

Effect of Flipped Classroom Instructions on Secondary School Students' Critical Thinking and Achievement in Matrices and Determinants

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Abstract

The study investigated the effect of flipped classroom instruction on secondary school students' critical thinking and achievement in matrices and determinants. Two research questions and two hypotheses guided the study which adopted pretest posttest non-equivalent group quasi-experimental research design. The study sample consisted of 54 SS3 students in two intact classes drawn using purposive sampling technique. Data were gathered using 'Students' Critical Thinking Scale' (SCTS) and 'Students' Achievement in Matrices and Determinants Tests' (SAMDT) designed by the researchers. Mean and standard deviation were used to answer the research questions while ANCOVA was used to test the hypotheses at .05 level of significance. Results showed that flipped classroom instruction had a significantly positive effect on students' critical thinking and achievement in matrices and determinants. It was thus recommended that flipped classroom instruction should be integrated in teaching matrices and determinants and mathematics in general in secondary schools.

Keywords: Flipped classroom, Lecture method, Critical thinking, Achievement, Matrices and Determinants.

Introduction

Mathematics is a very important subject in the world over, its importance to the development of nations cannot be overburdened. Thus, Harbor-Peters as cited in Adelodun (2014) noted that the subject remains a pivot upon which every true science rest and that science cannot succeed without mathematics. Owing to its utilitarian value, the subject was made a core (compulsory) subject in Nigeria from the primary to the secondary school level (Federal Republic of Nigeria FRN, 2014). Also, due to its importance to national development, several reviews have been carried out in mathematics in Nigeria with the aim of introducing topics that could enable it meet the needs of the 21st century learner. The latest of such reviews was done in 2008 which became operational in 2011 and incorporated many new topics including introductory calculus, gradients, matrices and determinant among others (Awofala, 2017).

The curriculum seems to be very different from previous mathematics curricula and as such it is hoped that teachers will teach it using constructivists teaching methods such as concept mapping, problem solving, cooperative learning, among others (Awofala, 2012, Awofala & Awolola, 2011a). However, evidence show that many teachers are not receptive to the new curriculum because they view the topics as been strange, burdensome, laborious and unattractive (Awofala, Ola-Oluwa & Fatade, 2012). As reported by WAEC (2019) many students do not questions on teese new topics in mathematics in the examinations which could partly be dues to the fact that they were not properly taught these topics or were not taught at all. To tackle this problem, WAEC

(2019) suggests that teachers should use interactive teaching methods in teaching mathematics. As a result, many stakeholders as well as researchers in the field of education are calling for the integration of technology into the teaching and learning of school subjects including mathematics. Hence, there is a need for a transformation in the pedagogies in schools (Alsowat, 2016), for more interactive, students' friendly and technologically enabled teaching techniques. It is pertinent to note that students' achievement in mathematics has been poor and inconsistent over time (Zalmon & Wanu, 2017). This can also have a reciprocal effect on students' critical thinking. If this trend continues, Nigerian students will not be able to compete favourably with their peers from other parts of the world in the global economy. This could hamper the development of the country as a whole. Hence, research is needed on teaching methods that could positively impact on students' critical thinking and achievement in mathematics. One of such teaching methods that needs to be explored is the flipped classroom.

Flipped classroom is a new method of teaching whereby the classwork and homework activities are reversed. According to Du, Fu and Wang (2014) explained that the flipped classroom inverts the usual teaching methods. This assertion is supported by the Charles-Ogan and Willaims (2015) who explained that flipped classroom is a pedagogical method where home works are done at school and school works done at home. It therefore means that the flipped classroom is a reverse form of the traditional teaching methods. In flipped classroom method, the teacher develops materials in form of CDs, Audio devices and or other printed materials and hand them over to the students for review on their smartphone, tablets, DVD players, internet among others, before class is held (Bergman, Overmyer & Wilie, 2013). The authors noted that during class, the teacher guides the students on doing exercises, activities, practices and helping solve home assignments. The students also collaborate with their peers and discuss misconceptions about what they had studied at home, hence encouraging collaborative learning, problem solving and active participation in learning activities. This approach to Glynn (2013) provides students additional time that can be spent on higher-order questioning and problem solving. Strohmeyer (2016) also suggest that the approach help students to develop critical thinking.

Critical thinking is viewed as a high-level reasoning involving the ability to analyze, determine the relevance of information gathered and then to interpret it in solving problems (Shazaital & Saat, 2014). Facione as cited in Alpat (2019), defines critical thinking as a logical and rational form of reasoning before drawing conclusions. It therefore implies that critical thinking involves reasoning in a logical way when trying to solve a particular problem. As such it helps for better information analyses and evaluation which can promote students' academic achievement (Harish, 2014). Academic achievement is defined as the extent to which students, teachers or institutions have achieved the goals of education as well as the extent to which a student has accomplished specific goals that were the focus of school activities (Amalu, 2017). Thus, students' examination marks obtained in the school constitutes their academic achievement (Adeyemo, 2011) and a key criterion for judging a student's potentiality and capability (Abdullahi & Bichi, 2015).

Previous studies have suggested that the flipped classroom could have a positive effect on students' learning outcomes. For instance, the study by Andrini, Pratama and Maduretno (2019) reported that flipped classroom had a substantial effect on student's critical thinking ability, likewise Ghoneim, and Badawy (2018) revealed that flipped learning method significantly improved Nursing students' higher-order thinking skills and engagement. More so, a study by Alpat (2019) reported a momentous increase in the critical thinking skill of the students due to

flipped classroom experiences. Other studies (Fulton, 2012; Saunders, 2014; Sirakaya & Özdemir, 2018) concluded that flipped classroom promotes students' academic achievement as well as their critical thinking unlike the normal teacher centred methods of teaching. In the same vein, Elian and Hamaidi (2018) submitted that the flipped classroom strategy had a positive effect on the academic achievement of fourth grade students in Jordan. Similarly, Fish (2016) observed that the flipped learning can lead to higher student achievement and engagement because it is students' centred unlike the normal lecture method. Conversely, Overmyer (2014) found no significant difference in students' achievement in algebra for the flipped classroom and the traditional methods, though they reported that students in the flipped sections did score slightly better than student in the traditional sections.

Giving the fact that students' achievement in mathematics has been poor over the years, research on teaching methods that could improve students' achievement is required. Previous researches have shown that the flipped classroom instruction could enhance students' learning outcomes if properly applied in the classroom. However, research is needed to take decision on its efficacy in the classrooms in Nigeria and Cross River State in particular. The aforesaid reasons coupled with the fact that there are few research studies in Nigeria on the effect of flipped classroom on students' critical thinking and achievement. Hence, the problem of this study posed as a question is; what is the effect of flipped classroom instruction on secondary school students' critical thinking and achievement in matrices and determinants.

Research Questions

The following research questions were posed to guide this study.

1. What is the difference in the mean critical thinking scores in matrices and determinants of students exposed to flipped classroom and those not exposed to it?
2. What is the difference in the mean achievement scores in matrices and determinants of students exposed to flipped classroom and those not exposed to it?

Hypotheses

The following null hypotheses were formulated for this study and were tested at .05 level of significance.

H₀₁: There is no statistically significant difference in the mean critical thinking scores in matrices and determinants of students exposed to flipped classroom instruction and those not exposed to it.

H₀₂: There is no statistically significant difference in the mean achievement scores in matrices and determinants of students exposed to flipped classroom instruction and those not exposed to it.

Method

The researchers adopted a non-equivalent group pretest and posttest quasi-experimental research design. The study was conducted in Cross River state, Nigeria and the population of the study involved all the senior secondary school three (SS3) students in the 473 private schools in the state for first term 2020/2021 academic session. The SS3 class was chosen because matrices and determinants form part of their syllabus for first term. Purposive sampling technique was used to draw two schools from where two intact classes purposively selected. The study sample consisted of 54 students (30 males and 24 females). Intact classes were used to avoid disruption of the normal teaching and learning activities of the schools. The two intact classrooms were randomly assigned one each to experimental and control group respectively. The control group had 28

students (15 males and 13 females) while the experimental group had 26 students (15 males and 11 females). A pilot survey was conducted to determine schools that meets the criteria for selection. School whose students have the required facilities to enhance flipped classroom instruction were selected.

Two instruments; Students' Critical Thinking Scale (SCTS) and Students' Achievement in Matrices and Determinants Tests (SAMDT) developed by the researchers were used for data collection. The SCTS consisted of section A and B. Section A elicited personal information of the students (student's gender, class identification number, school code), while section B contained 20 items that elicited data on the students' critical thinking. The ratings for each of the items ranged from 1-4 depicting very low, low, high and very high critical thinking skills respectively. Also, the SAMDT had section A and B. Section A also elicited personal information of the students (student's gender, class identification number, school code), while section B contained 20 dichotomously scored multiple choice items with four response options of A, B, C and D that elicited data with respect to students' achievement in matrices and determinants. Students' achievement was measured using Bloom's taxonomy of educational objectives. Add and subtract matrix of order up to 2×2 had 4 questions, multiply matrix by a scalar, 2 questions; multiply two matrices of order 2×2 , 3 questions; transpose matrix, 1 question; find determinants of a matrix, 6 questions; inverse of a matrix, 1 question; apply 2×2 matrix algebra to solve simultaneous equation, 4 questions. 40% of the questions were from the knowledge level; 30% from comprehension level; 20% percent from application level; 5% percent from analysis and synthesis while zero percent was assigned to evaluation.

The SAMDT together with lesson plans and the video-aided instructional package (A lecture series video on matrices and determinants developed by the researchers) were face-validated by three experts; one each from Mathematics Education, Measurement & Evaluation and Educational Technology. The SCTS and SAMDT were later trial-tested on 20 SS3 students in a private school that was not among those used for the actual study but met the criteria for the study. The estimate of internal consistency reliability was established for the SCTS using the Cronbach Alpha technique while Kuder-Richardson20 method was used to establish the measure of internal consistency of the SAMDT. The reliability coefficients for both instruments were .91 and .87 for the SCTS and SAMDT respectively.

Procedure

Before commencement of the experiment, the researchers sought informed consent and permission of the authorities of two sampled school the researchers informed the school authorities about the study. Upon granting of the permission to the researchers, the researchers recruited the regular mathematics classroom teachers for the intact classes as research assistants. The reason for using the regular class teachers was to avoid experimental bias. This is to ensure that the students were not aware that they were involved in an experiment. The research assistants were adequately informed and well-orientated about the objectives of the study, method of lesson presentation, and were exposed to the experimental video and how to administer the instruments for data collection.

The experiment lasted for a duration of five weeks. In the first week, coaching of the research assistants was done after which the instruments were pretested on the students in both control and experimental groups. In the second week through fourth week, the actual experiment commenced in both control group and experimental group. The experiment was conducted using

the normal lesson periods following the schools' timetable for the three weeks of 40 minutes per lesson period daily. Two sets of lesson plans, with the same content, specific objectives, duration and evaluation were developed for the two groups, except that each student in the experimental group was provided with a video on the content to be studied at home. The experimental group students were also informed each day on the content to study from their textbooks at home before the next class while the control group was taught using the normal lecture teaching approach. The control group students were also given their homework after each class to be done at home whereas those in the experimental class were to do their homework at school in collaboration with their peers and gets guidance from the teachers. In the experimental group, student misconceptions were also discussed during classes with peers and the teacher.

At the fifth week, items in the same SCTS and the SAMDT administered at pretest were reshuffled and re-administered to the students as posttest in order to determine the effect of the different treatments on the students' critical thinking and achievement in matrices and determinants. The students rated the SCTS and answered questions in the SAMDT and were scored by the teachers. Each correct option in the SAMDT was scored four points whereas each wrong option attracted zero point. To begin the analysis of the pretest and posttest, the researchers entered the data on SPSS version 24. The data were analyzed using mean and standard deviations to answer the research questions while the null hypotheses were tested using analysis of covariance (ANCOVA) at 0.05 level of significance.

Results

Table1: Mean and Standard deviation of critical thinking scores of students exposed to flipped classroom instruction and those not exposed to it

Groups	Pretest			Posttest		Mean Difference
	N	\bar{x}	SD	\bar{x}	SD	
Experimental (flipped classroom)	26	39.69	5.21	67.30	7.08	27.61
Control (No flipped classroom)	28	37.07	5.37	46.50	6.41	9.43

Result in Table 1 shows that students exposed to flipped classroom instruction had a mean critical thinking score of ($\bar{x} = 39.69$, $SD = 5.21$) at pretest and a score of ($\bar{x} = 67.30$, $SD = 7.08$) at posttest while those not exposed to flipped classroom instruction had a mean critical thinking score of ($\bar{x} = 37.07$, $SD = 5.37$) at pretest and a score of ($\bar{x} = 46.50$, $SD = 6.41$) at posttest. Mean difference of 27.61 and 9.43 for the experimental and control groups respectively depicts that flipped classroom instruction had positive effect on students' critical thinking in matrices and determinants.

Table 2: Analysis of Covariance (ANCOVA) of the effect of flipped classroom instruction on students' critical thinking in matrices and determinants

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1574.770	2	787.385	16.969	.000	.400
Intercept	2598.256	1	2598.256	55.995	.000	.523
Pre-critical	.049	1	.049	.001	.974	.000

Methods	1476.600	1	1476.600	31.822	.000	.384
Error	2366.489	51	46.402			
Total	148298.000	54				
Corrected Total	3941.259	53				

Note: S = Significant, NS = Not Significant, η^2_p = partial eta squared

The result in Table 2 shows that the effect of flipped classroom instruction on students' critical thinking in matrices and determinants was significant ($F(1, 53) = 31.822, p < .05, \eta^2_p = .384$), thus the hypothesis is rejected. This is because the exact probability value of 0.00 is less than 0.05 set as level of significance. The effect size of ($\eta^2_p = .384$), moreover, indicates that 38.4 percent changes in students' critical thinking in matrices and determinants is accounted for by the use of flipped classroom instruction. Thus, inference drawn is that flipped classroom instruction has a significantly positive effect on students' critical thinking in matrices and determinants.

Table 3: Mean and Standard deviation of achievement scores of students exposed to flipped classroom instruction and those not exposed to it

Groups	Pretest			Posttest		Mean Difference
	N	\bar{x}	SD	\bar{x}	SD	
Experimental (flipped classroom)	26	30.61	4.40	74.07	8.30	43.46
Control (No flipped classroom)	28	31.28	3.96	45.00	4.94	13.72

Result in Table 3 shows that students who were exposed to flipped classroom instruction had mean achievement score of ($\bar{x} = 30.61, SD = 4.40$) at pretest and a mean score of ($\bar{x} = 74.07, SD = 8.30$) at posttest while those not exposed to flipped classroom instruction had a mean achievement score of ($\bar{x} = 31.28, SD = 3.96$) at pretest and a mean score of ($\bar{x} = 45.00, SD = 4.96$) at posttest. Mean difference of 43.46 and 13.72 for the experimental and control groups respectively implies that flipped classroom instruction had positive effect on students' mean achievement scores in matrices and determinants.

Table 4: Analysis of Covariance (ANCOVA) of the effect of flipped classroom instruction on students' critical thinking in matrices and determinants

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1172.736	2	586.368	12.880	.000	.336
Intercept	3092.835	1	3092.835	67.935	.000	.571
Pre-achieve	61.990	1	61.990	1.362	.249	.026
Methods	1061.210	1	1061.210	23.310	.000	.314
Error	2321.856	51	45.527			
Total	135116.000	54				
Corrected Total	3494.593	53				

Note: S = Significant, NS = Not Significant, η^2_p = partial eta squared

Result in Table 4 shows that the effect of flipped classroom instruction on students' achievement in matrices and determinants was significant ($F(1, 53) = 23.31, p < .05, \eta^2_p = .314$), hence, the

null hypothesis is rejected. This is because the exact probability value of 0.00 is less than 0.05 set as level of significance. Additionally, the effect size of ($\eta^2_p = .314$), indicates that 31.4 percent changes in students' achievement scores in matrices and determinants is attributable to the use of flipped classroom instruction. Consequently, inference drawn is that flipped classroom instruction has a significantly positive effect on students' achievement in matrices and determinants.

Discussions

The purpose of the study was to investigate the effect of flipped classroom instruction on secondary school students' critical thinking and achievement in matrices and determinants. The findings of the study show that flipped classroom instruction had a significantly positive effect on students' mean critical thinking and achievement scores in matrices and determinants. This implies that flipped classroom instruction is a more effective and efficient method in improving students' critical thinking and achievement in matrices and determinants than the lecture method of teaching. The above finding corroborates with the previous findings of Andrini, Pratama and Maduretno (2019) who reported that flipped classroom had a positive effect on student's critical thinking ability, and Ghoneim, and Badawy (2018) who likewise reported that utilization of flipping learning method significantly improved students' higher-order thinking skills and engagement.

Furthermore, the results of the study also lend support to previous studies from Fish (2016) whose research revealed that flipped learning can lead to higher student achievement and student engagement, and Sirakaya and Özdemir (2018) who found a difference in academic achievement of students in favour of those exposed to the flipped classroom. This could be so because the flipped classroom instruction avails the students the opportunity to interact with the devices putting the students in charge of the learning. This makes the teaching process students' centred, and more engaging which could lead to higher achievement scores. Also, while in class, the students collaborate with other peer in hand on activities, the teacher also guides the students in solving problem and other activities which helps the students develop problem solving skills. All these can possibly lead to higher gains in achievement scores of students in matrices and determinants.

Conclusion

Often, students are noted to be deficient in mathematics, thereby adding a major concern for the mathematics educator. The students' ability to progress sufficiently in the mathematics is a concern to the educators. The present study therefore provides insight into the efficacy of flipped classroom instruction on secondary school critical thinking and achievement in matrices and determinants. The researchers based on the findings of the study conclude that the flipped classroom instruction have significant positive effect on secondary school students' critical thinking in matrices and determinants. The findings further showed that the flipped classroom instruction have a significant positive effect on students' achievement in matrices and determinants. These provided information about the potential to use flipped classroom instruction and alternative curricula in secondary mathematics.

Recommendations

Based on the findings, the researchers recommended that:

1. Flipped classroom should be integrated in teaching secondary school students, matrices and determinants and mathematics in general as it could improve students' critical thinking and achievement in the subject.
2. Government and other stakeholders in education should provide schools with adequate technology tools, modern laboratory devices and high speed internet facilities to help teachers in preparing the needed materials for implementing the flipped classroom teaching technique.

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