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Effects of Flipped Classroom Approach on Students' Achievement in Mathematics Among Senior Secondary School Students in Federal Capital Territory, Abuja, Nigeria

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Abstract: This study investigated the effect of the flipped classroom approach on students' achievement in mathematics among senior secondary school students in the Federal Capital Territory, Abuja, Nigeria. A quasi-experimental, non-equivalent control group design was employed with a sample of 107 Senior Secondary Two (SSII) students from two co-educational public schools. Data were collected using the Mathematics Achievement Test (MAT), which demonstrated a reliability coefficient of 0.83. Analysis of Covariance (ANCOVA) was the primary statistical method used to determine significant differences. Key findings revealed that students taught using the flipped classroom approach achieved significantly higher mathematics scores compared to those taught with the conventional method (p=.002). Furthermore, no significant difference was found in mathematics achievement between male and female students within the flipped classroom group (p=.353). The study concludes that the flipped classroom is an effective and equitable instructional strategy for enhancing mathematics achievement among secondary school students in FCT Abuja.

Keywords: Flipped classroom, Mathematics achievement, Secondary school, FCT Abuja, Instructional approach, Gender.

Background

Mathematics is widely recognized as a fundamental discipline, playing a crucial role in scientific, technological, economic, and everyday problem-solving endeavors. It is often regarded as the universal language for its precision in describing complex phenomena and its ability to provide a systematic framework for logical reasoning and critical thinking. The significance of mathematics in education is further underscored by its strong correlation with success in higher education, future employment opportunities, and a wide array of career paths. Despite the critical importance of mathematics, a persistent and concerning problem of student underachievement continues to plague the Nigerian educational system. This issue is consistently evidenced by recurring reports of poor performance in the West African Senior School Certificate Examination (WASSCE). This underachievement not only poses a significant barrier to students' academic and career prospects

but also hinders the nation's overall development. A primary factor contributing to this challenge is the use of ineffective instructional approaches that fail to foster deep understanding and active participation. Research consistently suggests that ineffective instructional approaches, often characterized by one-way knowledge transmission, contribute significantly to these negative outcomes by leading to decreased student engagement and motivation (Khotimah et al., 2022).

To mitigate these challenges and improve student outcomes, there is an urgent need to explore innovative teaching methods that can actively foster student engagement, cultivate positive attitudes, and ultimately enhance academic achievement. The flipped classroom model emerges as a promising pedagogical approach. It reverses traditional teaching by delivering instructional content (e.g., videos, readings) outside of class, thereby freeing in-class time for interactive activities, discussions, and problem-solving. This approach promotes active learning, student-centered instruction, and personalized feedback, empowering students to take ownership of their learning (Fernández-Martín et al., 2020).

This study specifically focuses on the effect of the flipped classroom approach on senior secondary school students' *achievement* in mathematics within the Federal Capital Territory (FCT), Abuja. It aims to assess whether this innovative method can lead to significantly higher academic performance compared to conventional teaching methods, and to investigate if there are any gender-based differences in achievement within the flipped classroom setting.

Statement of the Problem

The Nigerian educational system faces a significant challenge in mathematics education, characterized by a persistent and concerning rate of student underachievement. This problem, clearly documented by fluctuating and often declining credit pass rates in the WAEC Senior School Certificate Examination, severely limits students' future academic and professional opportunities and, by extension, constrains national development.1 Traditional, teacher-centric instructional methods frequently fail to address the core issues of disengagement and lack of deep understanding which contributed to poor achievement in Mathematics. To tackle this critical issue, there is an urgent need to investigate and implement innovative teaching methods that can actively foster a deeper understanding of mathematical concepts and thereby lead to improved achievement in Mathematics. The flipped classroom approach, which promotes active learning and personalized support, is identified as a potential solution that warrants specific investigation in the context of senior secondary school students in FCT Abuja.

Purpose of the Study

This study aimed to ascertain how flipped classroom approach affects senior secondary school students' achievement in mathematics in FCT Abuja.

Specifically, the study seeks to:

1. Ascertain the effect of flipped classroom approach on secondary school students' achievement in mathematics in FCT Abuja.
2. Find out the effect of flipped classroom approach on male and female secondary school students' achievement in mathematics in FCT Abuja.

Research Questions

The following research questions were formulated to guide this study:

1. What is the difference in the mean achievement score of students taught mathematics with the flipped classroom approach and those taught with the conventional method?
2. To what extent does the mean mathematics achievement scores of male and female students taught with the flipped classroom approach differ?

Hypotheses

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

H_{01}: *There is no significant difference in the mean achievement scores of students taught with the flipped classroom approach and those taught with the conventional method.*

H_{02}: *There is no significant difference in the mean achievement scores between male and female students taught with the flipped classroom approach.*

Literature Review

Flipped classroom approach is a pedagogical model that redefines traditional instruction by shifting content delivery (e.g., lectures) outside of class time, thereby freeing in-class sessions for interactive activities, discussions, and collaborative problem-solving. This approach promotes active, student-centered learning and facilitates personalized feedback. Theoretical underpinnings for this research were drawn from B.F. Skinner's Behaviorism Theory (1953) and Jean Piaget's Theory of Constructivism (1947), both of which align with principles of the flipped classroom model. Piaget's constructivism emphasizes active knowledge construction, while Skinner's behaviorism highlights the modification of behavior through reinforcement, both pertinent to the flipped learning environment.

The flipped classroom approach has garnered significant attention in educational research due to its potential to enhance student learning outcomes. This section summarizes existing research related to the flipped classroom's impact on academic achievement and identifies gaps that this study aims to address. Didem and Özdemir (2018) investigated the impact of a flipped classroom model on students' academic achievement, self-directed learning readiness, and motivation in a "Scientific Research Methods" course. Their quasi-experimental study found significant differences in academic achievement and motivation favoring the flipped classroom group. Similarly, Khadjieva and Khadjikhanova (2019) explored the effects of the flipped classroom on achievement and motivation in Math and English Language among pre-foundation students in Tashkent, concluding significant improvements in both areas for the experimental group. Mubarok, Purnomo, and Widodo (2019) also reported significantly higher writing achievement for Indonesian EFL students in a flipped classroom compared to a control group. Wei, Yang, and

Further studies reinforce these positive trends. Elian and Hamaidi (2021) found a significant positive effect of flipped learning on English language achievement and attitude among eighth-grade students in Jordan. Uy (2022) concluded that the flipped classroom approach was highly effective in improving the academic performance of university students in "Mathematics in the Modern World" in the Philippines. Harmini et al. (2022) similarly reported that a flipped classroom-based mathematical learning model effectively improved student achievement in Multivariable Calculus courses in Indonesia.

While many studies highlight the positive impact on achievement, some also explore gender differences. Gakbish et al. (2021), in a study on GeoGebra software in algebra, found no significant gender difference in achievement. Similarly, Ikwuka and Okoye (2022) found no significant gender difference in academic achievement for CEP students in Basic Methodology using a flipped classroom, though males achieved slightly better. Osuafor and George (2023) observed that flipped classroom instruction via Google Classroom was gender unbiased in chemistry achievement. Kadiri (2024) also revealed no significant effect of gender on the academic achievement of students taught with a flipped classroom in Economics. These findings suggest that the benefits of flipped learning may extend equitably across genders in various subjects.

Conversely, some studies have reported gender-specific differences in other outcomes or contexts. Egara and Mosimege (2024) found a significant gender difference in mean retention scores for

mathematics with blended learning, favoring female students. Chebotib et al. (2022), while showing overall academic achievement was higher in the flipped learning group for biology, also noted significant gender differences in scores within the study group. Kutigi (2022) investigated gender differentials in Oral-English and found that the flipped classroom performed better irrespective of gender, and retention was high without discrimination.

Despite the growing body of literature, specific investigations into the comprehensive impact of the flipped classroom on mathematics achievement, particularly among senior secondary school students in the Nigerian context, remain crucial. This study aimed to contribute to this body of knowledge by rigorously examining the flipped classroom's effect on mathematics achievement among SSII students in FCT Abuja, while also specifically assessing gender-based differences in this outcome.

Methodology

The study employed a quasi-experimental design, specifically a pretest-post-test non-equivalent control group design. This design was deemed appropriate as it allowed for the use of intact classes, minimizing disruption to the existing school structure. This approach addressed potential internal validity threats related to initial group equivalence, as pre-test scores were used as a covariate. The experimental group (EG) received instruction via the flipped classroom approach, while the control group (CG) was taught using the conventional method. A pre-test (O1) was administered to both groups to establish baseline knowledge, followed by a ten-week intervention (X1 for EG, X0 for CG), and then a post-test (O2) to measure the effectiveness of the intervention.The target population for this study comprised 23,920 Senior Secondary School Two (SSII) students enrolled in 30 public senior secondary schools within the Abuja Municipal Area Council (AMAC), FCT Abuja, Nigeria, during the 2024/2025 academic year. SSII students were selected as they are in a relatively stable academic period, not directly preparing for high-stakes external examinations, making them suitable for an innovative instructional approach. A sample of 107 SSII mathematics students was purposively selected from two co-educational public secondary schools in AMAC. The selection criteria for schools included: reliable internet access for students, a minimum of five years of WAEC/NECO graduates (indicating established academic environments), availability of appropriate classroom technology (e.g., projectors, screens), and similar operating conditions. A simple balloting procedure was used to assign one school to the experimental group and the other to the control group, ensuring unbiased allocation. The experimental group consisted of 53 students (25 male, 28 female), and the control group comprised 54 students (28 male, 26 female). The primary instrument for data collection was the Mathematics Achievement Test (MAT**)**. This researcher-developed test consisted of 30 multiple-choice questions with four options (A-D), derived from past National Examinations Council (NECO) questions. A table of specifications guided the construction of the MAT, ensuring questions covered both lower-order (knowledge, comprehension, application) and higher-order (analysis, synthesis, evaluation) cognitive domains, aligned with the senior secondary school mathematics curriculum. Each correct answer was awarded two marks, totaling 60 marks. The pre-test and post-test versions of the MAT had reshuffled items to prevent test-wiseness. A pilot test conducted with 20 students (excluded from the main study) confirmed the clarity and readability of the items. The reliability of the MAT was determined using the Kuder-Richardson formula, yielding a coefficient of 0.83, indicating satisfactory internal consistency. The MAT was administered as a pre-test to both experimental and control groups to determine their initial entry-level knowledge in mathematics. This was followed by a ten-week intervention period. Regular mathematics teachers, who received training from the researcher on the respective instructional methods, delivered the lessons according to the prepared lesson plans. The experimental group was taught using the flipped classroom approach, while the control group utilized the conventional teaching method. Immediately after the ten-week treatment, the MAT was administered as a post-test to measure the relative effectiveness of the flipped classroom on

students' mathematics achievement. The collected data were analyzed using the Statistical Package for Social Science (SPSS) software. Descriptive statistics, including mean and standard deviation, were used to summarize the data. Inferential statistical techniques, specifically one-way and two-way Analysis of Covariance (ANCOVA), were employed to test the null hypotheses. ANCOVA was chosen for its suitability in comparing group means while statistically controlling for the influence of the pre-test scores (covariate). All hypotheses were tested at a significance level of $p<0.05$.

Results

This section presents the findings of the study, focusing on the effect of the flipped classroom on secondary school students' achievement in mathematics and examining potential gender differences within the flipped classroom group.

Research Question One: What is the difference in the mean achievement score of students taught mathematics with the flipped classroom approach and those taught with the conventional method?

Table 1: Mean and Standard Deviation of Achievement Scores of Students Taught Mathematics with a Flipped Classroom and the Conventional Method

Group	Sample Size(N)	Pre-test Mean	Pre-test Std dev	Post-test Mean	Post-test Std dev	Mean Difference
Experimental	53	29.35	7.04	48.91	5.80	19.56
Control	54	27.59	8.00	43.96	9.69	16.37

Table 1 clearly illustrates that the flipped classroom method positively impacts students' mathematics achievement. The experimental group, taught using the flipped approach, saw their mean achievement score jump from 29.35 (SD=7.04) on the pre-test to 48.91 (SD=5.80) on the post-test, yielding a significant mean difference of 19.56. In comparison, the control group, taught conventionally, also improved from a pre-test mean of 27.59 (SD=8.00) to a post-test mean of 43.96 (SD=9.69), but their mean difference was lower at 16.37. This larger mean difference for the experimental group (19.56 vs. 16.37) strongly indicates that the flipped classroom approach led to a more substantial improvement in mathematics achievement compared to conventional teaching methods

Research Question Two: To what extent does the mean mathematics achievement scores of male and female students taught with flipped classroom approach differ?

Table 2: Mean and Standard Deviation of Achievement of Male and Female Students Taught Mathematics with a Flipped Classroom

Group	(N)	Pre-test Mean	Pre-test Std dev	Post-test Mean	Post-test Std dev	Mean Difference
Male	25	29.58	7.04	49.20	5.23	19.62
Female	28	29.14	7.21	48.64	6.35	19.50

Table 2 presents the effect of the flipped classroom on male and female student achievement at post-intervention, showing positive results for both genders. At the post-test, male students achieved a mean score of 49.20, while female students achieved a mean score of 48.64. When we look at the mean difference male students showed a difference of 19.62, slightly higher than the 19.50 mean gain for female students. Both the post-test mean scores and the mean difference indicate that male students achieved slightly higher than female students in mathematics after the flipped classroom intervention.

Test of Hypotheses

H_{01}: *There is no significant difference in the mean achievement scores of students taught with the flipped classroom approach and those taught with the conventional method.*

Table 3: ANCOVA Results of Achievement Scores of Students Taught Mathematics with Flipped Classroom and Those Taught with Conventional Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	688.906	4	344.453	5.359	.006
Intercept	15899.085	1	15899.085	247.346	.000
Pretest	35.454	1	35.454	.552	.459
Method	682.863	1	682.863	10.623	.002
Error	6685.000	104	64.279		
Total	237852.000	107			
Corrected Total	7373.907	106			

The ANCOVA results (Table 3) for the "Method" factor yielded an F-value of 10.623 with 1 degree of freedom, and a significance (p-value) of .002. As $p<0.05$, the null hypothesis was rejected. This indicates a statistically significant difference in the mean post-test mathematics achievement scores between students taught using the flipped classroom and those taught using the conventional method, even after controlling for their initial achievement levels.

H_{02}: *There is no significant difference in the mean achievement scores between male and female students taught with the flipped classroom approach.*

Table 4: ANCOVA Analysis of Achievement Scores of Male and Female Students Taught Mathematics with Flipped Classroom

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	858.797	4	214.699	3.361	.013
Intercept	15806.659	1	15806.659	247.468	.000
Pretest	76.781	1	76.781	1.202	.275
Method	690.139	1	690.139	10.805	.001
Gender	55.683	1	55.683	.872	.353

Method* Gender	116.443	1	116.443	1.8233	.180
Error	6515.109	102	63.874		
Total	237852.000	107			
Corrected Total	7373.909	106			

The ANCOVA results for the "Gender" factor (Table 4) yielded an F-value of 0.872 with a significance (p-value) of .353. Since p>0.05, the null hypothesis was not rejected. This indicates that there is no statistically significant difference in the mean mathematics achievement scores between male and female students who were taught using the flipped classroom approach.

Discussion of Findings

The findings of this study robustly demonstrate that the flipped classroom approach significantly enhances secondary school students' achievement in mathematics in FCT Abuja. The observed substantial mean difference in achievement scores for the experimental group (19.56) compared to the control group (16.37) (Table 1) provides strong empirical support for the efficacy of this instructional approach. This outcome aligns with a growing body of literature that highlights the positive academic impact of flipped learning environments (e.g., Egara & Mosimege, 2024) The enhanced achievement can be attributed to the fundamental pedagogical shift inherent in the flipped classroom: by moving content delivery outside of class, valuable in-class time is liberated for active learning, collaborative problem-solving, and personalized teacher-student interaction. This active engagement fosters deeper conceptual understanding and application of mathematical concepts, which is often a challenge in traditional, passive learning settings.

Furthermore, a significant finding of this study is the absence of a statistically significant difference in mathematics achievement between male and female students taught using the flipped classroom (Table 4). This result suggests that the flipped classroom approach serves as an equitable instructional strategy, promoting comparable academic achievement for both genders in mathematics. This finding contributes to the debate on gender disparities in STEM education by demonstrating a context where such differences are not pronounced. It resonates with other studies that have found gender neutrality in achievement within innovative teaching contexts (e.g., Kadiri, 2024; Ikwuka & Okoye, 2022). The equitable impact on achievement is likely due to the inherent flexibility of the flipped classroom, which allows students to engage with pre-class content at their own pace, potentially reducing performance anxiety and accommodating diverse learning styles. The collaborative and supportive in-class environment further ensures that all learners, irrespective of gender, receive targeted support and opportunities for active participation, thereby mitigating potential gender-based stereotypes or expectations in mathematics.

Conclusion

Based on the empirical findings of this study, the flipped classroom approach is concluded to be an effective instructional approach for significantly improving secondary school students' achievement in mathematics. This model successfully fosters a learning environment conducive to higher academic performance. Critically, the study also concludes that the flipped classroom promotes equitable educational outcomes, as no significant gender difference was observed in mathematics achievement among students exposed to this instructional method. This suggests its strong potential to create a more inclusive and supportive learning environment for all students in mathematics.

Recommendations

Based on the study's findings, the following recommendations are put forth:

1. **For Mathematics Teachers:** Given the clear improvement in mathematics achievement, it is strongly recommended that mathematics teachers in Senior Secondary Schools adopt the flipped classroom model. Training and resources should be provided to facilitate their effective implementation of pre-class content delivery and interactive in-class activities.
2. **For School Administrators and Curriculum Planners:** School administrators and curriculum developers should actively encourage and integrate the flipped classroom approach into the mathematics curriculum. This necessitates investing in technology infrastructure and providing continuous professional development opportunities for teachers.
3. **For Educational Policymakers:** Policymakers should advocate for the widespread adoption of the flipped classroom model across secondary schools, particularly in subjects like mathematics where enhancing achievement is a priority. Policy support should include provisions for essential resources and teacher training programs.

References

1. Chebotib, L. C., Okere, M., & Amukowa, D. (2022). Effect of flipped learning approach with the aid of a computer-based collaborative concept mapping to foster meaningful learning and creativity in Biology instruction in secondary schools in Uasin Gishu County, Kenya. *Journal of Education and Practice, 13(16), 11–25*. https://files.eric.ed.gov/fulltext/EJ1342676.pdf
2. Didem, İ., & Özdemir, G. (2018). The effect of a flipped classroom model on students' academic achievement, self-directed learning readiness, and motivation. *Journal of Education and Learning, 7(2), 25–34*. https://doi.org/10.5539/jel.v7n2p25
3. Egara, A. O., & Mosimege, M. (2024). How blended learning affected secondary school students' achievement and retention in mathematics. *Eurasia Journal of Mathematics, Science and Technology Education, 20(1), em2378*. https://doi.org/10.29333/ejmste/14022
4. Elian, M., & Hamaidi, D. A. (2021). The effect of using the flipped learning strategy on the development of achievement and the trend towards it among eighth grade students in the English language subject. *Journal of Educational and Psychological Sciences, 5(2), 1–20.* https://www.sja.journals.ekb.eg/article_162386.html
5. Fernández-Martín, F., Hernández-Pérez, P., & Peinado, M. R. (2020). Flipped classroom model: Benefits, challenges and new trends in higher education. Springer. https://link.springer.com/chapter/10.1007/978-3-030-41031-6_1
6. Gakbish, R. L., Mang, J. G., & Akusobi, P. A. (2021). Effect of Geogebra software on senior secondary students' academic achievement in algebra in Pankshin LGA of Plateau State. *Journal of Education and Practice, 12(35), 7–14.* https://files.eric.ed.gov/fulltext/EJ1325141.pdf
7. Harmini, S., Suryanto, A., & Widodo, A. (2022). Acceptance of a flipped classroom to improve university students' learning: An empirical study on the TAM model and the unified theory of acceptance and use of technology (UTAUT). *Frontiers in Psychology, 13, 9816777*. https://doi.org/10.3389/fpsyg.2022.9816777
8. Ikwuka, E. C., & Okoye, C. O. (2022). Differential effects of flipped classroom and gender on academic achievement of CEP students in Basic methodology in Nigerian federal universities. *Journal of Educational Policy and Management,* 7(1), 1–10. https://www.researchgate.net/publication/359672688_

9. Kadiri, S. O. (2024). Effect of integrating social-media platforms into teaching-learning activities in colleges of education through the use of flipped classrooms on students' academic achievement in economics. *Journal of Education and Practice, 15(2), 1–10*. https://files.eric.ed.gov/fulltext/EJ1412034.pdf

10. Khadjieva, R., & Khadjikhanova, N. (2019). The effects of flipped classroom strategy on students' achievement and motivation to learn Math and English language among pre-foundation students at Westminster University in Tashkent. *European Journal of Training and Development, 43(7/8), 705–720*. https://doi.org/10.1108/EJTD-06-2019-0104

11. Khotimah, S. A., Nanda, B. Y., & Pujiastuti, Y. (2022). Academic interest determines the academic performance of undergraduate accounting students: Multinomial logit evidence. Cogent Business & Management, 9(1), 2101326. https://doi.org/10.1080/23311975.2022.2101326

12. Kutigi, A. B. (2022). Gender differentials in the use of flipped classroom instructional models in enhancing achievement and retention in Oral-English contents of senior secondary school in Minna, Niger state, *Nigeria. Journal of Education and Practice, 13(28), 1–12*. https://files.eric.ed.gov/fulltext/EJ1358908.pdf

13. Mubarok, A., Purnomo, S., & Widodo, H. P. (2019). The effect of flipped classroom model on Indonesian EFL students' writing achievement across cognitive styles. Journal of English Language Teaching and Linguistics, 4(2), 211–224. https://doi.org/10.22236/jetll.v4i2.3392

14. Osuafor, A. M., & George, C. U. (2023). Effect of flipped classroom instruction via Google classroom on secondary school students' academic achievement on chemistry in Onitsha educational zone. *International Journal of Research and Innovation in Social Science (IJRISS), 7(11), 1–10*. https://doi.org/10.47772/IJRISS.2023.71100

15. Uy, E. P. (2022). Effectiveness of flipped classroom approach on the academic performance of students in mathematics in the modern world. *International Journal of Research Publications, 107(1), 1–10*. https://doi.org/10.47119/IJRP1071191220221376