin the state in order to help improve students' academic achievement in Physics.

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