Effect of Mathematical Game on Students Achievement in Quadratic Expressions

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Abstract - This study was designed to investigate the effect of mathematical game on student's achievement in quadratic expression. The study employed a non-equivalent control group quasi-experimental design. The sample for this study comprised of one hundred and ten J.S.S II students. The study was conducted in six secondary schools (2 male, 2 female and 2 co-educational). The schools were drawn through a stratified random sampling technique. In each school, one intact class was drawn for the study through simple balloting. Out of the six schools, three schools (one male, one female and one co-educational) were assigned to the treatment group while the remaining three schools were assigned to the control group. The treatment group was taught quadratic expression using the game approach while the control group was taught quadratic expression using the conventional method. Three research questions and three hypotheses guided the study. Quadratic Expression Achievement Test was used to collect data on the achievement of students. The data were analyzed using mean, standard deviation and analysis of co-variance (ANCOVA). The result revealed that the mathematical game approach is superior to the conventional method in facilitating achievement in mathematics. The study also revealed that although with mathematical game approach males showed higher achievement than the females, the difference in the mean achievement of males and females taught using the method is not statistically significant. There was no significant interaction between gender and instructional method on student's achievement in quadratic expression.

Key Words: Achievement in mathematics, Mathematical games, Quadratic expressions.

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INTRODUCTION

Mathematics was defined by Isineyi, (1990) as a science, which deals with the meaning of numbers and their relationship to space. Ukadike (1997), shared the view that mathematics is indispensable because it has application in all other human activities including school science and technology based subjects. It has become the central intellectual discipline of the technological society. As such mathematics is one of the most important subjects Nigeria needs in this present era of technological advancement and in the realization of Nigerian vision of the year 2010 (Ukeje, 1997).

In spite of its importance and contributions in development and efforts made to improve the teaching and learning of mathematics in schools, there is still persistent poor achievement of students in mathematics. Studies indicated low level of mathematics achievement for Nigerian Secondary Schools (Obioma and Ohuche, 1987; Ale, 1989; Isineyi, 1990). Again, the Chief Examiner's reports (WAEC, 2006, 2007 and 2008) stated that the mark for most centers in mathematics was either zero or near zero.

Recently, Chief Examiners' reports showed that poor student's performance in secondary school mathematics has been more prominent in some aspects of mathematics curriculum than in others. Such content areas like algebra have been reported to be very difficult to understand by students (WAEC, 2008)

In a nation wide survey, carried out by Science Teachers' Association of Nigeria (STAN) on Mathematics and Physics panel, it was observed that majority of secondary school mathematics teachers indicated many concepts/topics that are difficult to teach or learn. The topics indicated include: Quadratic Expression, Series and Sequences (Ozofor, 1993). Quadratic Expression has also been identified as one of the mathematics concepts which poses difficulties to secondary school students as established during the Federal Ministry of Education Vacation Course held for mathematics teachers in Owerri Imo State for Science and Mathematics Teachers Vacation Course organized by State Ministry of Education Imo State (2000).

The teaching and learning of mathematics at all levels of the educational system may be described to be in a dismal state, students find it difficult to understand (Amazigo, 2000), teachers find difficulties in teaching many topics (Oyedeji, 1992). Teaching has been described as being ineffective (Oyedeji, 1992). The difficulties of students and the poor teaching usually come to light through the poor performances of students. Students are seen to perform poorly in both internal and external examinations. For instance in 2009 over 26% of the students failed mathematics in Senior Secondary School Examination (WAEC Chief Report). The situation is most pathetic in the junior secondary level (Ozofor, 1993). Thus every concerned educationist is seeking a way out of these problems of poor performances in mathematics. One of such ways teaching aids is the mathematical games.

With the relationship of the indispensability of mathematics in the survival of our society and the educational system, mathematics educators have been concerned with the ways in which students learn mathematics effectively and with utmost interest and better

achievement. Hence effort now is to use mathematical games to harness the students' intellectual power.

A mathematical game is a type of play that follows a set of rules, aims at definite goal or outcome, and involves competition against other players or against barriers imposed by the nature of the game itself (Worth 1981). A game is regarded as 'mathematical when the players can perceive and/or influence the course of the game on the basis of mathematical considerations (Rudiger, 1994).

Mathematical games may be used to introduce concepts as a prelude to explicit teaching or practice skills or consolidate a concept after explicit teaching. Educational games do lead to improved learning (Dennis and Stewart 1999). Some researchers have evaluated the effectiveness of mathematical games and gave reasons for the use of games. Among them are the powerful motivation, involvement, and the development of positive attitudes in learning have long been recognized as being essential and necessary. Games are also valuable for encouraging social skill, for stimulating discussions, helping the development of understanding, for developing strategies for learning new concepts, reinforcing skills and concepts as an aid to symbolization and logic (Old field, 1991).

Ascher and Ascher (1994) asserted that mathematical games are culturally oriented and that each culture has its own sets of mathematical games. They stressed that mathematical ideas are panhuman and are developed within cultures. Mathematical ideas are taken to be those that involve numbers, logic, spatial configuration and most importantly, the combination or organization of these into systems or structures. From culture to culture and within any culture, mathematical games and ideas appear in various contexts, which are either clear-cut or mutually exclusive.

With the inter-cultural variations in mathematics game approach and obvious differentials in play patterns, it has been speculated that the impact of such mathematics games on male and female could vary. According to Rudiger (1994), the extent to which mathematical games influence the learning process of males and females still remain a source of concern to the proponents of game approach to mathematical instruction.

Quadratic expressions are called quadratic because quadratus is latin word for "square" in the leading term the variable is squared (Free Encyclopedia, 2008). Quadratic expression can be using three pieces of flat wood in teaching factorization and expansion. Because of the interrelationship between board games and quadratic expression it has been speculated that its application in quadratic expression instruction will have an interesting implication not only in boosting students' interest in

algebra but also in enhancing achievement in algebra and mathematics in general.

In fact, the extent to which the game approach influences the achievement of secondary school students in quadratic expression, both collectively and differentially demands very urgent attention.

OBJECTIVES OF THE STUDY

The main objectives of this study are to find out the effects of mathematical games on students' achievement in quadratic expression. The study specifically determined:
1. The effect of Mathematical games on students' achievement in quadratic expression.
2. The effect of mathematical games on the achievement of male and female students in quadratic expression.
3. The interaction of gender and instructional approach on students' achievement in quadratic expression.

SCOPE OF THE STUDY

The study was restricted to the effect of mathematical games on student's achievement in quadratic expression. The study took place in Abakaliki Local Government Area of Ebonyi State. The study was also restricted to the content area of quadratic expression for J.S.S.ll students, which included:
1. Factorization of quadratic expression.
2. The expansion of quadratic expression.

RESEARCH QUESTION

The following research questions guided this study.
1. What is the effect of mathematical games instructional approach on students' mean achievement in quadratic expression?
2. What is the effect of mathematical games on the mean achievement scores of male and female students in quadratic expression?

3. What is the interaction effect of gender and instructional approach on students' mean achievement in quadratic expression?

HYPOTHESES

The following null hypotheses were tested at 0.05 significant levels for the study:

H0$_1$: There is no statistically significant difference in the mean achievement score of students taught quadratic expression using the game approach and those taught quadratic expression using the conventional approach.

H0$_2$: There is no statistically significant difference in the mean achievement score of male and female students

taught quadratic expression using the mathematical game approach.

H0₃: There will be no statistically significant interaction between gender and instructional approach on students' mean achievement in quadratic expression.

RESEARCH METHOD

This study employed a quasi-experimental procedure. The reason is because the researcher used intact classes and as such could not achieve random assignment of subject to treatment and control groups. The specific design the researcher adopted is a pretest – posttest non-equivalent control group design. This study was conducted within the Abakaliki Education Zone of Ebonyi State. Six secondary schools were drawn for this study (2 male, 2 female and 2 co-educational) through a simple stratified random sampling. Three of the schools (1 male, 1 female and 1 co-educational) were assigned to the treatment group while the remaining three were assigned to the control group through a simple toss of coin. In each school that was drawn for this study all the intact classes of JSS II were used.

The instruments the researcher used for data collection is Quadratic Expression Achievement Test (QEAT). The Quadratic Expression Achievement Test (QEAT is a 20-item structured question developed by the researcher from the content area taught during the study. Details of item coverage with relation to content of the syllabus are shown in appendix III. The instrument is made up of two parts: Part 1 and part 2. The part 1 explores the personal data of the respondents while part 2 contains the main items of the test. The part 2 is further subdivided into two section – section A and B. Section A contained 10 items on Factorization of quadratic expression while B also contains 10 items but on the expansion of quadratic expression

The Quadratic Expression Achievement Test (QEAT) was subjected to face validation, content validation and item analysis. The thirty five (35) item Quadratic Expression Achievement Test (QEAT) was face validated by experts in research and mathematics education. The face validation scrutinized the items in terms of relevance, general test format, suitability and clarity. After the face validation, twenty items survived. The instrument was further subjected to content validation using the table of specification and item analysis. The Quadratic Expression Achievement Test was assessed for reliability using the test-retest procedure and the Kuder-Richardson 20 approach. Using the Pearson's Product Moment's Correlation procedure the QEAT yielded a retest coefficient of 0.96. The

test of internal consistency with the K.R 20 yielded a reliability index of 0.97.

Experimental Procedure

Two instrumental approaches were used for this study. The first approach is the incorporation of mathematical game approach while the second is conventional or non-game approach. The contents were drawn from the junior secondary mathematics core curriculum of the Federal Ministry of Education. The mathematical game approach is identical to the conventional package in terms of content, basic instructional objectives and mode of evaluation. The only difference is in the instructional activities where the game approach deviates from the conventional approach by employing mathematical game during the instructional process. The game approach was used for treatment group whereas the conventional approach was used for the control group.

Before the experiment, subjects in both the treatment and control group were given the pre-test. After the pre-test the regular mathematics teachers began the experiment in their respective schools adhering striating to the lesson procedures which were developed from the package during the pre-experimental conference conducted by the researcher. The experiment was conducted during the normal school periods following the school timetable. At the end of the experiment, which lasted for 6 weeks, the teacher administered the post-test to the subjects in the two groups. The pre-test and posttest are the same except that the colour of the paper was changed from white to yellow and the item numbers were reshuffled. Data that were collected from the pre-test and post-test on achievement were kept separately for the two groups and used to answer the researcher questions and test the hypotheses that guided this study.

Research questions were answered using mean and standard deviation while hypothesis were tested using the Analysis of Co-variance (ANCOVA) at an alpha level of 0.05.

RESULTS
Research Questions
Research Question 1

What is the effect of mathematical games instructional approach on students' mean achievement in quadratic expression?

For this research question data obtained with the Algebraic Expression Achievement Test for the treatment and control groups were used to answer the research question. Mean for pre and post test were adjusted statistical in the analysis to take care of the initial equivalence of the research subjects. Summary of result of data analysis is presented in table 1.

Table 1: *Mean algebraic expression achievement scores of students taught algebraic expression using the game approach and those taught with the conventional method.*

Groups	N	Adjusted Mean	Std Dev.
Treatment Group (Group Taught with Mathematical Game Approach)	61	82.1311	14.2729
Control Group (Group taught with conventional method).	49	52.7551	21.0916

Summary of result presented in table 1 reveal that mathematical game approach yielded a mean achievement score of 82.1311 with a standard deviation of 14.2729 while the conventional method yielded a mean of 52.7551 and a standard deviation of 21.0916 implying that the mathematical game approach is superior to the conventional approach in enhancing students achievement in algebraic expressions.

Research Question 2

What is the effect of mathematical games on the mean achievement scores of male and female students in quadratic expression?

In answering this research question the researcher used the subjects from the treatment group only. The pre and posttest scores of males and females who were taught quadratic expressions using the game approach were adjusted in the analysis. The summary of result is shown in table 2.

Table 2: *Mean quadratic expression scores of males and females taught quadratic expressions using the game method*

Gender Categories	N	Adjusted Mean	SD
Male Students	26	83.0769	14.2882
Female Students	35	81.4286	14.4289

The mean achievement scores of male taught using mathematical game is 83.0769 with a standard deviation of 14.2882 while the female students had a mean achievement scores of 81.4286 a standard deviation of 14.4289. Although the mean score of males is higher than those of their female counterparts, the difference is negligible.

Research Question 3

What is the interaction effect of gender and instructional approach on students' mean achievement in quadratic expression?

The adjusted mean for the two levels of gender that were subjected to the game approach and those subjected to the Conventional approach were used to assess the interaction. Summary of result is presented in table 3.

Table 3: *Summary of interaction effect of gender and teaching method on students' mean achievement scores in Quadratic expression.*

GENDER GROUPS	Adjusted Mean for Treatment Group	Adjusted Mean for Conventional Method
Males	83.0769	61.9231
Females	81.4286	49.4444

Summary of result presented in table 3 reveal clearly that there is no interaction effect of gender and teaching method on students' mean achievement scores in quadratic expression. Result presented in the table indicated that game approach is superior to the conventional approach at the two levels of gender (mal and female).

Hypotheses

$H0_1$: *There is no statistically significant difference in the mean achievement score of students taught quadratic expression using the game approach and those taught quadratic expression using the conventional approach.*

$H0_3$: *There will be no statistically significant interaction between gender and instructional approach on students' mean achievement in quadratic expression.*

These two hypotheses were tested using Analysis of Co-Variance. Summary of the analysis for these two null hypotheses is shown in table 4.

Table 4: *Analysis of Co Variance for Students Overall Quadratic expression Achievement scores by teaching methods and by gender*

Sources of variation	Sum of squares	Df	Mean Squares	F	F_{cv}

Covariates	22477.853	1	22477.853	225.120	
Main Effects	23984.374	2	11992.187	120.104	
Teaching Methods	21954.210	1	21954.210	219.876	3.89
Gender	382.896	1	382.896	3.835	3.89
2 – Way Interaction	78.475	1	78.475	.786	3.89
Teaching Methods & Gender					
Explained	46540.702	4	11635.175	116.529	
Residual	10484.071	105	99.848		
Total	57024.773	109	523.163		

For hypothesis 1, the ANCOVA table shows the F-cal 219.876 is greater than the critical value (3.89) at an alpha level of 0.05. The decision rule is to reject the null hypothesis when the calculated value exceeds the critical value at a given probability level. Since the calculated value is greater than the critical value, the null hypothesis was rejected. The researcher, therefore, concludes that there is a significant difference in the mean achievement scores of students taught quadratic expression using the game approach and those taught quadratic expression using the conventional approach.

For hypothesis 3, result in table 4 reveals that for two way interaction, the F-cal is .786 while the critical value at 5% probability level is 3.89. Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant interaction between gender and instructional approach on students' mean achievement in quadratic expression.

H0₂: *There is no statistically significant difference in the mean achievement score of male and female students taught quadratic expression using the mathematical game approach*.

This hypothesis was also tested using the Analysis of Co-variance. Summary of result is shown in Table 5

Table 5: *Analysis of Co Variance for Students Overall Quadratic expression Achievement scores by teaching methods and by gender*

Sources of variation	Sum of squares	Df	Mean Squares	F	F_{cv}
Covariates	7406.460	1	7406.460	90.722	
Main Effects (GENDER)	81.403	1	81.403	.997	
Explained	7487.863	2	3743.932	45.859	
Residual	4735.088	58	81.639		
Total	12222.951	60	203.716		

For hypothesis 2, table 5 reveal that F-cal (.997) is less than the significance of F (3.89) at alpha level of 0.05 since the calculated is les than the critical value at the given alpha level, the null hypothesis is accepted. The researcher, therefore, upholds the null hypothesis and concludes that there is no significance difference between the mean achievement score of male and female students taught quadratic expression using the mathematical game approach.

Summary of Results

Results of this study reveal the following:

1. Mathematical game approach fostered higher achievement in quadratic expression than the conventional approach. Mathematical game approach is therefore is superior to conventional approach in facilitating higher achievement among students.

2. The difference in the mean achievement scores of male and female students taught quadratic expression using the using mathematical game approach is not significant

3. There is no significant interaction between gender and instructional approach on students' mean achievement in quadratic expression.

DISCUSSION

The results from this study indicated that students taught quadratic expression using mathematical game performed significantly better than students taught using the conventional method. In other words' the experimental group produced higher mean achievement score than the control group taught the same topic using the conventional method.

The finding of this study is in agreement with the earlier research such as Singmaster (1997) who supported that mathematical games with its ability to general fun enhance cognition without stressing the learners. This is also in consonance with the findings of smith (1993) that mathematical game provides a clear understanding of mathematical rules and principles.

The finding is not surprising since mathematical games encourage systematic ideas or patterns. From this one could infer that students in the experimental group of this study advanced in level of understanding as they applied their own understanding of the rules of the game in solving mathematical problems such as the one of quadratic expression.

Summary of data analysis in table 2 reveal effects of the game approach on the mean achievement scores of male and female students. The findings indicated that male students achieved better than the female students. Although the achievement of the male students in the algebraic expression test is higher than those of their female counterpart, the test of significance revealed that the difference in their achievement scores is very insignificant. The findings of this study did not agree with the earlier arguments of Greenfield and Feldman (1997). They argued that mathematical games are masculine and as such will favour male more than females. This study has dispelled the argument with concrete data and most importantly the purported masculinity of game approach was not manifested in this experiment as females were observed progressing smoothly during the experimental sessions.

Summary of result presented in table 3 reveal that there is no interaction between gender and teaching approach on students achievement in quadratic expression. Summary of result in table 3 also indicated that mathematical game approach is superior to the conventional approach at the two levels of gender in fostering achievement. Treatment interaction generally implies that different learners with different characteristics may profit more fro one type of instructional than from another and that therefore it may be possible to find the best match of learners characteristics and instructional approach in other to maximize learning outcomes or whichever dependent variable that is involved.

Although the goal of research in treatment interaction is to find significant disordinal interaction between alternative treatments and personal variables, it must be emphasized here that any approach which yields a superior no-interaction is cost effective and better in all ramification. With this in mind, one may begin to appreciate the worth of the mathematical game approach both in its superiority over the conventional approach and its ability to accommodate both males and females in fostering achievement in quadratic expression.

RECOMMENDATIONS

Based on the finding of the study, the researcher made the following recommendations:

(a). Both primary and secondary school mathematics teachers should be encouraged to adopt mathematical game approach as part of their teaching methods.

(b). State and Federal Government should establish, equip and fund mathematical resource centres in each education zone. This will ensure that teachers can go to these centres and learn how to use the games in teaching mathematical concepts.

(c). State and Federal Governments should encourage and sponsor in-service training for mathematics teachers to learn the tenets of mathematical games

(d). The Government in collaboration with curriculum developers and mathematics teachers should review the existing curriculum and integrate the basic tenets of the game approach in the curriculum.

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