Evaluating the Effectiveness of the Flipped Classroom Approach on Junior High School Students' Mathematics Performance in Ghana

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ABSTRACT

The mathematics curriculum for pre-university students in Ghana necessitates the application of mathematical concepts in practical, real-world contexts. The ability of students to translate word problems into mathematical equations and resolve them has consistently raised concerns. Results from the Chief Examiner of the Basic Education Certificate Examination (BECE) for 2007, 2011, and 2012 reveal that students encounter challenges in comprehending and resolving word problems in algebra, specifically linear equations. Reports from 2020, 2021, and 2023 indicate that students continue to experience challenges in word problems, implying that the issues remain despite efforts to improve mathematics education. Therefore, this study investigates the effectiveness of the flipped classroom model in enhancing the academic outcomes of mathematics students in Cape Coast, considering the existing challenges. A quasi-experimental design was employed, involving two groups: an experimental group taught using the flipped classroom model and a control group taught through conventional methods. Data were collected using achievement tests administered before and after the intervention. The data was analysed using Mann-Whitney U. The results revealed that students who were exposed to the flipped classroom approach performed significantly better in mathematics than their counterparts in the control group. The findings suggest that the flipped classroom strategy enhances student academic performance. Therefore, this study recommends integrating the flipped classroom model into the mathematics curriculum to foster deeper understanding and boost achievement, especially in contexts where traditional teaching dominates.

Keywords: flipped, Pre-class activities, in-class activity, traditional approach

INTRODUCTION

Mathematics plays an integral role in the curriculum of Ghanaian educational institutions. It cultivates logical reasoning, creative thinking, and problem-solving skills, empowering students with essential tools and cognitive adaptability to tackle diverse and complex issues. The Ghanaian education system strives to produce students who are not only academically capable but also socially and ethically equipped to address critical local and global challenges. This goal is supported by a comprehensive curriculum that seamlessly integrates mathematics with related disciplines (Ministry of Education, 2020). To realise these educational aspirations, innovative teaching approaches, such as the flipped classroom model, have been introduced to improve student engagement and academic achievement, particularly in mathematics. The syllabus emphasises the use of guided discovery and other student-centred methods as key frameworks for teaching at the basic school level, ensuring alignment with the educational objectives set forth by the Ministry of Education (Ministry of Education, 2020). Despite these efforts, teachers commonly employ the traditional teaching method for instruction across all educational levels, from primary to tertiary (Nyagblormase, Yaayin, and Hanson, 2023), which often results in students being passive participants in the learning process. This approach has faced criticism for its teacher-centred methods, depicting the instructor as the "sage on the stage" (Morrison, 2014). This approach positions the teacher as the central authority on knowledge, potentially constraining student engagement and critical analysis. Research increasingly supports alternative teaching methods that emphasize the learner's role in knowledge construction.

The flipped classroom method is a learner-centred pedagogical strategy based on the constructivist framework, as highlighted by the current mathematics curriculum. The flipped classroom model requires students to interact with instructional materials, including video lectures or readings, before attending class. Class time is allocated for practical activities, problem-solving, and discussions, which enhance comprehension and application of knowledge. The flipped classroom approach fosters an interactive and participatory learning environment, enhancing student ownership of learning and advancing critical thinking skills. The shift towards a learner-centred approach aligns with the goals of modern education, which seeks to prepare students for the complexities of the 21st century. Previous research has shown its capacity to markedly improve academic outcomes. (Moormann, Voorhees, Jundt, & Ziemann, 2015) documented significant academic improvements in middle and high school students in the United States after implementing the flipped classroom model. Peterson (2016) conducted a quasi-experimental study that demonstrated that the flipped classroom approach was more effective than traditional teaching methods in improving academic success. (Mensah, Yeboah, & Adom, 2017) compared traditional and flipped classroom approaches, concluding that the flipped learning method was more effective than the conventional teaching method. Sezer (2017) argues that the flipped classroom model improves student accountability, personalises the learning experience, and transforms the teacher's role into that of a facilitator. The flipped classroom model's implementation promotes the advancement of 21st-century competencies (Santos & Serpa, 2020; Cabı, 2018). In Ghana, Mensah, Yeboah, & Adom (2017) reported that 96% of students utilising the flipped classroom approach attained scores surpassing the average grade of five. The existing research regarding the influence of the flipped classroom model on the academic performance of mathematics students in Ghana, especially at the Junior High School (JHS) level, is significantly inadequate. The existing literature predominantly examines pre-service teachers (Nyagblormase, None, & Hanson, 2023; Aidoo Macdonald, Vesterinen, Pétursdóttir, & Gísladóttir, 2022) and student performance in disciplines outside of mathematics, especially at the senior high school level. This gap underscores the necessity for additional research on the efficacy of this instructional strategy in enhancing mathematics outcomes in junior high schools. This investigation may yield significant insights regarding the influence of the flipped classroom model on student learning and engagement in mathematics for junior high school students.

Mathematics, particularly algebra, provides a foundational framework for progress in economics, science, and technology. A mathematics curriculum centred on problem-solving emphasises the practical application of mathematical principles in real-world scenarios. Word problems, presenting mathematical challenges in narrative rather than symbolic form, are fundamental to this methodology. The mathematics curriculum for pre-university students in Ghana necessitates the application of mathematical concepts in practical, real-world contexts (Baah-Duodu, Ennin, Borbye, & Amoaddai, 2019). The ability of students to translate word problems into mathematical equations and resolve them has consistently raised concerns. Results from the Chief Examiner of the Basic Education Certificate Examination (BECE) for the years 2007, 2011, and 2012 (West Africa Examinations Council), reveal that students encounter challenges in comprehending and resolving word problems in algebra, specifically linear equations. Reports from 2020, 2021, and 2023 (West Africa Examinations Council), indicate that students continue to encounter challenges in word problems, implying that the issues remain despite efforts to improve mathematics education. Therefore, this study investigates the efficacy of the flipped classroom model in enhancing the academic outcomes of mathematics students in Cape Coast, considering the existing challenges. This research objective investigated the effectiveness of the flipped classroom in improving students' performance in mathematics

METHODS

A quasi-experimental design was adopted to evaluate the impact of the flipped classroom approach on students' mathematics performance, without the use of random assignment (Maciejewski, 2020). Students were allocated to control and experimental groups based on existing classroom structures, providing a practical framework for investigating the effects of the intervention. Although quasi-experimental studies share similarities with true experimental designs, they lack randomisation and instead aim to establish a cause-and-effect relationship between the independent and dependent variables (Lim & Loh, 2019).

The study was carried out in Cape Coast, within the Cape Coast Municipality. A convenience sampling technique was employed to select a Junior High School (JHS), taking into account logistical considerations and

the school's readiness to participate. The research targeted Form Two students, focusing specifically on solving word problems involving linear equations. The selected school had two streams, one assigned as the experimental group and the other as the control group, comprising a total of 61 students. Informed consent was obtained from all participants prior to the intervention.

Data collection was conducted systematically to uphold methodological rigour. A pre-test consisting of 10 multiple-choice questions sourced from past Basic Education Certificate Examination (BECE) papers was administered to both groups to determine baseline knowledge. These test items were adapted from a nationally standardised examination, ensuring their reliability.

The experimental group was exposed to the flipped classroom approach over one week. Students in this group engaged with instructional materials outside class time, while in-class sessions were devoted to interactive learning and problem-solving activities. In contrast, the control group continued with traditional instructional methods. At the end of the intervention, a post-test comprising 20 multiple-choice questions was administered to evaluate learning outcomes. To ensure the reliability and validity of the assessment instruments, test items were carefully selected in alignment with curriculum standards and previous BECE questions. A panel of educators and subject matter experts reviewed the items to confirm content validity. Data was collected in adherence to ethical standards and research protocols, following the one-week intervention period. The effectiveness of the flipped classroom approach was analysed using the Mann-Whitney U test, which enabled a statistical comparison of academic performance between the experimental and control groups.

Ethical Approval

Written consent forms were obtained from all participating students, ensuring they fully understood the purpose and scope of the study. The students were informed of their rights, including their ability to withdraw at any time without consequences. Additionally, parental or guardian consent was secured where necessary, in accordance with ethical guidelines. All information provided by the students remains confidential and will be used strictly for academic purposes**.**

RESULTS AND DISCUSSION

The research questions sought to determine if a substantial disparity exists in the mean accomplishment scores between the control and experimental groups. The Mann-Whitney U test, a non-parametric statistical tool, was employed for data analysis to accomplish this. This method was used to guarantee the authenticity of results, especially in instances where the assumption of normalcy in data distribution was not satisfied. Table 1 presents the pre-test outcomes of the two groups.

Table 1: Descriptive statistics of pre-test results of the two groups.

	Group	N	Mean Rank
Pre-test	Control	30	31.47
	Experiment	31	30.55
	Total	61	

Table 1 presents the descriptive statistics of the pre-test scores. The closeness of the mean ranks 31.47 for the

control group and 30.55 for the experimental group suggests that there was no notable difference between the two groups before the intervention. To statistically confirm whether this difference was significant or not, the Mann-Whitney U test was conducted. Table 2 displays the results of this analysis.

Table 2: Mann-Whitney statistical result of the pre-test

	Experimental
Mann-Whitney U	451.000
Z	-.208
Asymp. Sig. (2-tailed)	.836

A pre-test was administered before the intervention to evaluate the initial behaviour and existing knowledge of both the control and experimental groups. Given that the data did not follow a normal distribution, the Mann-Whitney U test was employed as a non-parametric alternative to the independent samples t-test. The results from the Pre-Test Analysis reveal that the control group achieved a mean rank of 31.47, while the experimental group recorded a mean rank of 30.55. The proximity of these ranks indicates that the two groups possessed almost equivalent levels of prior knowledge before the intervention. Mann-Whitney U is 451.000, and the Asymptotic Significance (2-tailed) is 0.836. The p-value of 0.836 exceeds the conventional significance threshold of 0.05, suggesting that there is no statistically significant difference in the pre-test scores between the two groups. The Z-score of -0.208 is quite minimal, further supporting the absence of a significant difference. The findings indicate that both groups began with a comparable baseline, implying that any differences noted following the intervention can be ascribed to the treatment itself rather than to prior disparities. The absence of a significant difference in pre-test scores between the control and experimental groups indicates that both groups commenced from a comparable baseline. This is an essential element in experimental studies, as it guarantees that any changes noted in later stages of the investigation can be linked to the intervention instead of pre-existing differences. The carefully aligned characteristics of the groups enhance the internal validity of the study, minimising potential biases and bolstering confidence in the reliability of the intervention's effects. As a result, any variations observed in the post-test phase can be more precisely understood as outcomes of the intervention, rather than discrepancies in prior knowledge. The results of the control and experimental groups following the intervention are presented in Table 3.

Table 3: Descriptive statistics of the post-test

	Group	N	Mean Rank	Sum of Ranks
Experimental	Control	30	25.65	769.50
	Experimental	31	36.18	1121.50
	Total	61		

Table 4: Mann-Whitney U test

	Experimental
Mann-Whitney U	304.500
Z	-2.330
Asymp. Sig. (2-tailed)	.020

The post-test data were examined to assess the influence of the flipped classroom approach on students' academic performance in mathematics. The post-test data revealed a statistically significant enhancement in the performance of students within the experimental group when contrasted with the control group. The findings presented in Table 3 indicate that the experimental group achieved a mean rank of 36.18, in contrast to the control group, which recorded a mean rank of 25.69. The Mann-Whitney U statistic recorded was 306.500, and the Z-score calculated was -2.330. The two-tailed asymptotic significance was .020, falling below the standard significance threshold of 0.05. The findings reveal a statistically significant disparity in the post-test scores between the two groups. The rise in outcomes for the experimental group indicates that the flipped

classroom approach has notably enhanced students' comprehension and retention of mathematical concepts, especially in addressing word problems related to linear equations. The results indicate that incorporating flipped learning into mathematics instruction for junior high school students enhances both engagement and understanding. The elevated mean score for the experimental group indicates that students participating in flipped learning achieved superior academic results compared to their peers in traditional education.

The results of this study support the existing literature that highlights the effectiveness of the flipped classroom model in enhancing student learning outcomes. A wealth of studies indicates that flipped learning improves academic performance by shifting the focus of teaching from passive reception to active engagement. The improvement observed in the experimental group's performance is consistent with earlier findings in the field. Peterson (2016) conducted a quasi-experimental study illustrating that the flipped classroom model surpasses traditional teaching approaches in enhancing academic performance. Moormann et al. (2015) also reported notable advancements in learning among students who experienced flipped instruction. The findings of this study support earlier investigations, highlighting that flipped learning creates an engaging environment that enhances deeper understanding and comprehension. Mahasneh (2020) investigated the effectiveness of traditional versus flipped classrooms, finding that the flipped approach resulted in better academic outcomes. The significant post-test enhancements observed in this study support Mahasneh's claim, demonstrating that flipped learning can be an effective teaching method for improving student performance in mathematics. The effectiveness of the flipped classroom model can largely be credited to its emphasis on learner-centred education. The flipped model enables learners to interact with instructional resources (videos, readings) beyond the classroom, promoting a more profound engagement in in-class activities (Cabı, 2018). The results of this study align with the assertions made by Sezer (2017), indicating that flipped classrooms enhance student accountability, customise learning experiences, and promote collaboration. Santos and Serpa (2020) emphasised that flipped learning fosters the development of crucial competencies for the 21st century, such as problem-solving and critical thinking. The significant improvement in student performance in the experimental group suggests that participation in problem-solving activities and discussions fostered a deeper conceptual understanding, consistent with the core principles of constructivist learning theory.

Prior investigations have shown that learners in Ghana encounter difficulties with word problems associated with linear equations (Baah-Duodu et al., 2019). The persistent challenges outlined in the BECE Chief Examiner's reports (2007, 2011, 2012, 2020, 2021, 2023) indicate that conventional teaching approaches have not effectively addressed this issue. The flipped classroom model shows promise as a feasible solution, as evidenced by the current study. The active learning opportunities offered through flipped instruction probably enabled students to engage in word problem-solving with greater effectiveness compared to conventional lecture-based approaches. The findings of Mensah, Yeboah, and Adom (2017) align with this, revealing that 96% of students participating in flipped learning exceeded the average grade threshold in their assessments. The flipped classroom approach, although proven to be effective, remains underutilised in junior high schools across Ghana. Research by Nyagblormase, Yaayin, and Hanson (2023) in conjunction with Yeboah et al. (2020) indicates that many educators continue to favour teacher-centred methods, a tendency linked to their comfort with these approaches, resource constraints, and hesitance to embrace innovative practices. This study provides compelling evidence that the adoption of flipped learning can lead to notable improvements in student performance.

CONCLUSIONS

The post-test results confirm the efficacy of the flipped classroom model in enhancing students' performance in mathematics, especially in tackling word problems. the results are backed by a wealth of studies that emphasise the advantages of active learning, student involvement, and conceptual comprehension. considering the increasing evidence supporting flipped learning, teachers in Ghana should integrate this model into their teaching strategies to improve student performance in mathematics suggestions for implementation.

Conflict of Interest

The authors declare no conflicts of interest.

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