Effects of Inductive and Deductive Teaching Strategies on Oyo State Schools of Science Students' Academic Achievement in Further Mathematics based on Gender

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Abstract
An aspect of research with an inconclusive outcomes overtime is on students' gender. Hence, this study on the Effects of Inductive and Deductive Teaching Strategies on Oyo State Schools of Science Students' Academic Achievement in Further Mathematics based on Gender. Guided by two hypotheses, tested at 0.05 level of significance, quasi-experimental design was employed involving 108 SSII students from three Schools of Science in Oyo State. Students were grouped into Inductive, Deductive and Conventional groups with 42 students; 44 students; and 22 students respectively. Differential and Integral Calculus Achievement Test (DICAT)(KR-20=0.84) was used for data collection and analyzed using Analysis of Covariance (ANCOVA). Results showed that the Inductive Teaching Strategy (Male = 24.99, Female = 24.01, Mean Difference = 0.98, Relative Percentage Gender Gap = 3.92%) minimized gender disparities compared to the Deductive Strategy (Male = 20.58, Female = 19.68, Mean Difference = 0.90, Relative Percentage Gender Gap = 4.37%). The Conventional Method (Male = 27.30, Female = 23.85, Mean Difference = 3.45, Relative Percentage Gender Gap = 12.64%) exhibited the widest gender gap. The main effect of gender was not statistically significant ($F_{(1,105)} = 2.149$, $p > 0.05$), though interaction effects between teaching strategies and gender were observed ($F_{(3,101)} = 1.525$, $p > 0.05$). The study concluded that, Inductive Teaching Strategy enhances academic achievement and reduces gender disparities in Further Mathematics. It recommended adopting Inductive Teaching Strategies and improving teacher training programme to enhance instructional effectiveness.

Keywords: Inductive Teaching Strategy, Deductive Teaching Strategy, Gender, Academic Achievement, Further Mathematics
Word Count: 237

Introduction

Mathematics is one of the fundamental subjects studied at all academic levels and across all scientific disciplines. It serves as the foundation upon which other sciences are built. The rapid evolution of technology and scientific advancements is deeply intertwined with the ever-changing nature of Mathematics, making it an indispensable tool for progress in various fields (Siahaan, 2020). Given its crucial role in shaping the scientific, technological, economic, and social development of nations, Mathematics is regarded as a key driver of innovation and digital transformation (Chinofunga, et. al, 2022). The significance of Mathematics extents to various disciplines and as a core component of school curriculum, Mathematics facilitates the connection between different fields of knowledge and plays a pivotal role in a nation's scientific and economic growth. Without a strong foundation in Mathematics, scientific and technological advancements would be nearly impossible, making its mastery essential for both individual academic progress and national development (Chand et al., 2021).

In the Nigerian education system, secondary school serves as the bridge between primary and tertiary education. Mathematics remains compulsory, while students have the option to take Further Mathematics, particularly those in the sciences (Jennyfer, 2019). Recognizing its importance, Mathematics is one of the compulsory subjects in Nigerian secondary schools, which is divided into two categories at the senior secondary school as General Mathematics and Further Mathematics. General Mathematics is a compulsory subject that all students must take and is a key requirement for admission into universities and other higher institutions in Nigeria. In contrast, Further Mathematics is an advanced subject, primarily offered as optional subject by science students which is being avoided by many students due to the perceived difficulty and abstract nature of its content. It is crucial as it provides a deeper understanding of mathematical concepts and serves as a bridge between secondary and higher-level Mathematics. The subject covers topics such as Calculus, Coordinate Geometry, Matrices, Probability, Statistics, and Mechanics, essential for students pursuing careers in science, engineering, and technology-related fields (Olarewaju et al., 2019; Rajwinder 2017).

Despite the importance of Further Mathematics, many students shy away from it due to misconceptions that it is only meant for exceptionally intelligent students. Often, students need encouragement from teachers and parents to take the subject seriously. The reluctance to study Further Mathematics is compounded by ineffective teaching strategies, which contribute to

fluctuating performance in the subject (Badmus & Jita, 2023; Hillary & Iwok, 2018). In Oyo State, students' performance in General Mathematics and Further Mathematics has fluctuated over the years. The percentage of students who achieved a credit pass or above in the WAEC Senior Secondary Certificate Examination (SSCE) over the past decade are as follows:

General Mathematics: 2013 (30.9%), 2014 (31.4%), 2015 (32.3%), 2016 (41.2%), 2017 (72.8%), 2018 (72.6%), 2019 (45.0%), 2020 (57.0%), 2021 (74.9%), 2022 (78.7%).

Further Mathematics: 2013 (40.0%), 2014 (49.6%), 2015 (54.3%), 2016 (57.4%), 2017 (58.7%), 2018 (60.0%), 2019 (52.0%), 2020 (52.4%), 2021 (74.8%), 2022 (72.1%) (Oyo State May/June WAEC Results Analysis, 2024).

The fluctuating performance in Further Mathematics has been attributed to several factors, including gender disparities, poor teacher quality, lack of motivation, inappropriate peer influence, negative student attitudes, and ineffective teaching strategies (Olarewaju & Yusuf, 2019; Omere, 2019). A typical Further Mathematics class often follows a teacher-centered approach where the teacher solves problems on the chalkboard while students passively take notes. Assignments are given, but there is little room for discussion or immediate feedback. This approach limits students' engagement and contributes to their struggles with the subject (Abdullahi, 2013). To improve teaching and learning outcomes, educators employ various instructional strategies such as lectures, guided discovery, problem-solving, modeling, and simulations. Among these, Inductive and Deductive Teaching Strategies are particularly relevant in the teaching of Further Mathematics (Nguyen & Dung, 2022).

Inductive Teaching Strategy (ITS) allows students to discover mathematical rules by observing patterns and solving examples. It follows a specific-to-general learning process, where students first explore concrete examples before deriving general principles which promotes deeper understanding and better retention of mathematical concepts (Olarewaju et al, 2019; Siswono, Hartono & Kohar, 2020). Deductive Teaching Strategy (DTS) in contrast, follows a general-to-specific learning process. The teacher first presents rules and formulas, and students apply them to solve problems. While this method is effective for direct instruction, it may not always engage students actively in the learning process (Fakomogbon et al., 2014; Mohammad & Moh'd, 2020).

A factor identified as a contributor to students' performance in Further Mathematics is gender disparities which is due to social and cultural beliefs that shape the academic interests of boys and girls from an early age. In traditional Nigerian society, boys are typically encouraged to pursue challenging careers in engineering and technology, while girls are steered toward less technical fields. These stereotypes influence students' choices and participation in subjects like Further Mathematics (Chen & Shelley, 2022; Steegh et al., 2019; Tarfa & Dike, 2022). Considering the identified challenges and disparities in student engagement and achievement in Further Mathematics, this study aimed to investigate the effects of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State, with a specific focus on gender disparities.

Statement of the Problem

Despite the recognized importance of Further Mathematics in Nigerian educational framework, many students particularly girls are reluctant to engage with the subject due to deep-seated misconceptions and cultural biases that suggest it is only suitable for exceptionally talented individuals. Social norms often encourage boys to explore technical disciplines while steering girls away from such subjects, leading to significant gender disparities in participation and performance. While previous studies have identified instructional strategies and gender biases as key factors influencing achievement in Further Mathematics, yet little has been done known to the current researchers in systematic examination of the effectiveness of Inductive and Deductive Teaching Strategies in bridging gender gaps and improving academic performance. This study therefore investigated the effects of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State. Addressing this gap, entitled the study to contribute to the development of more effective teaching strategies and promote equitable participation in Further Mathematics among male and female students.

Aim and Objectives of the Study

This study examined the effectiveness of Inductive and Deductive Teaching Strategies on Senior Secondary School students' academic achievement in Further Mathematics, with a focus on gender differences.

The objectives were to:

i. assess the main effect of gender on senior secondary school students' academic achievement in Further Mathematics.
ii. analyze the interaction effect of inductive teaching strategy, deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.

Hypotheses

The following null hypotheses were tested at the 0.05 level of significance based on the stated objectives:

$H_0$1: There will be no significant main effect of gender on senior secondary school students' academic achievement in Further Mathematics.

$H_0$2: There will be no significant interaction effect of inductive teaching strategy, deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.

Methodology

This study adopted a quasi-experimental design to compare the academic achievement of male and female students taught Calculus concepts using three different teaching strategies: Inductive Teaching Strategy (ITS) (Group A), Deductive Teaching Strategy (DTS) (Group B), and the Conventional Method (Group C-Control Group). The population of the study was 1,604 Senior Secondary School II students from all the seven science-focused schools in Oyo State. A sample of 108 students from three intact classes in three schools of science participated in the study, consisted of 50 males and 58 females. Group A had 42 students (17 male, 25 female) taught with Inductive Teaching Strategy (ITS), Group B had 44 students (22 male, 22 female) taught with Deductive Teaching Strategy (DTS), while 22 students (11 male, 11 female) in Group C were exposed to Conventional Method as the Control Group. A multistage sampling procedure was used to select the three intact classes from three schools of science from each senatorial district in Oyo State. A validated instrument tagged Differential and Integral Calculus Achievement Test (DICAT) was employed for data collection, with a reliability coefficient of 0.84 determined using the Kuder-Richardson (KR-20) formula. The study was conducted over eight weeks, during which

students in the experimental groups (ITS and DTS) and the control group (Conventional Method) were taught Calculus using trained research assistants on the respective teaching strategies. Data collected were analyzed Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Results

$H_0$1: There will be no significant main effect of Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics.

Table 1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	90.680[a]	2	45.340	1.308	0.275	0.024
Intercept	3976.715	1	3976.715	114.766	0.000	0.522
Gender	74.453	1	74.453	2.149	0.146	0.020
Pretest	26.426	1	26.426	0.763	0.384	0.007
Error	3638.311	105	34.651			
Total	60907.000	108				
Corrected Total	3728.991	107				

a. R Squared = 0.024 (Adjusted R Squared = 0.006)

Source: *Fieldwork, 2025*

In table 1, the corrected model yielded an F-value of 1.308 with a significance level (p-value) of 0.275, indicating that the overall model did not significantly explain variations in students' academic achievement. The R-squared value of 0.024 suggests that only 2.4% of the variance in students' posttest scores can be attributed to the independent variables in the model, while the remaining variance is unexplained.

Gender variable specifically had an F-value of 2.149 and a significance level (p = 0.146), which is greater than the 0.05 threshold for statistical significance. This result indicated that there was no statistically significant difference in the posttest mean scores between male and female students in Further Mathematics. The partial eta squared value of 0.020 suggests a minimal effect size, further reinforcing the finding that gender had a negligible influence on students' academic achievement. Additionally, the pretest scores did not significantly impact the posttest results (F =

0.763, p = 0.384), indicating that students' initial performance did not play a major role in their post-intervention achievement. However, the intercept term was highly significant (F = 114.766, p < 0.05), suggesting that factors outside the measured variables influenced students' overall performance. Based on these findings, it can be concluded that gender does not have a significant effect on students' academic achievement in Further Mathematics. This implies that both male and female students performed similarly when exposed to the different teaching strategies.

Table 2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Gender

					95% Confidence Interval		Partial
Parameter	**B**	**Std. Error**	**T**	**Sig.**	**Lower Bound**	**Upper Bound**	**Eta Squared**
Intercept	25.887	2.488	10.406	0.000	20.955	30.820	0.508
[Gender=Female]	-1.680	1.146	-1.466	0.146	-3.953	0.593	0.020
[Gender=Male]	0.000[a]	0.000	0.000	0.000	0.000	0.000	0.000
Pretest	-0.147	0.168	-0.873	0.384	-0.480	0.186	0.007

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2025*

In table 2, the parameter estimated for the influence of gender on students' academic achievement in Further Mathematics was presented. The intercept (B = 25.887, p < 0.05) is significant, indicating that the baseline achievement level, independent of gender and pretest scores, is statistically meaningful. The partial eta squared value of 0.508 suggests a strong effect size for the intercept. The parameter estimate for female students is B = -1.680, meaning that, on average, female students scored 1.680 points lower than their male counterparts. However, this difference is not statistically significant (p = 0.146), as the confidence interval (-3.953 to 0.593) includes zero. This aligns with the ANCOVA results, confirming that gender does not significantly influence students' academic achievement in Further Mathematics. The pretest score (B = -0.147, p = 0.384) also does not have a significant impact on posttest performance, indicating that students' initial achievement levels did not strongly determine their final scores.

Table 3: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Gender

					95% Confidence Interval for Difference[a]	
(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.[a]	Lower Bound	Upper Bound
Female	Male	-1.680	1.146	0.146	-3.953	0.593
Male	Female	1.680	1.146	0.146	-0.593	3.953

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Source: *Fieldwork, 2025*

Table 3 presented the pairwise comparisons between male and female students' academic achievement in Further Mathematics, using Bonferroni adjustment for multiple comparisons. The mean difference between female and male students is -1.680, indicating that, on average, female students scored 1.680 points lower than their male counterparts. However, this difference is not statistically significant (p = 0.146), as the confidence interval (-3.953 to 0.593) includes zero. Conversely, the mean difference for male students compared to female students is 1.680, but it is also not statistically significant (p = 0.146).

$H_0$2: There will be no significant interaction effect of Inductive Teaching Strategy, Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics.

Table 4: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	756.152[a]	6	126.025	4.282	0.001	0.203
Intercept	3276.152	1	3276.152	111.305	0.000	0.524
Pretest	0.142	1	0.142	0.005	0.945	0.000

Strategy	652.605	2	326.302	11.086	0.000	0.180
Strategy * Gender	134.656	3	44.885	1.525	0.213	0.043
Error	2972.839	101	29.434			
Total	60907.000	108				
Corrected Total	3728.991	107				

a. R Squared = 0.203 (Adjusted R Squared = 0.155)

Source: *Fieldwork, 2025*

Table 4 presented the ANCOVA results analyzing the effects of Inductive Teaching Strategy (ITS), Deductive Teaching Strategy (DTS), and Gender on students' academic achievement in Further Mathematics. Teaching Strategy ($p = 0.000$, partial $\eta^2 = 0.180$) had a significant effect on students' achievement. The large partial eta squared value (0.180) suggests that 18% of the variance in students' posttest scores can be attributed to the teaching strategies used. The interaction effect between teaching strategies and gender ($p = 0.213$, partial $\eta^2 = 0.043$) was not significant. This means that the effectiveness of the teaching strategies did not differ significantly between male and female students. Pretest Scores ($p = 0.945$, partial $\eta^2 = 0.000$), indicating that, students' prior knowledge (pretest scores) had no significant effect on their posttest performance. The overall Model ($p = 0.001$, $R^2 = 0.203$, Adjusted $R^2 = 0.155$), explains 20.3% of the variance in students' posttest scores, indicating that while teaching strategies play a significant role, other factors may also contribute to students' academic achievement.

Table 5: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval Lower Bound	Upper Bound	Partial Eta Squared
Intercept	27.155	2.400	11.315	0.000	22.394	31.916	0.559
Pretest	0.011	0.159	0.069	0.945	-0.304	0.326	0.000
[Strategy= Inductive]	-2.311	2.113	-1.093	0.277	-6.503	1.881	0.012
[Strategy=Deductive]	-6.728	1.787	-3.765	0.000	-10.272	-3.183	0.123
[Strategy= Conventional]	0.000[a]	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy= Inductive] * [Gender=Female]	-0.983	2.326	-0.423	0.674	-5.598	3.632	0.002
[Strategy= Inductive] * [Gender=Male]	0.000[a]	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy=Deductive] * [Gender=Female]	-0.896	1.647	-0.544	0.588	-4.163	2.372	0.003
[Strategy=Deductive] * [Gender=Male]	0.000[a]	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy= Conventional] * [Gender=Female]	-3.455	1.706	-2.026	0.045	-6.838	-0.072	0.039
[Strategy= Conventional] * [Gender=Male]	0.000[a]	0.000	0.000	0.000	0.000	0.000	0.000

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2025*

Table 5 presented the parameter estimates for the effects of Inductive Teaching Strategy (ITS), Deductive Teaching Strategy (DTS), Conventional Teaching Strategy (CTS), and Gender on students' academic achievement in Further Mathematics. Students taught using the Deductive Strategy scored significantly lower (B = -6.728, p = 0.000) than those in the Conventional Strategy group. This suggests that while Deductive Teaching Strategy was effective, it was less impactful than the Conventional approach. The Inductive Strategy also showed a negative coefficient (B = -2.311, p = 0.277), though this difference was not statistically significant. The Conventional Strategy was set as the baseline (B = 0.000). There was no significant interaction between gender and teaching strategies (p > 0.05), meaning that the effect of the teaching strategies on academic achievement did not significantly differ between male and female students. However, female students in the Conventional Strategy group performed significantly lower than their male

counterparts (B = -3.455, p = 0.045). Pretest Scores (p = 0.945, B = 0.011): Prior knowledge had no significant impact on students' posttest performance.

The confidence intervals for the Deductive Strategy (-10.272 to -3.183) confirm that the negative effect is statistically significant. The Inductive Strategy and gender interactions had wide confidence intervals that crossed zero, indicating no significant effects. The findings suggest that teaching strategy plays a crucial role in students' academic achievement in Further Mathematics. The Deductive Teaching Strategy resulted in significantly lower achievement compared to the Conventional Strategy, while the Inductive Strategy showed no significant difference. Gender did not significantly moderate the effects of teaching strategies, except in the Conventional group, where female students performed lower than males. This indicates the need for further research into gender-related learning differences and the effectiveness of Inductive and Deductive strategies in teaching Further Mathematics.

Table 6: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

			Std.	95% Confidence Interval	
Gender	**Strategy**	**Mean**	**Error**	**Lower Bound**	**Upper Bound**
Female	Inductive	24.009[a]	1.641	20.754	27.265
	Deductive	19.680[a]	1.157	17.385	21.975
	Conventional	23.848[a]	1.092	21.683	26.014
Male	Inductive	24.992[a]	1.640	21.740	28.245
	Deductive	20.576[a]	1.178	18.240	22.912
	Conventional	27.303[a]	1.322	24.680	29.926

a. Covariates appearing in the model are evaluated at the following values: Pretest = 13.472.
Source: *Fieldwork, 2025*

The mean academic achievement scores of male and female students across the three teaching strategies (Inductive, Deductive, and Conventional) in Further Mathematics was presented in table 6. With Inductive Teaching Strategy (ITS), Female students had a mean score of 24.009 (95% CI: 20.754 – 27.265). Male students scored slightly higher, with a mean of 24.992 (95% CI: 21.740 – 28.245). The small difference suggests that both male and female students performed similarly under the Inductive Strategy. For Deductive Teaching Strategy (DTS), Female students had a mean score of 19.680 (95% CI: 17.385 – 21.975). Male students performed slightly

better, with a mean of 20.576 (95% CI: 18.240 – 22.912). The lower mean scores for both genders indicate that the Deductive Strategy was the least effective of the three strategies. At the Conventional Teaching Strategy (CTS), Female students scored 23.848 (95% CI: 21.683 – 26.014), performing better than their counterparts in the Deductive Strategy group. Male students had the highest mean score of 27.303 (95% CI: 24.680 – 29.926), making them the highest-performing group overall. This suggests that male students benefited more from the Conventional Strategy compared to females. Considering gender comparison across Strategies, in all strategies, male students consistently scored higher than female students. The performance gap was more pronounced in the Conventional Strategy, where males (27.303) significantly outperformed females (23.848).

Inductive Teaching Strategy (Male = 24.99, Female = 24.01, Mean Difference = 0.98, Relative Percentage Gender Gap = 3.92%) minimized gender disparities compared to the Deductive Strategy (Male = 20.58, Female = 19.68, Mean Difference = 0.90, Relative Percentage Gender Gap = 4.37%). The Conventional Method (Male = 27.30, Female = 23.85, Mean Difference = 3.45, Relative Percentage Gender Gap = 12.64%) exhibited the widest gender gap. The Inductive Strategy resulted in the most balanced performance between male and female students, reinforcing its potential as a more inclusive teaching method. The findings highlight that the Inductive and Conventional strategies were more effective than the Deductive Strategy in teaching Further Mathematics. While males consistently outperformed females, the Inductive Strategy minimized gender disparities compared to the other approaches. These results suggest that educators should consider adopting Inductive Teaching Strategies to enhance both male and female students' academic achievement in Further Mathematics.

Discussion of Findings

The findings of this study revealed that there was no significant main effect of gender on Senior Secondary School Students' Academic Achievement in Further Mathematics. This result suggests that both male and female students performed comparably in Further Mathematics. These results align with Rajwinder (2017), who found that while there was a significant difference in students' achievement when comparing the inductive method with the traditional method, and the deductive method with the traditional method, no significant difference was observed between the inductive and deductive methods themselves. However, this result was at variance with Abdullahi (2013) who examined the impact of teaching methods, gender, and school location on students'

performance in Mathematics in Kano State, where the results indicated that male students outperformed their female counterparts. In Fakomogbon et al (2014), it was also found that gender played a crucial role in science education, particularly in technological development, showing that male students performed better in Further Mathematics when taught using Computer-Assisted Instruction (CAI).

In another study by Olarewaju and Yusuf (2019) analyzed students' achievement in WASSCE and NECO SSCE Further Mathematics examinations from 2007 to 2016 in Kwara State, it was revealed that male students consistently performed better than females in Further Mathematics: In WASSCE, 54.13% of male students obtained credit in Further Mathematics, compared to 45.20% of female students. In NECO, 56.13% of male students earned credit, while only 38.39% of female students achieved the same. These statistics suggest that male students consistently outperformed female students in Further Mathematics in that study. The findings of the present study, indicated that both inductive and deductive teaching strategies can be effective in teaching Further Mathematics, but neither holds a clear advantage over the other when gender is considered. This implies that the choice of teaching method should be based on factors such as the nature of the topic, students' learning styles, and instructional objectives, rather than gender differences.

Conclusion

This study found that Inductive and Conventional Strategies were more effective than the Deductive Strategy in Further Mathematics. Inductive Strategy (Male = 24.99, Female = 24.01) minimized gender disparities, whereas the Deductive Strategy (Male = 20.58, Female = 19.68) showed a wider gap. While males outperformed females across all strategies, the Inductive Strategy promoted better gender balance. The findings highlight the need for Inductive Teaching Strategies to enhance students' understanding of Calculus and reduce gender performance gaps in Further Mathematics.

Recommendations

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

1. Implement Inductive Teaching Strategy to enhance students' understanding and bridge gender gaps in Further Mathematics.
2. Train Mathematics *Teachers* on effective instructional strategies to improve student engagement and performance.

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