Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.14, No.22, 2023

Flipped Classroom and Academic Performance of Senior High School Students in Geometry

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Abstract
This study sought to determine how senior secondary school students' geometry performance is affected by the flipped classroom model. To direct the investigation, two research hypotheses were developed. The research used a quasi-experimental approach. Students in senior secondary school two (SHS2) in the Sagnarigu Municipality of Ghana's Northern Region made up the study's population, which was split evenly between male and female students from various racial and ethnic backgrounds, cultural backgrounds, and geographic locations. 72 students from two senior high schools in the municipality were chosen at random to participate in the study. The study's tool was the Geometry Performance exam (GPT), which consisted of 20 standardized multiple-choice exam items modified from earlier mathematics problems administered by the West Africa Examination Council. The control groups were instructed using the conventional technique whereas the experimental groups were given instruction utilizing the flipped classroom model. The four-week experiment was conducted. A $P \leq 0.05$ level of significance was considered for the t-test to assess the research hypotheses. The findings showed that the experimental group significantly outperformed the control group in terms of accomplishment scores. Regarding the gender issue, the results showed that the flipped classroom model is effective because there was no appreciable difference in the performance of the experimental group's male and female students. It is advised that math educators should use the flipped classroom approach for teaching geometry and other concepts in the subject that are thought to be challenging.
Keywords: Flipped classroom, Academic Performance, Gender, Geometry, Senior High School Students.
DOI: 10.7176/JEP/14-22-02
Publication date: August 31st 2023

1.0. Introduction

Science, Technology, Engineering, and Mathematics (STEM) education has been increasingly popular around the world in recent years, with a focus on the advancement of industry and technology through the use of mathematics as mathematics opens and closes doors for individuals more than any other subjects and also serve as the key to the development of any nation in the globe (Suleiman, et.al 2021). Mathematics as the cornerstone of STEM is a composite subject made up of different fields, including algebra, statistics, geometry, and others. These branches are interconnected and regularly cross over in the mathematical problem-solving process.

Geometry is one of the branches of mathematics which is crucial and has a significant bearing on life on Earth. It involves the study of the appearances, proportions, locations, and characteristics of objects in space. Without an understanding of geometry, life would be meaningless, hence geometry plays a central role in our daily lives. Without knowledge of geometry, it is impossible to build, mold, travel to space, or create anything

else (Bornaa et al., 2023). Furthermore, because shapes and things from geometry are also found in our reality, geometry is essential to daily life, and a number of vocations such as architects, engineers, physicists, land surveyors, and many others all use geometry on a daily basis as a gateway to many other mathematical areas, particularly measurement. The foundation for learning mathematics has been viewed as geometric concepts. Geometry is important because it relates not only to math classes but also to the growth of students' cognitive abilities, including inquiry, research, critical analysis, creative thinking, application of what they have learned, and self-expression (Suleiman et.al 2021).

As stated above, it is evident that geometry is a significant area of mathematics and that it is essential to many disciplines, such as engineering, architecture, physics, and computer science. But it is usual for pupils to struggle with geometry and do poorly in this subject area. Suleiman et al. (2021) claim that the annual WASSCE chief examiner's report shows that the majority of pupils who attempt geometry questions typically fail. The concepts and principles of angles in the same segment, as well as alternate and corresponding angles, were difficult for many of the high school pupils to understand. This subpar performance was claimed to be non-gender specific, proving that geometry is gender-neutral.

According to Idoko Inah et al. (2021), teaching geometry in the appropriate way can foster discovery, stimulate curiosity, and assist learner intuition, all of which can improve communication and students' enthusiasm for learning about geometry and mathematics in general. This would further inspire students to analyze geometry difficulties, articulate their thoughts, and construct rational arguments. It would also help students understand the significance of the subject, which would ultimately improve performance.

Teachers are looking for new ways to incorporate online resources and approaches into their curricula in the modern era of the internet and social media as studies suggest this approach to be a performance booster and the flipped classroom instruction paradigm has been their reaction to this intensified digital migration (Shukla & Mcinnis, 2021). key education stakeholders believe that new, creative approaches are needed to ensure that students and teachers are both more actively involved in the learning process. This can be accomplished by distributing lecture materials in advance and involving students in discussion during lecture time (Aggarwal et al., 2019).

The flipped classroom model is a cutting-edge strategy that turns traditional teaching methods on its heads by delivering instructional content outside of the classroom through pre-recorded videos or online materials, allowing students to learn at their own pace. In-class time is then used for active learning, problem-solving, and student-teacher interaction. In many industrialized countries and all throughout the world, the idea of the "flipped classroom" has gained popularity as a teaching method. It is considered to be the most efficient method of instruction that guarantees complete student engagement and great output (S. Anbalagan, 2022). Jay et al. (2019) argued that the flipped classroom is a more effective method of instruction than the conventional one which increases students' willingness to study, boosts their achievement on final exams, and may improve their ability to communicate and think critically.

Despite the concepts of the flipped classroom being incorporated into a variety of instructional content forms and used in a variety of courses, the learning outcomes of students in mathematics and specifically Geometry in the flipped classroom have mostly gone unresearched. Therefore, this work aims to close this gap.

1.1. Statement of the Problem

The emphasis on using technology in the classroom necessitates the use of modern didactic methods and pedagogical techniques in the study and teaching of mathematics in modern high schools to improve performance (Bornaa et al., 2023). All across the world, established curricula and teaching methods are always being revised and improved. Technology adoption is encouraged in order to improve pupils' academic achievement in mathematics. If students are to become more than merely secondary school math workers, these aspects of the mathematics classroom seem to constitute the future's wave and are inevitable (Makinde, 2019).

A fundamental area of mathematics called geometry is essential for students' development of spatial reasoning abilities. Lectures and passive learning are frequent components of traditional classroom instruction, which may hinder students' interest in and comprehension of challenging geometric ideas. An alternate educational model that encourages active learning and student-centered methods is the flipped classroom strategy. The flipped classroom is an active learning strategy that lets students show up to class after watching a tutorial video online that gives them a general understanding of the topics they will be studying in class. After watching the film, students are then required to apply what they have learned to group projects in the classroom, which encourages active learning (Itokazu, 2019).

The flipped classroom's efficacy and success are being discussed as educational delivery and performance booster globally. This model has been recommended in studies as a way to improve arithmetic achievement, however, senior high schools in Ghana are not using it especially in mathematics. In order to determine which method is more effective for teaching geometry to senior high school pupils in the Sagnarigu Municipality of Ghana's Northern Region, this study compares traditional classroom instruction with the flipped classroom

model. The purpose of this study is to look at how the geometry performance of secondary school students is affected by the flipped classroom paradigm.

1.2. Objectives of the study

1. To ascertain the effect of the flipped classroom on secondary school students' academic performance in Geometry in the Sagnarigu Municipality of the Northern Region, Ghana.
2. To investigate the gender-related impacts of the flipped classroom on secondary school students' academic performance in Geometry in the Sagnarigu Municipality of the Northern Region, Ghana.

1.3. Research Hypothesis

1. There is no significant difference in the post-test mean scores of students taught using the flipped classroom model and those taught using the traditional method.
2. There is no significant difference in the mean performance of male and female students taught Geometry using the flipped classroom model.

2.0. Literature Review

According to the Shukla & Mcinnis (2021) qualitative study, when geometry was taught in a flipped classroom, pupils admitted that they felt a level of comfort in a math class that they had never experienced before. Many students admitted to watching films more than once, both before and during class. After the class, it was observed that student perception of mathematics performance had significantly improved (by 45%). Their study recommended flipped classrooms as the best approach to teaching challenging topics in mathematics. They indicated that the flipped classroom does not only boost performance but also reduce cost as large number of students can be handle at the same time, hence, reducing pressure on infrastructure and improved access to education. However, the study did not compare this model to any other teaching technique. Also, some of the participants said they have challenges with the model.

Nielsen, (2023) used a qualitative technique to test the effectiveness of the flipped classroom with 118 first-year engineering students in Norway. The outcome showed that a greater percentage of students (69%) were pleased with the flipped classroom. Students appeared to have a good outlook on the flipped classroom, according to their results and students' performance also improved significantly after an assessment. However, 10% of students said the flipped class left them feeling disoriented and impatient. Lo & Hew (2021) concentrated on the level of participation of students in mathematics classes using various teaching strategies to improve performance in mathematics. The flipped classroom was contrasted with the conventional approach. The findings indicated that the implementation of the flipped classroom strategy could boost some aspects of behavioral, emotional, and cognitive engagement. enhancing performance as a result. Their study revealed that students are engaged throughout the flipped classroom and have full concentration which may be a reason for the improved performance. In a middle school in the heart of Yantai City, China, Wei et al. (2020) incorporated the flipped classroom strategy into a mathematics lesson. The investigation compared how the flipped classroom and conventional teaching methods affected students' learning outcomes. The findings show that, in comparison to traditional classroom learning, the suggested flipped classroom strategy enables students to increase their learning performance. The proposed flipped classroom strategy appears to assist students at the middle mathematics level more than those at high or low levels, according to a comparison of students' various maths levels. Lu et al. (2023) indicated that a more efficient teaching strategy for education is provided by flipped classrooms. Their study used this model and the results revealed an enhanced students' academic achievement in the final exam results and everyday performance. The model to said to encourage the development of higher-order abilities in students. Itokazu (2019) explained that, most students favor flipped classrooms over traditional classroom settings. His research revealed that because students were working in groups in the flipped classroom, they were engaged. The flipped classroom's advantages include the fact that students learn foundational information by watching videos before to class and develop their knowledge during lectures. His study's findings showed that following the intervention, student performance had improved by 70%. In agreement with the above, Sarker et al. (2023) argued that the flipped classroom model has the potential to be the ideal educational system in the twenty-first century and to address the Fourth Industrial Revolution. Students are more engaged and satisfied in flipped classrooms than in traditional classrooms, and they can also be differentiated based on class activity and regularity, which the traditional classroom cannot. (Jay et al., 2019) said that, to make the most of class time and encourage more meaningful interaction and activity-based learning rather than lecture-only discussions, math teachers might implement the flipped classroom method in the classroom. Because interaction is prioritized in flipped classroom instruction, their performance in math may be improve. Their study found the treatment class to outperform their counterparts when the flipped classroom model was employed

To compare the traditional approach with the flipped classroom, S. Anbalagan (2022), investigated B.Ed. students majoring in mathematics at Tamil Nadu's College of Education. The outcomes showed that there is a

significant difference in post-test mathematics achievement scores between the experimental group of B.Ed. teacher candidates and the control group. The experimental group's mean score (M=27.50) is higher than the control group's mean score (M=20.57). The flipped classroom idea was found to be more advantageous than a conventional approach. It has been established that the flipped classroom approach is superior to conventional teaching techniques as a result. Traditional teaching and learning approaches do not foster convergence or rational thought. In a flipped classroom, students have the chance to study and delve into subject-related topics. According to Romero & Angeles (2023), participants in the flipped classroom are driven and like learning mathematics whereas the conventional approach has a detrimental impact on students' attitudes and lowers their motivation, self-confidence, and sense of enjoyment for mathematics. In flipped classroom, learner is more conscious and responsible of their learning process therefore may lead to positive results in the long run(Aggarwal et al., 2019). Makinde (2019) argued that Nigeria urgently needs a flipped classroom learning technique to overcome the low mathematics performance of kids and advance science and technology. When his study contrasts the conventional approach with the flipped classroom, this becomes important. The results showed that the flipped classroom mode of instruction promoted learning and enhanced secondary school students' post-test math performance. Additionally, research demonstrated that when flipped classrooms were used instead of regular classrooms, kids performed well in terms of mathematics retention. (Bhavsar et al., 2022) used the flipped classroom with medical students and recommended that the flipped classroom model helps students successfully cultivate critical thinking and other abilities, as well as their performance and exam-taking abilities.

According to (Alviar & Solon, 2023), Performance in mathematics does not differ with regard to gender. Their study used the One-Group Pre-Test-Post-Test Design to investigate the effectiveness of the flipped classroom with 57 students. The post-test scores of male and female students were compared to see if there was a gender gap in flipped classrooms. Results indicate that there was no statistically significant difference between the post-test scores of male and female students; W = 342.5, p=.3579. This shows that when the flipped classroom was implemented in mathematics, both male and female students performed equally well.

3.0. Methodology

The study adopts the quantitative approach. The quasi-experimental research design that included Pretest and Posttest was used for this study. The experimental group (EG) and control group (CG) are the two groups used in the design, which compares the scores and means of the two groups in order to test the equality assumption. While the control group received instruction in geometry using the traditional teaching approach, the experimental group received instruction utilizing the flipped classroom paradigm. The experimental group was selected through purposive sampling.

The target population consisted of 2,132 Senior High School students in Form 2. Two schools were chosen by simple random sampling (lottery method) from the five schools in the municipality. Thirty-seven (37) students from Tamale Senior High School and thirty-five (35) students from Kalpohin Senior High School were among the fifty-two (72) total participants in the study. SGAT, or Students' Geometry Achievement Test, was used to gather data for the study. The items on the SGAT were based on previous WASSCE (West African Senior High School Certificate Examination) questions. In order to ensure the exam items' face and content validity, first mathematicians served as a focus group for them, and then mathematics department heads contributed their ideas. The goals of the study and the questions that would guide their work were presented to the specialists in the field of mathematics education. The questions' degree of alignment with the stated aims was to be taken into account when the experts evaluated the validity of the instrument. Their suggestions are reflected in the updated Students' Geometry Achievement Test (SGAT).

A pilot test of the research instruments (SGAT) involved 55 students from Vitting Senior High School in the Tamale Metro of the Northern Region. As part of the test-retest process, the instrument was delivered to the respondents once, and then two weeks later. The researchers found that the test-retest results of the study were internally consistent (highly correlated), with a value of 0.84 for the Pearson Product Moment Correlation Coefficient. The test items were determined to be adequate and suitable for use because this value demonstrates a positive correlation between the two sets of data. Following the pre-test, the intervention process ran for six weeks and a post-test was conducted immediately. Descriptive statistics and an independent sample t-test at a 0.05 confidence interval was used to analyze the data.

4.0. Results

Hypothesis 1: There is no significant difference in the post-test mean scores of students taught using the flipped classroom model and those taught using the traditional method. To test this null hypothesis, an analysis of the pre-test and post-test mean scores for both the traditional classroom and the flipped classroom groups was done. The pre-test analysis for both the conventional and the flipped classroom groups is displayed in Table 1 whereas the post-test analysis for both was shown in Table 2

Table 1: T-test analysis of the academic performance of students in experimental and control groups in the pretest

Variable	N	Mean	SD	T	Df	(Sig.2tailed)
Control	36	7.36	4.409	1.11	70	0.270
Experimental	36	6.28	3.884			

Table 2: T-test analysis of the academic performance of students in experimental and control groups in the Post Test

Variable	N	Mean	SD	T	Df	(Sig.2tailed)
Control	36	7.89	3.600	-8.43	70	**P< 0.001**
Experimental	36	14.22	2.716			

The pre-test means scores of the traditional group (Mean = 7.36, SD = 4.409) and the flipped classroom group (Mean = 6.28, SD = 3.884), as shown in Table 1, did not differ significantly (t (70) = 1.11, sig. = 0.27). The p-value in Table 1 was 0.270 which was greater than 0.05, This suggests that prior to the intervention, students in each treatment group had comparable academic aptitude in geometry

According to Table 2, there is a significant difference between the mean post-test scores for the traditional classroom group (mean = 7.89, SD = 3.600) and the flipped classroom group (mean = 14.22, SD = 2.716), with a t (70) = -0.843, sig. = 0.00. The p-value in Table 2 was 0.00 which was less than 0.05, thus, the null hypothesis was rejected. This indicates that the academic performance of the experimental group and the control group pupils differs significantly and flipped classroom has a positive influence over students' performance in geometry.

H_{02}: There is no significant difference in the mean performance of male and female students taught Geometry using the flipped classroom model.

Table 3: T-test Analysis of the academic performance of male and female students in the experimental group

Variable	N	Mean	SD	T	D	(Sig.2tailed)
Male	18	10.81	4.915	1.106	70	0.273
Female	18	9.48	5.243			

According to Table 3, the p-value was 0.273, which is greater than 0.05. As a result, the null hypothesis H_{02} was kept. This indicates that there is no discernible difference in the performance of the experimental group's male and female individuals. This means that there were no appreciable differences in the performance ratings of the male and female students who took the flipped geometry course**.**

5.0. Discussion

There is a substantial difference in the performance of students who are taught geometry using the flipped classroom and those who are taught using the traditional approach, according to the results of statistical analyses related to research hypothesis one, as shown in Table 2. This indicates that the experimental group's performance was greatly improved by the flipped classroom. This supported the findings of Makinde (2019), S. Anbalagan (2022), and Shukla & Mcinnis (2021) who found that experimental groups using the flipped classroom gained knowledge significantly more than their counterparts who were strictly taught using the traditional lecture method in a classroom setting**.**

According to Table 3's results, male students who were taught geometry utilizing the flipped classroom did slightly better than their female counterparts. But as indicated, the statistical analysis of hypothesis two showed that the difference was not statistically significant. This demonstrates the inclusivity of the flipped classroom model. The findings of (Alviar & Solon, 2023), and were backed by the findings, which showed that when geometry was taught using the flipped classroom, both male and female students made the same progress. Shukla & Mcinnis (2021) reported that female students had a less positive attitude towards geometry than their male counterparts but do not differ in performance significantly and that the flipped classroom model can help to improve or boost this attitude.

6.0. Conclusion

According to the study's results, the experimental group scored much higher on accomplishment tests than the control group did. The flipped classroom is a useful method for raising geometry students' academic achievement in senior high school. The study also demonstrated that the flipped classroom is gender-friendly because it reduced the achievement gaps between male and female students by raising both groups' performance levels.

7.0. Recommendation

1. The flipped classroom approach should be used as the preferred technique for teaching geometry and other challenging math concepts to students.
2. The importance of introducing mathematics instructors to the flipped classroom through workshops and seminars cannot be overstated in order for it to be adopted and implemented successfully.

References

Aggarwal, K., Thakur, B., Agrawal, M., Jhajharia, S., Madaan, H., & Mahapatra, S. K. (2019). A comparative study between flipped classroom and traditional lecture-based classroom in first-year medical students. *International Journal of Research in Medical Sciences*, *7*(10), 3654. https://doi.org/10.18203/2320-6012.ijrms20194191

Alviar, J. V., & Solon, L. J. V. (2023). Flipped Classroom in Post-Pandemic: Evaluating Gender Divide and Impact on the Student's Achievement in Mathematics. *International Journal of Multidisciplinary: Applied Business and Education Research*, *4*(2), 454–462. https://doi.org/10.11594/ijmaber.04.02.13

Bhavsar, M. H., Javia, H. N., & Mehta, S. J. (2022). Flipped Classroom versus Traditional Didactic Classroom in Medical Teaching: A Comparative Study. *Cureus*. https://doi.org/10.7759/cureus.23657

Bornaa, C. S., Abdulai, A. M., & Iddrisu, A. B. (2023). Comparative Study of Traditional Face-to-Face and E-Learning Modes of Teaching Senior High School Geometry. *American Journal of Education and Technology*, *2*(2), 10–14. https://doi.org/10.54536/ajet.v2i2.1374

Effectiveness of Flipped Classroom Strategies on Enhancing Mathematics Performance Among B.Ed. Teacher Trainee's Effectiveness of Flipped Classroom Strategies on Enhancing. (2022). https://ssrn.com/abstract=3926048

Effects of Mastery Learning Approach on Performance in Geometry among Senior Secondary School Students in Northwest Zone, Nigeria. (2021). *Kano Journal of Educational Psychology*, *3*, 175–180. https://doi.org/10.5281/zenodo.7266672

Idoko Inah, L., Idoko, L., & Agbudu, P. (n.d.). *Effects of Polya Problem Solving Strategy and Lecture Method on Performance in Geometry Among Senior Secondary School Students in Kaduna State, Nigeria The Researcher's Journal: A Journal of Contemporary Educational Research Effects of Polya Problem Solving Strategy and Lecture Method on Performance in Geometry Among Senior Secondary School Students in Kaduna State, Nigeria*. https://www.researchgate.net/publication/357635997

Itokazu, M. (2019). Relationship between Students' Preferences for Flipped or Traditional Classrooms and Perceived course workload The Journal of Asian Rehabilitation Science Relationship between Students' Preferences for Flipped or Traditional Classrooms and Perceived course workload. In *J. Asi. Reha. Sci* (Vol. 2, Issue 3). https://www.researchgate.net/publication/335690463

Jay, R., Gumban, B., & Tan, D. A. (2019). *STUDENTS' MATHEMATICS PERFORMANCE, ENGAGEMENT AND INFORMATION AND COMMUNICATION TECHNOLOGY COMPETENCIES IN A FLIPPED CLASSROOM ENVIRONMENT*. https://www.researchgate.net/publication/334591505

Lo, C. K., & Hew, K. F. (2021). Student Engagement in Mathematics Flipped Classrooms: Implications of Journal Publications From 2011 to 2020. In *Frontiers in Psychology* (Vol. 12). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2021.672610

Lu, C., Xu, J., Cao, Y., Zhang, Y., Liu, X., Wen, H., Yan, Y., Wang, J., Cai, M., & Zhu, H. (2023). Examining the effects of the student-centered flipped classroom in physiology education. *BMC Medical Education*, *23*(1), 233. https://doi.org/10.1186/s12909-023-04166-8

Makinde, S. (2019). *THE FLIPPED CLASSROOM: ITS EFFECTS ON STUDENTS' PERFORMANCE AND RETENTION IN SECONDARY SCHOOL MATHEMATICS CLASSROOM Student-perceived influence of electronic media literacy on instructional delivery of academia View project*. https://www.researchgate.net/publication/334046424

Nielsen, K. L. (2023). Why Can the Flipped Classroom Frustrate Students? Experiences from an Engineering Mathematics Course. *Education Sciences*, *13*(4). https://doi.org/10.3390/educsci13040396

Romero, A. A., & Angeles, E. D. (2023). Flipped Classroom in a Digital Learning Space: Its Effect on the Students' Attitude Toward Mathematics. *International Journal of Learning, Teaching and Educational Research*, *22*(1), 210–227. https://doi.org/10.26803/ijlter.22.1.12

Sarker, P. C., Siddique, Md. N.-E.-A., Sultana, S., & Pal, S. K. (2023). Comparison between Traditional Classroom and Flipped Classroom on Student's Engagement and Satisfaction. *International Journal of Multidisciplinary: Applied Business and Education Research*, *4*(2), 624–635. https://doi.org/10.11594/ijmaber.04.02.29

Shukla, N. J., & Mcinnis, E. (2021). Flipped Classroom: Success with First Year Mathematics Students. *International Journal on Social and Education Sciences*, *3*(1), 32–47. https://doi.org/10.46328/ijonses.56

Wei, X., Cheng, I. L., Chen, N. S., Yang, X., Liu, Y., Dong, Y., Zhai, X., & Kinshuk. (2020). Effect of the

flipped classroom on the mathematics performance of middle school students. *Educational Technology Research and Development*, *68*(3), 1461–1484. https://doi.org/10.1007/s11423-020-09752-x