Effects of a Flipped Classroom Instructional Strategy on Senior Secondary School Students' Interest and Achievement in Physics in Niger State, Nigeria

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ABSTRACT

Background. Physics performance and student interest remain concerns in Nigerian secondary education. This study compared a flipped classroom approach with conventional instruction in a local senior secondary physics setting.

Methods. This non-randomised pre-test/post-test quasi-experiment involved two intact SS II physics classes in two public schools in Suleja, Niger State (N = 100; flipped classroom n = 54; conventional instruction n = 46). Each school contributed one class, with instructional condition assigned by coin toss. Following one week of pre-testing, six weeks of lessons on light and one week of post-testing, students completed a 30-item Physics Achievement Test (pilot KR-20 = .81) and a 15-item researcher-developed Physics Interest Scale (pilot Cronbach's α = .85). ANCOVA adjusted post-test outcomes for the corresponding pre-test scores. School, teacher and instructional condition could not be disentangled.

Results. Post-test interest was higher in the flipped group (M = 2.96, SD = 0.28) than the comparison group (M = 2.23, SD = 0.42); the adjusted group effect was $F(1, 97) = 106.12$, $p < .001$, partial $\eta^2 = .522$. Adjusted achievement means were 39.31 (95% CI [38.52, 40.10]) and 37.00 (95% CI [36.15, 37.86]), respectively, $F(1, 97) = 15.12$, $p < .001$, partial $\eta^2 = .135$. Within the flipped group, gender was not associated significantly with adjusted interest ($p = .068$) or achievement ($p = .258$). These individual-level statistics are descriptive of a two-class comparison and do not account for independent replication of schools.

Conclusion. Flipped instruction was associated with higher measured interest and achievement in these two classes. Because each method was implemented in only one school, the associations cannot be attributed uniquely to instructional strategy. Gender findings are exploratory and do not establish equivalence or differential effectiveness. Larger multi-school studies with independent intervention replication are needed.

Keywords: flipped classroom; physics education; student interest; academic achievement; gender; quasi-experiment; Nigeria

INTRODUCTION

Physics underpins much of modern technology, from medical imaging and communications to energy systems, and the national curriculum for Nigerian secondary schools therefore aims to give learners basic scientific literacy and the skills and attitudes needed for later technological work (Fasanya & Abdulwaheed, 2023). Yet performance in the subject is weak. Results of the West African Senior School Certificate Examination (WASSCE) show that the proportion of candidates earning a credit pass or better in physics ranged only from 26.8 % to 38.8 % between 2015 and 2023 (Figure 1), with roughly seven in ten candidates failing to reach that standard in a typical year.

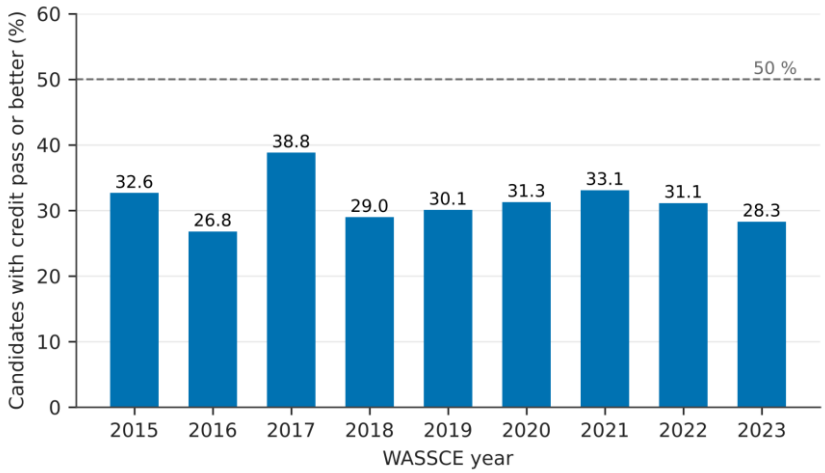


Figure 1. Percentage of WASSCE physics candidates obtaining a credit pass or better, 2015–2023. Computed from the number of candidates and the number of credit passes reported by the West African Examinations Council (2023); 2015–2023 pooled credit-pass rate = 31.1 %.

Several explanations for this pattern have been offered: the abstract nature of many physics concepts (Adeyemo, 2015), inadequate instructional resources, gender-related perceptions of the subject (Akano, 2018), and teaching that relies on traditional, teacher-centred methods (Obabori et al., 2024). In a lecture-based class, students mostly listen and copy notes, with few opportunities to discuss ideas, practise problem solving or relate concepts to everyday experience. Such passivity is likely to depress both understanding and interest, and interest in turn affects the attention and persistence on which achievement depends.

The flipped classroom is one learner-centred alternative. In this blended-learning approach, first exposure to content takes place before the lesson, typically through teacher-prepared video and reading, and class time is used for discussion, problem solving and teacher feedback (Bergmann & Sams, 2012; Raheem-Folayinka et al., 2024). Reviews and primary studies from several countries have examined its effects on academic achievement (Karagol & Esen, 2019), and a growing Nigerian literature has tested it in mathematics (Charles-Ogan & Williams, 2015), accounting (Ugwoke et al., 2018), and physics (Yusuf et al., 2019; Okokon et al., 2021; Ibrahim & Achimugu, 2022; Akanbi et al., 2024). Findings are not uniform, however: some studies, for instance, found no advantage for flipped instruction in student interest (Boeve et al., 2016). Evidence on whether flipped instruction works equally well for male and female students is also mixed (Ibrahim & Lawal, 2019; Usman & Adebayo, 2020).

Although flipped instruction has been studied elsewhere in Nigeria, evidence specific to the sampled schools and the combined outcomes of interest and achievement remains limited. The present study provides a local, preliminary comparison. Given the two-school design, it cannot isolate an instructional-method effect from differences between schools or teachers.

Purpose, research questions and hypotheses

The study compared physics interest and achievement in two intact classes taught using flipped and conventional instruction, respectively. It also described differences by gender within the flipped class. Because gender was not tested in an instructional-method × gender interaction across both classes, the latter comparisons are exploratory rather than tests of moderation.

- **RQ1.** What is the difference between the mean interest scores of students taught physics with the flipped classroom strategy and those taught with the conventional method?
- **RQ2.** What is the difference between the mean achievement scores of the two groups?
- **RQ3.** What is the difference between the mean interest scores of male and female students taught with the flipped classroom strategy?

- **RQ4.** What is the difference between the mean achievement scores of male and female students taught with the flipped classroom strategy?

Four null hypotheses were tested at the 0.05 level of significance: H_{01}, no significant difference in mean interest between the flipped and conventional groups; H_{02}, no significant difference in mean achievement between the groups; H_{03}, no significant difference in mean interest between male and female students in the flipped group; and H_{04}, no significant difference in mean achievement between male and female students in the flipped group.

Theoretical and Conceptual Framework

The study draws on two constructivist traditions. Bruner's (1960) theory of discovery learning holds that learners build understanding most effectively when they actively select, organise and transform information, with the teacher acting as a guide who structures tasks and provides corrective feedback until learners can work independently. Dewey's (1963) view of learning as the reconstruction of meaningful experience in a social setting likewise places the learner at the centre and casts the classroom as a community in which knowledge is constructed jointly. The flipped classroom operationalises both ideas: moving content delivery out of class frees lesson time for guided discovery, group problem solving and feedback, and the teacher's role shifts from presenting information to facilitating learning.

Figure 2 illustrates the study variables. Instructional condition distinguishes the two participating classes, and student interest and achievement are measured outcomes. Gender is considered only for exploratory within-flipped-class comparisons; the design does not estimate gender moderation of an instructional-method effect.

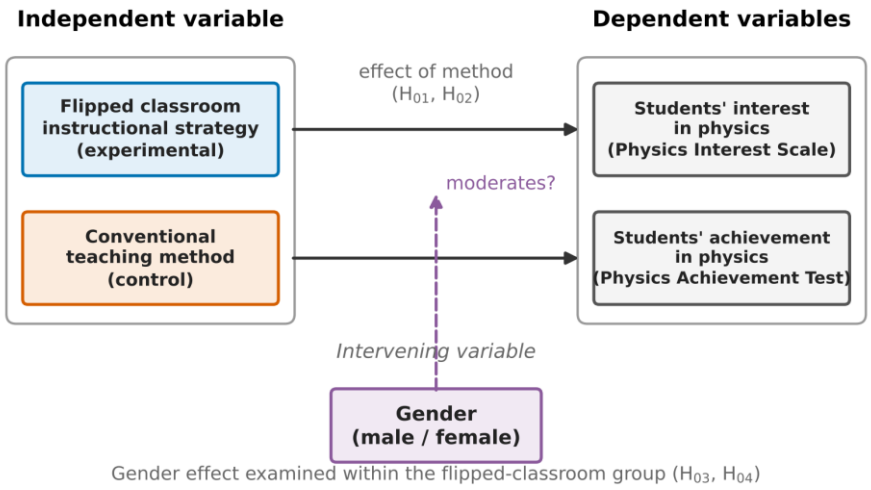


Figure 2. Conceptual framework of the two-class comparison. Instructional condition is associated with measured interest and achievement; gender is examined descriptively within the flipped classroom only.

METHODS

Research design

A pre-test/post-test non-randomised control-group quasi-experimental design was used (Table 1). One intact class from each of two different schools was assigned to the flipped or conventional condition by coin toss. Individual students were not randomised. Because the unit receiving each instructional condition was also the sole school/class for that condition, school, classroom and teacher differences are completely confounded with instructional strategy. ANCOVA adjustment for individual pre-test scores cannot remove this design limitation. Figure 3 summarises the study sequence.

Table 1. Symbolic representation of the research design

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X_1 (flipped classroom)	O_2
Control	O_1	X_0 (conventional method)	O_2

Note. O1 = administration of PAT and PIS before instruction; O2 = administration of PAT and PIS after instruction. The PAT pre-test and post-test were separate versions prepared from the same specification; formal equivalence of the versions was not demonstrated.

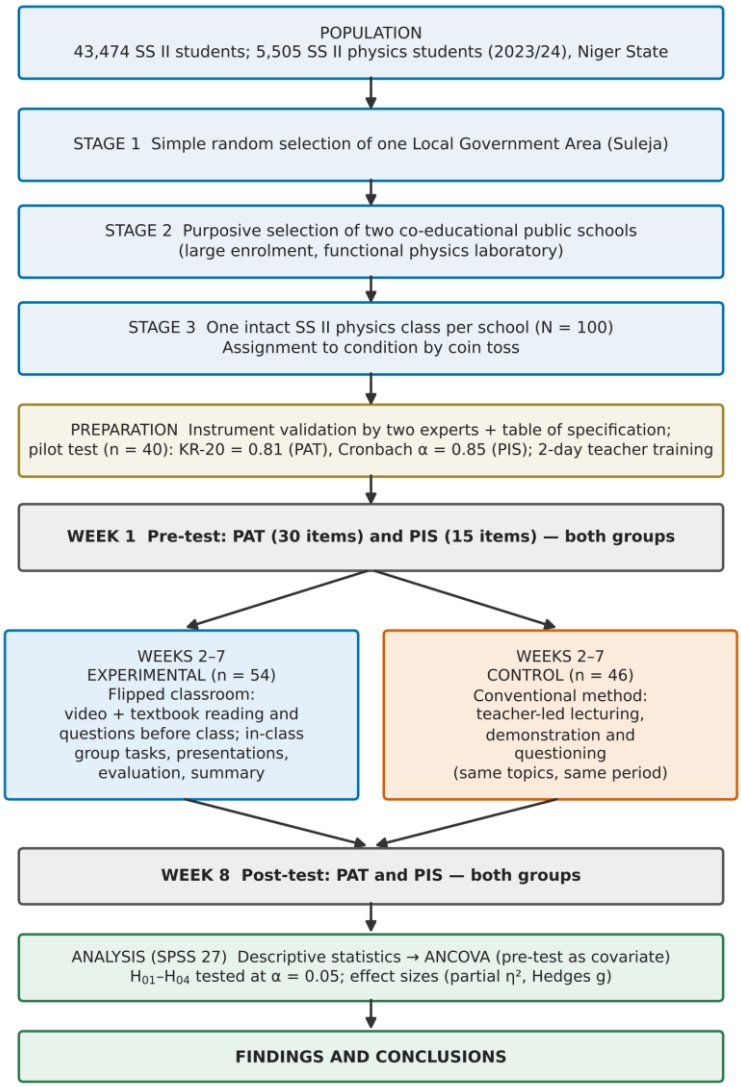


Figure 3. Workflow of the study, from sampling through instrument preparation, pre-test, eight-week instruction, post-test and analysis.

Population, sample and sampling procedure

The population comprised 43,474 SS II students (24,156 male; 18,818 female) in 224 senior secondary schools in Niger State, of whom 5,505 were SS II physics students in the 2023/2024 academic session (Ministry of Education, Science and Technology, Minna, 2024). A multi-stage procedure was adopted. First, one Local Government Area (Suleja) was selected by simple random sampling. Second, two co-educational public schools with large enrolments and physics laboratories were purposively selected. Third, one intact SS II physics class

was selected at random from each school, and the two classes were assigned to the experimental and control conditions by the toss of a coin. The final sample was 100 students (Table 2).

Table 2. Distribution of the sample by group and gender

Group	**Male**	**Female**	**Total**
Experimental (flipped classroom)	29	25	54
Control (conventional)	25	21	46
Total	**54**	**46**	**100**

Instruments

Two researcher-developed instruments were used (Table 3). The Physics Achievement Test (PAT) contained 30 four-option items on light, scored at two marks per correct answer (range 0–60). Separate pre-test and post-test versions were constructed using the same table of specification (Table 4), but evidence of statistical equating, item-level difficulty matching or parallel-form equivalence was not reported. Consequently, raw pre/post changes should not be interpreted as unequivocal learning gains. The Physics Interest Scale (PIS) consisted of 15 positive and negative statements on a four-point agreement scale, with reverse scoring of negative items and reporting of mean item scores (range 1–4). Two experts reviewed the instruments for face validity, and the PAT used a content specification. The PIS did not undergo reported construct validation or factor analysis; reliability coefficients alone do not establish validity.

Table 3. Characteristics of the research instruments

Feature	**Physics Achievement Test (PAT)**	**Physics Interest Scale (PIS)**
Construct	Achievement in light	Interest in learning physics
Items and format	30 multiple-choice items (A–D)	15 statements; 4-point agreement scale
Scoring	2 marks per correct item; range 0–60	4–1 (positive items), 1–4 (negative items); mean item score 1–4
Validity	Face validity (two experts, University of Abuja); content validity via table of specification	Face validity (two experts, University of Abuja)
Reliability (pilot, n = 40)	KR-20 = 0.81	Cronbach's $\alpha = 0.85$

Table 4. Table of specification for the Physics Achievement Test

Content area	**Periods**	**Knowledge**	**Comprehension**	**Application**	**Items**
Reflection (plane and curved mirrors)	6	2	3	5	10
Refraction (glass block, prism, critical angle)	6	2	3	4	9
Lenses and optical instruments	5	2	3	3	8
Defects of vision	2	1	1	–	2

Optical devices	1	1	–	–	1
Total	20	8	10	12	30

Treatment

Separate lesson plans covered the same specified physics content and instructional period in both classes. Regular teachers delivered the lessons following a two-day training session. In the flipped class, students were provided short videos, textbook readings and pre-class questions; class sessions included guided exploration, peer discussion, presentations and feedback. In the conventional class, teaching used lectures, demonstrations, questioning and teacher-led discussion (Figure 4; Table 5). The sequence was one week of pre-testing, six weeks of instruction and one week of post-testing. Records quantifying students' completion of pre-class tasks, actual access to learning materials, teacher adherence to lesson plans and independent observations of delivery were not available. Thus, fidelity and exposure to the intervention cannot be assessed.

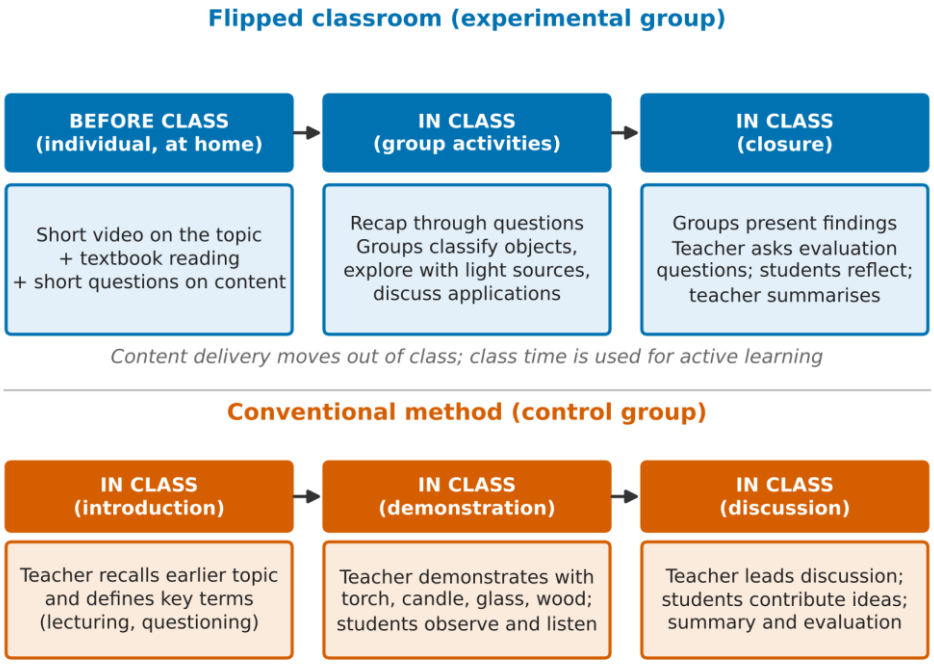


Figure 4. Lesson structure in the flipped classroom (experimental group) compared with the conventional method (control group), based on the lesson plans used in the study.

Table 5. Comparison of instructional conditions

Phase	**Flipped classroom (experimental)**	**Conventional method (control)**
Before class	Short video and textbook reading; short questions on the pre-class material	No pre-class task
Start of lesson	Recap of previous topic through questions; link to pre-class material	Teacher recalls earlier topic and defines key terms (lecturing and questioning)
Main activity	Small groups classify real objects, explore with light sources and discuss applications; teacher guides	Teacher demonstrates with real objects; students listen, observe and answer questions

Closure	Groups present findings; teacher evaluates with questions; students reflect and teacher summarises	Teacher-led discussion; teacher summarises and evaluates
Role of teacher	Facilitator / guide	Presenter of information
Content and duration	Same topics; same number of lessons and period of instruction	Same topics; same number of lessons and period of instruction

Procedure and data analysis

School principals granted permission following an introduction letter from the University of Abuja. Available documentation does not state whether institutional ethics committee review, parental/guardian consent, student assent, confidentiality safeguards or the right to decline participation were addressed. These procedures should be checked against the original study records before submission; principal permission alone should not be represented as equivalent to informed consent. Both instruments were administered before and after instruction. Descriptive means and standard deviations were reported, followed by individual-level ANCOVA with the relevant baseline score as covariate (SPSS 27). Partial η^2 and Hedges' g with 95% confidence intervals were reported. The analyses treat students as independent observations even though they belong to only two classes. A defensible school-cluster-adjusted test of treatment effect is not available with one school per condition; therefore, p values and intervals must not be construed as population-level confirmation of a method effect. Gender ANCOVAs use only the flipped group and are exploratory.

RESULTS

Preliminary checks

The flipped class had higher baseline achievement (M = 28.81, SD = 3.47) than the conventional class (M = 27.22, SD = 4.95), an observed difference of 1.59 points (Welch t(78.8) = 1.84, p = .070). Baseline interest means were 1.76 (SD = 0.54) and 1.85 (SD = 0.65), respectively (Table 6). Failure to reject a baseline difference does not demonstrate equivalence. A previously reported test of homogeneous regression slopes for achievement gave group × pre-test F(1, 96) = 0.65, p = .421; this provides no evidence of unequal slopes but does not prove the assumption. No corresponding slope-interaction test for interest, residual-diagnostic results, or complete checks of linearity, residual normality and variance homogeneity were supplied. Those checks require raw data and should be reported before treating the ANCOVA assumptions as fully verified.

Students' interest in physics (RQ1, H_{01})

Mean interest increased from 1.76 to 2.96 in the flipped class and from 1.85 to 2.23 in the conventional class (Table 6; Figure 5). The observed post-test mean difference was 0.73. Values are rounded, so displayed gains may not equal subtraction of rounded means exactly. These patterns describe differences between the two sampled classes.

Table 6. Descriptive statistics for interest (mean item score, range 1–4) by instructional group

Group	***n***	**Pre-test *M***	**Pre-test *SD***	**Post-test *M***	**Post-test *SD***	**Mean gain**
Flipped classroom	54	1.76	0.54	2.96	0.28	1.19
Conventional	46	1.85	0.65	2.23	0.42	0.38
Difference		–0.08		0.73		0.81

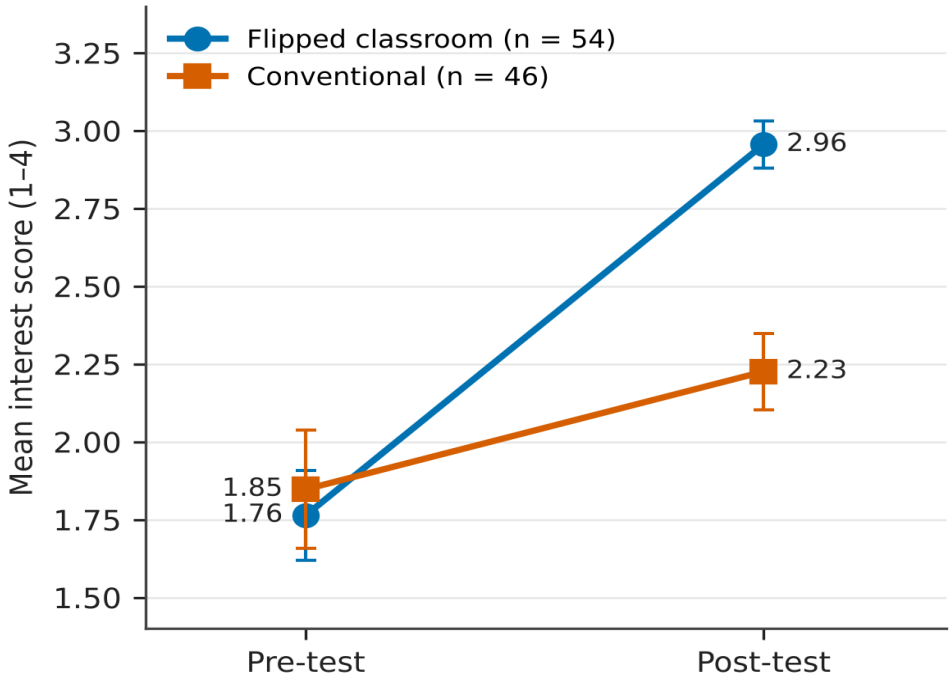


Figure 5. Mean interest score (1–4) at pre-test and post-test by instructional group. Error bars are 95 % confidence intervals.

Individual-level ANCOVA showed an adjusted association between instructional condition and post-test interest, $F(1, 97) = 106.12$, $p < .001$, partial $\eta^2 = .522$ (Table 8). The baseline-interest covariate was not significant, $F(1, 97) = 2.76$, $p = .100$. The unadjusted standardised difference was Hedges' $g = 2.06$ (95% CI [1.58, 2.55]). The very large estimate warrants caution because treatment and school were not independently replicated. Adjusted interest means with standard errors were not available in the supplied report and must be calculated from the original data rather than inferred from raw means.

Students' achievement in physics (RQ2, H_{02})

Both classes showed higher post-test than pre-test achievement scores (Table 7; Figures 6 and 7). Raw post-test means were 39.43 and 36.87, respectively. Adjusted means were 39.31 (95% CI [38.52, 40.10]) for the flipped class and 37.00 (95% CI [36.15, 37.86]) for the conventional class, corresponding to an adjusted difference of 2.31 points (95% CI [1.13, 3.48]). These within-sample adjusted results cannot identify whether the difference arises from instruction rather than school or teacher characteristics. Furthermore, the absence of formal pre-test/post-test version equating limits interpretation of raw gains.

Table 7. Descriptive statistics for achievement (score range 0–60) by instructional group

Group	***n***	**Pre-test *M***	**Pre-test *SD***	**Post-test *M***	**Post-test *SD***	**Mean gain**	**Adjusted post-test *M* [95 % CI]**
Flipped classroom	54	28.81	3.47	39.43	3.34	10.61	39.31 [38.52, 40.10]
Conventional	46	27.22	4.95	36.87	2.45	9.65	37.00 [36.15, 37.86]
Difference		1.59		2.56		0.96	2.31 [1.13, 3.48]

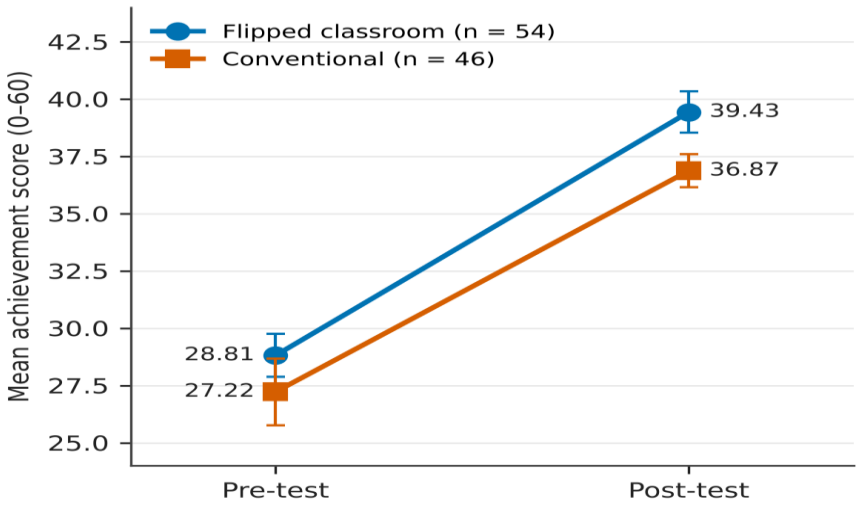


Figure 6. Mean achievement score (0–60) at pre-test and post-test by instructional group. Error bars are 95 % confidence intervals.

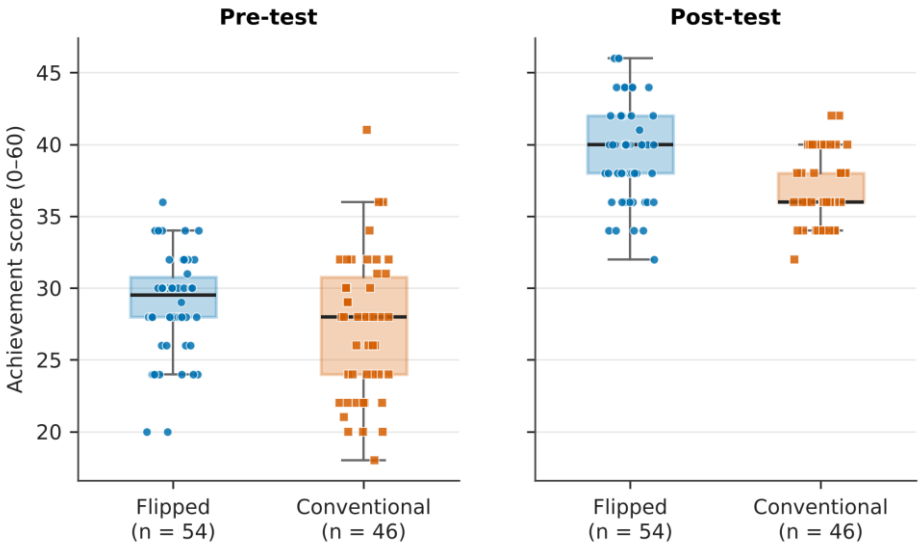


Figure 7. Distribution of individual achievement scores at pre-test and post-test. Boxes show the interquartile range and median; points are individual students.

The individual-level ANCOVA yielded $F(1, 97) = 15.12$, $p < .001$, partial $\eta^2 = .135$ for instructional condition and $F(1, 97) = 5.07$, $p = .027$ for baseline achievement (Table 8). The unadjusted standardised group difference was Hedges' $g = 0.86$ (95% CI [0.45, 1.27]). These nominal tests do not adjust for the class-level design and should be understood as exploratory evidence of association, not a causal estimate.

Table 8. ANCOVA of post-test interest and achievement by instructional method (pre-test as covariate)

Source	**Type III *SS***	***df***	**Mean square**	***F***	***p***	**Partial η^2**
Interest (H_{01})						
Pre-test (covariate)	0.334	1	0.334	2.76	.100	.028
Instructional method	12.865	1	12.865	106.12	< .001	.522
Error	11.759	97	0.121			

Achievement (H_{02})						
Pre-test (covariate)	42.697	1	42.697	5.07	.027	.050
Instructional method	127.461	1	127.461	15.12	< .001	.135
Error	817.725	97	8.430			

Gender and interest in the flipped classroom group (RQ3, H_{03})

Among the 54 students in the flipped class, males (n = 29) and females (n = 25) had similar reported baseline-interest means (1.76 and 1.77). Post-test interest means were 3.02 and 2.88 (Table 9; Figure 8). Within-class ANCOVA yielded F(1, 51) = 3.47, p = .068, partial η^2 = .064 (Table 10). The unadjusted male–female effect was Hedges' g = 0.50 (95% CI [−0.04, 1.04]). The interval includes both no difference and potentially meaningful differences; the result does not establish gender equivalence.

Gender and achievement in the flipped classroom group (RQ4, H_{04})

Within the flipped class, female students had a post-test achievement mean of 39.96, compared with 38.97 for males (Table 9; Figure 8). The adjusted within-class comparison was F(1, 51) = 1.31, p = .258, partial η^2 = .025 (Table 10); the unadjusted female–male Hedges' g was 0.29 (95% CI [−0.24, 0.83]). There is insufficient evidence to conclude that achievement differs by gender in this class, but also insufficient precision to claim equivalence. Neither gender test addresses an instructional-method × gender interaction.

Table 9. Descriptive statistics by gender in the flipped classroom group (*n* = 54)

Measure and gender	***n***	**Pre-test *M***	**Pre-test *SD***	**Post-test *M***	**Post-test *SD***	**Mean gain**	**Post-test difference**
Interest (mean item score, 1–4)							
Male	29	1.76	0.44	3.02	0.25	1.26	0.14 (M > F)
Female	25	1.77	0.64	2.88	0.30	1.11	
Achievement (score, 0–60)							
Male	29	28.86	3.60	38.97	3.32	10.11	0.99 (F > M)
Female	25	28.76	3.38	39.96	3.35	11.20	

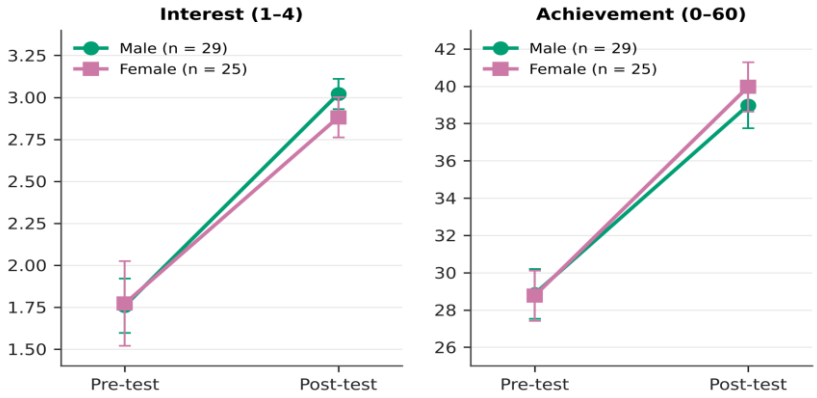


Figure 8. Mean interest (left) and achievement (right) of male and female students in the flipped classroom group at pre-test and post-test. Error bars are 95 % confidence intervals.

Table 10. ANCOVA of post-test interest and achievement by gender in the flipped classroom group (pre-test as covariate)

Source	Type III *SS*	*df*	Mean square	*F*	*p*	Partial η²
Interest (H03)						
Pre-test (covariate)	0.189	1	0.189	2.60	.113	.049
Gender	0.252	1	0.252	3.47	.068	.064
Error	3.710	51	0.073			
Achievement (H04)						
Pre-test (covariate)	34.621	1	34.621	3.25	.077	.060
Gender	13.918	1	13.918	1.31	.258	.025
Error	543.304	51	10.653			

Summary of results

Table 11 and Figure 9 summarise the four reported individual-level tests. Differences between classes favoured the flipped condition, but the class-level design precludes attributing them exclusively to the method. The two gender comparisons were exploratory, non-significant and compatible with a range of effect sizes.

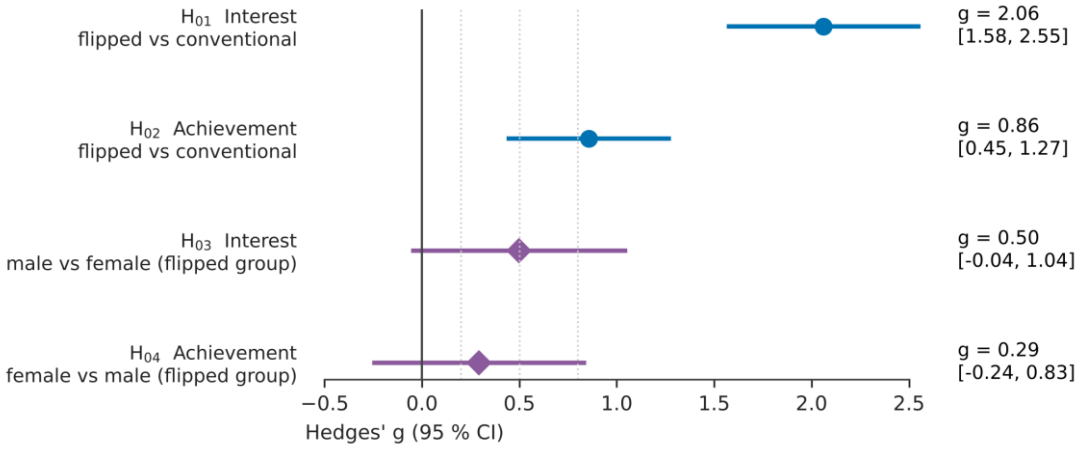


Figure 9. Standardised effect sizes (Hedges' g with 95 % confidence intervals) for the four hypotheses. Positive values favour the flipped classroom (H_{01}, H_{02}), males (H_{03}) and females (H_{04}) respectively.

Table 11. Summary of hypothesis tests

Hypothesis	Comparison	*F* (*df*), *p*	Partial η²	Decision
H_{01}	Interest: flipped vs conventional	106.12 (1, 97), < .001	.522	Rejected
H_{02}	Achievement: flipped vs conventional	15.12 (1, 97), < .001	.135	Rejected
H_{03}	Interest: male vs female (flipped group)	3.47 (1, 51), .068	.064	Retained
H_{04}	Achievement: male vs female (flipped group)	1.31 (1, 51), .258	.025	Retained

DISCUSSION

Instructional method and interest

In the sampled classes, the flipped condition was associated with higher reported physics interest. This pattern is consistent with the rationale for active participation and preparation before class, but neither preparation completion nor lesson fidelity was independently measured. Therefore, any explanation based on enhanced engagement remains hypothetical. Prior studies cited in the source manuscript suggest that outcomes may vary across topics and settings; the present two-school design cannot distinguish a teaching-method advantage from differences in teachers, schools, student access to materials or novelty.

The interest contrast was exceptionally large (partial $\eta^2 = .522$; Hedges' $g = 2.06$). Its magnitude is especially uncertain because only one class was exposed to each teaching condition, the PIS was researcher-developed without reported construct-validation evidence, and the flipped group had a relatively small post-test standard deviation (0.28). The statistical confidence interval does not capture uncertainty from unreplicated school-level assignment. The result should be regarded as hypothesis-generating.

Instructional method and achievement

The flipped class also scored higher on the achievement post-test. The reported adjusted difference was 2.31 points on a 60-point scale, a more modest contrast in raw-score terms than the standardised difference ($g = 0.86$) might imply. Both classes improved on the reported scores, but formally equivalent PAT versions were not established; maturation, test-form effects and other contemporaneous differences remain possible explanations. Since the school and instructional conditions coincide, the estimate cannot be interpreted as the independent effect of flipping instruction.

Gender

The exploratory analysis within the flipped class found no statistically significant gender difference in interest or achievement. This does not demonstrate equivalent outcomes, gender fairness or reduction of any gender gap. Confidence intervals were wide, and there was no method × gender interaction analysis involving both classes. Even a calculated interaction would remain difficult to interpret causally without independently replicated schools for each condition. A suitably powered, multi-school design is necessary to evaluate gender-specific responses.

Table 12. Consistency of the present findings with previous studies

Finding in this study	Consistent with	Different from or qualified by
Higher interest under flipped instruction	Abubakar & Okoye (2021); Udo & Effiong (2020)	Boeve et al. (2016): no interest difference (university statistics)
Higher achievement under flipped instruction	Udo & Effiong (2020); Ibrahim & Lawal (2019); Omotayo & Danjuma (2023)	Effect size in this study is based on two intact classes
No significant gender difference in interest	Usman & Adebayo (2020); Abubakar & Okoye (2021); Omotayo & Danjuma (2023)	Ibrahim & Lawal (2019): females marginally more engaged; here $p = .068$ favouring males
No significant gender difference in achievement	Usman & Adebayo (2020); Abubakar & Okoye (2021)	Ogunniyi (2017): males ahead under conventional teaching

Implications

The observed results justify further evaluation of structured pre-class preparation followed by active in-class physics tasks, not a general claim of effectiveness. Any wider implementation should first assess access to videos or printed alternatives, students' preparation rates, teacher training and fidelity of classroom delivery. Teachers and administrators should avoid treating the present estimates as transferable to other schools without replication.

Limitations

- School and teacher confounding. Two different schools provided one intact class each, with one class per method. Instructional condition therefore coincides with school, teacher and classroom. Non-random student allocation and the absence of independent clusters prevent isolation of a treatment effect; individual-level ANCOVA cannot correct this.

- Restricted setting and exposure. The study included 100 students from Suleja and six weeks of instruction on light. Findings may not extend to other school systems, age groups, topics or longer implementation periods. Class-level attendance/exposure information was not reported.

- Measurement uncertainty. The PAT forms were built from the same specification but not formally equated. The PIS had expert face review and internal-consistency evidence but no reported dimensionality, construct-validity or externally validated comparator evidence. Consequently, both raw achievement gains and interest changes require cautious interpretation.

- Incomplete fidelity and ANCOVA diagnostics. Available records do not quantify pre-class task completion, students' material access, independent lesson observations or full fidelity. A reported homogeneity-of-slopes test exists for achievement only; the corresponding interest test and complete residual diagnostics were not provided.

- Gender and ethics documentation. Gender contrasts were restricted to the flipped class, with limited precision and no method × gender interaction. Principal permission is recorded, but ethics committee review, guardian consent and student assent were not documented in the supplied text and must be verified from study records.

RECOMMENDATIONS AND FUTURE RESEARCH

- School-based pilots may evaluate the feasibility of pre-class video or print preparation and guided in-class activity, but adoption decisions should not rely on this single two-school comparison.

- Teacher-education programmes should consider training on lesson design, inclusive participation and low-connectivity delivery, alongside explicit monitoring of actual preparation, attendance and instructional fidelity.

- Claims about gender responsiveness should be reserved for studies that include both genders in several independently assigned schools per instructional condition and formally estimate the method × gender interaction.

- Future work should recruit multiple independently allocated schools per condition, prespecify cluster-aware analysis and adequate power, document student and guardian consent as appropriate, validate the interest instrument, equate achievement test forms, assess ANCOVA assumptions, monitor pre-class completion and teacher fidelity, and test retention across topics.

CONCLUSION

In this two-school, quasi-experimental comparison of 100 SS II physics students in Suleja, Niger State, the flipped class recorded higher post-test physics interest and achievement than the conventional class after individual baseline adjustment. Because school, teacher and instructional condition were inseparable, the results

cannot establish that the strategy itself caused the differences. Non-significant gender comparisons within the flipped class do not demonstrate equivalence or differential effectiveness. Replicated multi-school trials with stronger measurement, fidelity monitoring and cluster-aware analyses are required.

Declarations

Ethics approval and consent. Permission from participating school principals via a University of Abuja introduction letter was reported. The supplied study record does not establish whether ethics committee approval or exemption, parental/guardian consent, student assent and data-protection procedures were obtained. Authors must verify and disclose these details from contemporaneous documentation; no approval or consent is asserted here without evidence.

Reporting note. The article retains the statistical summaries in the supplied manuscript. Raw data, ethics records and fidelity logs were not available for independent verification. Required additional checks must not be presented as completed until verified.

Data availability. The source manuscript states that pre-test/post-test achievement scores and item-level interest responses appear in appendices to the underlying thesis and that processed data may be requested from the corresponding author. Those records were not supplied for this revision. Reanalysis, including complete ANCOVA diagnostics, adjusted interest means and standard errors, instrument checks and interaction testing, requires access to the original data.

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