Effects of Algebraic Process Board Game` on Students Interests and Achievement in Algebra

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Abstract
The study investigated the effects of algebraic process board game on senior secondary students interest and achievement in algebra. Four research questions and four null hypotheses were formulated. Design for the study was a quasi-experimental non-equivalent control groups pre-test and post-test design. The population for the study comprised of all the 5210 senior secondary students in the area of study while the simple random sampling technique was used to draw four senior secondary schools (SSS) with 455 students as the sample. Two schools each were randomly assigned to the treatment and control groups. Mathematics interest inventory (MII) and mathematics achievement test (MAT) of multiple choice type, developed by the researchers validated and yielded reliability coefficient of 0.74 and 0.71 respectively were used for data collection. The treatment group was taught algebra using algebraic process board game while the control group was taught using conventional talk and chalk method. Research questions were answered using mean and standard deviation while` the hypotheses were tested using ANCOVA at an alpha level of 0.05. The results revealed that the Algebraic Process Board Game is superior to the conventional method in facilitating interest and achievement but no significance interaction between gender and method. The researchers therefore recommended that the algebraic process board game approach should be used in teaching algebra.
Keywords: Algebraic Process, Board Game.

1.0 Introduction
The urge to devise an acceptable, conducive, relevant and functional approach to the teaching and learning of mathematics has been an issue that attracted wide concern both from local and international bodies (Ubana, 2009). New development in child centered approach to mathematics tends to reveal some striking qualities of game instructional approach which, when adequately utilized during normal classroom instruction, may enhance the proper understanding and appreciation of mathematics. It has been suggested that creating a child-centered environment in mathematics classrooms can reduce phobia associated with mathematics. Such stress free environment can be achieved through the use of game instruction.

One aspect of learning, which has been neglected in mathematics instruction but has relevance in experimental learning theory, is the game instructional approach (Ezeugwu, Onuorah, Asogwa and Ukoha, 2016). Ezeugwu et al, (2016), described games as innovative instructional approach that could help stimulate student's interest to learn and enhance achievement in mathematics. It is an interactive activity with set of rules in which the primary target is to achieve specific objectives and win play. Games motivate students, helps to develop positive interest, develop skills, abilities and strategies to learn. Although game instructional approach is one of the most basic and recent development and advocated for use in mathematics instruction, it has not formed a part of normal instructional practice in Nigerian secondary schools (Iji, Emiaku & Utubaku, 2015). While it has become explicit that a lot of advanced mathematical principles are embedded in games of various forms, current emphasis on mathematics instruction has continually ignored game approach.

In mathematics, an algebraic process is an expression built up from constants, variables, and a finite number of algebraic operations (addition, subtraction multiplications, division and exponentiations) by an exponent that is a rational number (Iji et al, 2015). Like Iji et al (2015) rightly stated, algebra serves as an opportunity getaway to higher studies involving mathematics. They also affirmed that algebra develops one's thinking in specific areas like logic, patterns, problem-solving, deductive and inductive reasoning.

Despite the importance placed on algebra in mathematics curricula, many students find it to be abstract and difficult to comprehend (Odili, 2007). The conventional teaching method (chalk and talk or the traditional method) used in schools by teachers has not improved students achievement and not much attempts has been made towards exploring mathematical games in complementing secondary mathematics (Iyekekpolor, 2007).

Some researchers like Odili (2012) and Uka and Ekwueme (2014) argued that many students at the elementary school level face difficulties in moving from an elementary level of mathematics that involves the manipulations of the arithmetic operations of addition, subtraction, multiplication and division in problem solving to a level that involves the use of letters in addition with the arithmetic operations in problem solving mainly because they cannot understand the structure and patterns of arithmetic but this can be corrected through mathematics games.

Mathematical games are one of the strategies of the National Mathematical Centre (NMC, 2010) for

improving the teaching and learning of mathematics in schools. Mathematical game approach involves two or more students working together to find a solution to a given mathematics problem. In a mathematical game, the winner, the loser and the spectator(s) are all expected to learn the mathematics concept being practiced in the game. According to Anugwo (2011), mathematics games encourage students to discuss mathematical strategies with their peers, teachers and parents. As they are joking around, interest is captured and unusual solutions (solutions that were not easy to come by when the conventional teaching method is being used) to problems are achieved. Mathematical games can take the forms of puzzles, magic tricks, fallacies paradoxes, or any other form which provides amusement or curiosity (Okenyi, 2010). They tend to bring joy to the learner, breakdown resistance to learning by reducing tension, clearing boredom, and providing an environment where the student can develop skills and acquire more knowledge. They also have the features that may stimulate mathematical thinking and generate excitement and spirit of individualism, co-operation and competition (Anugwo, 2011).

This study adopted Board Game for Algebraic Expressions as instructional technique. The game combines mathematical skills with a competitive strategy. The objective of the game is similar to that of the ordinary "tic-tac-toe" or attack" (that is, each player ensuring that the opposition player did not make a four consecutive game play vertically, horizontally or diagonally as that guarantees a win),. The winner is the first of the two players, who places four tokens, either vertically, horizontally, or diagonally. Player 'A' begins the game by placing one of his factor markers and one of player 'Bs' factor markers on any factors on the factor board. The product of these factors determines the placement of player 'A' game token. Then on his own turn, player B can move only his/her factor marker (while A's marker remains in place) to another factor on the factor board. The product of these new factors (B's new position and A's position) determines the placement of player B's game token. For example, if player A placed his factor marker on X+1 and player B's marker on X-1, and player A then continued by placing a game token on x^2-1 because $(x+1)(x-1) = X^2 -1$. The game continues with each player moving only his/her factor marker and placing a game token on the corresponding product on the game board until either a winner is decided or a draw results is recorded. A winner is decided when either player succeeds in placing four games token in a row either vertically, horizontally, or diagonally. A player is penalized when a product that has already been covered is used or when an incorrect response to the factors is given. In the event of a penalty, the opposing player has the opportunity to move both factor markers, as in the beginning of the game.

The board game is easy to understand, can easily be developed by the classroom teacher, is portable can be played by the students anytime and anywhere. From culture to culture and within any culture, mathematical instruction appear in various contexts which are either clear-cut or mutually exclusive. With the variations in instructional approaches and obvious differentials in drill patterns, it has been speculated that the impact of such mathematical instructional games on male and females may vary. According to Okenyi (2010), the extent to which game influences the learning process of males and females still remains a source of concern to the proponents' of game learning approach in mathematics. In fact, the extent to which the algebraic process board game instructional approach influences the achievement and interest of secondary school students in mathematics may have some far-reaching implications which are worth exploring.

1.1 Objective of the Study
The purpose of the study was to investigate the effects of algebraic process board game instructional approach on senior secondary school students' interest and achievement in algebra. Specifically, this study investigated the effects of algebraic process board game instructional approach on:
1.   Students' interest in algebra;
2.   Students' achievement in algebra;
3.   interaction effect of method and gender on students' interest in algebraic;
4.   Interaction effect of method and gender on students' achievement in algebra.

1.2 Scope of the Study
This study was restricted to the effects of Algebraic Process Board Game instructional approach on students' achievement and interest in mathematics. In terms of content the following topics were taught: factorizations of algebraic expressions, expansions of algebraic expressions; and simple linear algebraic expressions. These topics fall within the syllabus of SSII class who participated in this study.

1.3 Research Questions
The following research questions guided the study:
1.   What is the effect of algebraic process board game instructional approach on students' mean interest scores in algebra?
2.   What is the effect of algebraic process board game instructional approach on students' mean achievement scores in algebra?
3.   What is the interaction effect of method and gender on students' interest in algebraic?

4.   What is the interaction effect of method and gender on students mean achievement scores in algebra?

1.4 Hypotheses
The following hypotheses were formulated for the study and tested at an alpha level of 0.05.

H_{01}:   There is no significant difference in the mean interest scores of students taught algebra using the algebraic process board game and those taught using the conventional approach.

H_{02}:   There is no significant difference in the mean achievement scores of students taught algebra using the algebraic process board game and those taught using the conventional approach.

H_{03}:   The interaction effect of method and gender on mean interest score of students in algebra will not be significant.

H_{04}:   The interaction effect of method and gender on the mean achievement scores of students in algebra will not be significant.

2.0 Research Method
This study adopted the quasi-experimental design. The reasons for this are that the researchers used intact classes and as such could not achieve random assignment of subjects to treatment and control groups. The pretest-posttest non-equivalent control group design was used as symbolically represented below:

Y^b x Y^a
$\overline{Y^b \sim x\ Y^a}$

    Where
            Y^b =   Pretest
            Y^a =   Posttest
            X   =   Treatment
            ~x   =   Control

2.1 Population of Study
The population of the study comprised all the 5210 senior secondary school SS II students in all the forty-six secondary schools in Awgu Education Zone of Enugu State, Nigeria. SS II students were chosen because their scheme of work contains the topics for which the game instructional programmes were developed and the classes were not disrupted since the students did not face any external examination.

2.2 Sample and Sampling Techniques
A total of 455 SSII students were used for this study drawn from four co-educational secondary schools were randomly drawn for this study. The choice of co-educational schools is because almost all the secondary schools in the zone are co-educational and co-educational schools are adequate in providing data on variables of gender. The researchers employed simple random sampling technique in drawing the schools. Out of the four secondary schools that were used for the study, two were assigned to the treatment group while the other two were assigned to the control group through a simple toss of coin. All the intact classes of SS2 in the drawn schools were used for the study.

2.3 Instrument for Data Collection
This study made use of Algebraic Achievement Test (AAT) and Mathematics Interest Inventory (MII) test as instruments for data collection. The Algebraic Achievement Test is a 40-item multiple choice objective test that was designed to assess students on the topics that were taught during the experiment. The topics were factorization, algebraic expansions, and simple linear algebraic expressions. The items of the instrument were drawn in such a way that a total of twelve items were drawn from algebraic factorization, twelve from algebraic expansions, and sixteen from simple linear algebraic expressions. The Mathematics Interest Inventory test contains 30 items spread cross four factors, academic, vocational, leisure and general interests. The MII is structured on a four point rating scale of strongly agree, agree, disagree and strongly disagree.

2.4 Validity of the Instrument
The AAT was subjected to both face and content validation. The face validation scrutinized the items in terms of relevance, general test format, suitability and clarity. After the face validation and modification in line with recommendations of the specialists (2 Mathematics Education specialists and one Measurement and Evaluation specialist), the AAT was further subjected to content validation using the test blueprint. The 30 item of the interest inventory was subjected to construct validity using Factor Analysis. Two items were dropped out of the 30 items making it 28 items that were used for this study.

2.5 Reliability of the Instrument

The AAT assessed for reliability using Kuder-Richardson formula 20. The researchers administered 25 copies of the instrument to 25 JSS2 students from other secondary schools outside the sampled secondary schools. The test of internal consistency of the instrument yielded a coefficient of 0.71. The surviving items of AAT were subjected to test of reliability using Cronbach alpha and it yielded a coefficient of 0.74.

2.6 Experimental Procedure

Two instructional approach used for this study. The first package was the game instructional package developed by the researchers and used for the treatment group. The second package was the conventional approach drawn from the mathematics curriculum module of the Federal Ministry of Education, Nigeria and used for the control group. The game instructional approach was identical to the conventional package in terms of content, basic instructional objectives and mode of evaluation. The only difference was in the instructional activities, the game package deviated from the conventional approach by utilizing game instructions during the instructional process. Before the commencement of the experiment, subjects in both treatment and control groups were given the pre-test. After the pre-test, the regular mathematics teachers started the experiment in their respective schools adhering strictly to the lesson procedure that were developed from the approach during the pre-experimental conference. The experiment was conducted during the normal school periods, following the normal timetable of the schools. At the end of the experiment which lasted for six weeks, the teachers administered the post-tests to the subjects in the two groups. Data were collected from the pre-test and post-test of the interest and achievement of the students and were kept for analysis.

The game procedure normally involved two players at a time. Player or Group 'A' begins the game by placing one of his/their factor markers and one of player or Group 'B's factor markers on any factors on the factor board. The product of these factors determines the placement of player or Group 'A's game token. The teacher gives an example using the game and factor boards. Player or Group A places his/their factor marker on X+1 and player or Group B's marker on X-1, player or Group A then continues by placing a game token on X^2-1 because $(X+1)(X-1)$ = X^2-1. Actually, the two factor markers could be placed on the same factor, which should result in squared factors. Then for his/their own turn, player or Group B can move only his/their factor marker (while A's marker remains in place) to another factor on the factor board, as shown on the game and factor boards. In this example, player or Group B moved his/their factor marker to x. Now, the product of these new factors (B's new position and A's position) determines the placement of player or Group B's game token. In this case, player or Group B has to place his/their game token on the product of X+1 (player or Group A's marker) and X (player or Group B's marker), that is X^2+X on the game board. The game continues with each player or group moving only his/their factor marker and placing a game token on the corresponding product on the game board until either a winner is decided or a draw results. A winner was decided when either player/group succeeds in placing four game tokens in a row, either vertically, horizontally, or diagonally without interception. That is mixing them up with the opponents game token.

A players/group is penalized when a product that has already been covered is used or when an incorrect response to the factors is given. A move was considered to be complete when a player's/group's hand is removed from the factor marker in the duplicate product or from the game token in the event of an incorrect response. In the event of a penalty, the opposing player/group has the opportunity to move both factor markers, as it was in the beginning of the game. The teacher moderates the play by calling up students in two's/or groups to come and play the game while others watch. After game play must have gone round the class, test was given to the students to assess their level of understanding.

2.7 Control of Extraneous Variables

The following extraneous variables, which may influence the internal validity of the findings were controlled:

2.7.1 *Teacher Variable:* In order to minimize errors, which might arise as a result of teacher difference, the researchers organized a pre-experimental training for the mathematics teachers that assisted in the study. Separate training was organized for teachers in the two groups. A manual containing the specifications of the approach was made available to the teachers that participated in the experiment. In addition, the researcher monitored the experiment very closely so as to ensure that no teacher deviates from the agreed format.

2.7.2 *Intergroup Variable:* Because intact classes were used for this study, it implied that initial equivalence was not achieved for the research subjects in the two groups. In order to eliminate the errors of non-equivalence arising from the non-randomization of the subjects, the researcher used the Analysis of Co-variance (ANCOVA) for data analysis.

2.7.3 *Subject Interaction:* The researcher did not select treatment and control groups from the same school to ensure that the students in the treatment and control groups do not mix up at all. This was ensured to reduce the errors that would arise from interaction and exchange of ideas among research subjects (students) from the two groups and further eliminate the possibility of a John Henry Effect.

2.7.4   *Instructional Situation Variable:* To ensure that instructional situation was the same for all the schools, the researchers issued out instructional guides to the teachers in each group.

2.7.5   *Hawthrone effect:* The pre-test and teaching was conducted in all the classes to avoid hawthorn effect. The researchers did not select treatment and control groups from the same school to ensure that the students in the treatment and control groups did not mix up. This was done to reduce the error arising from interaction and exchange of ideas among research subjects from the two groups.

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

3.0 Findings
3.1 Research Questions
3.1.1 Research Question 1: What is the Effect of Algebraic Process Board Game on students' interest in algebra?

Table 1: Mean and standard deviation of interest scores of students taught algebra using algebraic process board game and those taught with the conventional method

Group	Adjusted Mean	SD	N
Treatment	65.53	8.84	242
Control	41.64	11.84	213

The result on Table 1 show that students taught algebra using algebraic process board game had adjusted a mean interest score of 65.53 and standard deviation score of 8.84 while those taught using the conventional method had adjusted mean interest score of 41.64 and standard deviation score of 11.84. The implication is that algebraic process board game enhanced interest of students in algebra better than the conventional teaching method.

3.1.2 Research Question 2: What is the effect of algebraic process board game on students' achievement in algebra?

Table 2: Mean and standard deviation of achievement scores of students taught algebra using algebraic process board game and those taught with the conventional method

Group	Adjusted Mean	SD	N
Treatment	49.26	7.12	242
Control	28.52	7.24	213

The result on Table 2 show that students taught algebra using algebraic process board game had adjusted mean achievement score of 49.26 and standard deviation score of 7.12 while those taught using the conventional method had adjusted mean achievement score of 28.52 and standard deviation score of 7.24. Implying that algebraic process board game enhance achievement of students in algebra better than the conventional teaching method.

3.1.3 Research Question 3: What is the interaction effect of method and gender on students mean achievement in algebra?

Table 3: Summary of interaction effect of method and gender on students mean achievement in algebra

Gender Groups	Adjusted Mean For Treatment Group	Adjusted Mean for Conventional Method
Males	48.56	30.12
Females	49.99	26.93

Summary of results presented in table 3 reveal clearly that there is no interaction between teaching methods and gender on students' mean achievement scores in algebra. Result presented in the table indicated that algebraic process board game is superior to the conventional approach in enhancing students' interest at the two levels of gender (male and female).

3.2 Hypotheses
3.2.1 Ho1: There is no statistically significant difference in the mean interest scores of students taught algebra using algebraic process board game and those taught using the conventional method.

3.2.2 Ho3: There is no statistically significant interaction between methods and gender on students' mean interest in algebra.

Table 4: Analysis of Co Variance results for Students overall algebra interest scores by teaching methods and interaction between methods and gender

Source of variation	Sum of squares	Df	Mean square	F	F. probability
Covariates	28226.87	1	28226.873	659.094	.000
Pretest	28226.87	1	28226.873	659.094	.000
Main Effects	65198.384	2	32599.192	761.187	.000
Methods	**63905.399**	**1**	**63905.399**	**1492.183**	**.000***
Gender	1112.362	1	1112.362	25.974	.000
2-Way Interactions	93.966	1	93.966	2.19	.129
Method Gender	**93.966**	**1**	**93.966**	**2.19**	**.129***
Explained	93895.086	4	23473.772	548.110	.000
Residual	19272.048	450	42.827		
Total	113167.134	454	249.267		

Summary of result in Table 4 shows that for hypothesis 1, the alpha level (0.05) is greater than the f-probability value (0.00). Based on the decision rule the researchers reject the null hypothesis and conclude that there is a significant difference between the mean interest scores of students taught algebra using the board game and those taught with the conventional method.

For hypothesis 3, the alpha level (0.05) is less than the f-probability value of 0.29, as such, the researchers uphold the null hypothesis and conclude that there is no statistically significant interaction between methods and gender on students mean interest in algebra.

3.2.3 H$_{o2}$: There was no statistically significant difference in the mean achievement scores of students taught algebra using algebraic process board game and those taught using the conventional method

Summary of result of the two hypotheses is as presented in Table 5.

Table 5: *Analysis of Co Variance for Students overall algebra achievement scores by teaching methods and interaction between methods and gender*

Source of variation	Sum of squares	Df	Mean square	F	F. probability
Covariates	9332.827	1	9332.827	256.236	.000
Pretest	9332.827	1	9332.827	256.236	.000
Main Effects	45997.388	2	22998.694	631.436	.000
Methods	**459946.734**	**1**	**45996.734**	**1261.482**	**.000***
Gender	28.342	1	28.342	0.778	.378
2-Way Interactions	81.939	1	81.939	2.250	.076
Method Gender	**81.939**	**1**	**81.939**	**2.250**	**.076***
Explained	55692.155	4	13923.039	382.261	.000
Residual	16390.276	450	36.423		
Total	72082.431	454	158.772		

Summary of result in table 5 showed that for hypothesis 2, the alpha level (0.05) is greater than the f-probability value (0.00). Based on the decision rule the researchers reject the null hypothesis and conclude that there is a significant difference between the mean achievement scores of students taught algebra using the board game and those taught with the conventional method.

For hypothesis 3, the alpha level (0.05) is less than the f-probability value (0.076). At such the researchers uphold the null hypothesis and conclude that there is no significant interaction between methods and gender on students mean achievement in algebra.

3.2.4 H$_{o4}$: There was no significant difference between the mean achievement scores of male and female students taught algebra using the algebraic process board game.

Data obtained for males and females on interest for the treatment group only was used to test this hypothesis. Summary of the result is shown in table 11.

Table 6: *Analysis of Co Variance for male and female Students* overall achievement

Source of variation	Sum of squares	Df	Mean square	F	F. probability
Variation	Squares		Square		
Covariates	356.153	1	356.153	7.234	.008
Pretest	356.153	1	356.153	7.234	.000
Main Effects	107.384	1	107.384	2.181	.141
Gender	**107.384**	**1**	**107.384**	**2.181**	**.141***
Explained	463.537	2	231.769	4.707	.010
Residual	11767.537	239	49.237		
Total	12231.074	241	50.751		

Result on Table 6 showed that the alpha level (0.05) is less than the f-probability value (0.141). The researcher

therefore upholds the null hypothesis and concludes that there is no significant difference in the mean achievement scores of males and females taught algebra using the board game.

3.3 Summary of Findings
The results revealed that:
1. The algebraic process board game approach is superior to the conventional approach in facilitating both interest and achievement of students in algebra;
2. There is no interaction between methods and gender on students interest and achievement in algebra;
3. While there is a significant difference in the mean interest scores of male and females taught algebra using board game approach in favour of males, there is no significant difference in the mean achievement of male and females taught algebra using the board dame approach.

4.0 Discussion
From the result of the finding, students taught algebraic concepts using algebraic process board game had higher mean interest score than those taught with the conventional chalk-talk approach, the result equally showed that the difference in the mean interest scores of students taught algebra using algebraic game board and those taught using the conventional chalk-talk approach was statistically significant in favour of the students taught using algebraic process game board.

The result is in consonance with that of Okigbo and Sam (2012) who recorded a significant difference in the mean interest scores of students taught mathematics using mathematical game and instructional analogy and those taught using the conventional chalk and talk method. The results have shown that using games as instructional strategy sustains enhances students' interest in learning algebra and mathematics in generally.

It is equally observed that both gender benefit from algebraic process board game. There was no interaction effect between method and gender on the students means interest scores in algebra indicating that algebraic process board game was superior to conventional chalk-talk approach at the two levels of gender. It is therefore suitable for use in teaching both male and female as instructional approach.

Result of analysis as presented in table 2, 3, and 5 showed that students taught algebraic concepts using algebraic process board game had higher mean achievement score than those taught with the conventional chalk-talk approach and was statistically significant in favour of students taught using algebraic process board game

The result is in consonance with that of Anugwo (2011) who recorded a significant difference in the mean achievement scores of students taught mathematics using algebraic game and those taught using the conventional chalk and talk method.

The result in table 3 showed that using games as instructional method enhances male and female students' achievement in learning though it favours the females than the males.

The result from table 5 revealed that there was no interaction effect between methods and gender on the students mea n achievement scores in algebra. The result showed that algebraic process board game was superior to the conventional chalk-talk approach at the two levels of gender (male and female).

5.0 Conclusion
This study introduced a new dimension that may reduce stress and anxiety usually associated with teaching and learning of mathematics and since some games have some cultural underpinning, their utilization during mathematics instruction may awaken the recent call for indigenized instruction in our system. This will further simplify and bridge the gap between traditional Africans and the Western oriented mathematics and further improves interest and achievement in mathematics. Algebraic Process Board Game as a teaching method is significantly better than the conventional chalk-talk teaching approach in enhancing students' interest and achievement in algebra. With algebraic process board game, male students showed higher interest than the female students while the female students had higher achievement than the males. The difference in the mean achievement of male and female students taught algebra using algebraic process board game was however no statistically significant. There was no significant interaction between methods and gender on students' mean interest and achievement in algebra. For both male and female students, algebraic process board game was superior to the conventional package in facilitating interest and enhancing achievement in algebra.

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