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Effects of Reflective and Flipped Classroom Instructional Strategies on Secondary School Students' Interest in Mathematics in Anambra State, Nigeria.

CHUKWUNYELU Onyedika Maduegbunam[1], OKIGBO Ebele Chinelo[2]
dikajesus1@yahoo.com[1], ec.okigbo@unizik.edu.ng[2]
1 - Department of Science Education, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.
2 - Department of Science Education, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Abstract
The effects of reflective instructional strategy (RIS) and flipped classroom instructional strategy (FCIS) on academic interest of SS 2 students in mathematics in Nnewi Education Zone of Anambra State was determined. Two research questions and three hypotheses tested at 0.05 level of significance guided the study. The research adopted a quasi-experimental design, specifically, pre-test and post-test non- randomized control group design. The population comprised 4006 students in the public secondary schools in Nnewi Education Zone of Anambra State, Nigeria. The sample size was 142 (71 male and 71 female) students selected from three of the 37 co-educational public secondary schools in the Zone through multistage sampling procedure. Mathematics Interest Scale (MIS) was used as instrument for data collection while researchers-developed RIS and FCIS lesson plans were used as instructional tools. The reliability of the MIS was established using Cronbach alpha (α) formula which yielded a reliability index of 0.83. Experimental group 1 (RIS) was taught using RIS while Experimental group 2 (FCIS) was taught using FCIS and the control group was taught using Lecture method (LM). Mean and standard deviations were used to answer the research questions while the hypotheses were tested using Analysis of covariance. The findings showed among others that RIS and FCIS significantly improved students' interest in mathematics but the most effective strategy was FCIS. Also, gender does not have significant effect on the interest of students' taught mathematics using RIS, FCIS and LM and interaction effect of instructional strategies and gender was not significant on students' interest in mathematics. The study concludes that RIS and FCIS are effective in improving the interest of SS 2 students in mathematics. Based on the findings, it was recommended among others that; Government should provide appropriate resource materials required to facilitate the use of reflective and flipped classroom instructional strategies in the secondary schools and mathematics teachers should also use RIS and FCIS in teaching mathematics for improved interest in mathematics.

Keywords: *Reflective, Flipped classroom, Mathematics, Interest, SS 2 students.*

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I. Introduction

Education is the process of teaching, learning and training to acquire knowledge, skills, habits and values which leads to change in behavior. It helps individuals develop their critical thinking and problem solving skills preparing them for personal growth. Nigeria as a nation has adopted Education as a dynamic instrument of change (Ganiyu & Makinde, 2021). All the subjects taught in the school are aimed at bringing about the expected changes in a student. The aim is that, the subjects taught would not only impart knowledge to the students but also help in the development of right attitudes, interests and values which makes the person to be useful to the society. One of such subjects in the secondary school curriculum is mathematics.

Mathematics is the study of numbers, quantities, shapes and relationships between them. It makes use of logical reasoning, problem solving, and abstraction to develop and apply mathematical theories, models and techniques. Duru & Okeke, (2019), averred that mathematics predisposes the scholars in the field to the skills of numeracy, measurement, calculation and construction without which the learning of science and science-related subjects may become difficult to apply. Mathematics as a subject therefore, is all encompassing, for there is hardly any subject that does not need mathematics for proper functioning.

Despite the significance of mathematics in different areas of academic decision making among the students, analysis of the students' achievement in WASSCE Mathematics between the years 2012 – 2024 shows that students' performance in mathematics is fluctuating. Supporting this, Zalmon & Charles-Ogan, (2021) asserted that poor achievement of students in both internal and external examinations in Mathematics have been on the increase in recent time. In addition, Ahmed & Okigbo (2021) lamented that the situation of poor

achievement in mathematics at all levels had remain almost unchanged nationwide and remained relatively poor when compared with other subjects. Moreover, low and fluctuating performance of students in mathematics has become a great concern to science educators and researchers as they seek to unravel the cause and proffer probable solution to the problem.

However, Boris (2019) identified some factors as the major cause of poor achievement of students in mathematics among which are lack of students' interest in mathematics, ineffective teaching methods and strategies, lack of competent teachers, poor motivation of students, poor students' attitude to science and students' laziness among others. Ezeugwu et al (2016) and Awodun (2020) also added students' lack of confidence in the subject and poor learning environment as part of the factors. Despite the number of factors outlined as being responsible for low achievement in mathematics, many fingers have been pointing at ineffective instructional strategies like lecture method, which lack the ability to sustain students' interest in mathematics (Abudulkamid, 2016 & Enebechi, 2017) while Mohammed & Sani, (2023), insist that students' lack of interest in mathematics is the major factor.

Instructional Strategies are techniques utilized by teachers to promote mastery of objectives, understanding of content, and independent learning in students According to Makinde (2019), a major cause of the current poor performance and interest in mathematics can be attributed to the passive learning experiences students receive in the classroom in lecture teaching method, which is a major characteristic of traditional mode of instruction. However, Tani & Segumpan (2018) argued that lecture method does not provoke and sustain students' interest which is very relevant for effective learning. Therefore, there is need for more effective student-centered learning strategies like Reflective Instructional Strategy (RIS) and Flipped Classroom Instructional Strategy (FCIS) to sustain the students' interest in mathematics.

Reflective Instructional Strategy (RIS) is a broad based instructional strategy that engages the learners to think deeply, discuss, collaborate and share their experiences together on a particular subject matter (Oguezue & Osuafor, 2021). It affords learners the opportunity of thinking, discussing and sharing their experiences and wealth of knowledge together in small groups on particular subject matter. The act of reflection is a vital human activity in which facilitator and respondents revisit their experiences, they ponder on them and evaluate them (Gupta, Shree & Mishra, 2019). According to Ogbuanya & Owodunni in Agbasi & Okeke (2020), reflective instructional strategy is an innovative strategy that draws from certain skills. These skills include: (a) assertive questioning, (b) thinking skills, (c) scaffolding, (d) oral discourse and (e) collaborative learning.

On the other hand, the flipped classroom is a learning methodology that combines e-learning and the face-to-face classroom, its purpose being to improve learning by allowing students to control the time and pace of their online learning and maximize their active learning (Gutiérrez, 2022 and Koh, 2019). The basic idea of the flipped learning model is to teach the course content before the course through online videos in order to allocate more time for active learning and problem solving activities in the classroom (Yakar, 2021 and Lo & Hew, 2017). Therefore the students learn the basic information about the course/content before they come to the classroom as a result of the technological access provided by their teachers according to Hayırsever & Orhan (2018).

RIS and FCIS are learner centred and engage the students in series of questioning and thinking processes which enable them to construct their own knowledge within and among themselves without necessarily depending on the teacher for everything. Because of the interactive nature of RIS and FCIS, students' interest are sustained throughout the learning process. However, student's achievement in mathematics rests among other things on the student's interest in the subject. A student usually achieve higher in a subject he or she has interest in, thus, interest is closely related to achievement (Mohammed & Sani, 2023).

Interest is a subjective feeling of curiosity or intentness over something, It could also be defined as the focusing of the sense organs on or giving attention to some person, activity, situation or object (Zaveri, 2016). Interest is a subjective feeling of concentration or persisting tendency to pay attention and enjoy some activity or content (Ezeugwu et al, 2016). Interest is an essential factor in learning because when one is interested in an activity, one is likely to perform positively, he or she is likely to be more deeply involved in that activity. Interest will induce one to behave or act in a certain way towards one's studies. Even while some children have the mental and physical capacity to learn, it might not happen until their interest is aroused. As long as the teacher maintains their interest in the subject matter, students who have been stimulated will continue to study. The interest in a thing is a feeling manifested in an activity (Mohammed and Sani, 2023). The present researchers are interested in finding out the effects of RIS and FCIS on academic interest in mathematics of male and female students.

Gender issue has been a subject of discourse and concern to science educators (Ogoke & Okigbo, 2021). Gender is an important variable that could influence students' interest in mathematics. Godpower-Echie & Owo (2019) defined gender as the stratification and assignment of roles along sex line which may be culturally determined, and is ascribed to male and female. There is a growing recognition that there are psychological differences between gender which affect the way the males and females think, communicate and behave. In the same vein, the gender difference in interest of students in mathematics has been a thing of worry to mathematics

educators and researchers. Gender disparity in students' interest in mathematics is one that cannot be swept under the carpet. Chiakwelu & Okigbo (2020), observed that the problem of gender stereotyping in science learning is a widely debated issue. Studies further revealed that effect due to gender on interest do not significantly differ (Egara & Mosimege , 2023 and Eze, 2023). Ombuguhim et al (2021) and Arthur et *al*. (2015) also discovered that gender has no significant effect on the interest of students. Conversely, Allahnana et al (2018) concluded that there was significant difference in the mean interest scores of male and female students. Agbasi & Okeke (2020) also averred that significant difference exists between the mean interest scores of male and female in favour of the females.

From the foregoing, it becomes clear that inconclusive report exists on the influence of gender on secondary school students' interest in mathematics. This calls for serious attention and if unchecked, it would be a great challenge to gender equality in Mathematics. To this end, there is need to test the outcome of teaching and learning of mathematics using RIS and FCIS on gender. This is with the hope of investigating their effectiveness in improving secondary school students' interest in mathematics in Nnewi Education zone of Anambra state, Nigeria.

II. Purpose of the Study

The study determined the effect of Reflective and Flipped classroom instructional strategies on secondary school students' interest in mathematics in Nnewi Education Zone of Anambra State. Specifically, this study determined:

1. Mean interest rating scores of students taught mathematics using Reflective instructional strategy (RIS), Flipped classroom Instructional Strategy (FCIS) and that of those taught using lecture method (LM).
2. Mean interest rating scores of male and female students taught mathematics using RIS, FCIS and that of those taught using LM.

III. Research Questions

Based on the purpose of the study, the following research questions were stated to guide the study:

1. What are the differences in mean interest rating scores of students taught mathematics using RIS, FCIS and that of those taught using LM?
2. What are the differences in mean interest rating scores of male and female students taught mathematics using RIS, FCIS and that of those taught using LM?

IV. Hypotheses

The following hypotheses were stated to guide the study at 0.05 level of significance:

1. There is no significant difference in the mean interest rating scores of students taught mathematics using RIS, FCIS and that of those taught using LM.
2. There is no significant difference in the mean interest rating scores of male and female students taught mathematics using RIS, FCIS and that of those taught using LM.
3. There is no significant interaction effect of instructional strategies (RIS, FCIS & LM) and gender on students' interest in mathematics.

V. Methodology

The design adopted by the researcher was pretest-posttest non-randomized control group quasi-experimental design. Intact classes were used in each sampled school. The study was conducted in Nnewi Education Zone of Anambra State, Nigeria. The population consisted of 4,006 senior secondary class two (SS 2) students (1,936 males and 2,070 females) offering mathematics in all the public secondary schools in the Nnewi Education Zone. The study's sample consisted of 142 (71 male and 71 female) SS 2 students offering mathematics selected from three out of the 37 co-educational public secondary schools in the Zone. A multistage sampling procedure was used to sample the participants namely: purposive sampling, simple random sampling and lucky dip without replacement techniques. Mathematics Interest Scale (MIS) was used for data collection. The Mathematics Interest Scale (MIS) is a 25-item students' interest scale with 4-point response scale. This scale was adapted to assist students in indicating the kinds of mathematics-related activities in which they are interested and would like to take part. Each item is rated on a 4-point scale with four response alternatives. The options are: Strongly agree (SA), Agree (A), Disagree (D), and strongly disagree (SD). Students in each group in the sampled schools were taught by the school's regular mathematics teacher trained as research assistants using researcher developed lesson plans on RIS, FCIS and LM. Three experts validated the instruments, each from Departments of Science Education, Educational foundations (Measurement and Evaluation Unit) and Mathematics, from Nnamdi Azikiwe University, Awka.. The reliability of the MIS was established using Cronbach alpha (α) formula which yielded a reliability index of 0.83.

The regular mathematics teachers in the sampled schools were trained by the researchers to serve as research assistants, which lasted for one week over three contacts. They taught their students in each school using regular school time table, of two contacts per week.

The experimental group 1 (RIS) was taught by the research assistant using reflective instructional strategy as guided by the researchers-developed RIS lesson plan. The following components of reflective instructional strategy were applied by the research assistant in teaching the experimental group: Thinking skill, Questioning, Collaborative learning, Oral discourse and Scaffolding.

The experimental group 2 (FCIS) was taught by the research assistant using Flipped classroom instructional strategy making use of the researchers-developed FCIS lesson plan and flipped classroom model (recorded video of the math's lesson). In the pre-class phase of FCIS, a developed flipped classroom model was uploaded to the already existing class WhatsApp platform so that students could watch videos, listen to audio lessons, and read text lessons at home or at any other convenient locations using their phones or their parents' or guardians' phones before engaging in the in-class activities. After going through the online video lessons, students were given a short quiz to complete as a way of confirming they read, listened, or watched the video prior to class discussion. Major assignments or projects on the subject were to be completed together by the teacher and the students, either individually or in groups with classmates during the interactive period of the in-class phase, and any group of students or individual needing assistance were entertained by the teacher.

The control group (LM), on the other hand, was taught using the usual lecture method of teaching, with lesson notes developed by the researcher to reflect the same learning objectives as the RIS and FCIS equivalent. The group was evaluated at the appropriate time with the same test instrument: MIS used for the experimental groups.

The actual treatment lasted for five weeks (week 2 – week 6) in each of the schools. The first week was for administering the pre-test (MAT) while the sixth week was for the revision and administering of the post-test. The research questions were answered using mean and standard deviation while the hypotheses were tested using Analysis of Covariance at 0.05 level of significance which addressed the imbalance of non-equivalence in groups caused by non-randomization of participants. The p-value and alpha level ($\alpha = 0.05$) were compared to determine whether to retain or reject the null hypotheses tested. When the precise probability value was less than or equal to the 0.05 level of significance, the null hypothesis was rejected; but, when the exact probability value was more than the 0.05 level of significance, the null hypothesis was not rejected.

VI. Results

Research question 1: What are the differences in Mean interest rating scores of students taught mathematics using RIS, FCIS and those taught using LM?

Table 1: Mean interest rating scores of students taught Mathematics using RIS, FCIS and those taught using LM

Method	n	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean gain
LECTURE	41	30.22	10.02	37.09	11.31	6.87
RIS	56	32.92	10.83	49.25	17.61	16.33
FCIS	45	32.11	10.74	57.78	14.33	25.67

Results in Table 1 show that the control group taught mathematics using LM had a mean gain of 6.87 while the experimental groups – RIS and FCIS had mean gain of 16.33 and 25.67 respectively in their interest scores. However, for each of the group, the post-test mean scores were greater than pre-test mean scores with FCIS having the highest mean gain of 25.67. The post-test mean score for FCIS, 57.78 is greater than that of RIS, 49.25 while that of the LM, 37.09 is the least. This is an indication that Flipped Classroom Instructional Strategy had more positive effect on students' interest in mathematics than Reflective Instructional Strategy (RIS) and lecture method respectively.

Research question 2: What are the differences in Mean interest rating scores of male and female students taught mathematics using RIS, FCIS and those taught using LM?

Table 2: Mean interest rating scores of male and female students taught Mathematics using RIS, FCIS and those taught using LM

Method	Gender	n	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Difference
LECTURE	Female	16	31.25	8.67	35.00	10.68	
	Male	25	29.56	10.91	38.44	11.70	3.44
RIS	Female	34	31.35	11.51	50.61	18.77	
	Male	22	35.36	9.40	47.13	15.81	3.48
FCIS	Female	24	34.04	11.32	54.48	18.77	
	Male	21	31.54	11.34	61.23	6.05	6.75

Results in Table 2 show the mean interest scores of male and female students taught Mathematics using LM, RIS and FCIS. The female students taught mathematics using LM had a post-test mean of 35.00 while their male counterparts had post-test mean of 38.44 with a mean difference of 3.44 in favour of male students. Furthermore,

female students taught mathematics using RIS had post-test interest rating score of 50.61 as against their male counterparts that scored 47.13 with a mean difference of 3.48 in favour of female students. Also, female students taught mathematics using FCIS had post-test interest rating score of 54.48 as against their male counterparts that scored 61.23 with a mean difference of 6.75 in favour of male students. For each of the groups, the post-test mean interest scores were greater than the pre-test mean interest scores with the male group having a higher post-test mean interest score when taught using FCIS and LM while the female students scored higher when taught using RIS. This result shows that gender may also have some effect on students' interest in mathematics.

Hypothesis 1: There is no significant difference in the mean interest rating scores of students taught mathematics using RIS, FCIS and that of those taught using LM.

Table 3: ANCOVA Test of significance of difference between the Mean interest rating Scores of students taught Mathematics using RIS, FCIS and those taught using LM.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9235.162[a]	2	4617.581	20.575	.000
Intercept	322200.082	1	322200.082	1435.632	.000
PRE-INT	.258	1	.258	.001	.973
METHOD	9235.162	2	4617.581	20.575	.000
Error	31195.888	139	224.431		
Total	373675.000	142			
Corrected Total	40431.049	141			

Table 3 reveals that there is significant difference in the mean interest rating scores of students taught mathematics using RIS, FCIS and that of those taught using LM, F (2, 142) = 20.575, P = 0.000 < 0.05. Therefore, the null hypothesis is rejected meaning there is significant difference in the mean interest rating scores of students taught mathematics using RIS, FCIS and that of those taught using LM in favour of the students taught using FCIS and RIS respectively.

Hypothesis 2: There is no significant difference in the mean interest rating scores of male and female students taught mathematics using RIS, FCIS and that of those taught using LM.

Table 4: ANCOVA Test of significance of difference between the Mean interest rating Scores of male and female students taught Mathematics using RIS, FCIS and those taught using LM.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.161[a]	2	50.474	.174	.841
Intercept	33292.555	1	33292.555	1153.053	.000
PRE-INT	100.788	1	100.788	.347	.557
GENDER	.161	1	.161	.001	.981
Error	40430.889	140	288.792		
Total	373675.000	142			
Corrected Total	40431.049	141			

Table 4 reveals that there is no significant difference in the mean interest rating scores of male and female students taught mathematics using RIS and that of those taught using LM, F (1, 142) =.001, P = .981 > 0.05. Therefore, the null hypothesis is not rejected meaning there is no significant difference in the mean interest rating scores of male and female students taught mathematics using RIS and that of those taught using LM**.** Hence, Male and female students taught mathematics using RIS, FCIS and Lecture method did not significantly differ in their mean interest scores.

Hypothesis 3: There is no significant interaction effect of instructional strategies (RIS, FCIS & LM) and gender on students' interest in mathematics.

Table 5: ANCOVA Test of interaction effect of instructional strategies (RIS, FCIS and LM) and gender (male and female) on students' interest in Mathematics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10024.666[a]	5	2004.933	8.968	.000
intercept	309093.585	1	309093.585	1382.497	.000
PRE-INT	15.699	1	15.699	.070	.792
GENDER	168.959	1	168.959	.756	.386
METHOD	9354.745	2	4677.372	20.921	.000
GENDER * METHOD	674.168	2	337.084	1.508	.225
Error	30406.383	136	223.576		
Total	373675.000	142			
Corrected Total	40431.049	141			

Table 5 reveals that there is no significant interaction effect of instructional strategies (RIS, FCIS & LM) and gender on students' interest in mathematics, F (2, 142) = 1.508, P = .225 > 0.05. Therefore, the null hypothesis is not rejected meaning there is no significant interaction effect of instructional strategies (RIS, FCIS & LM) and gender on students' interest in mathematics.

VII. Discussion

The findings from the results revealed that significant difference exists in the mean interest rating scores of students taught mathematics using reflective instructional strategy (RIS), Flipped classroom Instructional strategy (FCIS) and those taught using lecture method (LM). Students taught mathematics with FCIS had the highest mean interest rating scores in mathematics, followed by those taught mathematics using RIS while LM group has the least interest rating scores. RIS and FCIS significantly improved students' interest in mathematics probably because they are activity based and student-centred. This is in line with Agbasi & Okeke (2020), who observed that students are mostly interested in classroom moments marked with activities.

The study further indicated that male and female students taught mathematics using RIS, FCIS and LM did not significantly differ in their mean interest scores. This implies that the interest of students in relation to RIS, FCIS and LM is not influenced by the gender of the students. This finding supports Egara & Mosimege (2023); Eze (2023) and Arthur *et al* (2015),who found out that gender has no significant influence on interest of students. However, the finding contradicts Agbasi & Okeke (2020) and Allahnana *et al* (2018) who concluded that there was significant difference in the mean interest scores of male and female students.

Furthermore, the study showed that there was no significant interaction effect of instructional strategies (RIS, FCIS and LM) and gender on students' interest in mathematics. No significant interaction effect between gender and instructional strategies on students' interest scores in mathematics could be due to the fact that the effect of instructional strategies was the same on male and female students. The result is in line with the findings of Egara and Mosimege (2023); Eze (2023) and Arthur *et al* (2015), who stated that there is no significant interaction effect between gender and instructional strategies on students' interest scores in mathematics. However, the result disagrees with Allahnana *et al* (2018) and Ugwoke *et al* (2018) who stated that there is significant interaction effect between gender and teaching methods on students' interest scores in mathematics. From the above discussion, it is clear that RIS and FCIS lead to students' success, arouse their interest and also contribute a lot to an effective classroom teaching. However, RIS and FCIS neither favor nor disfavor a particular sex in their interest in mathematics.

VIII. Conclusion

Based on the findings of this study, it was concluded that use of RIS and FCIS in teaching mathematics was more effective than LM in improving students' interest in mathematics. RIS and FCIS are also gender friendly, as they improved interest of both male and female students equally in mathematics.

IX. Recommendations

Based on the findings, the following recommendations are made that:

1. Mathematics teachers in secondary schools should adopt the use of RIS and FCIS in teaching mathematics.
2. Government should provide appropriate resource materials required to facilitate the use of reflective and flipped classroom instructional strategies in the secondary schools.
3. School administrators should set aside funds and resources to support teachers' professional development in order to provide long-term institutional development of the technical skills required for RIS and FCIS.
4. Students' mathematics teachers should be trained in their method class on the use of RIS and FCIS by the teacher educators in tertiary institutions.

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