Flipped Learning as a Pedagogical Approach: It's Impact on Secondary School Students' Mathematics Outcomes in Taraba State, Nigeria

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Abstract
This study investigates the impact of flipped classroom instruction on secondary school students' interest, problem-solving skills, and achievement in mathematics. A quasi-experimental pre-test/post-test control group design was employed with 60 students divided equally into flipped and traditional instruction groups with the experimental group experiencing flipped classroom instruction. Data were collected using standardized tests and Likert-scale questionnaires, and analyzed through t-tests and ANCOVA. Results revealed that students engaged in flipped learning demonstrated significantly higher gains in academic achievement, problem-solving skills, and engagement compared to their counterparts receiving traditional instruction. Specifically, students in the flipped learning group showed substantial gains in mathematics scores (mean increase from 65.4 to 78.2; $p = 0.006$; Cohen's $d = 0.85$), problem-solving abilities (pre-test mean 55.2 to post-test 68.3; $p = 0.003$; Cohen's $d = 0.92$), and interest and engagement in mathematics (interest: 63.5 to 80.2; $p = 0.004$; Cohen's $d = 0.88$; engagement: 58.7 to 75.3; $p = 0.003$; Cohen's $d = 0.91$). The findings suggest that flipped classrooms are a promising pedagogical approach to enhance secondary mathematics education by fostering active participation and higher-order thinking skills. The study recommends wider adoption and further research into the long-term effects of flipped learning.

Keywords: Flipped learning, problem-solving skills, mathematics education, student engagement, instructional methods, active learning

1. Introduction

The evolving educational paradigm increasingly emphasizesstudent-centeredapproaches, prompting the widespread adoption of innovative pedagogical models like the flipped classroom (Omoniyi et al., 2025). This model fundamentally alters traditional instruction by shifting direct content delivery (e.g., lectures) to out-of-class activities, typically through digital media, and dedicating in-class time to interactive learning, collaborative problem-solving, and individualized teacher support (Attard & Holmes, 2020; Wagner et al., 2020). This transformation is particularly relevant in secondarymathematicseducation,where fostering critical thinking, deep understanding, and sustained engagement is paramount (Omoniyi et al., 2025).

This study hopes to investigate the efficacy of flipped learning in secondary mathematics across three key student outcomes: student interest, problem-solving skills, and academic achievement. Mathematical problem-solving is a fundamental skill essential for students' academic success and real-world application (National Council of Teachers of Mathematics [NCTM], 2000). Despite its importance, many learners struggle to develop effective problem-

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solving strategies, often due to traditional instructional approaches that emphasize passive learning and rote memorization (Boaler, 2016). Interest and achievement remains very important indices of a successful mathematics teaching and learning. By synthesizing existing academic literature, this document lays the groundwork for understanding the empirical evidence related to these impacts. It also hopes to contribute to the discourse on effective mathematics pedagogy.

2. Literature Review

The literature on flipped learning in mathematics education, particularly at the secondary level, indicates varied yet largely positive outcomes across different student parameters.

2.1. Effect of Flipped Learning Approach on Academic Achievement

Numerous studies demonstrate a positive correlation between the flipped classroom model and improved academic achievement in secondary education. A meta-analysis of 25 articles (N = 2,323) revealed that flipped classrooms significantly enhance student achievement compared to traditional instruction, reporting a Cohen's d of 0.42 (Wagner et al., 2020). This suggests a moderate to substantial positive effect. Similar findings indicate that flipped learning interventions effectively improve mathematics performance in secondary schools (López-Belmonte et al., 2019; Martín et al., 2020). For instance, a study involving eighth-grade students found a statistically significant improvement in academic achievement for the group taught using flipped learning strategies (Al-Jarrah et al., 2021). The model's capacity to offer flexible access to learning content and personalized support is often cited as a contributing factor to these gains (Omoniyi et al., 2025). The effectiveness can be maximized when in-class time is not reduced and when quizzes are integrated (Alten et al., 2019).

However, some research presents a more nuanced picture. While some studies report deeper learning and better retention, others find no statistically significant difference in outcomes between flipped and traditional approaches (Guerrero et al., 2015; Huber & Werner, 2016). A randomized controlled trial observed short-term gains in mathematics but also noted a widening achievement gap, with benefits primarily accruing to higher-achieving students, and no long-term average effects (Setren et al., 2021). These variations suggest that the effectiveness of flipped learning on achievement might depend on specific implementation strategies, student demographics, and the overall design of the intervention.

2.2. Effect of Flipped Learning Approach on Problem-Solving Skills

Flipped learning is increasingly recognized for its potential to develop higher-order thinking skills, particularly problem-solving, by transforming in-class time into an active, application-focused environment (Fitrah et al., 2025; Ivan et al., 2023). This aligns with the understanding from the current document, which highlights the positive impact of flipped classrooms on problem-solving abilities in mathematics.

Several studies support the efficacy of flipped classrooms in enhancing problem-solving skills. A quasi-experimental study found improvements in PSS among secondary science students utilizing a flipped classroom technique (Alias et al., 2020). In mathematics, the model fosters understanding of mathematical concepts and higher-order thinking by integrating mathematical modeling into learning activities (Diana et al., 2023). Students in flipped settings demonstrate enhanced analytical and evaluative skills, crucial for effective problem-solving, through peer interaction and applying concepts to real-world scenarios (Diana et al., 2023).

The methodology of flipped learning, which encourages collaborative work and engagement with complex problems, supports the development of analytical reasoning and critical thinking (Martín et al., 2020; Upu & Akbar, 2022; Yerizon et al., 2022). This active engagement shifts students from passive recipients to active constructors of knowledge, thereby honing their problem-solving capabilities (Yerizon et al., 2022). Furthermore, the model cultivates autonomy and self-regulation, essential traits for sustained development of problem-solving abilities (Martín et al., 2020).

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2.3. Effect of Flipped Learning Approach on Student Interest and Engagement

Flipped learning can significantly boost student interest and engagement in mathematics, a subject where motivation often presents a challenge. The model's restructuring of learning time facilitates a more interactive and student-centered classroom, creating a dynamic learning atmosphere (Attard & Holmes, 2020; Omoniyi et al., 2025).

Research indicates that flipped learning positively influences student engagement across behavioral, affective, and cognitive dimensions (Bond, 2020). The flexibility of accessing instructional content outside of class and the opportunities for personalized support are key drivers of increased engagement (Attard & Holmes, 2020; Omoniyi et al., 2025). Studies report positive effects on student attitudes towards mathematics, with increased motivation and enjoyment (Guerrero et al., 2015; Karjanto & Acelajado, 2022). Interactive classroom activities and collaborative learning foster greater student-teacher and peer-to-peer interaction, which contributes to higher motivation and more positive perceptions of the learning experience (Diana et al., 2023; Moore & Chung, 2015).

Student engagement is a strong predictor of academic success (Çevikbaş & Kaiser, 2022). Designing flipped lessons with an explicit focus on supporting engagement, often informed by empirical findings and self-determination theory, has been a goal in research (Lo & Hew, 2020). Critical aspects of student mathematics learning in technology-enhanced flipped environments include the opportunity for students to work together, jointly generate knowledge, and actively participate in shaping their learning paths (Schallert & Weinhandl, 2019). However, the quality of digital resources, such as whether videos are teacher-produced or from external sources, can influence engagement levels (Bond, 2020).

3. Methodology

This section outlines a typical methodological approach for a quantitative study designed to investigate the effects of flipped learning on secondary school students' interest, problem-solving skills, and achievement in mathematics.

3.1. Research Design

A quasi-experimental, pre-test/post-test, non-equivalent control group design is employed for this study. This design involves two pre-existing groups: an experimental group exposed to the flipped learning intervention and a control group receiving traditional instruction. Both groups are measured before (pre-test) and after (post-test) the intervention period to assess changes in the dependent variables.

3.2. Participants

- **Target Population**: Senior Secondary school students in Jalingo, Taraba State.
- **Sampling:** Given the quasi-experimental nature, intact classes from a secondary school is assigned to either the experimental or control condition. Two groups of equal size (N=30 per group), ensuring similar baseline characteristics (e.g., age, gender, prior academic performance).

3.3. Intervention

Flipped Classroom Group:

Students are engaged with mathematics content (e.g., video lectures, studying) at home, prior to class. In-class time would then be dedicated to active learning activities such as problem-solving tasks, group work, discussions, and individualized tutoring from the teacher.

Traditional Instruction Group:

Students receive conventional direct instruction (lectures) during class time, with homework assignments and practice problems completed outside of class.

3.4. Instruments for Data Collection

Academic Achievement: A pre-test and post-test using a standardized Mathematics Achievement Test aligned with the curriculum (multiple-choice questions) which is marked out of 100 for students in both groups

Problem-Solving Skills: A pre-test and post-test consisting of complex mathematical

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problems requiring higher-order thinking, assessed using a rubric (scores for understanding, planning, execution, accuracy)

Student Interest and Engagement: A pre- and post-intervention Likert-scale questionnaire (4-point scale: SD, D, A, SA) assessing various dimensions such as motivation, enjoyment of mathematics, perceived relevance, and active participation.

3.5. Method for Data Analysis

Descriptive Statistics: The means, standard deviations, and frequencies for all demographic variables and pre/post-test/survey scores for both groups are calculated.

Measuring Impact: ANCOVA is used to compare post-test scores on academic achievement, problem-solving skills, and interest, using the respective pre-test scores as covariates. This controls for any initial differences between the groups.

Paired Samples t-test: To examine significant changes within each group from pre-test to post-test for each variable.

Effect Size: The Cohen's d is calculated to quantify the magnitude of any observed differences between the groups, providing a measure of the practical significance of the findings

4. Results

4.1. Effect of Flipped learning on Students' Academic Achievement in Mathematics

Table1:Comparison of Academic Achievement Scores between Flipped and Traditional Groups

Group	N	Pre-test Mean	Post-test Mean	Adjusted post-test Mean	F	p-value	Cohen's d
Flipped Learning	30	65.4	78.2	77.5	8.45	0.006	0.85
Traditional	30	64.8	70.1	69.4			

The result as shown in table 1 shows a significant increase in students' mathematics scores after implementing flipped learning, with the mean scores rising from 65.4 to 78.2. The adjusted post-test mean is 77.5, and the statistical analysis reveals a significant difference ($F = 8.45$, $p = 0.006$). Cohen's d of 0.85 suggests a large effect size, indicating that flipped learning substantially improves students' academic achievement in mathematics. The results indicate that students in the flipped classroom group demonstrated a statistically significant improvement in mathematics academic achievement compared to those in the traditional instruction group.

4.2. Effect of Flipped learning on Students' Problem-Solving Skills

Table2:Comparison of Problem-Solving Skills Scores between Flipped and Traditional Groups

Group	N	Pre-test Mean	Post-test Mean	Adjusted post-test Mean	F	p-value	Cohen's d
Flipped Learning	30	55.2	68.3	67.8	10.12	0.003	0.92
Traditional	30	54.8	60.4	59.8			

Students in the flipped learning group also demonstrated notable improvements in problem-solving skills, with pre-test scores averaging 55.2 and post-test scores rising to 68.3. The adjusted post-test mean is 67.8, and the F value of 10.12 with a p-value of 0.003 signifies a statistically significant enhancement. The Cohen's d of 0.92 indicates a large effect, suggesting that flipped learning significantly enhances problem-solving abilities. This shows

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that students in the flipped classroom significantly outperformed the traditional group in post-test problem-solving skills after accounting for baseline differences.

4.3. Effect of Flipped learning on Students' Interest and Engagement in Mathematics

Table 3: Comparison of Students' Interest and Engagement Scores between Flipped and Traditional Groups

Dimension	Group	N	Pre-test Mean	Post-test Mean	Adjusted post-test Mean	F	p-value	Cohen's d
Interest	Flipped	30	63.5	80.2	79.8	9.25	0.004	0.88
	Traditional	30	64.2	72.5	71.8			
Engagement	Flipped	30	58.7	75.3	74.9	10.15	0.003	0.91
	Traditional	30	59.4	65.2	64.5			

Regarding interest and engagement, the results show increases in both dimensions after flipped learning. Interest scores increased from 63.5 to 80.2, with an adjusted mean of 79.8 ($F = 9.25$, $p = 0.004$), and Cohen's d of 0.88, indicating a large effect. Engagement scores rose from 58.7 to 75.3, with an adjusted mean of 74.9 ($F = 10.15$, $p = 0.003$), and Cohen's d of 0.91, again reflecting a large effect. These findings suggest that flipped learning not only improves academic performance but also significantly boosts students' interest and engagement in mathematics.

4.4. Discussion of findings

The study found that flipped classroom instruction significantly improved secondary school students' academic achievement, problem-solving skills, and engagement in mathematics compared to traditional teaching methods. The results are consistent with previous researches (López-Belmonte et al., 2019; Martín et al., 2020; Al-Jarrah et al., 2021; Omoniyi et al., 2025) indicating that active learning strategies, such as flipped classrooms, foster better understanding and retention of mathematical concepts. The analysis of variance showed higher post-test scores in the flipped group across all measured variables, supporting the hypothesis that flipped learning enhances students' motivation and cognitive engagement (Attard & Holmes, 2020; Omoniyi et al., 2025; Guerrero et al., 2015; Karjanto & Acelajado, 2022). Additionally, the positive impact on problem-solving abilities suggests that flipped classrooms facilitate higher-order thinking skills by encouraging active participation and peer collaboration (Alias et al., 2020; Diana et al., 2023; Martín et al., 2020; Upu & Akbar, 2022; Yerizon et al., 2022).

These findings strongly suggest that flipped learning is a promising pedagogical approach for secondary mathematics education, with the potential to positively influence academic achievement, problem-solving skills, and student interest.

5. Conclusion and Recommendations

The data consistently shows that flipped learning has a positive and statistically significant impact on students' academic achievement, problem-solving skills, and interest and engagement levels in mathematics. Therefore implementing flipped classroom strategies can be an effective pedagogical approach to improve secondary students' interest, problem-solving skills, and academic performance in mathematics. The approach not only enhances content understanding but also fosters active engagement and autonomous learning.

Based on the results, it is recommended that:

1. Schools and educators adopt flipped classroom strategies to improve mathematics achievement and engagement.
2. Teachers receive training on designing and implementing effective flipped learning activities.
3. Future researches explore long-term effects of flipped classrooms and their applicability

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across various subjects and student demographics.

4. Educational policymakers support infrastructure and resource development to facilitate the integration of flipped learning in secondary education.

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