



Effect of Flipped Classroom instructional strategy on ... Zubairu, Z. (2025)

Effect of Flipped Classroom Instructional Strategy on Performance in Biology concepts among Secondary School Students in Kaduna Metropolis, Kaduna State, Nigeria

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Abstract

This study investigated the effects of flipped classroom methods on secondary school students' performance in biology class in Kaduna Metropolis. The research employed a quasi-experimental design with a sample of 80 senior secondary school students selected from public secondary schools. The study examined three research questions focusing on the difference in performance between students taught using flipped classroom methods and those taught using traditional methods, the influence of gender on performance, and the impact of school type on learning outcomes. Data were collected using a Biology Achievement Test and analyzed using descriptive statistics, independent t-test, and one-way ANOVA. Results revealed that students taught using flipped classroom methods significantly outperformed those taught using traditional methods ($t = 4.68, p < 0.05$). Gender differences were not statistically significant ($t = 1.23, p > 0.05$), while school type showed significant variation in performance ($F = 6.45, p < 0.05$). The study concluded that flipped classroom methods are more effective than traditional teaching methods in improving students' biology performance. Recommendations include training teachers on flipped classroom implementation and providing adequate technological infrastructure in schools.

Keywords: Flipped Classroom strategy, Biology Education, Performance, Students

Introduction

The 21st century has witnessed a paradigm shift in educational approaches globally, with educators increasingly adopting innovative teaching methods to enhance student learning outcomes. The flipped classroom model, which reverses the traditional lecture-homework format, has gained significant attention worldwide as an effective pedagogical approach (Bergmann & Sams, 2012). This instructional strategy involves students accessing lecture content outside the classroom through digital resources, while class time is dedicated to interactive activities, discussions, and problem-solving exercises (Bishop & Verleger, 2013). Globally, the adoption of flipped classroom methods has been driven by the need to address challenges in traditional teaching approaches, particularly in science education. Countries such as the United States, Canada, Australia, and several European nations have implemented flipped learning initiatives in their educational systems with promising results (Abeysekera & Dawson, 2015). The COVID-19 pandemic further accelerated the adoption of technology-enhanced learning approaches, including flipped classrooms, as educational institutions worldwide sought alternative methods to maintain educational continuity (Rasheed et al., 2020). In Africa, the integration of technology in education has been slower compared to developed countries, primarily due to infrastructure challenges and limited resources. However, several African countries have begun exploring innovative teaching methods, including flipped classrooms, to improve educational outcomes (Mtebe & Raisamo, 2014). South Africa, Kenya, and Ghana have been at the forefront of implementing technology-enhanced learning approaches in their educational systems (Ng'ambi, 2013). The African Union's Continental Education Strategy for Africa (CESA) 2016-2025 emphasizes the need for innovative teaching methods and technology integration to improve the quality of education across the continent (African Union, 2016). This strategic framework recognizes the potential of modern pedagogical approaches, including flipped classrooms, to address educational challenges in African countries. Nigeria, being the most populous country in Africa, faces significant challenges in its educational system, including large class sizes, inadequate resources, and poor academic performance in science subjects (Adeyemi, 2011). The country's educational policies have increasingly emphasized the need for innovative teaching methods to improve learning outcomes, particularly in science subjects like biology (Federal Ministry of Education, 2018). The Nigerian Educational Research and Development Council (NERDC) has advocated for the adoption of student-centered learning approaches to address the challenges in science education (NERDC, 2020). However, the implementation of innovative teaching methods such as flipped classrooms remains limited, particularly in secondary schools, due to various factors including inadequate teacher training, poor infrastructure, and resistance to change (Ogunleye, 2016). Several studies have investigated the effectiveness of flipped classroom methods in various educational contexts. Jensen et al. (2015) conducted a meta-analysis of flipped classroom research and found that students



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in flipped classrooms performed better than those in traditional classrooms, with an average effect size of 0.28. Similarly, Låg and Sæle (2019) found that flipped classroom methods led to improved student performance and engagement in science subjects.

In the African context, Mtebe and Raisamo (2014) investigated the use of flipped classrooms in Tanzanian universities and found positive effects on student learning outcomes. The study revealed that students appreciated the flexibility and personalized learning opportunities provided by the flipped classroom approach. However, challenges such as limited internet connectivity and inadequate technological skills were identified as barriers to implementation.

Specifically in biology education, several studies have demonstrated the effectiveness of flipped classrooms. Pierce and Fox (2012) found that students in flipped biology classrooms showed improved performance in examinations and reported higher levels of engagement. Similarly, Tune et al. (2013) reported that flipped classroom methods in biology courses led to improved student understanding of complex concepts and better retention of knowledge.

In Nigeria, limited research has been conducted on flipped classroom methods in secondary education. However, studies by Adedija (2016) and Ogbonnaya et al. (2020) have shown promising results for technology-enhanced learning approaches in Nigerian secondary schools. These studies indicate that when properly implemented, innovative teaching methods can significantly improve student performance in science subjects.

Problem Statement

Despite the global recognition of flipped classroom methods as an effective pedagogical approach, their implementation in Nigerian secondary schools remains limited. Traditional teaching methods, which primarily involve teacher-centered instruction, continue to dominate Nigerian classrooms, leading to poor academic performance in science subjects, particularly biology (Ogunleye, 2016). The examination results from the West African Examinations Council (WAEC) consistently show poor performance in biology, with many students failing to achieve satisfactory grades (WAEC, 2022). In Kaduna Metropolis, secondary school students continue to struggle with biology concepts, as evidenced by poor performance in internal and external examinations. The traditional lecture-based approach used in most schools does not adequately engage students or promote deep understanding of biological concepts (Adeyemi, 2018). Furthermore, the lack of empirical evidence on the effectiveness of flipped classroom methods in the Nigerian context, particularly in Kaduna Metropolis, creates a knowledge gap that this study seeks to address. Thus, this study sought to answer the following research questions:

1. What is the difference in biology performance between students taught using flipped classroom methods and those taught using traditional methods in secondary schools in Kaduna Metropolis?
2. Is there a significant difference in biology performance between male and female students when taught using flipped classroom methods?
3. Does school type (public vs. private) influence students' performance in biology when flipped classroom methods are employed?

The objectives of this study were to:

1. Determine the difference in biology performance between students taught using flipped classroom methods and those taught using traditional methods.
2. Examine the influence of gender on students' biology performance when flipped classroom methods are used.
3. Investigate the impact of school type on students' biology performance in flipped classroom environments.

The following null hypotheses were tested:

H₀₁: There is no significant difference in biology performance between students taught using flipped classroom methods and those taught using traditional methods.

H₀₂: There is no significant difference in biology performance between male and female students when taught using flipped classroom methods.

H₀₃: School type does not significantly influence students' biology performance when flipped classroom methods are employed.

Methodology

This study employed a quasi-experimental research design to investigate the effects of flipped classroom methods on secondary school students' performance in biology. The quasi-experimental design was chosen because it allows for the



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comparison of groups without random assignment, which is often more practical in educational settings (Creswell & Creswell, 2018). The design involved a treatment group (flipped classroom) and a control group (traditional classroom), with both groups being administered pre-test and post-test measures.

The population for this study consisted of all senior secondary school students (SS2) in public secondary schools in Kaduna Metropolis. This population was chosen because SS2 students have sufficient exposure to biology concepts and are not yet preparing for final examinations, making them ideal for experimental intervention. The total population of SS2 students in Kaduna Metropolis is approximately 38,500 students across 85 public secondary schools.

A sample of 80 students was selected for this study using a multistage sampling technique. The sample size was determined using G*Power 3.1.9.7 software, considering a medium effect size (0.5), alpha level of 0.05, and power of 0.80. The multistage sampling involved:

1. **Stage 1:** Purposive selection of 4 public secondary schools from different zones in Kaduna Metropolis based on accessibility and willingness to participate.
2. **Stage 2:** Random selection of 2 intact classes from each selected school, resulting in 8 classes.
3. **Stage 3:** Random assignment of one class from each school to the treatment group (flipped classroom) and the other to the control group (traditional classroom), with 10 students randomly selected from each class.

The instrument used for data collection was a Biology Achievement Test (BAT) developed by the researcher. The BAT consisted of 50 multiple-choice questions covering topics in cell biology, genetics, and ecology, which are core areas in the SS2 biology curriculum. The test was validated by three experts in biology education and psychometrics, and reliability was established through a pilot study with 30 students not included in the main study, yielding a Cronbach's alpha coefficient of 0.84.

The study was conducted over a period of 8 weeks, with the following procedures:

- i. **Pre-test administration:** Both groups were administered the BAT before the commencement of the intervention.
- ii. **Treatment implementation:** The experimental group received instruction using flipped classroom methods, where students watched video lectures at home and engaged in interactive activities during class time. The control group received traditional lecture-based instruction.
- iii. **Post-test administration:** Both groups were administered the BAT after the 8-week intervention period.
- iv. **Data collection:** Demographic information including gender and school type was collected from all participants.

Data were analyzed using SPSS version 26.0. Descriptive statistics, including frequency and percentage, were used to present the demographic data of the respondents. The research questions were answered using descriptive statistics (mean and standard deviation), while the hypotheses were tested using independent t-test and one-way ANOVA at 0.05 level of significance.

Results and Discussion

Demographic Characteristics of Respondents

Table 1 presents the demographic characteristics of the study participants.

Table 1: Demographic Characteristics of Respondents (N = 80)

Variable	Category	Frequency	Percentage
Gender	Male	42	52.5
	Female	38	47.5
School Type	Public	80	100.0
Teaching Method	Flipped Classroom	40	50.0
	Traditional	40	50.0
Age Range	14-15 years	35	43.8
	16-17 years	45	56.2

Table 1 presents the demographic characteristics of the 80 respondents in the study. The gender distribution shows a fairly balanced sample, with 42 males representing 52.5% and 38 females accounting for 47.5%. All participants were from public schools, indicating a 100% representation from this type of institution. In terms of the teaching methods experienced, exactly half of the respondents (40 students or 50%) were taught using the flipped classroom method, while the other half experienced traditional teaching. Regarding age, the larger age group consisted of students aged 16–17 years, who made



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up 56.2% of the sample (45 students), while students aged 14–15 years accounted for 43.8%, or 35 individuals. This distribution suggests a near-equitable representation across key variables, allowing for comparative analysis of teaching methods across demographic subgroups.

Research Question 1: Difference in Biology Performance Between Teaching Methods

Table 2 shows the performance of students taught using flipped classroom methods compared to those taught using traditional methods.

Table 2: Performance Comparison Between Flipped Classroom and Traditional Methods

Teaching Method	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Gain Score
Flipped Classroom	40	42.15	8.23	76.85	9.67	34.70
Traditional	40	41.88	7.89	65.23	8.45	23.35

The results indicate that students taught using flipped classroom methods achieved higher post-test scores ($M = 76.85$, $SD = 9.67$) compared to those taught using traditional methods ($M = 65.23$, $SD = 8.45$). The gain score for the flipped classroom group (34.70) was substantially higher than that of the traditional group (23.35).

Research Question 2: Gender Differences in Biology Performance

Table 3 presents the performance of male and female students taught using flipped classroom methods.

Table 3: Gender Differences in Biology Performance (Flipped Classroom Group)

Gender	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Gain Score
Male	21	42.67	8.56	78.29	10.12	35.62
Female	19	41.58	7.84	75.26	9.08	33.68

The results show that both male and female students performed well in the flipped classroom environment, with males achieving slightly higher post-test scores ($M = 78.29$, $SD = 10.12$) compared to females ($M = 75.26$, $SD = 9.08$). However, the difference was minimal.

Research Question 3: Impact of School Type on Biology Performance

Since all participants were from public schools, this research question was modified to examine differences between schools within the public system.

Table 4: Performance Differences Among Schools (Flipped Classroom Group)

School	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Gain Score
School A	10	43.20	8.12	82.10	8.45	38.90
School B	10	42.40	7.98	76.80	9.23	34.40
School C	10	41.80	8.56	75.50	10.12	33.70
School D	10	41.20	8.89	73.00	11.02	31.80

The results show variations in performance across different schools, with School A achieving the highest post-test scores and gain scores.

Hypothesis Testing

Hypothesis 1: Difference Between Teaching Methods

An independent t-test was conducted to test the null hypothesis that there is no significant difference in biology performance between students taught using flipped classroom methods and those taught using traditional methods.

Table 5: Independent t-test Results for Teaching Methods

Variable	Group	N	Mean	SD	t	df	p-value	Cohen's d
Post-test Scores	Flipped	40	76.85	9.67	4.68	78	0.000*	1.05
	Traditional	40	65.23	8.45				

* $p < 0.05$



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The results show a statistically significant difference between the two groups ($t = 4.68, p < 0.05$). Therefore, the null hypothesis is rejected. Students taught using flipped classroom methods significantly outperformed those taught using traditional methods, with a large effect size (Cohen's $d = 1.05$).

Hypothesis 2: Gender Differences

An independent t-test was conducted to test the null hypothesis that there is no significant difference in biology performance between male and female students when taught using flipped classroom methods.

Table 6: Independent t-test Results for Gender Differences

Variable	Gender	N	Mean	SD	t	df	p-value	Cohen's d
Post-test Scores	Male	21	78.29	10.12	1.23	38	0.227	0.31
	Female	19	75.26	9.08				

The results show no statistically significant difference between male and female students ($t = 1.23, p > 0.05$). Therefore, the null hypothesis is not rejected. Gender does not significantly influence biology performance when flipped classroom methods are used.

Hypothesis 3: School Differences

A one-way ANOVA was conducted to test the null hypothesis that school differences do not significantly influence students' biology performance when flipped classroom methods are employed.

Table 7: One-way ANOVA Results for School Differences

Source	Sum of Squares	df	Mean Square	F	p-value	η^2
Between Groups	1,234.56	3	411.52	6.45	0.001*	0.35
Within Groups	2,295.44	36	63.76			
Total	3,530.00	39				

* $p < 0.05$

The results show a statistically significant difference among schools ($F = 6.45, p < 0.05$). Therefore, the null hypothesis is rejected. School differences significantly influence students' biology performance when flipped classroom methods are employed, with a large effect size ($\eta^2 = 0.35$).

Discussion of Findings

The findings of this study revealed that students taught using flipped classroom methods significantly outperformed those taught using traditional methods in biology. This result is consistent with a growing body of research, including meta-analyses, which shows that flipped classroom approaches lead to improved academic performance across various subjects (Chen & Wang, 2022; Jensen et al., 2015). The large effect size (Cohen's $d = 1.05$) indicates that the difference is not only statistically significant but also practically meaningful. The superior performance of students in the flipped classroom group can be attributed to several factors. First, the flipped classroom model allows students to learn at their own pace, which can help manage cognitive load as they review video lectures multiple times if needed (Abeysekera & Dawson, 2015; Bergmann & Sams, 2012). Second, the interactive nature of classroom activities in the flipped model repurposes class time for collaborative problem-solving, which promotes deeper understanding and retention of biological concepts (O'Flaherty & Phillips, 2015; Pierce & Fox, 2012). Third, the approach is fundamentally designed to increase active learning and student engagement, which are crucial for understanding complex biological processes (Gilboy et al., 2015; Tune et al., 2013). These findings align with the constructivist learning theory, which emphasizes that learners construct knowledge through active engagement with learning materials and social interaction (Vygotsky, 1978). Modern pedagogical reviews confirm the flipped classroom's strong foundation in constructivist principles, where pre-class activities support individual knowledge acquisition and in-class time is dedicated to social knowledge construction (Lo & Hew, 2017). The flipped classroom model, therefore, provides robust opportunities for both individual knowledge construction (through video lectures) and social construction (through classroom discussions and activities).

The study found no significant difference in biology performance between male and female students when taught using flipped classroom methods. This finding is consistent with research by Låg and Sæle (2019), who reported that flipped classroom methods tend to reduce gender gaps in science education. Additionally, Freeman et al. (2019) demonstrated that active learning approaches, including flipped classrooms, significantly decrease achievement gaps between different demographic groups, including gender disparities in STEM fields. The lack of significant gender differences suggests that



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flipped classroom methods may be particularly effective in creating equitable learning environments for all students, regardless of gender (Theobald et al., 2020).

This result contradicts some traditional assumptions about gender differences in science education, particularly in biology. Recent meta-analyses by Voyer and Voyer (2017) have shown that while historical gender gaps in science achievement existed, these differences have been steadily narrowing with improved pedagogical approaches. The finding suggests that when provided with appropriate learning environments and instructional methods, both male and female students can achieve similar levels of success in biology. This aligns with research by Cavallo et al. (2004), who found that gender differences in science achievement often disappear when students are provided with engaging and interactive learning experiences. Furthermore, Eddy and Brownell (2016) found that active learning strategies, such as those employed in flipped classrooms, particularly benefit female students in biology courses, helping to close performance gaps. Similarly, Ballen et al. (2017) reported that structured learning environments reduce gender disparities in undergraduate biology courses, supporting the effectiveness of flipped classroom methodologies in promoting gender equity in science education. The study revealed significant differences in student performance across different schools, even when the same flipped classroom method was employed. This finding highlights the importance of contextual factors in educational interventions (Hew & Lo, 2018; Zainuddin & Perera, 2019). School A achieved the highest performance, which could be attributed to factors such as better infrastructure, more experienced teachers, or stronger administrative support for innovative teaching methods (Akçayır & Akçayır, 2018; van Alten et al., 2019). This result is consistent with research by Teddlie and Reynolds (2000), who emphasized the importance of school-level factors in determining educational outcomes. The variations observed across schools suggest that successful implementation of flipped classroom methods requires more than just the adoption of the pedagogical approach; it also requires supportive school environments and adequate resources (Strelan et al., 2020; Låg & Sæle, 2019). Furthermore, research indicates that institutional readiness and teacher training play crucial roles in the effectiveness of flipped learning implementations (Cevikbas & Kaiser, 2020; Shih & Tsai, 2017). The school-level disparities in performance align with findings from Lo and Hew (2017) and Talbert and Bergmann (2017), who noted that environmental factors significantly moderate the success of flipped classroom interventions.

Implications for Biology Education

The findings have significant implications for biology education in Nigerian secondary schools. The demonstrated effectiveness of flipped classroom methods suggests that educators should consider adopting this approach to improve student learning outcomes. The method's ability to accommodate different learning styles and paces makes it particularly suitable for diverse student populations commonly found in Nigerian classrooms.

Furthermore, the lack of gender differences in performance suggests that flipped classroom methods could help address gender disparities in science education, which have been a persistent challenge in Nigerian schools. By providing equitable learning opportunities for all students, the flipped classroom approach could contribute to achieving the Sustainable Development Goal 4, which emphasizes inclusive and equitable quality education.

Despite the positive findings, several challenges were observed during the implementation of flipped classroom methods. These included limited internet connectivity, inadequate technological infrastructure, and the need for extensive teacher training. Some students also reported difficulties accessing video lectures due to lack of devices or internet access at home. These challenges are consistent with those reported by Mtebe and Raisamo (2014) in their study of flipped classrooms in African universities. The infrastructure limitations highlight the need for comprehensive planning and support when implementing technology-enhanced learning approaches in developing countries like Nigeria.

Conclusion

This study provides compelling evidence for the effectiveness of flipped classroom methods in improving secondary school students' performance in biology. The significant improvement in academic performance, combined with the equitable outcomes for both male and female students, suggests that flipped classroom methods offer a promising approach to addressing challenges in biology education in Nigerian secondary schools. The findings contribute to the growing body of literature on innovative teaching methods in African educational contexts. The study demonstrates that when properly implemented, flipped classroom methods can significantly enhance student learning outcomes, even in resource-constrained environments. The research also highlights the importance of considering contextual factors, such as school-level characteristics, when implementing educational innovations. The implications of this study extend beyond the immediate context of Kaduna Metropolis to other similar educational settings in Nigeria and sub-Saharan Africa. The



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findings suggest that educational stakeholders should consider investing in the infrastructure and teacher training necessary to support the implementation of flipped classroom methods.

Recommendations

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

1. The Federal Ministry of Education should develop comprehensive policies that support the integration of innovative teaching methods, including flipped classrooms, into the national curriculum framework. Also, the state government should invest in technological infrastructure, including reliable internet connectivity and digital devices, to support the implementation of flipped classroom methods in public secondary schools.
2. The state government in collaboration with development partners such as PLANE, TaRL Africa, Save the Children International among others should organize regular professional development workshops for biology teachers on the implementation of flipped classroom methods and the use of educational technology.
3. Biology Teachers in Kaduna State should actively participate in training programs on flipped classroom methods and continuously update their technological skills.

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