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Effect of Mathematical Modeling-Based Teaching Activities on Basic Eight Students' Achievement in Mathematics in Bayelsa State, Nigeria

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Abstract

This study investigated the effectiveness of mathematical modeling-based teaching activities on Basic Eight students' achievement in Mathematics. In the specific objectives, it sought the effectiveness of mathematical modeling-based teaching activities on students and their gender. The study was conducted in Yenagoa Local Government Area of Bayelsa State in Nigeria. It adopted a quasi-experimental non-randomized pre-test post-test control group design with a population of 3,693 students in the 35 basic schools. A sample of 182 out of this population was used. To arrive at this, intact classes were used. Instrument for data collection was, Mathematics Achievement Test (MAT) which was validated by experts. MAT was trial-tested using Kuder-Richardson K-R_{20} and had a reliability coefficient of 0.84. Three research questions guided the study and three research hypotheses were formulated for the study. Descriptive statistic of Mean,

Standard Deviation and Scattergram was used to answer the research questions asked, while inferential statistic of Analysis of Covariance was used to test all the research hypotheses formulated at α=0.05 level of significance. It was found that Basic Eight Students' achievement in Mathematics improved when taught using mathematical modeling-based teaching activities. In addition, the use of mathematical modeling-based teaching activities enhanced students' achievement in Mathematics irrespective of their gender. Suggestions based on the findings were equally made that the serving teachers should use mathematical modeling-based teaching activities to improve students' achievement in Mathematics among others.

Keywords: Mathematics, students' achievement, mathematical modeling, mathematical modeling-based teaching activities

Introduction

Mathematics is very important in enhancing as well as sustaining of human subsistence, since Mathematics is all about profering solutions to human problems (Unodiaku, 2013). In spite of the fact that Mathematics is important and popular among Nigerian students, it is very disappointing to note that students' achievement in the subject has remained consistently low (Uche, 2011). The problem of Mathematics learning has been persistent and is topical and attracts the attention of researchers (Eniayeju, 2010; Mensah, Okyere & Kuranchie, 2013). The incessant low achievement in Mathematics examinations is a clear manifestation of this perceived problem (Adewale, 2011; Unodiaku, 2012). In an attempt to profer solution to this incessant low achievement, researchers such as Igwe and Ikatule (2011), Tshabalala and Ncube (2013), and Enu, Agyman and Nkum (2015) have considered several factors ranging from inadequate teaching facilities, negative attitude of students and teachers towards the subject and inappropriate method of teaching. Inappropriate methods of teaching seem to be the most prominent factor responsible for low achievement in Mathematics. In general, conventional Mathematics teaching begins with explaining the topic, reminding them of their previous knowledge, making correction from their home works, then solving examples on the board. Learning from such teaching approach makes students to be passive learners, resulting to limited Mathematics knowledge.

Enhancement of Mathematics learning experiences demands that Mathematics be taught through practical activities (Douglas, 2013; Annenberg, 2013). Okoyefi and Nzewi (2013) affirm that students achieved higher when they are exposed to methods that interest them during the teaching-learning process. This necessitates new search in Mathematics teaching and it becomes obligatory to try innovative approaches and methods of teaching Mathematics. One of such approaches is Mathematical modeling approach. Mathematical modeling approach is solving of complex, practical and open problems with the help of Mathematics. According to Heck (2010), Mathematical modeling-based teaching activities make contribution to meaningful learning of Mathematics topics and concepts.

Gender, as a concept, has captured the interest of Mathematics educators in Nigeria, especially now that gender equity is being emphasized in Nigerian school curriculum delivery. In educational system, gender is also important as it tends to influence

students' achievement. Gender issues have been linked with achievement of students' academic tasks in several studies without any definite conclusion. To Amoo and Onasanya (2010), gender is the social roles belonging to men and women in a particular society. In recent times, the gender factor has assumed prominence in Mathematics education discourse.

However, literature search revealed inconclusive concerning influence of gender on student's achievement in Mathematics. For instance, Olosunde and Olaleye (2010), Madu and Hogan (2010) reported that male students achieved significantly higher than female students at all class levels in Mathematics. On the other hand, Achor, Imoko and Ajai (2010), Usman and Nwoye (2010) reported that there was no significant difference between the male and female students' Mathematical abilities.

It appears that gender differences in Mathematics are inconclusive and need further enquiry in this study to justify the claims of other researchers. Literature indicate that Mathematical modeling practices enhance conceptual developments of individuals, their interdisciplinary relating capabilities (Iji, Abakpa & Fekumo, 2018). With the rising concern of educators and other stakeholders globally on the relevance of Mathematical modeling, Mathematical modeling-based teaching activities was used in this study to investigate its effect on students' achievement. The researcher is also of the opinion that Mathematical modeling-based teaching activities could likely bridge the gap between male and female achievement in Mathematics.

Purpose of the Study

The purpose of this study was to find out the effectiveness of Mathematical modeling-based teaching activities when used to teach Mathematics at the Basic Education level. Specifically, the study will:

i. establish if Basic Eight students improved upon their achievement in Mathematics due to the use of Mathematical modeling-based teaching activities.
ii. find out if mean achievement differ between male and female Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities.
iii. find out the interaction effect between gender and mathematical modeling-based teaching activities on Basic Eight students' achievement in Mathematics.

Research Questions

The following research questions guided the study.

i. what are the mean achievement scores of Basic Eight students taught Mathematics using mathematical modeling-based teaching activities and those taught without mathematical modeling-based teaching activities?

ii. what are the mean difference in achievement scores between male and female Basic Eight students taught Mathematics using mathematical modeling-based teaching activities?
iii. what is the interaction effect between gender and mathematical modeling-based teaching activities on Basic Eight students' achievement in Mathematics?

Hypotheses

The following research hypotheses formulated were tested at 0.05 level of significance.

i. There is no significant difference between the mean achievement scores of Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities and those taught without Mathematical modeling-based teaching activities.
ii. There is no significant difference between the mean achievement scores of male and female Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities.
iii. There is no significant difference in the interaction effect of Mathematical modeling-based teaching activities between male and female Basic Eight students' achievement in Mathematics.

Methodology

The study adopted a quasi-experimental of non-equivalent group design. Precisely, it used a non-randomized pre-test post-test control group design. A non-randomized pre-test post-test control group design was used as both experimental and control groups were not equal in size and treatment.

This study was carried out in Yenagoa Local Government Area of Bayelsa State, Nigeria. The Local Government Area is located in the Central Senatorial District of Bayelsa State with the headquarters at Yenagoa, the state capital. It has an area of 706 km^2. The choice of Yenagoa Local Government Area of Bayelsa State was as a result of the fact that it is observed that the achievement in Mathematics in the area is consistently low (Ministry of Education, 2019). Also, because it uses a national Mathematics curriculum and the area uses the same syllabus.

The population for this study was 3,693 Basic Eight students in the 35 public basic schools in Yenagoa Local Government Area of Bayelsa State (Ministry of Education, 2018). Basic Eight was used because it is part of the foundation class where Mathematics concepts can be modeled for better understanding of the students. Furthermore, the students in Basic Eight have relative stability in terms of subject coverage more than basic seven and because Basic Eight class exists in all the basic education schools in the selected local government area and the students are mature to the extent of being exposed to Mathematical modeling-based learning activities. The choice of public basic education schools was to have students with homogeneous background in terms of learning environment, teachers' experiences and qualification.

The sample size of this study was 182 students in their intact classes from two basic Schools in the Local Government Area. The sample consists of both male and female students in the control and experimental groups in their intact classes. To obtain this sample, multistage sampling technique was used. Firstly, the local government area was purposively chosen for the study. Simple random sampling technique was used for the selection of the schools and the experimental and control groups. For the students, all the students in their intact class participated in the study.

A Mathematics Achievement Test was a test instrument that covers all areas that were taught with regards to the study. 50 multiple-choice items of four options, A to D, one correct answer and three distracters, constructed by the researcher for Basic Eight students in the experimental and control groups, which subjects are expected to encircle the option bearing the answer. This comprised two sections, A and B. Section A sought for the students' personal information, gender. Section B contained a 50-items multiple choice test.

The Mathematics Achievement Test, initially comprise 55 items along with the marking scheme were validated by five experts made up of two experts in Mathematics education, two Mathematics Teachers and one measurement and evaluation expert to ascertain the content validity. The experts assessed if the test items conform to the table of specification, assessed adequate coverage of content under the study, individual items on agreement with answer, clarity of the items, and suitability of phrases to enable subjects respond adequately to the questions. Assessed was whether the test items were appropriate to reveal cognitive, affective and psychomotor conflicts in the students. Finally, to confirm if the test items are arranged in order of difficulty from simple to complex and assessed if the test does not have identifiable pattern of answers at the time of testing. After removing unsuitable items, the corrections were used to produce the final instrument of 50 MAT.

A trial test was done with 30 Basic Eight students outside the study area and a reliability coefficient of 0.84 using Kuder-Richardson formula (K-R_{20}) was obtained.

Pre-MAT was administered and collected from the respondents before the study. Again, post-MAT was administered and collected from the respondents after the study by the research assistants.

Data collected were analyzed using descriptive and inferential statistics. Research questions were answered using mean, standard deviation and scatter gram. In the MAT, the mean difference was used to determine level of achievement. The research hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Results

Research Question One

What are the mean achievement scores of Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities and those taught without Mathematical modeling-based teaching activities?

Answer to this research question is presented in Table 1.

TABLE 1: MEAN ACHIEVEMENT SCORES AND STANDARD DEVIATION OF STUDENTS IN EXPERIMENTAL AND CONTROL GROUPS.

Groups	N	Pre-MAT		Post-MAT	
		Mean	SD	Mean	SD
Experimental	66	22.88	6.63	34.50	7.08
Control	116	20.23	6.76	26.61	6.62
Mean Difference		**2.65**		**7.89**	
Total	**182**				

From Table 1, it could be seen that in the Pre-MAT, the experimental group had a mean achievement score of 22.88 with a standard deviation of 6.63, while the control group had a mean achievement score of 20.23 with a standard deviation of 6.76. Their mean difference is 2.65.

The Table also shows that in the Post-MAT, the experimental group had a mean achievement score of 34.50 with a standard deviation of 7.07, while the control group had a mean achievement score of 26.61 with a standard deviation of 6.62. Based on the mean achievement scores of students of the two groups, a mean difference of 7.89 was recorded, showing an improvement in achievement in favour of the experimental group.

Research Hypothesis One

There is no significant difference between the mean achievement scores of Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities and those taught without Mathematical modeling-based teaching activities.

The test result of this research hypothesis is presented in Table 2.

TABLE 2: ANALYSIS OF COVARIANCE RESULT OF EXPERIMENTAL AND CONTROL GROUPS' ACHIEVEMENT SCORES IN MATHEMATICS ACHIEVEMENT TEST

Source of Variance	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9007.919[a]	2	4503.959	422.222	.000	.825
Intercept	2069.200	1	2069.200	193.976	.000	.520
PRE-MAT	6390.599	1	6390.599	599.084	.000	.770
GROUPS	**1246.101**	**1**	**1246.101**	**116.815**	**.000**	**.395**
Error	1909.444	179	10.667			

Total	169008.000	182
Corrected Total	10917.363	181

a. R Squared = .825 (Adjusted R Squared = .823)

Table 2 shows that P-value is 0.00. This is less than the set P-value of 0.05. Since the P-value is less than the set P-value, the null hypothesis of no significant difference is rejected. This implied that there is significant achievement in the Mathematics taught in favour of the experimental group.

Research Question Two

What are the mean difference in achievement scores between male and female Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities?

Answer to this research question is presented in Table 3.

TABLE 3: MEAN ACHIEVEMENT SCORES AND STANDARD DEVIATION OF MALE AND FEMALE STUDENTS IN THE EXPERIMENTAL GROUP.

Gender	N	Pre-MAT		Post-MAT	
		Mean	SD	Mean	SD
Male	34	20.88	7.41	33.71	7.60
Female	32	25.00	4.98	35.34	6.49
Mean Difference		**4.12**		**1.63**	
Total	**66**				

Table 3 shows that in the pre-MAT, the male students in the experimental group had a mean achievement score of 20.88 with a standard deviation of 7.41, while, the female students had 25.00 achievement mean score with a standard deviation of 4.96. Their mean difference is 4.12

In the post-MAT, the male students in the experimental group had 33.71 mean achievement score and a standard deviation of 7.60, while the female students had 35.34 mean achievement score and 6.49 standard deviation. Their mean difference is 1.63, which is in favour of basic eight female students.

Research Hypothesis Two

There is no significant difference between the mean achievement scores of male and female Basic Eight students taught Mathematics using Mathematical modeling-based teaching activities.

The test result of this research hypothesis is presented in Table 4.

TABLE 4: ANCOVA RESULTS OF BASIC EIGHT MALE AND FEMALE STUDENTS IN EXPERIMENTAL GROUP IN MATHEMATICS ACHIEVEMENT TEST

Source of Variance	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2592.448[a]	2	1296.224	122.976	.000	.796
Intercept	628.400	1	628.400	59.618	.000	.486
PRE-MAT	2548.226	1	2548.226	241.756	.000	.793
GENDER	**89.512**	**1**	**89.512**	**8.492**	**.005**	.119
Error	664.052	63	10.541			
Total	81813.000	66				
Corrected Total	3256.500	65				

a. R Squared = .796 (Adjusted R Squared = .790)

Table 4 shows that P-value is 0.00. This is less than the set P-value of 0.05. Since the P-value is less than the set P-value, the null hypothesis of significant difference is rejected. This implies that there is a significant achievement in the Mathematics taught during the periods of this study in favour of female basic eight students.

Research Question Three

What is the interaction effect between gender and Mathematical modeling-based teaching activities on Basic Eight students' achievement scores in Mathematics?

Answer to this research question is presented in Figure 1.

Linearity Scatter Gram for Male and Female Basic Eight students in Experimental Group in Mathematics Achievement Test (MAT)

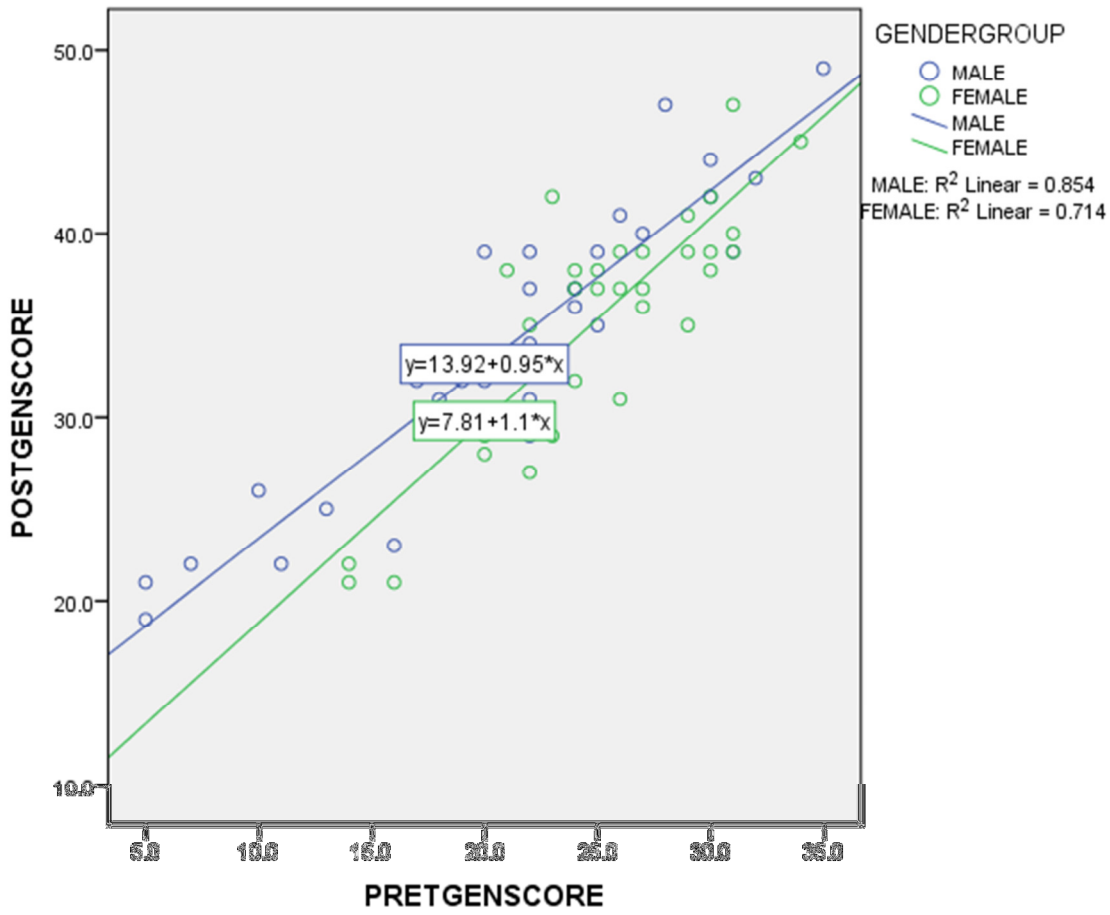

Figure 1: Scattered graph of interaction effect between gender and mathematical modeling-based teaching activities on basic eight students in MAT

Figure 1 shows that the two lines representing the male and female variables of gender are parallel. They both rise from y-axis to the top right of the x-axis. Their R-square or the coefficient of determination, variance explained, the squared correlation have such values as R^2 linear = 0.854 x 100 = 85% for male and R^2 linear = 0.714 x 100 = 71% for female. The parallel lines are indications that there is no interaction effect between gender and mathematical modeling-based teaching activities on Basic Eight students' achievement in Mathematics. In order words, it is an indication that Basic Eight students' achievement in Mathematics using mathematical modeling-based teaching activities is not dependent on gender.

Research Hypothesis Three

There is no significant difference in the interaction effect of Mathematical modeling-based teaching activities between male and female Basic Eight students' achievement scores in Mathematics.

The test result of this research hypothesis is presented in Table 5.

TABLE 5: ANCOVA RESULTS OF INTERACTION EFFECT OF MATHEMATICAL MODELING-BASED TEACHING ACTIVITIES BETWEEN MALE AND FEMALE BASIC EIGHT STUDENTS MEAN ACHIEVEMENT SCORES IN MATHEMATICS.

Source of Variance	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2605.193[a]	3	868.398	82.665	.000	.800
Intercept	424.090	1	424.090	40.370	.000	.394
Method	2268.564	1	2268.564	215.952	.000	.777
Gender	33.474	1	33.474	3.186	.079	.049
Method*Gender	**12.744**	**1**	**12.744**	**1.213**	**.275**	**.019**
Error	651.307	62	10.505			
Total	81813.000	66				
Corrected Total	3256.500	65				

a. R Squared = .800 (Adjusted R Squared = .790)

Table 5 reveals that the Method variable has a significance value of (0.00) less than the threshold value (0.05) while Gender variable has a significance value of (0.08) more than the threshold value (0.05). Again, the interaction between the two factors Method*Gender (0.28) is more than the threshold value (0.05). That is $F(1, 62) = 1.21$, $P = 0.29 > 0.05$. Thus, the null hypothesis of no significant difference was not rejected. Hence, there is no statistically significant interaction effect between gender and mathematical modeling-based teaching activities on Basic Eight students' achievement in Mathematics.

Summary of Major Findings

Based on the analyses of data from the study, the following major findings were made:

i. Students in the experimental group improved more in their mathematics achievement than those in control group. This was equally statistically significant.
ii. Male and female Basic Eight students taught mathematics using Mathematical modeling-based teaching activities improved in their mathematics achievement. However, the female improved more and this was statistically significant.
iii. Basic Eight students' achievement in Mathematics using Mathematical modeling-based teaching activities is not dependent on gender. The method is none discriminatory.

Discussion

The result has shown that students in the experimental group improved in their Mathematics achievement scores more than the students in the control group. From the test of hypothesis results, it revealed that, there was a significant difference in the mean achievement scores of experimental and control groups in Mathematics achievement test with $p<0.05$. This implies that using Mathematical modeling-based teaching activities in teaching Mathematics improved basic school students' achievement in Mathematics. This result is in line with studies of Ma, Rene and Rosemarievic (2015) and Zeynep and Nedim (2013) who found that the use of Mathematical modeling enhanced achievement in Mathematics. This could be as a result of students' high interest in Mathematics when taught using Mathematical modeling-based teaching activities, hence, concentrating in the learning process.

Furthermore, male and female Basic Eight students in the experimental group improved in their achievement scores. However, the female were better than the male. As a result, the gap between the male and female students was bridged in the post-test. However, the test of hypothesis reveals that, there is significant difference in the mean achievement scores of male and female students taught Mathematics using Mathematical modeling-based teaching activities. This result is contrary to Chima, Mumuni and Dike (2016) who concluded that both gender achieved high when taught with modeling instruction strategy in students' achievement in physics.

Finally, Basic Eight students' retention in Mathematics using Mathematical modeling-based teaching activities is not dependent on gender. Thus, test of hypothesis reveals that, there was no significant difference between the interaction effect of Mathematical modeling-based teaching activities and gender on students' achievement in Mathematics.

Conclusion

In conclusion, the learning and teaching of Mathematics at basic education schools could be simplified through the use of a pedagogical innovation such as Mathematical Modeling-Based Teaching Activities. In other words, the use of Mathematical modeling-based teaching activities in teaching mathematics could enhance achievement, irrespective of gender.

References

Achor, E. E., Imoko, B. I. & Ajai, J. T. (2010).Sex differentials in students' achievement and interest in geometry using games and simulations technique. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education.* 4(1), 1-10.

Adewale, J. G. (2011). Teacher factors as correlates of students' anxiety in junior secondary school Mathematics: A study in school effectiveness. *African Journal of Science, Technology and MathematicsEducation* (AJSTME), 1(1), 1-16.

Amoo, S. A. & Onasanya, W. A. (2010). Maintaining a gender-free culture in Mathematics classroom practice in junior secondary schools for attainment of millennium development goals. Abacus: *The Journal of the Mathematical Association of Nigeria,* 31(1), 103-114.

Annenberg, F. (2013). Teaching math: Grades k-2: Representations. Retrieved fromwww.learner.org/../section-03-b.html.

Douglas, H. C. (2013). "Concrete" manipulatives, concrete ideas. Retrieved from www.didax.com/articles/concretemanipulatives.

Eniayeju, A. A. (2010). Effect of cooperative learning strategy on the achievement of primary six boys and girls in Mathematics. Abacus: *The Journal of Mathematical Association of Nigeria,* 35(1), 1-9

Enu, J., Agyman, O. K. & Nkum, D. (2015). Factors influencing students' Mathematics performance in some selected colleges of education in Ghana. *International Journal of Education Learning and Development, 3(3)*, 68-74.

Heck, A. (2010). Modeling in cross-disciplinary authentic student research projects. *International Journal of Technology and Mathematics Education*, 17(3), 15-120.

Igwe, A. U. & Ikatule, O. R. (2011). Effects of computer tutorial and drill (CTD) on senior secondary school students' achievement in basic electronics in Lagos state. *Proceedings of Nigerian Association of Teachers of Technology*. Umunze, 108-119.

Iji, C. O., Abakpa, B. O., Agbo-Egwu, A. O. & Fekumo, B. (2018).Investigating Mathematics teachers' awareness in the use of modeling in Mathematics education. *International Journal of Scientific and Research Publications*, 8(9), 78-84.

Madu, B. C. & Hogan-Bassey, V. I. (2010). Gender-related differential item functioning in Mathematics multiple-choice test items set and administered by national examination council (NECO). *Journal of Mathematical Sciences Education*: *Journal of National Mathematical Centre,* Abuja, I (I), 101-114.

Mensah, J., Okyere, M., & Kuranchie, A. (2013). Student attitude towards Mathematics and performance: Does the teacher attitude matter? *Journal of Education and Practice*, *4*(3), 132-139.

Ministry of Education (2018). Analysis of junior WAEC results. Bayelsa State.

Ministry of Education (2019). Number of public schools, enrolment of students and teachers. Bayelsa State.

Okoyefi, Q. O. & Nzewi, U. M. (2013). Effect of 4 mode application (4MAT) instructional model on students achievement and interest in basic science. In O. Abonyi (Ed.) *54th Annual conference proceedings of Science Teachers association of Nigeria* (167-176). Ibadan. HEBN Publishers Plc.

Olosunde, G. R. & Olaleye, O. O. (2010). Effect of concept mapping strategy on senior secondary school students' performance in Mathematics. *Journal of National Mathematical Sciences,* (1), 29-53.

Tshabalala, T. & Ncube, A. C. (2013). Causes of poor performance of ordinary level pupils in Mathematics in rural secondary schools in Nkayi district. *Nova Journal of Medical and Biological Sciences,* 1(1),4-14.

Uche, S. A. (2011). The multiple intelligences teaching method andMathematics teaching. *Journal of Research in National Development* 9(1),116-123

Unodiaku, S. S. (2012). Development and validation of Mathematics readiness test for senior secondary school students. *AfricanJournal of Science Technology and Mathematics Education (AJSTME),* 2(1), 57-69.

Unodiaku, S. S. (2013). Effect of ethno-mathematics teaching materials on students' achievement in Mathematics in Enugu state. *Journal of Education and Practice*, 4(23), 70-77

Usman, K. O. & Nwoye, M. N. (2010). Effect of graphical-symbol approach on the pupils' achievement in ratio at upper primary school level in Nsukka central local government area. *Journal of Mathematical Sciences Education*, 1(1), 123-132.