Unraveling the Efficacy of Differentiated Based Instruction on Senior Secondary School Students' Achievement in Quadratic Equation

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Abstract: The study investigated the efficacy of differentiated dased instruction (DBI) on students' achievement in quadratic equation in Obollo-Afor Education Zone of Enugu State. To achieve the purpose of the study, two research questions and two null hypotheses guided the study. The design of the study was quasi-experimental; specifically non-equivalent control group design. The population of the study comprised four thousand eight hundred and twenty (4,820) SSS 2 students found in the forty-eight (48) public secondary schools in Obollo-Afor Education zone of Enugu state. The sample of the study consists of 162 students from four (4) intact classes from four schools. The sample of four (4) schools were drawn using proportionate Stratified random sampling techniques in which two (2) schools were assigned to experimental group and the other two (2) schools were assigned to control group. Mathematics Achievement Test (MAT) was the instrument used for the study. The instrument was validated by three experts and the reliability index obtained was 0.89 using Kuder Richardson 20 formula. The data collected were analyzed using SPSS and mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The results of the study revealed that differentiated based instruction improved students' achievement in quadratic equation than conventional based instruction of teaching quadratic equation. Also, gender has no significant influence on the achievement of students in quadratic equation. Based on the findings, it was recommended that mathematics teachers should use the differentiated based instruction while teaching the subject. Moreover, ministry of education should organize workshops, seminars, conferences etc and make the attendance to it compulsory to the mathematics teachers on the use of differentiated based instruction in their classroom instruction.

Keywords: Differentiated based instruction, Conventional based instruction, Quadratic equation, Students' Achievement, Gender, Mathematics teachers.

I. INTRODUCTION

Mathematics is the gateway to science and technology. The study of mathematics is needed in all aspect of human endeavor technology inclusive. As a science of structure, order and relation that is evolved from elemental practices of counting, measuring and describing the shapes of objects are all the pre-requisite for the study of science and technology in our society. . It is a mental activity which consists of carrying out one after the other the mental constructions which are inductive and effective. Mathematics is seen everywhere, in everything we do. It is the starting point for everything in our daily lives. This is why Umaru, Onuigbo and Eze (2013) asserts, that mathematics is regarded as the key to success in the study of science and other related disciplines. Mathematics is an essential ingredient in manufacturing industries and essential tool in economic activities. This lies on the fact that the knowledge of mathematics is needed in all the spheres of life economic activities inclusive and as such, it is regarded as an everyday activity. That is, the applications of mathematics to problem areas depend on the understanding of the concepts and the principles of mathematics by the problem solver (Ukwueze, 2017).

Despites the importance of mathematics, the achievement of students in the subject has been consistently below average especially in external examinations. This is evident in the West African Examination Council's (WAEC) Chief Examiners reports (2008, 2013, 2014, 2016 & 2020), National Examination Council's (NECO) Chief Examiners reports (2009, 2014 & 2020) which stated that the overall performances of candidates in mathematics was generally poor and below average. Other individual researchers also tell the same story of students' poor achievement in mathematics (Agwagah, 2004; Uka, Iji & Ekwueme, 2012; Ukwueze, 2017). The above mentioned researchers point accusing fingers to the methods or approaches used in teaching mathematics as a major, causes of students' poor achievement in the subject.

Different approaches to instruction have been proposed by researchers and mathematics educators in the field and the knowledge of these methods may help in working out better teaching strategies, such as Scaffolding based instructional approach, the use of game instructional approach, Concept mapping instructional strategy, the use of geometer's scratchpad in teaching of mathematics etc. In the classroom, there exist different individuals with individual differences which tend to pose problems in mathematics teaching and learning. On this note, it is not appropriate for a teacher to commit to one particular method while teaching mathematics. A good mathematics teacher should adopt an instructional approach to use after considering the nature of

his/her students, their interest and maturity and the resources available (Muthomi & Mbugua, 2014). All the strategies may not be equally appropriate and suitable for all levels of mathematics instruction as some may be needed in place of another at a particular stage. After the mathematics teacher has known all the strategies, their merits and demerits, he/she should be able to make his/her own strategy in the mathematics classroom by imbibing the good qualities of all the approaches and rejecting the odd qualities. The approach adopted by the teacher must ensure maximum participation of the students in the mathematics classroom, proceed from concrete to abstract and provide knowledge at the understanding level (Merchant, 2010). To this end, the differentiated based instruction was used in this study and its efficacy on students' achievement was sought.

Differentiated based instruction (DBI) implies approach to teaching and learning that gives students multiple options for taking in information and making sense of ideas in classroom setting. Differentiated based instruction is a teaching approach based on the premises that instructional approaches should vary and be adapted in relation to individual and diverse nature of students in the classrooms. The model of differentiated based instruction requires mathematics teachers to be flexible in their approach to teaching mathematics and adjust the curriculum and presentation of the information to learners rather than expecting students to modify themselves for the curriculum (Tomlinson, 2003). Differentiated based instruction is a structure that transforms teaching from teachers concentrating on the entire class to paying attention to individual problems arising from individuals. This approach to instruction can be effectively used in the teaching and learning of mathematics in general and teaching and learning of quadratic equation in particular.

Quadratic equation in mathematics is an equation of second degree (i.e raise to power 2). It is an equation of the form, $ax^2 \pm bx \pm c = 0$ where a, is the coefficient of the variable with power 2, b the coefficient of the variable without power 2 (i.e middle term) and c the constant term of the equation. Quadratic equation is a topic in the theme of algebraic expression in the senior secondary school two (SSS2) mathematics curriculums. The importance of equation whether quadratic or linear cannot be over-emphasized since experience have shown that equation is the "kpim" (a do without) to college mathematics, because many problems in mathematics and in word problem will be translated to form one kind of equation or the other. As important as this may be in mathematics, the instructional approaches used in solving problems bothering on quadratic equation by mathematics teachers look the same over the years and is not giving the required result.

The usage of poor instructional approach for which the students cannot figure out what the problem is, is rampant in mathematics in general and quadratic equation in particular. This according to Agwagah (2017) is a major factor contributing to the poor achievement in mathematics in general and quadratic equation in particular. The poor achievement is seen in the areas of unexplained quadratic formulae which it is driving from completing the square method. Besides, students found completing the square method of solving quadratic equation difficult and this is the next after factorization method in the scheme of work. The students here lack the understanding and knowledge of why adding square of half b to both sides. Moreover, among the four methods of solving quadratic equation, factorization, completing the square, formula and graph, it is the completing the square method that students find most difficult. In this method, there always exist a gap between what the students ought to learn (that square is not complete) and how the teacher impacts the knowledge in a more meaningful and resourceful ways as individual learners may want it (practical individual methodology). The individual learners, here is very important since the way people learn varies despite being in the same classroom.

Gender stereotyping in mathematics achievement has long existed in the area of sciences, mathematics inclusive. This is because there seems to be controversies on the effect of gender in students' achievement in mathematics while some research findings reported that there is no significant gender differences in mathematics abilities and achievement (Geary, 2000; Ukwueze, 2017), others are in contrary, Alio and Harbor-Peters (2000), Imoko and Agwagah (2006), Okigbo (2010) reported that boys achieved better than girls in mathematics generally. Voyer (2014) reported that girls had a higher school graduation rate, 84 percent than boys who had a rate of 77 percent. Since, there is no general consensus made yet on the issue of gender differences in mathematics achievement, thus could the use of differentiated based instruction techniques in teaching of mathematics bridge the gap between male and female students' achievement in mathematics. This study will answer this question. Hence, this study will seek to find out if the teaching of quadratic equation with DBI could improve both male and female students' achievement in mathematics.

Statement of the Problem

Students' achievements over the years have been reported to be poor as revealed by WAEC and NECO Chief Examiner's Report. The poor achievement of students in mathematics has been an issue of great concern to mathematics educators and researchers in the field. This has been blamed mostly on poor instructional approaches on the part of some teachers. Many researchers have carried out investigations on how to remedy the situation. But the fact that students continue to fail the subject in large number as reported by WAEC Chief Examiner's Report is a pointer that a gap still exists in mathematics and something new should be done in mathematics classroom teaching and learning. It is, therefore, a challenge to both researchers and mathematics educators, to carry out more empirical studies on how to enhance students' achievement in mathematics in general and

quadratic equation which is a do without in college mathematics and its associated word problem in particular. It is on this premise that the researchers decided to see if Differentiated based instruction (DBI) could help in improving SSS two students' achievement in quadratic equation. Therefore, the problem of this study put in question form is, "What is the efficacy of DBI on male and female students' achievement in quadratic equation"

Purpose of the Study

The purpose of the study was to determine the efficacy of Differentiated based instruction (DBI) on students' achievement in quadratic equation among SSS two mathematics students in Obollo-Afor Education zone of Enugu State. Specifically, the study sought to determine:

1. the efficacy of differentiated based instruction on students' achievement in quadratic equation;
2. the influence of gender on students' achievement in quadratic equation.

Research Questions

The study was guided by the following research questions:

1. What are the mean achievement scores of students taught quadratic equation using differentiated based instruction and those taught using conventional approach?
2. What are the mean achievement scores of male and female students in quadratic equation?

Hypotheses

The study was guided by the following null hypotheses, which were tested at 0.05, level of significance.

1. There is no significant difference in the mean achievement scores of students taught quadratic equation using differentiated based instruction and those taught with conventional instruction.
2. There is no significant difference in the mean achievement scores of male and female students exposed to differentiated based instruction in quadratic equation.

II. METHODS

The study was executed using a quasi-experimental, specifically non-equivalent control group design. The choice of this design was because the participants were not randomly assigned to experimental groups by the researcher (Ezeh, 2015). The population of the study comprised of all the four thousand eight hundred and twenty (4,820) senior secondary school two (SSS2) students found in Obollo-Afor education zone of Enugu state. A sample of one hundred and sixty two (162) SSS2 students found in four (4) intact classes from four (4) different schools was used for the study. Multistage sampling procedure was used to get the sample of the study. In the first stage, the schools in Obollo-Afor education zone were stratified based on the local government using stratified random sampling. Secondly, from each of the local government, proportionate stratified random sampling was used to sample two (2) schools from Igbo-Eze North, one (1) school each from Udenu and Igbo-Eze South LGAs making a total of four (4) schools. Finally, simple random sampling was used to sample one (1) intact class from each of the four (4) sampled schools. Two (2) schools were selected from Igbo-Eze North LGA, because the population of, students were more than the other LGAs put together. Two (2) intact classes were assigned to experimental group (teaching using differentiated based instruction approach) and two (2) other intact classes were assigned to control group (teaching with conventional instruction approach).

The instruments, Mathematics Achievement Test (MAT) and the lesson plan developed by the researchers were used for the study. The MAT constructed by researchers was face and content validated by three experts in the field of mathematics education and measurement and evaluation units of science education department all from (University of Nigeria, Nsukka). The instrument was trial tested using private schools in Nsukka Education Zone. The reliability of MAT was established using Kuder Richardson formula 20 (K-R 20) which was found to be 0.89. The instrument for collection of relevant data was administered to mathematics students in the sampled schools before the commencement of the experiment which serves as the pretest score. After the pretest, the actual experiment commenced, which started with the training/instructing of the mathematics teachers who were used as researchers' assistant for the study. The treatments involved presentation of polynomial equation (Identification of quadratic equation and methods use in finding the solutions to quadratic equation) using Differentiated based instruction (DBI) as an instructional approach. The students in the experimental group were taught quadratic equation using DBI following individual students in his/her peculiar case(s) with peculiar approach while the students in the control group were taught quadratic equation using conventional based instruction. The treatment lasted for six periods and the researchers and their assistants took several precautions in order to control the extraneous variables in the course of the instructions. Week one, contained identification of quadratic equations from several polynomials and factorization of quadratic equation, week two, contained graphical method of solving quadratic equation, week three, contained completing the square and formula methods of solving quadratic equation.

The researchers used the fourth week in summarizing the entire concept to students in both groups and were post-tested immediately using the MAT items.

Means and Standard deviations were used to provide answer to the research questions while the Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significant.

III. RESULTS

The results of the study were presented in accordance with the research questions and hypotheses that guided the study.

Research Question One: What are the mean achievement scores of students taught quadratic equation using DBI and those taught with conventional instruction?

Table 1: Mean achievement scores and standard deviations of students taught quadratic equation using DBI and those taught using conventional instruction

Group		Pre-test		Post-test		
	N	Mean	S D	Mean	SD	Mean Gain
Experimental	78	36.12	8.32	82.02	6.02	45.90
Control	84	38.34	10.02	65.46	10.95	27.12

Table 1 shows the mean achievement scores of students that were taught quadratic equation using DBI and those taught with conventional approach. From the table, mean achievement scores of 36.12 and 38.34 with the standard deviations of 8.32 and 10.02 were recorded for both experimental and control groups respectively at the pre-test. However, at the post-test, mean achievement scores of 82.02 and 65.46 with standard deviations of 6.02 and 10.95 were recorded for both experimental and control groups respectively. Moreover, mean gain scores of 45.90 and 27.12 were recorded for both experimental and control groups meaning that the students that were exposed to differentiated based instruction (Experimental group) achieved higher than their counterparts in the control group.

Hypothesis One: There is no significant difference in the mean achievement scores of students taught quadratic equation using DBI and those taught with conventional instruction.

Table 2: Analysis of Covariance of the effect of DBI approach on students' achievement in quadratic equation

Source	TypeIII Sum of Squares	Df	Mean Square	F		Sig.
Corrected Model	13584.660[a]	4	3396.165	19.780		001
Intercept	71567.376	1	71567.376	576.29		000
Pre-test	2998.658	1	2998.6586	29.968		.000
Group	12058.612	1	12058.612	147.95		.000
Gender	131.631	1	131.631	72.053		.089
Group*	4.192	1	4.192	94.207		.105
Error	764.716	156	41.745			
Total	563672.000	162				
Corrected Total	65615.143	160				
a. R Squared = .161 (Adjusted R Squared = .146)						

The results in Table 2 shows that the probability associated with the calculated value of F (147.95; df=1,156) for the efficacy of DBI approach on students' achievement in quadratic equation is .000. Since the probability value of .000 is less than .05 level of significant (P < .05), the null hypothesis was rejected. Thus, there is significant difference in the mean achievement scores of students taught quadratic equation using DBI and those with taught quadratic equation with conventional approach in favor of the experimental group.

Research Question Two: What are the mean achievement scores of male and female students in quadratic equation?

Table 3: Mean achievement scores and standard deviation of male and female students in quadratic equation.

Group		Pre-test		Post-test		
	N	Mean	S D	Mean	SD	Mean Gain
Male	36	37.35	7.80	83.64	4.32	46.29
Female	42	38.68	7.65	81.98	4.94	43.30

Table 3 reveals the mean achievement scores of male and female students in quadratic equation. From the table, male students obtained a mean achievement scores of 37.35 with standard deviation of 7.80 and female students obtained a mean achievement scores of 38.68 with standard deviation of 7.65were recorded at the pre-test. However, at the post-test, male students obtained a mean achievement scores of 83.64 with the standard deviation of 4.32 while their female counterparts obtained a mean achievement scores of 81.98with the standard deviation of 4.94. Moreover, mean gain scores of 46.29and 43.30 for the male and female students respectively. This indicates that male students achieved higher than their female counterparts. However, hypothesis two was therefore tested at 0.05level to see if this difference is significant.

Hypothesis Two: There is no significant difference in the mean achievement scores of male and female students in quadratic equation.

Table 2 shows that the probability associated with the calculated value of F (72.053) for the influence of gender on

students' achievement in quadratic equation is 0.089. Since the probability value of .089 is greater than 0.05 level of significant (P <.05), the null hypothesis is upheld. Thus gender has no significant influence on the achievement of students in quadratic equation.

IV. DISCUSSION

The result of this study indicated that DBI has significant effect on the students' achievement in quadratic equation. The group (experimental) taught quadratic equation using DBI performed significantly better than the group (control) taught quadratic equation with conventional approach. The significant differences in quadratic equation achievement of the experimental group as compared with the control group indicates that the DBI approach to teaching and learning shows a promising implications for the potential of using the approach in teaching quadratic equation in secondary school level. The significant improvement on the achievement on the account of differentiated based instruction as used in this study also, suggest that there is need to follow individual learners in their respective paces while learning quadratic equation.

This result is in agreement with the earlier research findings on the use of some innovative approaches to mathematics instruction viz: Odo and Ugwuada (2014), Ugwuanyi (2016), Ukwueze (2017) who researched on the use of innovative games and confirmed that the use of games has positive effect on students' achievement in mathematics. Also, Okigbo (2010), Ifeanacho (2012) and Oloto (2015) all researched on respective instructional approaches viz: Instructional analogy as advance organizer, Kumon teaching strategy, and Scaffolding instructional strategy respectively and found that they are all effective in the teaching and learning of mathematics and hence, improved mathematics achievement.

The result of this study revealed that there was no significant influence of differentiated based instruction on male and female students' achievement in quadratic equation. The finding of this study shows that gender has no significant influence on the achievement of students in quadratic equation. This could be attributed to the fact that both male and female enjoy DBI as each of them is been followed according to his or ability in the classroom. Learners like asking a lot of questions on how the concept, appear to them, this is encouraged by the use of DBI of teaching and learning.

This result is in agreement with the earlier research findings which were conducted by Eze (2010), Okeke (2011) and Ukwueze (2017) who reported that students' gender has no significant effect on science and mathematics achievement. However, the result is at variance with the study conducted by Ayotola, and Adedeji (2009), and Amatobi (2013) who reported that boys performed better than girls despite been in the same classroom.

V. CONCLUSION

On the basis of the findings of this study, the following conclusions have been drawn.

The group that was taught quadratic equation using DBI performed higher than those taught with conventional approach. The mathematics teacher in the course of teaching and learning of mathematics should endeavor to follow learners according to their respective paces. Mathematics instruction should be individualized by the teacher.

Gender had no significant influence on students' achievement in quadratic equation. The use of DBI is gender friendly. Mathematics instructions should be students, center and individualized to accommodate individual learners in the mathematics classroom.

VI. RECOMMENDATIONS

The following recommendations are made based on the findings of this study.

1. Mathematics teachers should follow students through with the use of differentiated based instruction in the teaching and learning of mathematics. This will help to correct the impression some students have about mathematics and mathematics instructors.
2. **Policy makers should organize seminars, workshop and conferences, on the use of DBI approach for serving teachers and teachers' educators.**
3. Students should make themselves, available and participate actively in order to benefit from DBI package from the mathematics teacher as the learners first of all ask questions as it affect them before the instructor react.

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