EFFECT OF FLIPPED-CLASSROOM STRATEGY ON PERFORMANCE OF SENIOR SECONDARY SCHOOL STUDENTS IN INORGANIC CHEMISTRY, MAKURDI METROPOLIS, BENUE STATE, NIGERIA

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Abstract

This study investigated the effect of the flipped-classroom strategy on Senior Secondary School students' academic performance in Inorganic Chemistry in Makurdi Metropolis, Benue State, Nigeria. Two objectives, questions and null hypotheses guided the study. A quasi-experimental pretest-posttest non-equivalent control group design was adopted. The population comprised 1,754 SS II Chemistry students, from which a sample of 116 students (66 males, 50 females) was drawn from two purposively selected schools. Data were collected using the Inorganic Chemistry Performance Test (ICPT), validated by experts and yielding a reliability coefficient of r = .733 via Pearson Product-Moment Correlation. Descriptive statistics (mean and standard deviation) were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance using SPSS version 24. Findings revealed that students taught using the flipped-classroom strategy performed significantly better in Inorganic Chemistry than those taught using the conventional method. The findings further revealed no statistically significant gender difference in academic performance among students exposed to the flipped-classroom strategy, indicating that the approach was equally effective for both male and female students. The study concluded that the flipped classroom strategy enhances students' academic performance in Inorganic Chemistry more effectively than the conventional method. It is recommended that Chemistry teachers adopt the flipped classroom strategy to promote active learning and improve student outcomes.

Keywords: Flipped-Classroom Strategy, Academic Performance, Inorganic Chemistry, Gender, Makurdi Metropolis.

Introduction

Science remains a dynamic and essential field of human inquiry, providing systematic and evidence-based approaches for understanding the natural world. Scholars affirm that science not only supplies organised knowledge but also promotes curiosity, critical thinking, and problem-solving competencies necessary for personal and societal development (Brewminate, 2025). With this strong epistemological foundation, science education in modern curricula emphasises knowledge acquisition, inquiry, creativity, and application. This naturally leads to the consideration of chemistry, one of the central pillars of science education.

Chemistry, widely recognised as the "central science," bridges the physical and life sciences by explaining the composition, structure, properties, and transformation of matter (Miller, 2024). Among its major branches, Inorganic Chemistry deals with metals, salts, minerals, oxides, acids, and coordination complexes, playing a vital role in environmental remediation, catalysis, nanotechnology, and material science (Abubakar et al., 2024). Core topics such as periodicity, bonding theories, redox processes, and acid-base interactions are fundamental to students' understanding of chemical behaviour, and a sound knowledge of the subject is essential for careers in engineering, environmental science, and medicine (Walanda et al., 2022).

Despite this importance, many students perceive Inorganic Chemistry as abstract and conceptually demanding due to complex symbolic representations, unfamiliar terminology, and limited practical engagement (Hancock, 2024). These challenges have been linked to ineffective teaching approaches and persistent reliance on teacher-centred instructional practices (Fatai et al., 2021; Agwu & Nmadu, 2023), which restrict learners to passive roles and hinder meaningful understanding (Napitupulu et al., 2024). Although several strategies, including demonstration, inquiry, and problem-solving methods, have been employed, students' achievement remains generally low with persistent conceptual difficulties (Abdullahi et al., 2022; Udu & Mbamalu, 2025), necessitating exploration of alternative instructional models.

The flipped-classroom strategy reverses the conventional model by engaging students with content outside class through videos, guided readings, and multimedia resources, while devoting class time to problem-solving, discussions, and collaborative tasks (Bergmann & Sams, 2012). Recent studies affirm that this approach enhances preparation, autonomy, conceptual mastery, and problem-solving proficiency in Chemistry (Holloway & Eichler, 2024; Ekpo et al., 2025), and has been shown to improve academic performance by creating interactive environments that support deeper learning (Akpomi & James-Ngochindo, 2024; Vermeulen & Volman, 2024). Gender is also considered, as the flipped-classroom approach, by accommodating diverse learning styles and paces, has been associated with equitable outcomes across gender groups (Oladejo et al., 2023; Samaila & Al-Samarraie, 2024).

While studies have examined flipped-classroom instruction across various subjects and contexts, its application in Inorganic Chemistry at the Senior Secondary School level within the Nigerian context remains underexplored, and the question of equitable outcomes across gender groups has not been sufficiently addressed (Isa & Bukar, 2023). This study, therefore, seeks to fill this gap by examining the effect of the flipped-classroom strategy on the academic performance of Senior Secondary School students in Inorganic Chemistry, Makurdi Metropolis, Benue State, Nigeria.

Statement of the Problem

Inorganic Chemistry is a core component of the secondary school chemistry curriculum, yet it remains one of the most poorly performed subjects among secondary school students in Nigeria. Students consistently struggle with abstract concepts such as redox reactions, chemical bonding, periodicity, ionisation, and stoichiometry, resulting in persistent poor academic performance characterised by disinterest, anxiety, and low motivation (Kyado et al., 2021; Agwu & Nmadu, 2023). These challenges have been largely attributed to the continued reliance on teacher-centred, lecture-based instructional methods, which restrict students to passive roles and limit meaningful engagement, critical thinking, and problem-solving during lessons.

Within secondary schools in Makurdi Metropolis, Benue State, classroom assessments and teachers' reports indicate persistent underachievement and disengagement in Inorganic Chemistry, with topics such as redox reactions, ionisation, and stoichiometry identified as particularly difficult for students (Kyado et al., 2022). This points to a problem that is both conceptual and instructional, and one that demands a deliberate shift toward more learner-centred approaches capable of addressing performance deficits. The flipped-classroom strategy has been shown in various educational contexts to improve students' academic performance by engaging them with instructional content before class and using classroom time for guided discussion, collaboration, and deeper conceptual engagement (Alarabi et al., 2023).

Despite its demonstrated potential, the strategy remains largely underexplored in Nigerian secondary schools, particularly in the teaching of Inorganic Chemistry in Makurdi Metropolis. Contextual factors such as limited digital infrastructure and varied students' technological readiness mean that findings from other settings cannot be uncritically applied here, leaving a significant gap in locally grounded evidence with direct consequences for instructional decision-making. It is against this background that the present study examined the effect of the flipped-classroom strategy on the academic performance of Senior Secondary School students in Inorganic Chemistry, Makurdi Metropolis, Benue State, Nigeria.

Objectives of the Study

The main objective of the study is to investigate the effect of the flipped-classroom strategy on the performance of senior secondary school students in inorganic chemistry, Makurdi Metropolis, Benue State, Nigeria. The specific objectives of the study are:

1. Determine the effect of the flipped-classroom strategy on students' academic performance in Inorganic Chemistry Concepts among senior secondary schools in Makurdi Metropolis.
2. Find the effect of the flipped-classroom strategy on the academic performance of male and female students taught Inorganic Chemistry concepts in senior secondary schools in Makurdi metropolis.

Research Questions

This study was guided by the following research questions:

1. What is the difference between the mean performance scores of students taught Inorganic Chemistry using the flipped-classroom strategy and those taught using the conventional method?
2. What is the difference between the mean performance scores of male and female students when taught Inorganic chemistry using the flipped-classroom strategy?

Hypotheses

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

H_{o1}: There is no significant difference between the mean academic performance scores of students taught using the flipped-classroom strategy and those taught using the conventional method.

H_{o2}: There is no significant difference between the mean academic performance scores of male and female students taught Inorganic Chemistry concepts using the flipped-classroom strategy.

Methodology

This study employed a quasi-experimental pretest-posttest non-equivalent control group design, utilising two intact classes without randomisation. Two research questions and two null hypotheses guided the study. The population comprised all SS II Chemistry students in Makurdi Metropolis, Benue State, totalling 1,754, from which a purposive sample of 116 students (66 males, 50 females) was drawn from two schools. The experimental group (n = 62) received instruction through the flipped-classroom strategy, while the control group (n = 54) received conventional lecture-discussion instruction.

The instrument for data collection was the Inorganic Chemistry Performance Test (ICPT), a 30-item multiple-choice test adapted from the West African Examination Council (WAEC) and National Examination Council (NECO) by the researcher based on the SS II Chemistry curriculum, covering selected topics: halogens, hydrogen, oxygen, nitrogen, and water across all six cognitive domains of Bloom's taxonomy. The instrument was validated by three experts with a minimum qualification of a PhD from the Department of Science Education. Item analysis was conducted using a Facility Index range of 0.30-0.70 and a Discrimination Index range of 0.20-0.60 (Bhavsar et al., 2022). Reliability was established through a test-retest pilot study involving 49 students in a non-sampled school, yielding a PPMC coefficient of r = .733.

Both groups were administered the ICPT as a pretest before the six-week intervention. During treatment, the experimental group engaged with video materials and lesson notes before class. Each video ranged from 25 to 50 minutes in duration, designed to provide comprehensive coverage of the weekly topic so that students could engage meaningfully with the content even without supplementary teacher explanation, while in-class sessions were devoted to guided discussions and question-answering. The control group was taught the same content using the conventional method. The same ICPT was administered as a posttest upon completion of the intervention.

Results

Research Question One: What is the difference in the mean performance scores of students taught Inorganic Chemistry using the flipped-classroom strategy and those taught using the conventional method?

Table 1: Mean and Standard Deviations of Students' Academic Performance Scores in the Experimental and Control Groups

		Pretest		Posttest		
Groups	**N**	**M**	**SD**	**M**	**SD**	**MD**
Experimental	62	16.76	3.73	17.68	4.80	2.16
Control	54	14.89	2.91	15.52	2.97	

Table 1 shows that the Experimental Group had a pretest mean performance score of 16.76 (*SD* = 3.73) and the Control Group had a pretest mean performance score of 14.89 (*SD* = 2.91), indicating a slight difference in baseline performance between the two groups. Following the six-week intervention, the Experimental Group

recorded a posttest mean performance score of 17.68 (*SD* = 4.80), while the Control Group recorded a posttest mean performance score of 15.52 (*SD* = 2.97). The mean difference of 2.16 in favour of the Experimental Group indicates that students taught using the Flipped Classroom Strategy performed better academically than those taught using the Conventional Method.

Hypothesis One: There is no significant difference between the mean academic performance scores of students taught inorganic chemistry using the flipped-classroom strategy and those taught using conventional method.

Table 2: Analysis of Covariance (ANCOVA) of Posttest Scores of Students Taught Inorganic Chemistry Using the Flipped-Classroom and Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	300.494[a]	2	150.247	9.934	.000	.150
Intercept	594.229	1	594.229	39.289	.000	.258
Pretest	165.972	1	165.972	10.974	.001	.089
Group	59.515	1	59.515	3.935	.050	.034
Error	1709.058	113	15.124			
Total	34254.000	116				
Corrected Total	2009.552	115				

Significant at $p \leq 0.05$

Table 2 presents the ANCOVA results comparing the posttest academic performance of both groups, with pretest scores as the covariate. After controlling for pretest scores, the covariate had a significant effect on posttest performance, $F(1, 113) = 10.974$, $p = .001$, partial $\eta^2 = .089$. The main effect of instructional method was statistically significant, $F(1, 113) = 3.935$, $p = .050$, partial $\eta^2 = .034$. The null hypothesis was therefore rejected, indicating a significant difference in academic performance in favour of the flipped-classroom strategy group.

Research Question Two: What is the difference between the mean performance scores of male and female students when taught Inorganic chemistry using flipped-classroom strategy?

Table 3: Mean and Standard Deviation of Posttest Performance Scores of Male and Female Students Taught Inorganic Chemistry Using Flipped-Classroom Strategy

Gender	N	Mean	SD	MD
Male	41	17.68	5.08	
				0.01
Female	21	17.67	4.34	

The results in Table 3 show the mean performance scores of male and female students taught Inorganic Chemistry using the Flipped-Classroom Strategy. Male students obtained a mean score of 17.68 (*SD* = 5.08), while female students obtained a mean score of 17.67 (*SD* = 4.34). The negligible mean difference of 0.01 indicates that both male and female students performed almost equally when taught using the Flipped-Classroom Strategy, suggesting that the strategy impacted the academic performance of both gender groups similarly.

Hypothesis Two: There is no significant difference between the mean academic performance scores of male and female students taught Inorganic Chemistry concepts using the flipped-classroom strategy.

Table 4: Independent Samples t-test of Male and Female Students' Academic Performance in Experimental Group

Groups	N	Mean	SD	df	t	p-value	Remark
Male	41	17.68	5.077				
				60	.013	0.990	Not Significant
Female	21	17.67	4.340				

Not Significant at $p \geq 0.05$

Table 4 presents the Independent Samples t-test results comparing the performance levels of male and female students taught Inorganic Chemistry using the Flipped-Classroom Strategy. Male students had a mean score of 17.68 (SD = 5.077), while female students had a mean score of 17.67 (SD = 4.340). The Independent Samples t-test revealed that the difference in performance levels between male and female students was not statistically

significant, t(60) = .013, p = .990. Since the p-value of .990 exceeded the significance level of α = .05, the null hypothesis which states that there is no significant difference between the mean academic performance scores of male and female students taught Inorganic Chemistry using the Flipped-Classroom Strategy is therefore not rejected.

Discussion of Findings

Findings revealed a significant difference in the mean academic performance scores of students taught Inorganic Chemistry using the flipped-classroom strategy and those taught using the conventional method, with the experimental group recording higher mean scores. This improvement can be attributed to the strategy's capacity to encourage prior exposure to learning materials before class and active engagement during in-class discussions and problem-solving activities. This finding aligns with that of Isa and Bukar (2023) who reported significantly better academic performance among students taught using the flipped-classroom strategy compared with those taught conventionally, attributing the gains to deeper interaction with content and increased learner engagement.

Furthermore, findings revealed no significant difference between the mean academic performance scores of male and female students taught Inorganic Chemistry using the flipped-classroom strategy, indicating that both genders benefited equally from the approach. This can be attributed to the strategy's provision of equal access to instructional materials and comparable active learning opportunities for all students regardless of gender. This finding is consistent with that of Abbas and Aliyu (2024) who reported no significant gender difference in academic performance among students exposed to the flipped-classroom strategy, confirming that the approach is gender-inclusive.

Conclusion

Based on the findings of this study, it was concluded that the flipped-classroom strategy produced a statistically significant improvement in students' academic performance in Inorganic Chemistry compared to the conventional method, with the experimental group recording a higher posttest mean score. The small effect size observed (partial η2 = .034) suggest that while the strategy's advantage is statistically established, its practical magnitude may be further enhanced if the intervention is implemented over a longer and more sustained period, with greater student compliance in pre-class content engagement.

It was further concluded that the flipped-classroom strategy yielded no statistically significant difference between the academic performance of male and female students, with a negligible mean difference of 0.01. This indicates that the strategy distributes its academic benefits equitably across gender, making it a viable and inclusive instructional option for co-educational secondary schools setting in Makurdi Metropolis and similar Nigerian contexts.

Recommendations

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

1. The Ministry of Education, National Teachers Institute, and National Commission for Colleges of Education, should encourage chemistry teachers to adopt the flipped-classroom strategy as a means to improve students' academic performance.
2. Since the flipped-classroom strategy is gender-friendly, it should be actively promoted and implemented in both Federal and State Government co-educational secondary schools across Nigeria.
3. School administrators should ensure the provision of adequate digital infrastructure, including functional devices and internet access, to support the effective implementation of the flipped-classroom strategy in secondary schools.

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