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Flipped Classroom Model and Senior Secondary School Students' Mathematics Achievement in Kolokuma/Opokuma LGA, Bayelsa State, Nigeria

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Abstract
This study examines the effect of the flipped classroom model on students' achievement in secondary school mathematics. This study adopted a quasi-experimental research design. Specifically, a pre-test, and post-test non-randomized control design was used for the study. Two schools were purposively selected with a total of 80 students drawn from intact classes. This is because the schools selected had computers and internet access. For the experimental (treatment) group, a total of 43 students were used for the study (25 males and 18 females). On the other hand, for the control group, 37 students were used for the study. The instrument used for data collection was a researcher-made Mathematics Achievement Test (MAT). The instrument was validated by three experts from the Department of Science Education, specifically, two experts in mathematics education and an expert in measurement and evaluation. The reliability coefficient was determined using the Kuder-Richardson (K-R_{20}) formula and a reliability coefficient of .75 was obtained. This method was used because the test items were dichotomously scored. The research questions were answered using mean and standard deviation. The null hypotheses were tested using Analysis of Covariance (ANCOVA) at the significant value of .05. The research findings demonstrated that students taught with the Flipped Classroom Model performed better compared to those taught using the traditional method. This implies that the Flipped classroom Model was a more effective learning method. It was therefore recommendations that Nigerian Senior Secondary School teachers should get involved in the use of the flipped classroom model in teaching and learning Mathematics. Flipped classroom model should be considered for incorporation into the mathematics curriculum by the relevant curriculum planners and policymakers.

Keywords: Flipped Classroom Model, Mathematics Education, Achievements, Blended Learning, Gender

Introduction

Recent advancements in information technologies, including increased internet speeds, expanded storage capabilities, and the evolution of cloud computing, have ushered in a transformative era in education. Due to these advancements, traditional teaching methods have given way to cutting-edge strategies including game-based learning, flipped and mixed learning, personalized learning, mobile learning, social collaborative learning, and distant learning. The possibility for self-paced, interactive, and customized learning experiences where educational resources are available to everyone, anywhere, and at all times characterizes this change. Teachers and educational institutions need to adjust as technology continues to change the face of education to take advantage of the potential for more dynamic and engaging learning environments (Ikechukwu & Amos, 2023). Education, being the cornerstone of societal progress, undergoes constant evolution to adapt to emerging pedagogical models and technological advancements. The Blended Learning Flipped Classroom Model, which combines two cutting-edge teaching approaches, is one such transformative strategy that is gaining popularity. While the Flipped Classroom Model reverses the traditional teaching sequence by delivering instructional content outside the classroom through

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pre-recorded videos, blended learning combines traditional face-to-face instruction with online learning components. This leaves in-class time for collaborative activities, discussions, and active learning.

With teacher-centered instruction at its core, the traditional educational environment has seen substantial transformation over time. The emergence of technology, particularly the widespread availability of internet connectivity, has encouraged educators to investigate more dynamic and learner-centred methods. Blended learning provides a tailored and adaptable learning environment that may meet the various needs of students by combining online and in-person learning experiences (Means et al., 2013). The emergence of the Flipped Classroom Model, credited to Bergmann and Sams (2012), represents a paradigm shift in instructional design. By transferring content delivery outside of the classroom and enabling students to interact with educational resources—often in the form of video lectures—before attending in-person classes, this model challenges the conventional lecture-based method. The in-class time is then dedicated to reinforcing concepts through discussions, problem-solving, and hands-on activities. The idea of blended learning connects traditional and online learning environments. The combination of the two modalities makes learning more flexible and adaptable. Students may interact with online resources, participate in in-person classes, work together virtually, and get tailored feedback in a blended learning setting. The adaptability of blended learning overcomes the drawbacks of conventional teaching strategies and offers chances for customized learning pathways (Bonk & Graham, 2012).

The realization that students learn at different rates and with varied preferences is driving the emergence of blended learning. Blended learning accommodates different learning styles by providing flexibility so that students can access knowledge whenever it's convenient for them. This model is particularly relevant in addressing the challenges faced by traditional classroom settings, such as large class sizes and time constraints. The Flipped Classroom (FC) Model is an approach based on learning the simple and theoretical parts of a subject in extracurricular time through educational technologies and performing higher-level studies during class time. Interest in the FC Model has grown as instructional technology, particularly in science and math, has developed and proliferated. One approach to teaching and studying mathematics is the flipped classroom, which was suggested by Clark (2015) and Berrett (2012). The FC Model has enormous potential to change the way mathematics is taught in senior secondary schools when it is incorporated into blended learning. This is because it will increase students' motivation to learn when applied properly (Inweregbuh et al., 2020). FRN (2014) and WAEC (2016) linked inadequate teaching methods and a hostile learning environment to students' subpar math performance. It might be difficult to fully address complicated ideas and real-world applications in a standard lecture-style because mathematics education frequently incorporates them. Students can access knowledge outside of class with the Flipped Classroom Model, which gets them ready for more dynamic and interesting in-class activities. A more student-centric approach to mathematics education is made possible by the Flipped Classroom Model. Complex material can be delivered through pre-recorded video lectures, which let students rewind, pause, and review at their leisure. With traditional lectures no longer an option, in-class time offers students a chance to participate in group projects, activities, and in-depth conversations led by the teacher to improve their academic performance.

Academic success is the result of learning exercises. It is described as the child's overall performance after a program or course. It establishes the learner's academic strengths and weaknesses. According to Obih (2017), it is the outcome of a data collection approach used to gauge performance, behaviour, and knowledge. By obtaining data regarding the learner's performance, the measurement of achievement can be ascertained (Azubuike, 2015). Thus, the result of a student's academic endeavour is what is meant to be understood as academic achievement. It is capable of evaluating students' learning value and forecasting their success in subsequent academic pursuits. It is called an achievement test or examination for this reason. Studies such as those of Ngbarabara (2021) and Azubuike (2015) discovered significant differences in students' academic achievements. Chukwuorji and Gusen (2020) in their research indicated a significant difference in favouring self-directed learning in the flipped classroom group. While, the studies of Ezeudo and Ezinwanne (2013) and Obih (2017) revealed that, there were no significant differences in students' academic achievements. This background, therefore, suggests that students' academic achievements vary depending on the circumstances and course of study. Gender, according to Obih (2022), is a social construct that establishes distinctions between men and women in a certain community. There is a sizable amount of work coming from the examination of gender variations in success over an extended period. Ngbarabara (2021) found that gender composition has a major impact on secondary school students' academic performance and that there is a substantial association between gender composition and students' academic performance. While Obih

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(2017) found no discernible gender differences in students' academic achievement in economics under the combined influence of inquiry, cooperative, and discovery methods, Azubuike (2015) found significant gender differences in academic achievement in physical and health education when inquiry method is used. In other words, the influence of gender may vary depending on the subject or course, the instructional strategy used and the ability of the teacher to teach the subject.

Statement of the Problem

Under the Federal Government's auspices, the Ministry of Communications and Digital Economy formally opened the National Adopted School for Smart Education (NASSE) in Junior Secondary Schools, Karshi, Abuja, in 2021. The Minister of Communications and Digital Economy, Dr Isa Pantami, emphasized during the launch that this effort, which is being carried out by the National Information Technology Development Agency (NITDA), is in line with the government's agenda for the digital economy. He underlined that the development of Nigeria's digital economy depends on digitizing several sectors, most notably education. He claims that NASSE provides a methodology for more effectively introducing young students to technology at an early age.

In a related development, the country's newly built smart schools are expected to open by January 2023, according to information released by the Universal Basic Education Commission (UBEC). Through the signing of a memorandum of understanding in October 2021, the Korea International Cooperation Agency (KOICA) and UBEC began a collaboration that is centred around the provision of cutting-edge equipment for recording and broadcasting studios, the development of science and mathematics content, and the capacity building of educators across the country to use new information and communication technologies (ICTs) and the blended learning methodology (Ikechukwu & Amos, 2023). To this end, the implementation of smart schools is ongoing across all states of the federation.

Given the Federal Government's bold plans, like the National Adopted School for Smart Education (NASSE) and the soon-to-be operationalization of recently built smart schools in Nigeria, we must investigate and comprehend the specific effects of novel pedagogical models on student outcomes. Nevertheless, despite these developments, little is known about the impact and efficacy of particular teaching approaches, such as the Flipped Classroom Model, on the academic performance of senior secondary school math students. The purpose of this study is to look at how the Flipped Classroom Model affects learning outcomes in the special KOLGA educational setting.

Aim and Objectives of the Study

The main aim of this research is to investigate the effects of flipped classroom model practice on senior secondary school mathematics students' achievements in KOLGA, Bayelsa State. Specifically, the study intends to:

1. investigate the effects of the Flipped Classroom Model on senior secondary school students' achievements in mathematics.
2. determine the influence of Flipped Classroom Model practice on senior secondary school students' achievements in mathematics concerning gender.

Research Questions

The following research questions guided the study:

1. What is the mean difference between the achievement scores of students taught mathematics with the Flipped Classroom Model and those taught using traditional teaching methods?
2. What is the mean difference between the achievement scores of male and female students taught mathematics with the Flipped Classroom Model?

Hypotheses

H_{01}. There is no significant difference between the mean achievement scores of students taught mathematics with the Flipped Classroom Model and those taught with the conventional method.

H_{02}. There is no significant difference between the mean achievement scores of male and female students taught mathematics with the Flipped Classroom Model.

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Methodology

This study adopted a quasi-experimental research design. Specifically, a pre-test and post-test non-randomized control design was used for the study. It's a design where the treatment variable is manipulated but the groups are not equated before the manipulation of the independent variable (Nworgu, 2015). The design was considered appropriate because the researcher intends to use intact classes as experimental and control groups to avoid disruption of the normal academic program of the schools. The population for the study comprises all 802 Senior Secondary Two (SSII) students from nine (9) public secondary schools in Kolokuma/Opokuma LGA of Bayelsa State in the 2023/2024 academic session. Two schools were purposively selected with a total of 80 students drawn from intact classes. Purposive sampling was necessary because the schools selected had computers and internet access. One school for experimental and the other for control. For the experimental (treatment) group, a total of 43 students were used for the study (25 males and 18 females). On the other hand, for the control group, 37 students were used for the study.

The instrument used for data collection in this study was a researcher-made Mathematics Achievement Test (MAT). The instrument is comprised of sections "A" and "B". Section A elicits demographic information of the students while section B contains fifteen (15) multiple choice items based on topics drawn from the senior secondary school mathematics curriculum which covers geometry. This study established two types of validity: face and content validity. To achieve this, three experts from the Department of Science Education, specifically, two experts in Mathematics Education and an expert in Measurement and Evaluation at the Federal University Otuoke, Bayelsa State validate the instrument. The content validity of MAT involved preparing a test blueprint. This blueprint was used to assess the questions in the achievement test based on the knowledge, comprehension, and application of the selected Mathematics topics. The objective is to ensure that the questions forming the test items align with the senior secondary mathematics curriculum and are suitable for the student's level. The researcher incorporated the comments and suggestions provided by the experts to create the final draft of the instrument.

The research instrument was trial-tested on a group of 20 students from a different population other than the population of the study. Thereafter, the Kuder-Richardson (K-R_{20}) formula was used to compute the reliability coefficient of .75. This method was used because the test items were dichotomously scored. The instrument for data collection was administered to the students with the help of a research assistant before the experimental and control treatments. This served as a pre-test of the study. At the end of the study, the instrument was reshuffled and re-administered to the students as a post-test. The reshuffling will act as a distracter to the students from realizing that they had responded to the items in the instruments previously.

Two resident mathematics teachers from each school were chosen as research assistants. The researcher conducted training for these teachers, covering the study's purpose, a rehearsal on how to conduct the study, and the procedure for administering the instrument. The experiment spanned for five weeks as follows:
Week 1: Training of the research assistants from the different schools.
Week 2: The research instrument was administered as a pretest.
Week 3 & 4: The research assistants utilized lesson plans developed by the researcher to teach intact classes, serving as experimental and control groups in the two schools. The regular periods in the schools' timetables were used to ensure that students were unaware they were part of an experiment.
Week 5: This involves administering the reshuffled research instrument as a posttest to assess the student's academic achievement in mathematics after the experimental treatment.
The research questions were answered using mean and standard deviation. The null hypothesis was tested using Analysis of Covariance (ANCOVA). The choice for the use of ANCOVA is because intact classes were used and initial differences cannot be guaranteed. The null hypothesis was rejected if the probability value was less than or equal to the significant value of .05 ($p \leq 0.05$) and if otherwise ($p > .05$), it was not rejected.

Results

Research Question 1: What is the mean difference between the achievement scores of students taught mathematics with the Flipped Classroom Model and those taught using traditional teaching methods?

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Table 1: Mean achievement scores and standard deviations of students taught mathematics with the Flipped Classroom Model and those taught using the traditional method.

Group	N	Pre-test		Post-test		Mean gain	Mean diff
		Mean	***SD***	**Mean**	**SD**		
Experimental	43	18.37	3.24	24.74	2.21	6.37	**4.05**
Control	37	17.92	3.60	20.24	2.67	2.32	

Table 1 shows that the mean achievement scores of students taught with the Flipped Classroom Model are higher than those taught using the traditional method because the gain in the mean of 6.37 for the experimental group is greater than the 2.32 gain in the mean for the control group. The mean difference is 4.05 which favours the experimental group.

Research Question 2: What is the mean difference between the achievement scores of male and female students taught mathematics with the Flipped Classroom Model?

Table 2: Mean achievement scores and standard deviations of male and female students taught mathematics using Flipped Classroom Model (post-test).

Gender	N	Pre-test		Post-test		Mean gain	Mean diff
		Mean	***SD***	**Mean**	**SD**		
Male	25	18.56	3.66	25.80	1.83	7.24	
Female	18	18.11	2.61	23.28	1.84	5.17	**2.07**

Table 2 shows that the male students who were taught using Flipped Classroom Model had mean scores that were greater than those of their female counterparts. The mean pretest for male were 18.56±3.66, and the mean posttest for males was 25.80±1.83, with a mean gain of 7.24. The mean pretest for female were 18.11±2.61, and the mean posttest for females was 23.28±1.84, with a mean gain of 5.17. The mean difference is 2.07 which favours the male students.

H_{01}: There is no significant difference between the mean achievement scores of students taught mathematics with the Flipped Classroom Model and those taught with the traditional method.

Table 3: Summary of Analysis of Covariance on the mean achievement scores of students taught mathematics with Flipped Classroom Model and those taught using traditional methods

Source	Sum of Squares	Df	Mean Square	F	Sig
Corrected Model	408.579[a]	2	204.290	34.549	.000
Intercept	1180.230	1	1180.230	199.596	.000
Pretest	5.689	1	5.689	.962	.330
Group	394.713	1	394.713	66.752	.000
Error	455.308	77	5.913		
Total	41951.000	80			
Corrected Total	863.888	79			

a. R Squared = .473 (Adjusted R Squared = .459)

Table 3 shows that there is a significant difference, F (1, 77) = 66.752, p = .000. Since the p-value is less than the alpha value of .05, the null hypothesis is rejected. This indicates a significant difference between the achievement of students taught mathematics using a flipped classroom and those taught using the traditional method as reflected in the mean and standard deviation. Thus the flipped classroom is more effective.

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H_{02}: There is no significant difference between the mean achievement scores of male and female students taught mathematics with the Flipped Classroom Model.

Table 4: Summary of Analysis of Covariance on mean achievement scores of male and Female Students taught mathematics using Flipped Classroom Model.

Source	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	67.177[a]	2	33.589	9.806	.000
Intercept	719.137	1	719.137	209.954	.000
Pretest	.603	1	.603	.176	.677
Gender	65.384	1	65.384	19.089	.000
Error	137.009	40	3.425		
Total	26532.000	43			
Corrected Total	204.186	42			

a. R Squared = .329 (Adjusted R Squared = .295)

Table 4 shows that there is a significant difference, F (1, 40) = 19.089, p = .000. Since the p-value is less than the alpha value of .05, the null hypothesis is rejected. This indicates a significant difference between the achievement of male and female students taught mathematics using flipped classrooms as reflected in the mean and standard deviation.

Discussion

The research findings demonstrated that students taught with the Flipped Classroom Model performed better compared to those taught using the traditional method. This was shown in the pre-test and post-test scores in mathematics of the experimental and control groups. This implies that the Flipped classroom Model was a more effective learning method. This result is consistent with the majority of previous studies on Flipped Classroom Models which suggests that the model is very successful. According to research by Ngbarabara (2021) and Azubuike (2015), there were significant differences in students' academic achievements in the use of the Flipped classroom model. The finding also corroborates the result of Chukwuorji and Gusen (2020) who discovered that there is a significant difference favouring self-directed learning in the flipped classroom group. The findings equally support the result of Mithun and Evans (2018) which revealed an increase in the class grade average for flipped sections compared to traditional sections, highlighting positive impacts on student motivation and engagement. While, the studies of Ezeudo and Ezinwanne (2013) and Obih (2017) revealed that, there were no significant differences in students' academic achievements. This background, therefore, suggests that students' academic achievements vary depending on the circumstances and course of study. Gender differences in this study saw a significant difference in both males and females. This result is in line with Ngbarabara (2021) and Azubuike (2015), who discovered a significant relationship between students' academic performance and that gender composition has a significant influence on secondary school students' academic performance. In other words, the influence of gender may vary depending on the subject or course, the instructional strategy used and the ability of the teacher to teach the subject.

Conclusion

This study seeks to investigate the effect of the flipped classroom model on the students' academic achievement in mathematics. The results of the analysis revealed that students who learned using the flipped classroom model got higher achievement scores than those taught using the traditional teaching method. The use of the flipped classroom model has proven to be an effective approach to enhancing students' achievement in mathematics as seen in this research. The results also indicate that the flipped classroom model gives students the avenue to take notes as they watch the videos and then the teacher can make do with the notes for in-class discussion which will help students improve their learning outcome when compared with the traditional classroom learning.

Recommendations

Based on the findings, the following recommendations were proffered:

1. The Nigerian Senior Secondary School teachers should get involved in the use of the flipped classroom model in teaching and learning Mathematics. This will arouse exposure and interest among the students.
2. The flipped classroom model should be considered for incorporation into the mathematics curriculum by the relevant curriculum planners and policymakers.

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3. ICT facilities and resources should be adequately provided in secondary schools with the help of the Federal and State governments through the Ministry of Education.
4. School principals should ensure the availability of ICT resources and materials that would enable the smooth usage of the flipped classroom approach to boost learners' mathematics achievement and interest
5. The government and educational bodies should constitute seminars and workshops for mathematics teachers on the use of the flipped classroom model in teaching and learning mathematics.
6. All stakeholders in the education industry including parents should see flipped classrooms as an innovation which must be welcomed, and supported and its usage sustained in Nigeria.

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