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Flipping the classroom environment: Effect on students' academic achievement

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Abstract
This study investigated the effects of Flipped Classroom Strategy (FCS) on students' academic achievement in Mathematics in Senior Secondary School 11 students in Obio/Akpor Local Government Area, Rivers State. A sample size of one hundred and four (104) students; fifty three (53) students (34 boys and 19 girls) in the control group and fifty one (51) students (34 boys and 17 girls) in the experimental group was used for this study. Purposive sampling technique was used to compose the sample. A pre-test post-test quasi experimental design was used. One instrument; Mathematics Achievement Test (MAT) was developed by the authors and was validated by mathematics teachers and experts in the field of measurement and evaluation. To test the internal consistency of the MAT, the Kuder Richardson technique was used and a reliability analysis produced a Kuder Richardson of 0.701. The obtained data was analysed for means and standard deviations, while t-test and analysis of covariance (ANCOVA) were used to test the hypotheses. It was found that FCS significantly improved students' academic achievement in mathematics. However, the students' academic achievement in mathematics for the two groups (FCS & TCM) was not improved significantly but was better for those taught using the TCM.

Keywords: flipped classroom, teacher centred method (TCM), flipped classroom strategy (FCS), mathematics, mathematics academic achievement

1. Introduction
The relevance of Mathematics for sustainable development and growth of any nation is not in doubt. People use mathematics knowingly or unknowingly in solving their day-to-day problems. Mathematics according to Gauhar (2012) is the Queen of Science and the language of nature. Eraikhuemen (2003) [13] asserted that a good foundation in Mathematics is an essential step for the study of Science and other Science related disciplines. For any nation to aspire to be competitive on a global market and in this technological era, that nation must first be scientifically and technologically outstanding. Mathematics is the pivot of these subjects. To buttress this fact, Ale and Lawal (2010) [1] posited that the difference between a developed and developing nation is based on their level of mathematical attainment and ingenuity. No wonder Mathematics is one of the compulsory subjects in the Nigerian educational system. As important as Mathematics is, unfortunately, there is persistent prevalence of poor academic achievement among senior secondary school students in Nigeria (Musa & Dauda, 2014) [29]. Research abounds on the factors that militate against the academic achievement of senior secondary school Mathematics students. According to Udonsa (2015) [39], some of such factors include but not limited to;

1. Lack of problem solving skills
2. Methods of teaching, such as the use of traditional chalk-and-talk method.

In the search to ascertain ways of improving the teaching and learning of Mathematics, there is need to cultivate innovative teaching strategy and improve students' academic achievement in Mathematics. Ma (2003), writing on the need for functionality in education and specifically in Mathematics stated that, "In the present quantitatively complex society, a person needs a functional knowledge of Mathematical content to make informed decisions as a citizen and as a worker." The aforementioned assertion has shown vividly the relevance of Mathematics in a globalized world, which made it imperative that it should be taught with an innovative approach of "flipped classroom".

2. Literature Review
Flipped classroom according to Lage and Platt (2000) [26] involves events that traditionally take place inside the classroom but now take place outside the classroom and vice versa. Similarly, Charles-Ogan and Williams (2015) [11] opined that flipped classroom is a classroom where home works are done at school and school works are done at home. According to Flipped Learning Network (2014) [14], it is an instructional method that moves direct instruction outside of the classroom in order to make room in the classroom for a more interactive learning environment where students can actively engage in the content. Similarly, Flipped classroom is an educational approach in which learners view pre-recorded lectures using technological devices at home, library environment or any place where the materials for instruction are made accessible and complete their assignment, test and projects in the classroom (Alvarez, 2012; Bergman & Sams, 2012, and Fulton, 2012) [2, 5, 16].

In addition, Bishop and Verleger (2013) [8] stated that flipped classroom is an educational technique that consists of interactive group learning activities inside the classroom and direct computer-based individual instruction outside the classroom. The implication is that students are to learn the concepts by using computer-based instruction at home while the lesson period is used in working on the assignments and

activities with their mates and the teacher acting as a guide. The essence of flipped classroom model is to direct the students to be self-prepared for the next class meeting. In this case, the students have in their preparation, watched the material given to be discussed in the next class meeting and possibly collaborate with their peers about the materials. During the process of discussion on the content watched, various areas of perceived problems could be dealt with effectively. To be precise, flipped classroom allows learners to learn at their own speed Davies, Dean, and Bell (2013) [12].

The forgoing definitions reveal that flipped classroom is an innovative teaching strategy in Nigerian educational system. This concept is a dramatic shift from the previous teacher – centered approach to student – centered approach as stated in Kong (2014) [24]. Today, flipped classroom has pronounced effects on teaching of various subjects such as Engineering, Medicine and other disciplines (Davis *et al*., 2013). The students who viewed the lectures in any of the subjects as recorded by the teacher could take notes before attending the next class. They would therefore work in class on inquiry–based assignments, which were regarded as home work traditionally.

Some of the proponents of flipped classroom (Foertsch, Moses, Strikwerda & Litzkow 2002; He, Swenson & Lents, 2012; Kay & Kletskin, 2012) [15, 17, 23]. Were emphatic in advocating that flipping the classroom has the capacity of inculcating in the students, problem-solving, critical thinking and spirit inquiry skills which are cardinal in attaining high academic achievement in mathematics subject. Therefore, flipped classroom strategy would endeavour to make available diverse activities that would help in facilitating the relevance of mathematics lessons, sensitize students' interest in the study of mathematics and subsequently enhance students' academic achievement.

Nevertheless, there are possible challenges that can hinder its implementation and effectiveness. Some of them could be infrastructural challenges meaning that some classrooms might not be designed for group work, class size management and many families have not integrated the needed technologies for their children pre-assignment works. However, literature abounds concerning the fact that flipped classroom has the potential to enhance students academic achievement in Mathematics (Anderson, 2007; Brunsell &Horejsi, 2011; Brown-Martin, 2012) [4, 10, 9].

Saunders (2014) [31] opined that the teaching method adopted by a teacher is very important to students' academic achievement and it can greatly affect on the way a student views a particular subject and even education as a whole. The way a teacher teaches would encourage or discourage the students from studying the subject. According to Anaduaka and Okafor (2013) [3], a mathematics teacher who is dedicated to his teaching should be able to lift his/her students to a level where they begin to appreciate mathematics as a subject. If students are able to appreciate the beauty and application of mathematics, their attitude towards the subject would change positively. Thus the learning of mathematics involves both the teacher and the students. This is a reason why this research is anchored on Vygotsky's Social Cultural Theory to explain the connections between the flipped classroom approach and students' academic achievement in senior secondary school mathematics.

This theory recommended that when students learned through social interactions, in groups, or in collaboration with the teacher as a facilitator, they retained the self-discovered knowledge and information comprehended based on the teacher's assistance, thereby enjoying the learning of Mathematics (Sedig, 2008) [33]. Vygotsky (1978) opined that students acquired knowledge through social interactions and through their culture to experience meaningful learning. When Vygotsky's social cultural theory was carried out in the mathematics classroom (via facilitation, collaboration, multiple representation, technology, etc.), students retained mathematical information longer and grasped the concepts easily regardless of the level of difficulty; in turn, students mathematics achievement was maximized (Jones, Jones, & Vermette, 2010) [19]. The major theme of the social cultural theory structure is that social interactions play an important part in cognitive development. Therefore lessons should be well planned so that students effectively interact within the classroom and construct their own understanding (Alvarez, 2012; Berrett, 2012) [2, 6]. Ideas from Vygotsky's social cultural theory are apparent within the flipped classroom and evidently work well within the flipped classroom approach.

Mathematics academic achievement (MAA) would imply the achievement of students' scores on standardized tests and scores obtained from class tests and external examination while students' academic performance are basically on general aptitude and the competencies that are the outcomes of good behaviour in the school environment (Maduewesi, 2005) [28]. The implication is that flipping the classroom in Mathematics should promote academic achievement of students and in addition, enhance academic performance of students in the school environment.

Therefore, there is need to verify the effect of flipped classroom on Senior Secondary School Mathematics Students in Rivers State.

2.1 Statement of the Problem

The abysmal poor academic achievement of senior secondary school mathematics students in Nigeria have become of great concern to all stakeholders in education. Observation reveals that teacher centered approach has dominated the teaching of mathematics in Nigerian educational system especially in Rivers State. This method according to researchers is one of the major factors impeding the teaching of Mathematics (Anaduaka & Okafor, 2013) [3]. Therefore, there is need to employ an innovative teaching approach which may have the capability of enhancing, the academic achievement of senior secondary school mathematics students. This study therefore, seeks to find out the extent to which the Flipped Classroom Strategy (FCS) can enhance senior secondary school students' academic achievement in mathematics.

2.2 Aim and objectives of the study

The aim of this study is to investigate the effects of the Flipped Classroom Strategy (FCS) on the academic achievement of senior secondary school students in Mathematics. Specifically, the study intended to:

1. Find out the effect of Flipped Classroom Strategy on students' academic achievement in mathematics.
2. Verify whether students taught with the FCS differ in their academic achievement in mathematics from those taught with the teacher centered method.

2.3 Research Questions

1. What is the effect of flipped classroom strategy on students' academic achievement in mathematics?
2. To what extent do students taught with the flipped classroom strategy differ in their academic achievement in mathematics from those taught with the TCM as measured by their post-test mean scores?

2.4 Hypotheses

H_{O1} The effect of the flipped classroom strategy on students' academic achievement in mathematics is not significant.

H_{O2} Academic achievement in mathematics of students taught using FCS does not differ significantly from that of the students taught using TCM.

3. Methods and Materials

The study focused on the academic achievement of senior secondary school II students in two co-educational schools in Rivers State, Nigeria. Flipped Classroom Strategy (FCS) and Teacher-Centred Method (TCM) were the pedagogical methods used in the classroom to evaluate the effects on students' academic achievement when classrooms are flipped. The design of this study is the two group pre-test post-test quasi-experimental design. Intact classes were used to determine the effects of the two teaching strategies on students' academic achievement in mathematics. The authors designed and developed a Mathematics Achievement Test (MAT) to collect data for the study. The MAT was validated by mathematics teachers and experts in the field of measurement and evaluation. For content validity, the use of table of specification well-structured and validated MAT items ensured the content validity of the instrument. To determine the internal consistency of the MAT, the authors administered the instrument to 20 SSII Mathematics students who were not involved in the study. Kuder Richardson Formula 20 (K-R 20) was used to calculate the reliability and a coefficient of 0.701 was obtained.

The mathematics content on which the MAT was based included; Bar Chart and Pie Chart, Grouped Data, Measures of Central Tendency for Grouped Data and Cumulative Frequency. The MAT consisted of 30- items multiple choice questions to ascertain the academic achievement of the students in mathematics. The MAT involved questions that probe students' problem-solving and critical thinking skills. Also, there were inputs from flipped classroom strategies and the social learning theories. Furthermore, there were inputs from research literatures that stressed the relevance of mathematics in Nigeria specifically and globally in general.

The sample size for this study was one hundred and four (104) students; fifty three (53) students (34 boys and 19 girls) in the control group and fifty one (51) students (34 boys and 17 girls) in the experimental group. The two co-educational senior secondary school students were selected using purposive sampling technique because they possessed the specific characteristics to be studied. The criteria that were used for adequate representation of male and female students were:

1. A school that was co-educational to offer opportunity to assess students' interest and achievement in mathematics based on gender.
2. A school that has ICT facilities needed for flipped classroom
3. Administrative consent
4. Qualified mathematics teachers
5. Individual student consent.

The experimental group was taught using the Flipped Classroom Strategy (FCS). Selected mathematics topics were built into the flipped classroom lesson plan using the flipping principles. There were also contributions from the recommended SS II Mathematics books; Essential Mathematics 2 for Senior Secondary Schools by Oluwasanmi (2013). These were imbedded into the instructional package which was burnt into the CDs for students to view at home in preparation for the next class. The instructional packages in the CDs reflected learning principles such as; active involvement of students; problem-solving, collaborative learning, student-to- student interactions, students' ownership of the lesson, student-teacher interactions and relating the lessons to real-world experiences. The control group were taught the same topics using the Teacher Centred Method (TCM). The instructional package for this group was based on the traditional teaching strategies where students are usually taught in class and have assignments given to them to be completed at home. The same recommended textbook was used.

Before the introduction of the treatment (that is, Instructional CDs for the Experimental group), both groups were given the pre-test instrument – Mathematics Achievement Test (MAT). Thereafter, treatment commenced and lasted for five weeks of twenty periods. For the experimental group, the traditional classroom was inverted. Thus students were given their instructional packages in CDs. During the next class, students were allowed to interact among themselves, discussed the content and answered questions based on the pre-assignment which they had already done at home. As these processes were going on, students were guided on difficult problems they encountered. During the process, students paused, replayed, and watched lessons repeatedly during the interaction process.

4. Results

Research Question 1: What is the effect of flipped classroom strategy on students' academic achievement in mathematics?

Table 1: Mean, Standard Deviation on the Effect of Flipped Classroom Strategy on Students' Achievement in Mathematics

Test	N	X	SD	Mean diff.
Post test	51	12.18	4.36	3.98
Pre test		8.20	3.16	

Table 1 shows that mathematics mean scores of students exposed to flipped classroom strategy group are 12.18 (standard deviation, 4.36) and 8.20 (standard deviation, 3.16) respectively for post- and pre-test scores. The gained mean score of 3.98 obtained shows that FCS improved students' achievement in mathematics.

Research question 2: To what extent do students taught with the flipped classroom strategy differ in their academic

achievement in mathematics from those taught with the TCM as measured by their post-test mean scores?

Table 2: Students' Mean and Standard Deviation for the Difference in Mathematics Achievement when taught using FCS and TCM

Group	Post-Test			Pre-Test			Post-Test Mean score Difference
	N	$\bar{X}$	Sd	N	$\bar{X}$	sd	
FCS	51	12.18	4.36	51	8.20	3.16	2.01
TCM	53	14.19	4.80	53	12.94	3.70	

Table 2 shows a post-test mean score of 12.18 and standard deviation of 4.36 for students' achievement in mathematics for the FCS group, and post-test mean score 14.19 and standard deviation of 4.80 for TCM group. Therefore, the difference of 2.01in the post-test mean scores shows that the group taught using TCM had a better achievement in mathematics.

Hypothesis 1: The effect of the flipped classroom strategy on students' academic achievement in mathematics is not significant.

Table 3: Paired t-Test on the Effect of Flipped Classroom Strategy on Students' Achievement in Mathematics

Test	N	x	Sd	Mean diff.	df	t-cal	p-value
Post test	51	12.18	4.36	3.98	50	5.95	0.000
Pre test		8.20	3.16				

Table 3 shows when the pre-test and post-test means were subjected to paired t-test, a t-value of 5.95 was obtained at degree of freedom 50, p-value of 0.000. Since the p-value obtained is lower than 0.05, the chosen level of probability, the null hypothesis 1 is therefore rejected. This indicates that flipped classroom strategy has significant effect on the mathematics achievement of students.

Hypothesis 2: Academic achievement in mathematics of students taught using FCS does not differ significantly from that of the students taught using TCM.

Table 4: Table 4.12 Two-way ANCOVA on the Effect of FCS and TCM on Students' Academic Achievement in Mathematics

Source of variation	Sum of squares	Df	Mean square	F	P-value
Pre-test MAT	395.558	1	395.558	23.010	0.000
Group (Teaching Strategy)	10.187	1	10.187	0.593	0.443
Error	1701.909	99	17.191		
Total	2256.760	101			

Table 4 reveals an F- value 0.593 for the teaching strategies at df of 1 and 99 and p-value of 0.443. Thus, there is no significant difference in the mathematics achievement of students taught using FCS and those taught using TCM. This is because the hypothesis 2 is accepted on the basis that the obtained level of significance is higher than 0.05, the chosen level of probability.

5. Discussion

Flipped Classroom and Students' Achievement in Mathematics

Table 1 shows that the students taught using flipped classroom strategy had a pre-test mean score of 8.20 and a standard deviation of 3.16, while the post-test mean score was 12.18 and standard deviation of 4.36. This showed a gained mean score of 3.98 which indicates that flipped classroom strategy improved students' academic achievement in mathematics. Statistical analysis table 4.2 showed that the effect was statistically significant at 0.05 level, which means that flipped classroom strategy had significant effect on the mathematics achievement of students. This result is not surprising because the flipped classroom students, who were the experimental group, had the opportunity to rewind, pause, fast-forward, work at their own pace, place and time.

The present result is in agreement with some previous research findings. For example, Charles-Ogan and Williams (2015), in a study to evaluate the advantages of a flipped classroom over conventional setting in students' academic achievement in mathematics in Rivers State found that the flipped classroom group performed better than the conventional and concluded that the advantages of the flipped classroom approach exceeded those of the conventional. Similar results were found in related studies by other researchers (Stone, 2012; Schultz *et al*, 2013; Szparagowski, 2014; Kadry and El Hami, 2014; Kaushai *et al*, 2016; Bhagat *et al*, 2016; and Kurt, 2017) [35, 32, 21, 22, 7, 25]. However, the results by Strayer (2007) [36] and Johnson and Renner (2012) [18] were inconsistent with the present study. For example, in Strayer (2007) [36] the students were 'less satisfied with how the structure of the class oriented them to the learning tasks in the course' while Johnson and Renner (2012) [18] argued that the 'failed attempt at the flipped model of instruction is what led to such result, rather than the intervention itself '.

Teaching strategies and students' academic achievement in mathematics

Table 2 showed a post-test mean score of 12.18 and standard deviation of 4.36 for students' achievement in mathematics for the FCS group, and post-test mean score of 14.19 and standard deviation of 4.80 for the group taught using TCM. Therefore, there existed a difference of 2.01 in the post-test mean score of the two teaching strategies; FCS and TCM in favour of the group that was taught using the TCM, which means that the TCM improved students' academic achievement. However, this was not statistically significant.

This result was not surprising as the flipped classroom teacher may not have had enough experience with the use of technology in the teaching of mathematics coupled with his disposition towards the use of technology. Furthermore, there was no guarantee that the experimental group actually watched the videos at home. This finding is consistent with the findings of JoRonna (2014) in a study of Flipped Classroom and its effect on students' academic achievement and critical thinking skills in High School Mathematics where it was found that students subjected to the flipped classroom did not perform better than those subjected to the traditional approach. Similar results were found in studies by Johnson and Renner (2012) [18] and Strayer (2007) [36]. Nevertheless, other researchers found contrary results. For example, some of these researchers are; Talley and Schere, 2013; Davies *et al* 2013; Bhaggat *et al*, 2016; Yang, 2017; and Kurt, 2017 who found that FCS improved achievement better than traditional approach and they attributed the

improvement to the ability of the students to rewind, fast-forward and interact with their peers.

6. Conclusion

The use of flipped classroom strategy was found to improve students' academic achievement in mathematics and the improvement was statistically significant (p=0.05). However, the students' academic achievement in mathematics for the two groups (FCS & TCM) was not improved but was better for those taught using the TCM.

The results of this study have provided ideas about the potential of an alternative strategy for teaching in senior secondary school mathematics. The findings from this study could also encourage teachers to employ alternative strategies combined with technologies in their classrooms to help students with different learning styles, uncover different methods of teaching, give students extra time for collaborations on one-on-one basis with their teachers and create an avenue for students to have momentous discussions with their peers. The advantages of implementing flipped classroom strategy may include enhancement of teacher effectiveness thereby impacting positively the students' academic achievement in senior secondary school mathematics.

7. Recommendations

1. The State Government/ stakeholders should provide training programs on information and communication technology (ICT) integration into mathematics curriculum to enhance teachers' effectiveness, since we are in the technological driven era.
2. Rivers State senior secondary schools should consider implementing the flipped classroom strategy in mathematics, as it engages and improves students' academic achievement.

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