IMPACT OF FOUR ALGEBRAIC GAMES ON STUDENTS' INTEREST IN ALGEBRAIC EXPRESSIONS

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Abstract

Research on games and their influence on students' interest has been generic with respect to types of games and the topics covered. This study focused on the impact of four algebraic games on students' interest in algebraic expressions. The population of the study was 5,476 Junior Secondary School two (JSS II) students in the 31 government schools in Enugu Education Zone of Enugu State. A sample of 380 JSS II students drawn from two boys' secondary schools and two girls' secondary schools was employed for the study. Non-equivalent control group quasi-experimental design was used for the study. Two JSS II classes were randomly assigned to experimental and control groups in each of the schools. The students were taught by their normal class mathematics teachers who served as research assistants. Two research questions and three hypotheses guided the study. The instrument for data collection was Algebra Interest Scale (AIS). The reliability coefficient was determined as 0.77 using Cronbach's Alpha. Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 alpha level. Major findings of the study revealed that the students in the four Algebraic Games' group showed more interest than those in Expository Method group. The game method showed gender parity in the interests of male and female students. The researcher recommended that Four Algebraic Games should be used by Mathematics teachers in teaching algebra, and that Mathematics teachers should be retrained through seminars, conferences, workshops and in-service training on how to apply the strategy for instructional improvement in algebra among others.

Keywords: four algebraic games, students' interest, algebraic expressions, expository method, gender.

Introduction

Game is a common term used in some areas of life. Such areas include recreational centers (for fun or pleasure), field of sports (for competition and prediction), computer operation (to improve on one's typing skill), gambling (for commercial purpose), mathematics (to solve problems and or improve on/master a given topic), etc. Ezeamaenyi (2014) defines games as social activities with a set of rules in which the hallmark is to win. According to Onuoha (2016), games are contests in which people agree to abide by a set of rules to win an objective. The above definitions can be summarized with three key words – activity, rules and competition or winning /losing. Therefore, a game can be defined as an activity which has a set of rules or order with the aim of winning or losing through competition. Okigbo and Agu (2010) described mathematical games as activity in form of puzzle, magic tricks, fallacies, paradoxes, or any other type of mathematics which provides amusement or curiosity and stimulates mathematical thinking, excitement and spirit of competition and co-operation. Irrespective of how beneficial algebraic games seem to be, science educators and researchers still have diverse opinions as regards their use in teaching Mathematics.

Literature Review

Roche et al. (2021) discovered that mathematical games enhance students' motivation, interest, and engagement in mathematics. Orim and Ekwueme (2011) stated that the use of games and activities can make mathematics enjoyable. Educational Game is one of the strategies that have been found to enhance the attitude and academic achievement of students in many subjects including Mathematics (Azuka & Awogbemi, 2012, pp.10). Learners who are introduced to online mathematics games often gain self-motivation and intense interest (McLaren et al., 2017, p. 49). However, some researchers alerted that the use of games can induce problems in teaching and learning. Mathematical games may seem to boost the students' achievement in a particular topic, but they may depreciate the students' achievement in the next lesson (Anibueze, 2017). Smith and Clark (2019) posited that games may pose potential distractions and influence the overall learning experience. The objective of using games should be fixed to what elements of games are efficient for a particular type of student, involved in each activity (Dichev and Dicheva 2017).

Expository method is a learning method that emphasizes the process of delivering material verbally from a teacher to a group of students with the intention that students can master the subject matter optimally (Chintya & Efendi, 2021). Chintya and Efendi (2021) examined the effect of the expository learning method on mathematics learning outcomes and found that there was a positive and significant effect of the expository learning method on learning outcome. However, Kayode (2014) observes that the expository teaching approach could hinder successful impartation of knowledge because students are not permitted to participate actively in the teaching-learning process unless the teacher allows them to do so.

Adeleke (2008) observed that a branch of mathematics which students' problems dominate is algebra. Also, Onuoha (2016) noted that one of the branches of mathematics that secondary school students find difficult to understand is algebra. Possibly, this is so because historically algebra has represented students' first sustained exposure to the abstraction and symbolism that make mathematics powerful. Discussion on this problem is a recurring decimal in most workshops, seminars and conferences organized towards effective teaching and learning of mathematics in secondary schools. The National Teachers' Institute (2010) made it clear that pupils can be generally sensitized towards the learning of numbers through practical and purposeful engagement in playing games as well as using concrete materials. More so, Kurrummeh and Achor (2008) reported that several variables are responsible for the poor performance of students in mathematics, and these include, method for which the content is being presented to the students, lack of interest among the students and abstractness of mathematics concepts among others. Interest is an important variable in learning because when one is interested in any activity, he/she is likely to perform positively. Onah (2018) in his opening speech in the National mathematics center Abuja said that the center has resolved to go back to the basis to address the poor performance of students in mathematics and develop students' interest and talents in mathematics in the country. Poor achievement of students in mathematics has been attributed to lack of interest, poor memory and inappropriate teaching methods and techniques (Obodo, 2014). Nneji (2017) discovered that the students taught mathematics with power Tac-Toe Game indicated significantly higher interest in Mathematics than those taught without game and that there was no significant interaction between teaching strategy (POTTOG strategy) and students' gender on students' interest in mathematics. Takor (2015) studied the Effect of Mathematical Manipulatives in Upper Basic One students' interest in Algebra in Kwande Local Government Area, Benue State. The results from the study showed that students taught using mathematical manipulatives developed more interest in algebra than those taught using expository method. There was no gender difference observed between male and female students in the experimental group. Onuoha (2016) studied on the Effect of Game-base Instructional Technique on achievement and interest of students in algebra at the basic educational level. The study depicted that the use of game-based instructional technique in teaching mathematics significantly affects the students' achievements and interest in algebra and there was a significant difference between the mean interest scores of male and female students in the experimental group. The study also showed a significant interaction effect between learning method and gender on students' interest in algebra.

WAEC (2014) Chief Examiner's report revealed that many candidates missed full marks because of arithmetic errors in factorization and solution of quadratic function. The reason for the errors in factorization is not farfetched as Obodo (2004) made it clear that it has been discovered that some teachers (mathematics teachers) lack techniques and materials for teaching certain topics to the extent that if given choice, they will not teach such topics. Factorization in algebra is a topic that many mathematics teachers do not really teach very well. This is due to its seeming abstract nature.

And this results in arithmetic errors by the students because they have no physical materials to concretize the knowledge. The above necessitated and spurred the National mathematical center through the mathematical improvement project (MIP) to introduce a new teaching methodology (game-based teaching) to enhance students' performance in mathematics. These games are intended to stimulate students' interest and curiosity in mathematics, as well as to enhance their logical reasoning and problem-solving abilities (Solarin, 2013). Mathematical games are very useful tools in arousing students' interest in Mathematics for a better achievement (Oluremi, 2012; Michelle, 2012 & Ngoma, 2013). Some studies have favored interest regarding mathematical games while a few others revealed the contrary, but no work has been done on the impact of four algebraic games on students' interest in algebraic expressions.

Students' Perception of Algebraic Expressions

Algebra and Algebraic Expression

Theories of perception of algebraic expressions are different approaches to understanding how students learn to interpret and manipulate symbolic representations of mathematical concepts. Some of the main theories are:

Semiotics theory: This theory, proposed by Basil Hiley, emphasizes the role of signs and symbols in communicating and constructing mathematical meaning. It suggests that students need to master the syntax and semantics of algebraic notation, as well as the ability to switch between different representations of the same concept (Duval, 1995; Ferretti, 2020). Mathematical operators such as Addition (+), Subtraction (-), Multiplication (x), and Division (÷) should be mastered by the students as a necessary in foundation algebra.

Perceptual theory: This theory focuses on how students perceive the structure and patterns of algebraic expressions, and how they use perceptual processes such as attention, grouping, and chunking to facilitate algebraic reasoning. It proposes that students can benefit from concrete and virtual manipulatives that align the perceptual and conceptual properties of algebraic objects (Landy & Goldstone, 2007; Ottmar & Landy, 2014).

Objectification theory: This theory views algebraic expressions as cultural objects that students need to internalize and appropriate through social and individual activity. It argues that students need to engage in different forms of theoretical thinking, such as generalizing, justifying, and reflecting, to grasp the meaning and significance of algebraic expressions (Radford, 2008; Özdemir & Dede, 2019)

Algebra is about abstract structures and how to use the principle of those structures in solving problems expressed in symbols (Araoye and Kehinde, 2014). Also, Algebra is a branch of mathematics dealing with symbols and the rules for manipulating those symbols (Robert, 2015). For example, (i) if in a shopping mall, Rita needs 5 sachets of biscuit and two tins of cowbell milk. The provisions can be represented as $5x + 2y$. Where x and y stand for one sachet of biscuit and one tin of cowbell milk respectively. (ii) If the cost of 5 sachets of biscuit and 2 tins of cowbell milk is ₦510, this can be represented as $5x+2y=510$. From the above example, each of 5x and 2y is called algebraic term, $5x+2y$ is known as algebraic expression, and $5x+2y=510$ is referred to as algebraic equation. Algebraic term, therefore, is made up of a letter or symbol (in some cases the letter or symbol can be divided or multiplied by a negative/positive number). Examples are x, -2x, 5x, 2y,3, etc. The number which multiplies or divides a letter or symbol to form an algebraic term is referred to as the **coefficient** of the algebraic term. The coefficient of each of the above terms are: 1, -2, 5, 2, and 3. Whenever two or more algebraic terms are joined together by any or a combination of the arithmetic signs/operators of addition, subtraction, multiplication and division, the result is known as algebraic expression. Examples are (i) 5x+2y (ii) 6y+3z (iii) 2p-5p+r (iv) 5a+ 3b-7c. There are two types of algebraic expressions. (i) **Like terms algebraic expression**. Example: 8x +4x+7x (ii) **unlike terms algebraic expression**. Example 3x+5y-8z. Note: when there is a bracket enclosing an algebraic expression, it can be removed. The procedure is called "removing bracket" for instance: -2(3x-7y) = -6x+14y

Simple algebraic equation: algebraic equation is where two sides of algebraic expressions are equal. A mathematical statement where the expression at the left-hand side is equal to the expression at the right-hand side is called an equation.

Simple equation: a simple equation or linear equation is one in which the highest power of the variable/unknown is one (Araoye and Kehinde, 2014). To solve a linear equation, the following operations must be noted: (i) Add the same value to each side (ii) Subtract the same value from each side (iii) Multiply each side by the same value (iv) Divide each side by the same value (v) Remove from each side the same value (vi) Collect like terms. Example of simple equation is 7x-3 = -5. Other areas of algebraic process encompass: **Substitution**- replacing the variable with a number (constant) in an algebraic expression to find the numerical values of the given algebraic terms or expressions (Arigbabu et al., 2016). Example: If n=3, m=5 and x=7, find the value of mx+n. Solution: 5(7)+3 = 35+3=38. **Expansion of algebraic expression:** to expand is when we multiply to remove the bracket (Pierce, 2018) Example: expand the following algebraic expressions (i) -5(2x-4y) (ii) (x-4) (x-3)

Solution: (i) -5(2x-4y) = -10x + 20y (removing bracket) (ii) (x-4) (x-3) = x(x-3) -4(x-3) = x^2 -7x+12. Note: when expanding algebraic expressions, the following are done: (a) − x − = + (b)– x

$+ = -$ (c)+ x $- = -$ (d)+ x + = +. Note also that the above rule is applied to division. Factorization of algebraic expressions: factorization is the act of finding the factors of a given algebraic expression. It is the reverse of expansion. Factorization can be applied to the following: (a) Factorization of binomial expressions - a binomial expression is one that has two terms only. Example: Factorize the following (i) 16y2+10x (ii) ab3c-3abd. Solution: (i) 16y2+10x= 2 × 2 × 2 × 2 × y × y+ 2 × 5 × x =2(8y2+5x) (ii) ab3c-3abd = a × b× b × b × c× − 3 × a × b × d =ab (b2c − 3d) (b)Factorization of quadratic expression – a quadratic expression is one whose highest power of the variable is two. Example: Factorize the following (i) $m^2 - 4m + 4$ (ii) $2x^2 + 5x + 3$. Solution: (i) $m^2 - 4m + 4$. Find the product of the first and last terms, that is $m^2 \times (+4) = 4m^2$, then find two terms whose product is $4m^2$ and their sum is −4m. They are -2m and -2m. Replacing −4m with −2m and −2m in the given expression and factorizing by grouping will give $m^2 - 4m + 4 = m^2 - 2m - 2m + 4 = m(m-2) - 2(m-2) = (m-2)(m-2)$ (ii) $2x^2 + 5x + 3$. Find the product of the first and last terms, that is, $2x^2$ x $3 = 6x^2$. Then find two terms such that their product is $6x^2$ and their sum is 5x. The terms are 2x and 3x. replacing 5x with 2x and 3x in the given expression and factorizing by grouping gives: $2x^2 + 2x + 3x + 3 = 2x(x+1) + 3(x+1) = (2x+3)(x+1)$. **Simplification of algebraic expression involving fractions** –to simplify algebraic expressions involving fraction means reducing such expressions to a single lowest algebraic fraction. Example, simplify the following: (i) $\frac{x}{4} + 5$ (ii) $\frac{2u}{6} - 3$. Solution: (i) $\frac{x}{4} + 5 = \frac{x+20}{4}$ (ii) $\frac{2u}{6} - 3 = \frac{2u-18}{6} = \frac{2(u-9)}{6} = \frac{(u-9)}{3}$. Note: In algebraic expressions with fractions the knowledge of lowest common factor (LCM) of the denominators is very essential. The above solutions on algebraic substitution, expansion, factorization, and simplification depict abstraction and dryness because they are obtained through expository approach only. There was no teacher – student activity backing up the solution. However, this study will make the solutions easier, practically oriented, and student-centered using four algebraic games.

Rationale for the Four Algebraic Games and how they are used to boost students' Interest in Mathematics

The rationale for using the four algebraic games is that each game is used to solve the problems in each of the four sub-topics that make up algebraic expressions in Junior Secondary School II. The four algebraic sub-topics encompass: (i) expansion of algebraic expressions of the form a(b+c)- **algebra evaluation dart game** was used. This game is played by two to four players and a judge. Materials for playing the game are a **Dart Board**, a **Pointer,** and a **Record Board**. The players throw the **pointer** and expand the affected algebraic expressions on the **Dart board**. The winner is the player who got the highest score on the **Record Board**.

Figure 1: Diagram of Algebra Evaluation Dart Game (Yellow, White, Black)

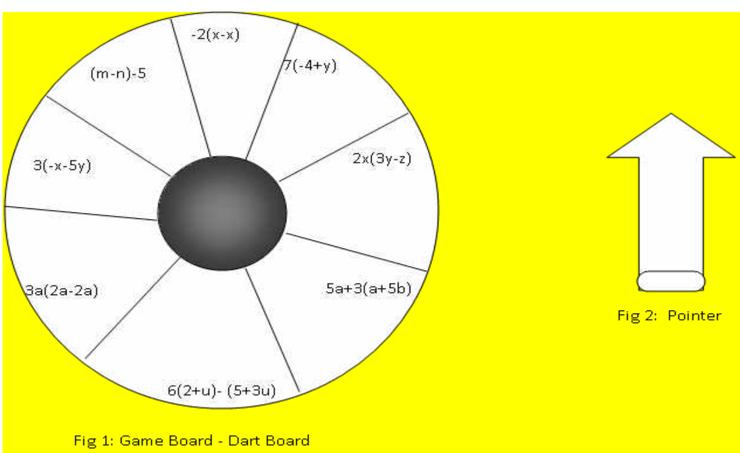

Fig 1: Game Board - Dart Board

Fig 3: Record Board (White)		
Players	**Score at each throw**	**Cumulative scores**
Ist		
2nd		

(ii) Expansion of algebraic expressions of the form (a+b) (c+d)- **algebra tic-tacmatics game** was used. This game normally involves two players at a time but if the materials for playing the game increase, the number of players will also increase. The materials for playing the game include: a **Factor Board**, a **Game Board**, **and forty Tokens of two different colors**- one Token each of the two colors is used as a **Factor Marker** while the remaining 38 are used as **Game Tokens**. The game begins as player "A" places his **factor marker** and B's **factor marker** on any factor on the **factor board**. The product of these factors determines the placement of A's **game token**. For example, if player "A" places his **factor marker** on x-2 and player B's **factor marker** on x-3, then player "A" will place a **game token** on x^2-5x+6 because (x-2) (x-3) = x^2-5x+6. Player "B" takes his turn by moving his own **factor marker** to another factor on the **factor Board** (say, x+1) while A's **factor marker** remains in place. "B" expands (x-2) (x+1) and gets the result as x^2-x-2, then places his **game token** on x^2-x-2. The game continues with each player moving only his/he **factor marker** and placing a **game token** on the corresponding product on the **game board** until a winner is decided - when a player succeeds in placing four **game tokens in a row, either vertically or horizontally**

Figure 4: Diagram of Algebra Tic-tacmatics Game (Olive Green)				
X^2-8x+6	X^2-6x+9	X^2-3x+2	X^2+x-2	X^2+3x+2

Fig 5

$X^2-7x+12$	X^2-5x+6	X^2-2x	X^2+2x-3	X^2+4x+3
X^2-6x+8	X^2-4x+3	X^2-x-2	X^2+3x-4	X^2+5x+4
X^2-5x+4	X^2-3x	X^2-4	X^2	X^2+4x+4
X^2-4	X^2-2x+3	X^2+x-6	X^2+x	X^2+5x+6
X^2-3x-4	X^2-x-6	X^2+2x-8	X^2+2x	X^2+6x+8
X^2-2x-8	X^2-9	X^2-2x+1	X^2+3x	X^2+6x+9
X^2-x-12	X^2+x-12	X^2-x	X^2+4x	$X^2+7x+12$
X^2-16	X^2-4x+4	X^2-1	X^2+2x+1	$X^2+8x+16$

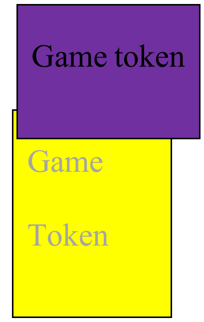

Fig 6

x-4	x-3	x-2	x-1	X	X+1	X+2	X+3	X+4

Fig 7: Factor Board (Green)

(iii) factorization of algebraic expressions- **algebra factorization card game** was used. The materials for playing this game are a **Game board**, **Cardboard papers of three different colors** – **White** is for the algebraic expressions to be factorized (**Game Board**), **Red** is for the **first player's Solution Card** and **Green is** for the **second player's Solution Card**. The **game board** consists of **25 algebraic expressions to be factorized**. Each of the algebraic expressions is in a box. Beneath each box containing an algebraic expression to be factorized is an **empty box** for receiving the **solution** (factorized algebraic expression). To start the game, each of the players works out the answers mentally or on paper, writes the solutions on the **solution cards** for the purpose and puts them in the boxes beneath the corresponding questions. The player that **fills five boxes first with correct answers, vertically or horizontally, wins the game**.

Figure 8: Diagram of Algebra factorization Card Game				
15a+25b	$6x^2$-4x	ms-ns	$21x^2$+15xy	18rs+30pqr
$8y^2$+12y	2ab+3bc	2xy-2yz	ab^2c-2abd	15xyz-9x2y
$3yx^2-2y^2x^2$	$12c^3d^2+3c^2d^3$	$6x^2y^3+4x^3y^2$	X^2+2x-24	X^2+x+2x+2
15xyz-$9x^2y$	3abc-21bdc	2ax+bx	Xyz-$5y^2z$	56pq-42ps
$4x2y^3$+4xy	6ky+4xy	$7a^2b$-49bc	$6a^2b-8ab^2$	X^2-8x+15

Fig 9: Game Board (Tan)

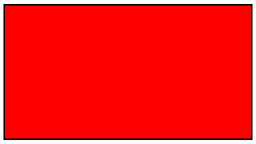

Fig 10: Solution Card (Red)

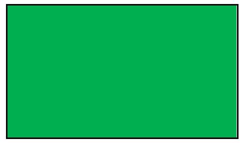

Fig 11: Solution Card (Green)

(iv) In this teaching method for **simplifying algebraic expressions**, an **algebra simplification card game** is utilized. The game involves **two or more students** with a **teacher as a moderator**. The materials include a **Game Board** with **twenty non-simplified fractional algebraic expressions**, **20 Play Cards numbered** 1 – 20, and a **Record Board**. The players shuffle and share equally **colored (Rose) play cards**. Each player sequentially selects a card, solves the corresponding problem on the game board, and scores **2 marks** for a correct answer. If incorrect, the opponent has a chance to solve and score. Correct answers also earn a bonus of **1 mark**. Each player has a **maximum time of one minute**, and a round ends when the last player finishes his card. The winner is determined by the cumulative score, and the aim is to enhance students' interest in algebraic sub-topics in the junior secondary school curriculum.

DIAGRAM OF ALGEBRA SIMPLIFICATION CARD GAME

Fig 12: Game Board (Light Blue)			
$\frac{x}{5}+\frac{5x}{8}$	$\frac{2u}{3}-\frac{u}{6}$	$\frac{5n}{6}-\frac{3x}{8}$	$\frac{2x}{9}+\frac{3x}{4}$
$\frac{9a3b}{6b}$	$\frac{x+2}{2}-\frac{x-1}{3}$	$\frac{1}{x}+\frac{1}{4}$	$\frac{x-11}{2}+\frac{x-3}{5}$
$\frac{3x}{5}+\frac{4x}{15}$	$\frac{9x}{3a}$	$\frac{15a+10b}{5}$	$\frac{1}{2}y$
$\frac{8z}{12z}$	$\frac{18xyz}{8xy}$	$\frac{4}{9a}\ X\ \frac{3b}{16}$	$\frac{3abc}{7dc}\ X\ \frac{28cd}{9ac}$
$\frac{3}{xy}\div\frac{6}{yz}$	$\frac{9}{5}+\frac{a}{6}$	$\frac{2b}{5}-\frac{3b}{25}$	$\frac{1}{2}+\frac{3}{y}$

1

Fig 13: Game Card (Rose)

Players	Score at each throw	Cumulative sum at each throw

1st player		
2nd player		

Fig 14: Record Board (lavender)

Gaming and Gamification

Game-based learning refers to the use of actual games to acquire skills or knowledge while gamification is about the use of game design elements in a non-game context (Welbers et al., 2023). Using games as motivation to solve mathematics problems can be considered gamification. Gamification is the integration of game elements, such as points, badges, or leaderboards, into non-game scenarios, such as learning activities, to increase engagement and motivation (Ingwersen, 2017). Game-based learning, on the other hand, is the use of educational games to teach specific concepts and skills (Ingwersen, 2017). A mathematics course that gives points or badges for finishing assignments or quizzes is an example of gamification (motivator) whereas a math game that requires players to solve equations or puzzles to advance in the game is an example of game-based learning (problem-solving). Nonetheless, Serious games and gamification are both trying to solve a problem, motivate, and promote learning using game-based thinking and techniques (Kapp, 2012).

Principles for using games.

Principles are general statements outlining what are important aims or considerations within a particular review process, given the unique objectives or challenges to be overcome with this type of review (Gentles et al, 2016). Russo et al. (2018) outlined five principles of educationally rich mathematical games as follows: (i) **Engagement of students**- Mathematical games have the ability to engage students, induce enjoyment among them, and generate mathematical discussion (ii) **Skill and luck**- Mathematical games should provide a level ground for skill and luck (iii) **Mathematics is central**- More emphasis and practice should be focused on mathematical concepts to be complemented with game strategy and gameplay (iv) **Flexibility for learning and teaching**- Mathematical games should have distinguishing features to accommodate different levels of learners and adjustable to take care of diverse concepts (iv) **Home–school connections**- Mathematical games should provide opportunities for fostering home-school connections

Statement of the Problem

The Director and Chief Executive Officer of National Mathematical centre, Abuja, Professor Stephen Onah in his opening speech at the event to commemorate the International Day of Mathematics in Abuja on the team "mass failure of candidates in mathematics worrisome" (Onah, 2018), showed great concern on the students' poor achievement in mathematics. In fact, there are increased worries over students' poor interest and achievement in mathematics and particularly algebra. This deplorable state of interest and achievement may be owing to abstract concepts, parental factors, students' poor self-esteem, teaching methods (especially expository). Despite innovations like laboratory approach, concept mapping technique, cooperative learning approach among others, poor interest and achievement persist.

Purpose of the Study: The general purpose of this study was to find the impact of four algebraic games on students' interest in algebraic expressions in Enugu Education Zone of Enugu State. Specifically, the study sought to: (i) Find the mean interest scores of students taught algebra using three algebraic games and those taught using expository method (ii) Determine the mean interest scores of male and female students taught algebra using three algebraic games.

Research Questions: (i) What are the mean interest scores of the students taught algebra with three algebraic games and their counterparts taught algebra with expository method? (ii) What are the mean interest scores of male and female students taught algebra in experimental groups?

Hypotheses: The study was guided with the following research hypotheses which were tested at 0.05 level of significance: (i) There is no significant difference between the mean interest scores of students in the experimental group and their counterparts in the control group as measured by Algebra Interest Scale (AIS) (ii) There is no significant difference between the mean interest scores of male and female students in the experimental group as measured by Algebra Interest Scale (A) (iii) The interaction effect of method and gender on students' mean interest scores is not significant as measured by Algebra Interest Scale (AIS).

Theoretical framework

This study is rooted in four prominent theoretical frameworks that underpin its approach to teaching algebraic expressions in Junior Secondary School II (equivalent to 7th-grade in the US). These frameworks provide valuable insights into how we can create a more engaging and effective learning environment for our students. The **constructivist theory** propounded by Piaget (1952) posits that students learn best when actively engaged in the learning process. It emphasizes hands-on experiences and interactions with the environment. In the context of teaching algebraic expressions, this means allowing students to explore and discover mathematical concepts on their own.

The next is the **Cognitive Load Theory** which suggests that the brain processes information more effectively when the cognitive load is appropriately managed (Sweller, 1988). Extraneous load should be minimized to allow for the acquisition of new knowledge. Board games and card games provide a low-stakes, enjoyable environment that reduces anxiety and minimizes extraneous cognitive load. By integrating games into algebraic expressions, students can focus on understanding concepts without feeling overwhelmed.

Another backbone of this study is the **Game-Based Learning Theory** (Gee, 2003) which submits that games inherently promote engagement, motivation, and active learning. Games provide a context for problem-solving, decision-making, and skill development. Board games and card games create an immersive and motivating environment for learning algebraic expressions. Students are more likely to invest effort in understanding mathematical concepts when they are presented in a game format, enhancing the overall learning experience.

Bruner's **theory of discovery learning, and cognitive development** supports child–centered and activity-oriented teaching methods where the learners are guided to discover more things by themselves through problem solving approach thereby making mathematics education enjoyable (Bruner et al., 1966; Ernest 1986). The use of instructional materials (especially games) will without doubt encourage teachers to use little effort and few words to plunge the learners (students) into an act of self-discovery which invariably leads to effective learning.

Design and participants

The design used for this study is non-equivalent control group quasi-experiment. The population of the study is 5,476 Junior Secondary School two (JSS II) students in the 31 government schools in Enugu Education Zone of Enugu State. A sample of 380 JSS II students drawn from two boys' secondary schools and two girls' secondary schools in Enugu education zone was employed for the study. Two JSS II classes were randomly assigned to experimental and control groups in each of the schools. The students were taught by their normal class mathematics teachers who served as research assistants.

Data collection

The instrument for data collection was Algebra Interest Scale (AIS). The AIS items were used to assess the students' interest in algebra both in pretest and posttest. Four points likert scale were employed in the scoring of the AIS. For positively interest statement, the range of the scoring code were strongly agreed (SA = 4), Agreed (A =3), Disagreed (D = 2) and Strongly Disagreed (SD = 1). However, the negative interest statements were strongly agreed (SA = 1), Agreed (A = 2), Disagreed (D = 3) and strongly disagreed (SD = 4). Since there are 20 items and 4 points scale for AIS, the minimum score is 20 (i.e. 1×20) while the maximum score is 80 (i.e. 20×4). The instrument was constructed by the researcher, face validated by three experts, two from Mathematics Education, one from Measurement and Evaluation and content validated to enhance its reliability and validity. A trial test was carried out to verify the reliability of the instrument. Cronbach Alpha was used to establish the reliability of AIS and the reliability coefficient was 0.77. AIS was administered to all the subjects of the study as pretest. Thereafter, the treatment was administered for two weeks. The experimental groups in each of the schools were taught algebra using four algebraic games while expository method was used for the control groups. After concluding the treatment, AIS was re-arranged and administered to all the subjects as posttest. After two weeks of administering the posttest, AIS was re-arranged and administered again to all subjects. The study lasted for six weeks.

Data analysis

Mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 alpha level. The reason for using ANCOVA is that it is the most appropriate statistical tool for analyzing data based on pre -test, post- test design where ANCOVA takes care of initial differences in the ability levels of the tests (Uzoagulu, 2014).

Results

The results for this study were presented according to the research questions and the corresponding research hypotheses that guided the study.

Research Question 1: What are the mean interest scores of the students in the experimental group and their counterparts in control group?

Table 1: Mean Interest Scores and Standard Deviation of Students in Experimental and Control Groups in AIS

		Pre-AIS		Post-AIS		
Groups	n	Mean	SD	Mean	SD	Mean Gain
Experimental	192	48.85	9.85	57.29	8.77	8.44
Control	188	43.30	13.74	47.91	10.19	4.61

From the result in Table 1, the mean interest scores of the pretest in experimental group are slightly higher than that of the control group while the mean interest scores of the experimental group are higher than that of the control group in the posttest.

Research Question 2: What are the mean interest scores of male and female students taught algebra in experimental group?

Table 2: Mean Interest Scores and Standard Deviation of Male and Female Students in Experimental Group

		Pre-AIS		Post-AIS		
Groups	N	Mean	SD	Mean	SD	Mean Gain
Males	97	47.68	9.55	55.95	8.43	8.27
Females	95	50.05	10.05	58.66	8.94	8.61

From the result in Table 2, the mean interest scores of male and female students in experimental group are almost equal in both the pretest and posttest.

Test of Hypotheses 1, 2 & 3

$Ho_{1:}$ there is no significant difference in the mean interest scores of the students in experimental group and their counterparts in control group.

Ho_2: there is no significant difference in the mean interest scores of male and female students taught algebra in experimental group.

$H_{O3:}$ the interaction effects of the four algebraic games and gender on students' mean interest scores are not significant.

Table 3: Test of Between-Subject Effects for Interest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Dec.
Corrected Model	8773.454[a]	4	2193.363	24.424	.000	
Intercept	61476.666	1	61476.666	684.561	.000	
Covariate (Pre-interest)	57.359	1	57.359	.639	.425	
Group	7647.873	1	7647.873	85.161	.000	S
Gender	239.676	1	239.676	2.669	.103	NS
Group * Gender	103.367	1	103.367	1.151	.284	NS
Error	33676.693	375	89.805			
Total	1095924.000	380				
Corrected Total	42450.147	379				

The data in Table 3 tested hypotheses 1, 2 and 3.

In hypothesis 1, the F-calculated of 85.161 has an associated probability of 0.000 which is less than 0.05. The null hypothesis of no significant difference is rejected. This means that there is a significant difference in the mean interest scores of students taught algebra in the experimental group and those taught in control group. The direction of the significant difference is in favor of experimental group with higher mean post-test interest score as shown in table 2.

In hypotheses 2 and 3, the F-calculated of 2.669 and 1.151 have associated probabilities of 0.103 and 0.284 which are greater than 0.05. Therefore, the null hypotheses of no significant difference in the mean interest scores of male and female students taught algebra in experimental group and that of no interaction effect between treatment and gender on students' interest relative to method used are not rejected. Hence, hypotheses 2 and 3 are not rejected.

Discussion of Findings

The finding for research question one in Table 1 shows that the mean interest scores of students taught algebra with four algebraic games are greater than that of the students taught algebra with expository method. This was confirmed by the finding of hypothesis 1 in Table 3 which shows that there is a significant difference between the mean interest scores of students taught algebra with four algebraic games and those taught algebra with expository method. The direction of the significant difference is in favor of the experimental group. This led to the rejection of the null hypothesis. This agrees that when students are taught with mathematical games, their interest is increased. This is in line with Takor et al. (2015) who agreed that students taught using Mathematical Manipulatives develop more interest in algebra than those taught with expository method. The current findings may have been got because the four algebraic games really aroused the interest of the students. This is in tandem with the finding of Oluremi (2012), Michelle (2012) and Ngoma (2013), who found that Mathematical games are very useful tools in arousing students' interest in Mathematics for a better achievement.

The finding for research question two in Table 2 reveals that the mean interest scores of male and female students who studied algebra with the four algebraic games are close to each other. The findings for hypotheses 2 and 3 in Table 3 show that there is no significant difference in the mean interest scores of male and female students taught algebra in experimental group and that there is no significant interaction effects of method and gender on students' mean interest scores. This implies that there is no significant difference in the mean interest scores of male and female students taught algebra with the four algebraic games and the interaction effects of the Four Algebraic Games and gender on students' mean interest scores are not significant. The null hypotheses were accepted. This gives an insight that when an exciting approach is used in the teaching process, students will gain more interest and maintain gender parity in their level of interest. These findings agree with those of Nneji (2017) who discovered that male and female students taught Mathematics with Power-Tic-Toe Game did not differ significantly in their interest scores in experimental group. He also found that there was no significant interaction effect between teaching strategy (PTTOG strategy) and students' gender on students' interest in Mathematics. He noted that strategy influences male and female students' interest equally. However, the study opposes that of Onuoha (2016) and Anibueze (2017) who found that there was a significant difference in the mean interest scores of male and female students in the experimental group (the use of game-based instructional technique in teaching Mathematics).

Significance and Implications

The findings reveal that students exposed to algebraic games displayed greater interest compared to those taught through the traditional Expository Method, supporting the positive impact of game-based instructional techniques. Notably, the study emphasizes gender parity in the effectiveness of algebraic games, submitting that these educational tools engage both male and female students equally. The research contributes to addressing common challenges in algebra education, such as students finding the subject difficult and teachers encountering obstacles in teaching specific topics like factorization. Importantly, the use of board and card games can serve as foundation for the designing of mathematical digital games and open the eyes of preservice mathematics teachers to the roles games play in mathematics. Additionally, the study aligns with broader educational strategies, emphasizing the importance of diverse teaching methods and their potential to enhance students' motivation, curiosity, logical reasoning, and problem-solving abilities in mathematics.

Conclusions: Based on the findings of this study, it was concluded that four algebraic games increased the students' interest and bridged gender gap.

Limitations of the Study: The pre-test sensitization, which exposed the test instrument to the students prior to any treatment might have introduced some weakness in the result. This is because some sharp students might have mastered some questions as they have seen and gone through them during the pretest exercise.

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