

THE FLIPPED CLASSROOM: ITS EFFECTS ON STUDENTS' PERFORMANCE AND RETENTION IN SECONDARY SCHOOL MATHEMATICS CLASSROOM

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Abstract

Flipped classroom (FC) is a classroom where homework is done at school and school work is done at home. In secondary schools, students' performance in mathematics is poor and calls for urgent attention. Hence, this study examined effect of flipped classroom on senior secondary school students' performance and retention in mathematics. This study examined: post-test performance (PP) and retention performance (RP) of students in Mathematics when taught with FC and traditional classroom (TC). The study adopted quasi-experimental design. Sample was drawn from two Secondary Schools in Lagos State, Nigeria. Respondents were 268 students (145 for experimental taught with offline video and 123 for control group taught with lesson note). The instrument used for data collection was the performance test and its reliability yielded 0.88 using Cronbach Alpha and two null hypotheses were tested using (ANCOVA). The findings revealed that: (i) there was a significant difference in the PP $F(1,265) = 142.002, p = .00$ and RP $F(1, 265) = 130.24, p = .00$ of students which favoured the FC with mean score of 28.44 and 25.48 respectively using benchmark of 20.00 and (ii) no significant difference in the PP $F(1,142) = .225, p = .64$ and RP $F(1,142) = 0.064, p = .80$ of both male and female students in FC. The study concluded that flipped classroom improves students' performance generally irrespective of gender. It was therefore recommended among others that teachers should be inspired in using FC to teach any subject because if fully integrated, there will be excellent improvement.

Keywords: flipped classroom, performance, retention

Introduction

Education is the process of imparting and acquiring knowledge through teaching and learning in educational institutions. In reaction to the National Council of Teachers of Mathematics publications (NCTM, 2005) and students' hatred towards learning mathematics, stakeholders in mathematics education have begun to develop alternatives to traditional methods of teaching to address students' mathematics deficiencies (DeJarnette, 2012). All over the nation, revisions and improvisations to traditional curricula are being proffered wherein technologies, easing, discovery learning, and student collaboration are being implanted into curricula in an effort to increase students' academic performance in mathematics through the use of information and communication technology (ICT) (Archambault, Wetzel, Foulger, & Williams, 2010). These facets of the mathematics classroom appear to be the wave of the future and are inexorable if students are to become more than just working in secondary school level mathematics.

Yusuf (2006) described ICT as an umbrella term that includes any communication devices or applications encompassing radio, television, cellular phones, computer (hardware and software) social network and satellite systems, and engendered terms like e-learning, e-teaching, virtual teaching/learning and e-training among others that are developed around the field of education. The use of ICT can offer a rich choice of learning experiences that are appropriate for students' needs, space, pace, aspirations and learning styles as opined by Olorundare (2011). The use of multimedia in an organisation has been extensive and has equally been effective in improving performance and retention rates. Research has shown that people remember 20% of what they see, 40% of what they see and hear, but about 75% of what they see, hear and do simultaneously (Oshinaike & Adekunmisi, 2012).

The poor performance of students in mathematics despite its importance was attributed to poor teaching approach (FRN, 2014; WAEC, 2016), and poor learning environment (Olunloye, 2010). Many research studies suggested a complete refurbishment of the public education system (Rycik, 2012), other research studies suggested that educators explore substitutes to the traditional classroom (Anderson, 2007). Educators are now applying mixed curricula that include artificial intelligence software, multimedia assisted instruction, and even the inverted curriculum (Ritter, Anderson,

Koedinger, & Corbett, 2007). Research suggested flipped classroom as one solution to this problem (Berrett, 2012; Alverze, 2012; Strayer, 2007 and; Rozinah & Siti, 2014).

The flipped classroom (FC) is defined as using technology to provide lectures outside of the classroom, while assignments with concepts are provided inside the classroom through learning activities (Clark, 2013). The FC is a classroom where homework is done at school and school work done at home. The school work is the recorded lessons' videos adopted or adapted by the teachers on all the topics in any subject or course. The students will need to watch the video at home online or offline in the absence of the teacher. Then, do the homework (assignments) in the class in the presence of the teacher who will render assistance in the area of difficulties and monitor the learning progress in the class.

Instead of using face-to-face classroom time mainly to inform, communicate and generate awareness, the flipped instructor will generally move this type of activity to an asynchronous environment. For instance, if the information is available online or offline on the DVD, students may read and refer to it as often as needed in order to recognise and recall it later. Procedural instruction that changes very little with time is also appropriate for the asynchronous environment. This type of instruction leads to near transfer (Clark & Mayer, 2011; Horton, 2012). The information or experience can be documented, simulated, and explained in a way that stays relatively consistent over time. A variety of technologies may be helpful in this move. For example, an instructor may link to a *YouTube* video demonstration from Khan Academy or other sites of such that shows how to solve a mathematical problem or how to use a particular piece of mathematical equipment. Students can follow along with the video and practise on their own.

A lot of learning approaches based on students-centered learning supported flipped classroom as illustrated in the Venn diagram in Figure 1. Prince (2004) defined active learning broadly as, any instructional method that engages students in the learning process. This definition is itself broad enough to include many traditional classroom activities such as lectures (provided students are reflecting, taking notes, or asking questions). However, in an effort to maintain contrast with traditional teacher-centered approaches, these methods are systematically dismissed by explicit exclusion. Thus, active learning acts as a superset for both peer-assisted and problem-based learning approaches. Prince also clarifies the relationship between these two, indicating that problem-based learning is, always active and usually (but not necessarily) collaborative or cooperative as illustrated in Figure 1. The theoretical foundations used for justifying the flipped classroom typically focus on reasons for not using classroom time to deliver lectures. These stem from a large body of literature on student-centered learning, which looks primarily to the theory of Piaget 1967 and Vygotsky 1978.

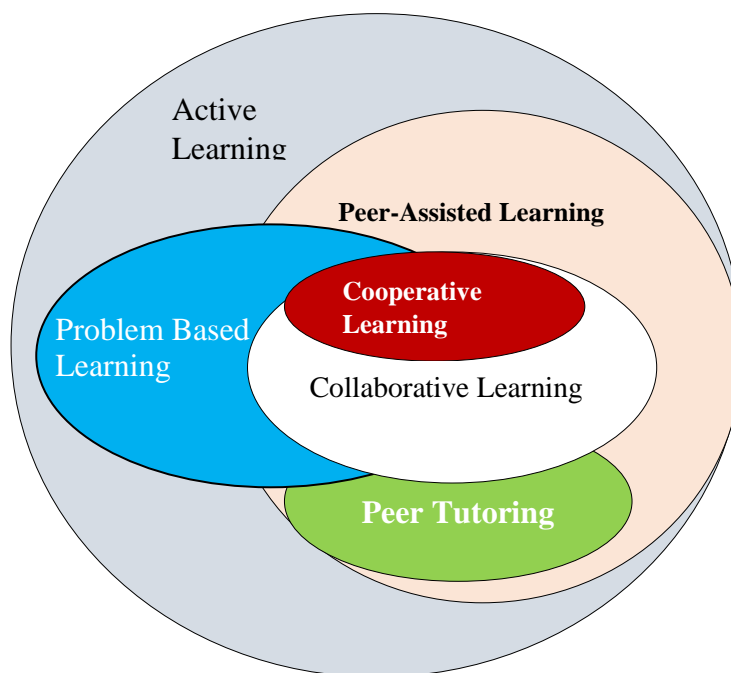


Figure 1: Venn diagram of Several Students-Centered Learning Theories and Methods
Adapted from: Bishop and Verleger, 2013

leading to peer-assisted learning. In particular, they pointed out that constructivism and collaborative learning stem from Piaget's theory of cognitive conflict, and that cooperative learning stems from Vygotsky's zone of proximal development. The importance of these (student-centered) learning theories to the flipped classroom cannot be understated. Without these, the flipped classroom simply does not exist. As shown in Simple model for flipping the classroom (Figure 2), the flipped classroom is made up of three components: pre-class component that requires students' interaction with learning materials through online or offline activities. In-class activities which involves interactions between the students and the teacher and students – student's collaboration in the class for real learning concepts.

Lastly, the post-class component that is automated by computer technologies. Student learning standard can be examined through the procedure. Obviously, the classroom component is critical, and the student-centred learning theories just presented provide the philosophical basis for the design of these activities. Unintentionally, some may overlook this fact and instead conceptualize the flipped classroom based only on the presence (or absence) of computer technology such as video lectures. This would be a mistake, since the pedagogical theory used to design the in-class experience may ultimately be the determining factor in the success (or failure) of the flipped classroom.

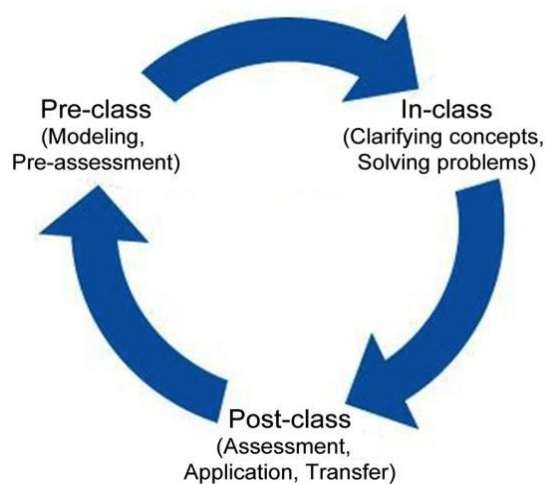


Figure 2. Simple model for flipping the classroom.

Source: Estes, Ingram and Liu (2014).

The concept of flipped classroom began about 15 years ago with the occasional marriage of computer technology and a few technologically advanced educators, including Baker (2000) who's description of the classroom teacher evolving into the guide on the side instead of the sage on the stage. Salman Khan, the Khan Academy originator in 2006 attempted to provide tutoring to his younger relatives online at a distance. He developed videos for them, which he uploaded for them to watch on their own. These videos became so significant in number, that he began to catalogue them, and eventually developed a website named Khan Academy.

Flipping the classroom empowers instructors to develop different learning experiences appropriate for each student. Alvarez (2012), Bergmann and Sams (2012), Bergmann and Sams (2013) and Strayer (2007) affirmed that FC in education has been used to support teaching and learning processes and thus, leading to improved design and development of instructional materials. It was added that teachers' facilitation of learning process improved even in a classroom learning context and environment. As a result, improving students' learning experiences, academic achievements, and performances.

The teacher substitutes in-class instruction with at home video instruction and utilises class time for homework assignments and other project-based learning activities. This is one of the features FC possesses that make it distinct from other methods of teaching like videoconferencing, computer-based teaching (CBT), mobile-learning and so on that do not require direct class interactive session. Little wonder, the recorded videos on subjects/topics for primary/secondary school students on Compact Disc/Digital Video Disc (CD/DVD) that are selling all over the places in Nigeria are only going to assist few students because no feedback and nobody is available to assess students'

understanding and explain the difficult concepts of the topics/lessons recorded. The students were not opportune to have one-on-one interaction with their teachers; hence, students' contribution will not be possible. As a result, subjects like Mathematics, English language and so on cannot understand effectively with this approach.

Despite the importance of mathematics to every individual, students' interest and performance have always been of concern to stakeholders. Usman (2002) noted that in everywhere people go, everything people do or propose to do, the structure of mathematics or its applications play a vital role, and therefore most countries, races, and peoples put emphasis in all aspects of studying, developing and applying mathematics. The National Mathematics Advisory Panel (2008) argued that for students to continue performing brilliantly in mathematics there must be an improvement in the quality of Mathematics instruction received by all school students. Human beings need mathematics to survive no matter how minimal. There is no gainsaying in the fact that an individual can get on sometimes without knowing how to read and write, but no one can push ahead smoothly without knowing how to measure, count, subtract and add.

Nigeria in her National Policy on Education (FRN, 2009) confirmed the need to make education a tool to meet the needs of individual citizens and society at large in consonance with the realities of the immediate environment and modern world. In support of this, the latest edition of Nigeria National Policy on Education (FRN, 2014) showed the reviewed curriculum for Senior Secondary Schools (SSS) whereby Mathematics was among the compulsory subjects to be selected among others. The poor performance in mathematics as illustrated in the statistical analysis of students' performance in final year mathematics examinations of West African Secondary School Certificate Examinations (WASSCE) (Table 1) requires urgent attention.

Table 1.

Students' Performance in Mathematics in (WASSCE), 2012-2016.

Year	Number of Candidates sat for the Examination	Pass at Credit (A1 - C6)	% Credit Pass (A1 - C6)
2012	1,657,754	839,046	50.61
2013	1,658,187	899,901	54.27
2014	1,632,377	1,011,608	61.97
2015	1,593,442	616,343	38.68
2016	1,544,234	878,040	52.97

Source: Statistic Office WAEC, Lagos, (2016)

For two consecutive years (2012-2013), students' performance in Mathematics was on average (50.61% and 54.27%) but improved in 2014 (61.97%). Deficient performance was recorded in 2015 (38.68%) but it was better in 2016 (52.97%). These results indicated that about 50% of the students do not have the required mathematics grade (at least a credit) for admission into higher institutions in Nigeria. According to the Chief Examiners Reports for 2012 - 2016 WASSC examinations (WAEC, 2016), the deficient performance was attributed to poor understanding of contents and concepts of some major aspects of the syllabus specifically geometry and trigonometry. Research reports also indicated that several reasons are responsible for students' poor performance in mathematics. Some of these are poor teaching methods (WAEC, 2016; Olunloye, 2010), students' lack of confidence in the subject (Basturk & Yavuz, 2010) and poor learning environment (Olunloye, 2010).

Another factor affecting the learning of mathematics have been traced to students' retention. Retention, as defined by Hornby (2001) is the ability to remember things. Retention could also be defined as the ability to keep or retain the knowledge of mathematics learnt and to be able to recall it when required. Also, in today's classrooms, retention should be one of the most important factors required to understand the concepts that are taught to the students. Without retention, there cannot be a successful transfer of knowledge from one subject area to another. If retention is not a top priority in the classroom, teachers will spend most of the class time reviewing and re-teaching concepts. Retention in mathematics is not acquired by students through mere rote memorization but through appropriate teaching method (Iji, 2002; Chianson, 2008).

Statement of the Problem

Due to poor teaching methods (WAEC, 2016), students' prior mathematics experiences and attitudes towards mathematics (Tulis & Ainley, 2011), students' lack of interest in, poor learning environment and motivation to learn mathematics (Aborisade, 2009), and prerequisite deficiencies (Hull & Seeley, 2010), research has indicated that mathematics students are not learning the concepts necessary for mathematics competence (Rock, Gregg, Ellis, & Gable, 2008; Schullery, Reck, & Schullery, 2011). If this trend continues, Nigerian students may not be able to efficiently compete in the universal economy (Ale & Lawal, 2012). To address this issue, this study sought to examine the effect of the flipped classroom on senior secondary school mathematics students' performance and retention using researcher developed flipped classroom package on DVD to determine: (a) whether FC will help to improve students' post-test performance in Mathematics, and (b) whether retention performance among SSS be improved if FC is adopted by Mathematics teachers.

Purpose of the Study

The main purpose of this study was to examine the effect of the flipped classroom on Senior Secondary School Students' performance in Mathematics. The specific objectives of this study are to:

1. determine the difference(s) in the post-test performance of students taught mathematics using the Flipped Classroom (FC) and those taught using the Traditional Classroom (TC) method.
2. examine the difference(s) between the retention of students taught mathematics using the flipped classroom (FC) and those taught using the Traditional Classroom (TC).

Research Questions

The following research questions were raised in the study:

1. Is there a difference in the post-test performance of students taught mathematics using the FC and those taught using the TC method during a twelve-week term?
2. Is there a difference between the retention performance of students taught mathematics using the FC and those taught using the TC during a twelve-week term?

Research Hypotheses

Based on research questions, the following null hypotheses were tested in this study:

- H₀₁: There is no significant difference in the post-test performance of students taught mathematics using the FC and those taught with TC.
- H₀₂: There is no significant difference in the retention performance of students taught mathematics using the FC and those taught using the TC.

Significance of the Study

The outcome of the study may serve as a useful guide to Nigerian secondary schools intending to adopt FC in teaching mathematics and other subjects that students find difficult to understand. The outcome of this study would help students in Nigerian secondary schools increase their preparation for examination, improve their opinions about mathematics, through FC. This may also increase students' computer experiences which may help to ease their phobia and lack of preparedness. More so, it will help students to increase their degree of computer literacy to avoid the mode effect on FC.

Parents being the intermediary between the schools and the students, will give the opportunity for thorough monitoring of the students' progress in their mathematics learning through FC. This will also allow parents to see by themselves since much activities would be taking place at home. Lazy students will be exposed through FC instruction and enable the parents to have first-hand information about the performance of their children and in turn, assist the school, examinations boards government and the teachers on how to help the student(s).

Research Methodology

This study employed quasi-experimental design in which 268 (145 experimental and 123 control groups) students of Senior Secondary School II (SSS II) in Lagos State from two schools in Anwar-UI-Islam movement of Nigeria group of secondary schools (AIMNGSS) purposively selected and participated in the study. The instruments used: (i) Flipped Classroom offline video Package (FCP); (ii) Mathematics Performance Test (MPT); and (iii) Lesson Notes (LN); were validated by six experts from mathematics science department, educational technology department, experts in software designing, University of Ilorin, Ilorin Nigeria and two secondary school mathematics teachers. Its reliability was also established through trial test. Test-retest method was used during and after the experiment to determine the retention of the students. The researcher with two research assistants

administered the MPT instrument. Two research questions were raised and answered along with their hypotheses at 0.05 level of significance using ANCOVA. The use of ANCOVA was to control for the differences between groups as revealed in the pre-test.

Results

Table 2:
Descriptive Statistics' on the Pre-test Scores for the Groups

Group	N	Mean	Std. Deviation
Experimental	145	10.051	2.8632
Control	123	10.048	2.8924
Mean Df		0.003	- 0.0292

Table 2 shows at a glance that the difference between the experimental group and the control group was very insignificant with the mean score and standard deviation for experimental group as 10.051 and 2.86 respectively while the control group being respectively 10.048 and 2.89. The mean and standard deviation indices are shown in Table 2 above are the indications that there was homogeneity in the level of mathematics performances among all the students before the treatment. However, the post-test analysis on research questions was meant to test the hypotheses on the effect of the treatment on the experimental group.

RESULTS ON HYPOTHESES

H₀₁: There is no significant differences in the performance of students taught mathematics using the Flipped Classroom (FC) and those taught with Traditional Classroom (TC).

The analyses for testing this hypothesis are shown in Table 3, descriptive statistics and Table 4, the ANCOVA results for the groups.

Table 3: Mean of Post-test Performance of Students' taught Mathematics with Flipped Class Package and Traditional Method.

Group	N	Mean	Std. Deviation
Experimental	145	28.441	4.8632
Control	123	23.886	5.7974
Mean Df		4.555	- 0.9342

Table 4:
Summary of Analysis of Covariance (ANCOVA) Result on the post-test performance of the Experimental and Control Groups in Mathematics.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4273.552 ^a	2	2136.776	122.737	.000
Intercept	16371.304	1	16371.304	940.374	.000
Pre-test	2892.680	1	2892.680	166.157	.000
Group	2472.158	1	2472.158	142.002	.000
Error	4613.478	265	17.409		
Total	194976.000	268			
Corrected Total	8887.030	267			

a. R Squared = .481 (Adjusted R Squared = .477).

The results in Table 3 showed that the flipped classroom experimental group had higher post mean score (M = 28.44, SD = 4.86) than their traditional classroom control group counterparts (M = 23.89, SD = 5.80), using a bench mark of 20.00. Results in Table 4 for ANCOVA, $F_{(1, 265)} = 142.002$, $p = .000$. Since the p-value is less than alpha value of 0.05, the null hypothesis is rejected; this shows that there was a significant difference in the performance of students taught mathematics using flipped classroom and those taught using the traditional classroom as reflected in the mean and standard deviation. The use of flipped classroom is more effective.

H₀₂: There is no significant difference in the retention performance of students taught mathematics using the FC and those taught using the TC.

For testing hypothesis two, the results analyses are as shown in Table 5 for the descriptive statistics, Table 6 for the ANCOVA results on the retention scores of the experimental and control groups.

Table 5:

Mean of Performance of Students' taught Mathematics with Flipped Class Package and Traditional Method.

Group	N	Mean	Std. Deviation
Experimental	145	25.476	5.0237
Control	123	20.756	5.3704
Mean Df		4.720	- 0.3467

Table 6:

Summary of Analysis of Covariance (ANCOVA) for Test of Significance of Effect of Treatment on Students' Retention

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3693.474 ^a	2	1846.737	99.029	.000
Intercept	12881.735	1	12881.735	690.770	.000
Pre-test	2211.028	1	2211.028	118.564	.000
Group	2428.767	1	2428.767	130.240	.000
Error	4941.820	265	18.648		
Total	154251.000	268			
Corrected Total	8635.295	267			

a. R Squared = .428 (Adjusted R Squared = .423)

As indicated in Table 5 the experimental group had the higher mean score (M = 25.48, SD = 5.0237), while the control group had (M = 20.76, SD = 5.3704) using 20.00 as a bench mark. The ANCOVA results shown in Table 6 reveals that there was a significant difference, F (1, 265) = 130.240, p = 0.000. Since the p-value is less than alpha value of 0.05, the null hypothesis is rejected; this indicates that there was a significant difference between the retention performance of students taught mathematics using flipped classroom and traditional classroom method as reflected in the mean and standard deviation.

Summary of Findings

The findings of the study corroborated earlier assertions of Charles-Ogan and Williams (2015) which reveals that there was a significant difference in pre-test - post-test scores in favour of the flipped classroom when comparing performance using offline Video CD recorded by the teacher with conventional classroom students in mathematics in River State, Nigeria. This is also consistent with the active learning studies which found that flipped classroom resulted in general improvement in academic achievement effect in mathematics activities and problem solving (Fulton, 2012). This study also agreed with the earlier finding of Marcellious (2001) which indicated that in today's classroom, one of the principal factors is retention of concepts that are taught to the students. It was added that without retention, there cannot be a successful transfer of knowledge from one subject area to another. Also, in agreement with Iji (2002) and Chianson (2008) that retention in mathematics is not acquired by mere rote memorisation but through appropriate teaching method like flipped classroom.

Conclusions

This study indicated that the flipped classroom method of teaching facilitated learning and improved the post-test performance of students in mathematics in secondary schools in Lagos, Nigeria. It also showed that the retention performance of students in mathematics was high in flipped classroom when compared with the traditional classroom. There is therefore an urgent need of flipped classroom learning approach to address the poor performance of students in mathematics to promote science and technological development in Nigeria, since the bedrock of all science and technological related discipline is Mathematics.

Recommendations

Based on the findings and conclusions of this study, the following recommendations were made;

1. Teachers should adopt the flipped classroom approach because it is a student-centered learning strategy that engages the students rather than spoon-feed them.
2. Teachers should seek for more knowledge on the utilization of flipped classroom for instruction because is a technology-driven; hence, attending workshops, seminars and conferences within and outside their education districts and state is a must if they must use this approach with all amount of expertise.
3. All stakeholders in the education industry including parents should see flipped classroom as an innovation which must be welcomed, supported and its usage sustained in Nigeria.

Implication of Research Findings

If flipped classroom method of teaching is adopted at secondary schools, it can help to increase students' involvement in instructional activities through enhanced confidence, the interaction between teachers and students during the period of learning mathematics, ability to learn mathematics at will and teachers as assessors may observe students displaying these skills. The findings of this study also indicated that students' retention in mathematics improves and enhanced their performance.

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The Flipped Classroom: Its Effects on Students' Performance and Retention in Secondary School Mathematics Classroom

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