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Retaining mathematical momentum: Investigating the impact of flipped classroom model on mathematics retention among senior secondary school students

Akorede Ayoola Asanre*
University of Zululand,
SOUTH AFRICA

Sondlo Aviw
University of Zululand,
SOUTH AFRICA

Abdullateef A. Adedeji
Tai Solarin University of Education,
SOUTH AFRICA

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Abstract

Background: This study investigates the impact of the flipped classroom model on the retention of mathematical concepts among senior secondary students in Ogun State, Nigeria, with attention to gender-based differences.
Aim. The study aims to examine both the main and interaction effect of strategies (flipped classroom model and conventional approach) and gender on the retention of secondary school students in mathematics in Ogun State, Nigeria. Having in mind to retain mathematical momentum within secondary school students in Ogun State.
Method. Employing a quasi-experimental, non-equivalent control group design, the study compared retention scores between an experimental group and a control group. Fifty-four Senior Secondary School II students were selected from two schools. Data was collected through pre-tests, post-tests, and delayed post-tests using the Mathematics Retention Test (MRT) with the reliability coefficient of 0.74. Analysis of Covariance (ANCOVA) was used to analyze the data.
Results. The outcomes showed that students in the flipped classroom model had much better retention scores than those in conventional environments, therefore underscoring the success of the flipped model in encouraging long-term retention. Furthermore, results revealed that the approach helped male and female students equally; there was no appreciable relationship between gender and retention results. These findings highlight the possibilities of the flipped classroom as an inclusive and successful teaching tool to improve mathematical retention.
Conclusion. The study concluded that the flipped classroom approach improves mathematical retention in Ogun State, Nigeria, without allowing any gender gap. Adopting the flipped classroom model will help schools in Ogun State optimize their advantages for different student groups by means of teacher preparation and digital resource support.

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INTRODUCTION

Mathematics holds a central place in Nigerian education, spanning from primary to secondary levels due to its critical role in developing analytical, problem-solving, and logical reasoning skills (Ogunsola et al., 2021). Asanre et al. (2024) further emphasize that mathematics fosters creativity and critical thinking, while Asanre and Chinaka (2024) highlight its significance across essential sectors such as engineering, economics, and technology, thereby reinforcing its contribution to Nigeria's socio-economic progress. Nonetheless, despite this prominence, many students struggle to retain mathematical concepts over time, which undermines long-term academic achievement and preparedness for quantitative careers (Ibrahim & Maruta, 2022).

Retention—the ability to recall and apply previously learned concepts—is vital in mathematics, as it supports the progression to more complex topics. In Nigeria, traditional teacher-centered approaches that emphasize rote memorization and passive learning dominate, limiting

* **Corresponding author:**
Akorede Ayoola Asanre, University of Zululand, SOUTH AFRICA
AsanreA@unizulu.ac.za

opportunities for students to meaningfully engage with content (O. a. Adeneye Awofala & Fatade, 2023). These methods contribute to low retention levels, as students quickly forget material after assessments due to limited application and active involvement (Ogunsola et al., 2021; VaraidzaiMakondo & Makondo, 2020). To overcome this challenge, educators are increasingly advocating for student-centered strategies that encourage active learning and deeper cognitive engagement (Abdullahi & Sirajo, 2022). Cognitive Load Theory also emphasizes that effective retention requires learning materials to be presented in ways that minimize extraneous processing and promote schema construction (Sweller, 2011).

Among these, the flipped classroom model offers a promising alternative by reversing the conventional learning structure. Students first engage with instructional materials, such as recorded lectures, outside class, allowing them to learn at their own pace (Izadpanah, 2022). Class time is then dedicated to interactive, problem-based tasks that reinforce comprehension through collaborative application (Rafon & Mistades, 2020; Strelan et al., 2020). Studies in developing countries also show improved retention using flipped models in mathematics-related courses (Zainuddin & and Perera, 2019).

Gender has emerged as a critical factor in mathematics education, influencing students' engagement and performance. Cultural norms, confidence levels, and learning preferences often lead to differentiated responses to instruction among male and female students (Egara & Mosimege, 2024). In Nigeria, where gender biases may limit participation, evaluating how the flipped classroom model affects both genders is crucial. Research indicates that such student-centered environments can reduce gender disparities by offering inclusive, flexible learning experiences (Makinde, 2020; Sulaimon & Manditereza, 2024). For example, female students facing higher anxiety or lower self-efficacy may benefit from the ability to review content privately, while male students may adapt well to collaborative in-class learning (Jensen et al., 2018; Lo & and Hew, 2020; Mashuri & Yawan, 2023). Meta-analytic evidence shows flipped classrooms support both genders equitably in STEM fields (van Alten et al., 2019)

Given the limitations of traditional teaching and persistent retention issues, the flipped classroom model presents a scalable and resource-efficient approach suitable for contexts like Ogun State, Nigeria, where educational resources are limited (Mohammed et al., 2023). This model not only supports individualized learning but also fosters gender inclusivity through structured engagement and cooperative learning.

This study, therefore, investigates the effectiveness of the flipped classroom model on the retention of mathematical concepts among senior secondary school students in Ogun State, with particular attention to gender-based differences. While prior research has focused largely on short-term academic achievement, little is known about the flipped model's impact on long-term retention or its differential effects across genders. This study aims to address these research gaps by providing empirical insights into how flipped learning supports sustained mathematical understanding and promotes inclusive education (Egara & Mosimege, 2024; Eze, 2023; Mohammed et al., 2023). By examining retention outcomes over time and comparing male and female students' performances, the study seeks to offer practical recommendations for mathematics educators and policymakers aiming to foster equitable and enduring learning experiences.

METHOD

Research Design

This study adopted a quasi-experimental, non-equivalent control group design to investigate the impact of the flipped classroom model on students' mathematics retention. Two groups were involved: the experimental group received instruction via the flipped classroom model, while the control group was taught through conventional methods. A pre-test and two post-tests (immediate

and delayed) were administered to assess both short- and long-term retention. This design enabled a comparative analysis of teaching effectiveness across groups.

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The flow diagram in Figure 1 presents the conceptual sequence of this quasi-experimental study, showing the progression from group assignment based on instructional strategy and gender, through the testing phases, and finally to the measurement of retention outcomes

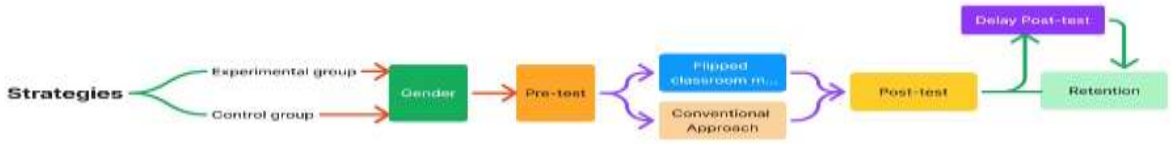

Figure 1. Flow diagram for Retention in Flipped Classroom Model

Participants

The population comprised Senior Secondary School II (SSS II) students in Ijebu-Ode Local Government Area, Ogun State, Nigeria. These students were selected as they had prior exposure to key mathematics concepts but were not yet involved in external examinations. Using purposive sampling, two private schools were chosen based on access, availability of qualified mathematics teachers, and readiness to implement flipped instruction. One class from each school participated, resulting in 54 students (27 in each group) with an even distribution of male and female students.

Instrument

Two instruments were utilized: the Flipped Classroom Package (FCP) and the Mathematics Retention Test (MRT). The FCP included a sequence of 10–15-minute video lessons aligned with the SSS II mathematics syllabus and was hosted on YouTube. Experimental group students watched these lessons before class and completed related assignments. Classroom sessions were dedicated to collaborative problem-solving. The MRT, adapted from an existing Mathematics Achievement Test, contained 20 multiple-choice questions to assess comprehension, application, and retention. It was administered three times: pre-test, post-test (after instruction), and delayed post-test (two weeks later).

Validity and reliability were ensured through expert review by specialists from Tai Solarin University of Education and secondary mathematics educators. Content and face validity were confirmed, and a split-half reliability test yielded a coefficient of 0.74, indicating strong internal consistency.

Data Analysis

Data analysis involved Analysis of Covariance (ANCOVA), which allowed comparison of retention outcomes while controlling for initial performance differences measured in the pre-test. This method also enabled examination of the interaction between teaching strategy and gender. Ethical considerations were observed throughout the study, including informed consent, confidentiality, and voluntary participation without repercussions.

RESULTS AND DISCUSSION

Results

The results of the study are presented in the tables below:

Research Question One: What are the mean retention scores of secondary school students in mathematics when taught using the flipped classroom model compared to those taught using traditional methods of teaching?

Table 1. Retention Scores for Secondary School Students' Mathematics Achievement in The Experimental and Control Groups

Group	N	Pre-test		Retention-test		Mean Diff.
		Mean	Std. Dev.	Mean	Std. Dev.	
Control	27	12.04	1.743	13.63	1.944	1.59
Experiment	27	12.67	1.797	16.15	2.282	3.48
Total	54	12.35	1.782	14.89	2.455	

In response to the research question regarding the mean retention scores of secondary school students in mathematics when taught using the flipped classroom model compared to traditional methods, Table 1 presents the relevant data. Students in the experimental group, who were taught using the flipped classroom model, had an average pretest score of 12.67 (SD = 1.797) and a mean retention test score of 16.15 (SD = 2.282), resulting in a mean improvement of 3.48 points. Conversely, students in the control group, taught using traditional methods, had a pretest score of 12.04 (SD = 1.743) and a mean retention test score of 13.63 (SD = 1.944), indicating a mean improvement of 1.59 points. Thus, students taught using the flipped classroom model retain more mathematical concepts compared to those taught using traditional teaching methods.

Research Question Two: What are the mean retention scores of male and female secondary school students in mathematics when taught using the flipped classroom model compared to those taught using traditional methods of teaching?

Table 2. Retention Scores of Male and Female Secondary School Students Taught Mathematics Using Flipped Classroom Approach

Gender	N	Pre-test		Retention-test		Mean Diff.
		Mean	Std. Dev.	Mean	Std. Dev.	
Female	15	12.6	1.502	16	2.104	3.4
Male	12	12.75	2.179	16.33	2.570	3.58
Total	27	12.67	1.797	16.15	2.282	

In addressing the research question concerning the mean retention scores of male and female secondary school students in mathematics when taught using the flipped classroom model, Table 2 highlights the relevant data. For students in the experimental group who were taught using the flipped classroom approach, the male students had a mean pretest score of 12.75 (SD = 2.179) and a mean retention test score of 16.33 (SD = 2.570), resulting in a mean difference of 3.58. Female students, on the other hand, had a mean pretest score of 12.6 (SD = 1.502) and a mean retention test score of 16 (SD = 2.104), with a mean difference of 3. The data shows that male students retain more mathematical concepts than their female counterparts when taught using the flipped classroom model.

Table 3. Analysis Of Covariance (ANCOVA) of The Variation in Students' Mathematics Retention Scores Considering the Effect of Treatment, Gender and The Interaction Effect of Gender and Treatment

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	146.519[a]	4	36.630	10.386	.000	.459
Intercept	75.635	1	75.635	21.446	.000	.304
Group	57.188	1	57.188	16.215	.000	.249
Gender	13.490	1	13.490	3.825	.056	.072
Pretest	43.786	1	43.786	12.415	.001	.202
Group * Gender	7.479	1	7.479	2.121	.152	.041
Error	172.814	49	3.527			
Total	12290.000	54				
Corrected Total	319.333	53				

a. R Squared = .459 (Adjusted R Squared = .415)

H_{01}: There is no significant effect of treatment on the retention of mathematics concepts of Secondary School Students.

The analysis presented in Table 3 shows the ANCOVA results comparing the retention scores of secondary school students taught using the flipped classroom approach (experimental group) and those taught using the conventional method (control group). The results indicate a significant effect of treatment on retention of mathematical concepts, $F\ (1, 51) = 16.215, p = 0.000$. Given that the p-value (0.000) is lower than the significance threshold of p < .05, the null hypothesis, which states that there is no significant effect of treatment (flipped classroom) on retention of mathematical concepts, is rejected. The findings conclude that the flipped classroom model significantly impacts the retention of mathematical concepts of secondary school students. Additionally, the partial eta squared value of 0.249 suggests that 24.9% of the variance in students' achievement scores can be attributed to the flipped classroom approach.

H_{02}: There is no significant influence of gender on the retention of mathematical concepts of Secondary School Students

The analysis presented in Table 3 also displays the ANCOVA results comparing retention scores based on gender. The results show no significant influence of gender on retention of mathematical concepts, $F\ (1, 51) = 3.825, p = 0.056$. Since the p-value (0.056) is greater than the significance threshold of p < .05, the null hypothesis, which posits that gender does not significantly affect students' retention of mathematical concept, is accepted. The findings suggest that gender does not have a notable impact on retention. Additionally, the partial eta squared value of 0.072 indicates that 7.2% of the variance in students' retention scores is attributable to gender.

H_{03}: There is no significant interaction effect of treatment and gender on the retention of mathematical concepts of secondary school students.

The analysis in Table 3 also presents the ANCOVA results on the interaction between treatment and gender on retention scores of secondary school students in mathematics. The results, $F\ (1, 49) = 2.121, p = 0.152$, indicate that there is no significant interaction effect between treatment and gender on students' retention scores, as the p-value (0.152) exceeds the significance threshold of $p < .05$.

Discussion

The findings from the research questions reveal key insights into the impact of the flipped classroom model on students' retention in mathematics. Specifically, the first research question's results show that students taught using the flipped classroom model experienced a greater mean improvement in retention scores (3.48 points) compared to those taught through traditional methods (1.59 points). This finding suggests that the flipped classroom model, with its emphasis on self-paced pre-class learning and active in-class application, effectively enhances students' long-term retention of mathematical concepts. By allowing students to engage with content repeatedly and apply it interactively during classroom sessions, the flipped approach supports deeper and more lasting understanding of material. This is also encouraged by the constructivist theory.

The second research question addresses the inclusivity of the flipped classroom model, examining its impact on retention across genders. Findings indicate that, while male students showed a slightly higher mean improvement in retention scores, the flipped classroom model positively impacts retention for both male and female students. This suggests that the model's structure provides a supportive learning environment that benefits all students, fostering effective retention across gender lines. Together, these findings highlight the flipped classroom model's potential to promote sustained retention and equitable learning outcomes in mathematics education.

Building on this, the study's findings further demonstrate that the flipped classroom model significantly enhances students' retention of mathematical concepts, corroborating extensive research on the effectiveness of active learning strategies. Studies by Makinde (2020) and Usman et al. (2020) similarly found that students taught through the flipped model retained information more effectively than those in traditional classrooms. This increased retention is attributed to the active learning elements within the flipped classroom, allowing students to engage with material at their own pace outside of class and then apply it interactively during in-class sessions. Strelan et al. (2020) emphasized that this dual-phase exposure, where students first encounter material independently and later reinforce it collaboratively in class, fosters lasting comprehension. Supporting this, Lo and Hew (2020) noted that the flipped model encourages cognitive engagement with content multiple times, thereby strengthening retention by reinforcing memory connections. Additionally, Jensen et al. (2018), Durojaiye and Oyarinde (2021), and Asanre et al., (2024) found that active learning through problem-solving and interactive activities, central to the flipped classroom approach, promotes retention by enabling students to internalize material more deeply compared to passive learning.

Regarding the role of gender in retention, the study found that the flipped classroom model supports both male and female students equally in retaining mathematical concepts. This finding aligns with Kutigi et al. (2023), who observed that flipped classrooms foster an inclusive environment conducive to equitable retention outcomes across genders. The model's flexibility allows students to learn at a personalized pace outside the classroom, creating a supportive structure that minimizes traditional gender disparities in learning outcomes. Egara and Mosimege (2024) further support this, noting that flipped classrooms encourage balanced engagement for male and female students by promoting a collaborative, inclusive setting. Similarly, Sulaimon and Manditereza (2024) reported that flipped classrooms foster gender inclusivity by enabling both male and female students to engage confidently, leading to comparable retention outcomes across genders.

Finally, the study found no significant interaction effect between the flipped classroom model and gender on retention outcomes, suggesting that the model's effectiveness in enhancing retention is consistent across genders. This result echoes findings by Moqian and Pereira (2022), who emphasized that active learning environments like the flipped classroom create a balanced framework that caters to diverse student needs, fostering equal retention benefits for all. Lo and Hew (2020) further noted that the inclusive, adaptive nature of flipped classrooms allows all students,

regardless of gender, to access learning support equitably, resulting in consistent retention. By minimizing gender-based disparities, the flipped classroom model provides an educational approach where both male and female students can effectively retain mathematical concepts, reinforcing its suitability as a gender-inclusive framework for long-term retention.

Implications

The findings of this study have significant implications for secondary mathematics education in Nigeria and similar contexts. The positive impact of the flipped classroom model on retention, regardless of gender, suggests that incorporating student-centered, technology-enhanced instructional approaches can lead to improved long-term learning outcomes. Educators are encouraged to adopt flipped learning to actively engage students in the learning process, thereby promoting deeper understanding and sustained recall of mathematical concepts. Furthermore, the model's ability to support both male and female students equitably indicates its potential to address gender disparities and foster a more inclusive learning environment.

Limitations

Despite its contributions, this study is not without limitations. First, the sample size was relatively small and limited to two private schools within a single local government area in Ogun State, which may restrict the generalizability of the results to broader populations. Second, the study relied on digital tools hosted on platforms like YouTube, which assumes stable access to internet and devices—conditions that may not be present in all Nigerian schools. Lastly, the study focused solely on short- and medium-term retention without tracking the long-term sustainability of the observed learning gains beyond the 8-week period.

Suggestions

Future research should explore the long-term retention effects of the flipped classroom model beyond the initial post-intervention phase to assess the durability of its impact. Expanding the study to include public schools and larger, more diverse student populations would enhance the generalizability of findings. In addition, comparative studies involving other active learning strategies such as blended learning, inquiry-based learning, or gamification could provide insights into the relative effectiveness of different pedagogical models. Finally, further exploration into how flipped learning can be effectively scaled in resource-constrained environments is recommended, including strategies for addressing infrastructural and technological limitations.

CONCLUSION

Based on the findings of this study, it can be concluded that implementing the flipped classroom model significantly enhances the retention of mathematical concepts among secondary school students in Ogun State. This teaching approach, which combines structured self-paced learning outside the classroom with interactive application during class, provides students with repeated, meaningful engagement with mathematical content, leading to more durable retention and deeper understanding. In Ogun State, where traditional lecture-based teaching methods have often limited students' long-term retention in mathematics, the flipped classroom model offers an innovative solution by fostering a more active and student-centered learning environment. Moreover, it promotes inclusivity by benefiting both male and female students equally, helping to minimize traditional gender-related disparities in mathematics achievement. This is particularly valuable in regions where socio-cultural factors can affect students' participation and confidence, especially among female learners.

Given these findings, it is recommended that schools adopt a strategic approach to implementing the flipped classroom model by providing targeted training for mathematics teachers

and securing resources to support students' access to digital learning materials. This includes the development of high-quality pre-class content such as instructional videos and digital exercises, as well as interactive in-class activities that reinforce learning and promote retention. Collaboration with local governments and private sector partners is essential to improve access to technology through initiatives like communal digital hubs, affordable internet, or device loan programs. Furthermore, regular assessment and feedback from students and teachers should be incorporated to evaluate effectiveness and make necessary adjustments. Policymakers in Ogun State are also encouraged to support this innovation by offering professional recognition and funding incentives to schools and educators implementing the model, ultimately fostering equitable and sustainable improvements in mathematics education.

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AUTHOR CONTRIBUTIONS STATEMENT

All authors contributed substantially to this study. AAA conceptualized the study, designed the methodology, and conducted the data analysis. SA contributed to data collection, literature review, and drafting of the manuscript. AAAd reviewed, edited, and provided critical feedback throughout the writing process. All authors discussed the main and interaction effects of the flipped classroom model and gender on students' retention in mathematics, and jointly finalized the manuscript.

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