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RELATIVE EFFECTIVENESS OF POLYA'S PROBLEM SOLVING AND ALGEBRAIC GAMES METHODS ON SECONDARY SCHOOL STUDENTS' INTEREST IN ALGEBRA IN ONITSHA EDUCATION ZONE

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ABSTRACT

The study investigated the relative effectiveness of Polya's problem solving and algebraic games methods on secondary school students' interest in algebra in Anambra state. Two research questions and three hypotheses guided the study. Quasi-experimental design was adopted. The population of the study comprised 5,562 senior secondary two (SS2) students offering mathematics in Onitsha Education Zone, from which 102 students were drawn using purposive and random sampling techniques. The instrument for data collection was Mathematics Interest Inventory on Algebra (MIIA) validated by three experts. The reliability of MIIA was established using Cronbach Alpha method which yielded a coefficient of internal consistency of 0.82. Research questions were answered using mean and standard deviation whereas analysis of covariance was used to test the null hypotheses. The findings from the results of the study showed that; students taught algebra using AGM had higher mean gain interest scores than those taught using PPSM and the observed difference in their mean gain score was not significant. It was therefore recommended among others that effort should be made by educational stakeholders to acquaint mathematics teachers on how to use PPSM and AGM in teaching mathematics.

Keywords: Algebra, Polya, games, Problem-solving, interest

Introduction

Mathematics is extremely important in today's society. According to Duru and Okeke (2020), mathematics provides the necessary foundation for economic knowledge. It is essential in the physical sciences, technology, business, financial services and many areas in ICT (Jesy, 2022). The subject is also of growing importance in biology, medicine and many social sciences. Certain content areas of mathematics such as algebra have also become more specifically need for technological advancements in today's contemporary society.

Algebra formulae are the cornerstone of many mathematical concepts. These formulae are used extensively in topics such as linear equations, quadratic equations, polynomials, coordinate geometry, calculus, trigonometry, and probability to understand and solve complex problems (Nnachi, Ugama and Udeh, 2019). The algebra formulae are useful for completing complex calculations in the shortest amount of time and with the fewest steps possible. The algebraic formulae have also been modified based on the complexity of the Mathematics topics. These formulae exist for topics such as logarithms, indices, exponents, progressions, permutations, and combinations. To show the importance of algebra in learning Mathematics, curriculum planners have features it in the Mathematics curriculum from basic or elementary Mathematics through senior secondary to university level (Okpube and Anugwo, 2016). However, students do not seem to have satisfactory level of interest in the subject content of algebra and the whole of

mathematics as well. Again, achievement in Mathematics have been shown to improve when students' interest in learning the subject is aroused, sustained and improved (Chiakwelu and Okigbo, 2020).

In this way, the student may become interested in any educational content or work. Interest as Okoli and Nwanze (2021) noted is a potent motivator that fuels learning, directs academic and professional paths, and is critical to academic success. Interest according to Obimalume (2021) is a psychological condition of attention and affect towards a specific item or topic, as well as a long-term proclivity to return to it. Students' interest in a topic is heightened when a topic is connected to what students enjoy doing or what they are more likely to spend time thinking, dialoguing, and reading about.

Interest could help to remove the blindfold so that students can perceive those invisible or abstract Mathematics concepts common in algebra as visible and realistic when teachers organize content, process, and product. Thus, the teaching methods adopted by the Mathematics teacher should not just aim at improving achievement but arousing and sustaining interest. Some of the student-centred methods in literature that bears the potency to improve interest in Mathematics according to Nwigwe and Osuafor (2019) include: discussion, problem-solving method, cooperative learning and use of computer assisted instruction. Studies have been conducted using these methods including problem-solving method. There are however, certain forms of problem solving approach to instruction that have not been widely used to teach mathematics in a way to arouse and sustain interest example Polya's Problem Solving strategy.

Polya's problem solving method is a problem-solving approach that focus on "finding unknowns" in mathematics and has wide applicability to problems whether they are purely mathematical or more general. It is was named after the finder George Polya and often tagged 'How to solve it'. It suggests the following steps when solving a mathematical problem: First, you have to understand the problem; after understanding, Make a plan; Carry out the plan; Look back on your work. The method owing to its numerous activities become very engaging for students just as when such methods as game-based approach is employed.

Game-based approach is a kind of instructional activity, which integrates games into teaching for instructional goals. Thus, algebraic games method is an instructional approach that involves integrating games into instructional activities in order to help both the teacher and students to meet instructional objectives (Nnachi, Ugama and Udeh, 2019). In Mathematics, an algebraic process according to Ali (2015), 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. Teaching the concept of algebra while integrating games in the instructional process is the principle tenet in algebraic games method (Jesy, 2022). Algebraic games method therefore, is an instructional method where algebraic Mathematics concepts and contents are taught by integrating games as instructional activities during the learning process.

The use of Polya's problem solving and algebraic games method hold potentials for enhancing students' interest in learning mathematics. However, the teaching methods adopted by Mathematics teacher may not arouse students' interest. There need the therefore arises, that some student-centred teaching methods that can facilitate proper understanding of algebra such as polya's problem solving approach and algebraic games method be investigated. Again there is the need, to establish which of the two approaches which have been proven effective could enhance students' interest enough to

facilitate active engagement in the learning process.

Active engagement in learning Mathematics concepts like algebra implies that students should not just memorise Mathematics facts, steps, long divisions as it could make them more prone to mistakes or feel frustrated. This is because for many students, both male and female, the issue with learning algebraic expressions is that the work is purely a question of memorising and following already established steps. The question about the most effective teaching method among Polya's problem solving and algebraic games method therefore becomes imperative, especially identifying which of the two methods could enhance interest of students irrespective of gender.

There exist some studies where no significant difference was observed in the interest of male and female students in Mathematics (Nwigwe and Osuafor, 2019; Asanre, Abiodun, Odupe and Ogendeji, 2021) while significant differences were found in others like the study by Ezeamenyi (2022). Ali (2015) and Ezeugwu, Onuorah, Asogwa and Ukoha (2016) also found no significant difference in male and female students' interest in algebra whereas Nnachi, Ugama and Udeh (2019) revealed that significant differences existed. There are barely any studies however, that have established conclusively the gender differences and gaps as regards secondary school students' interest in specific Mathematics concepts like algebra.

Research Questions

1. What are the mean interest scores of students taught algebra using Polya's problem solving method (PPSM) and those taught using algebraic games method (AGM))?
2. What are the mean interest scores of male and female students taught algebra using PPSM and AGM?

Hypotheses

1. There is no significant difference between the mean interest scores of students taught algebra using Polya's problem solving method (PPSM) and those taught using algebraic games method (AGM).
2. There is no significant difference between the mean interest scores of male and female students taught algebra using PPSM and AGM.

Research Method

The quasi-experimental design was employed in this study. It was carried out in Onitsha Education Zone of Anambra state, Nigeria. The study is made up of 5,561 (2,448 males, 3,113 females) SS2 students offering Mathematics in the Onitsha Education. The sample size for the study is 99 SS2 students offering Mathematics in Onitsha Education Zone of Anambra State drawn using random and purposive sampling techniques. The instrument for data collection was Mathematics Interest Inventory on Algebra (MIIA).

MIIA was adapted from Wei, Steven, Barnard-Brak, Stevens, and Arturo (2014). The MIIA was developed to address this issue by assessing interest through simple behavioural indicators. The MIIA consists of 27 items gauging three factors of Mathematics interest: Positive valence (PV), Negative valence (NV), and time. PV is assessed by 10 items and reflects the degree to which students report a positive attraction toward Mathematics (examples, "I like to answer questions in Mathematics class." "I feel good when it comes to working on Mathematics."). NV is assessed by 10 items and related to negative experiences associated with Mathematics (examples, "I am bored when working on Mathematics." "I get mad easily when working on Mathematics."). Time is assessed by seven items and reflects the amount of time and effort respondents commit to Mathematics (e.g., "I work more Mathematics problems than what I have to." "I

spent many hours working on Mathematics."). Students will be asked to rate how well each of the 27 items described them on a response scale 1 (not at all like me) to 4 (very much like me). The least score a student can have on the instrument is 27 whereas the highest score is 108. The instrument was completely modified as the sentences were altered to focus on algebra. Again some sentences that sounded similar to other items in the instrument were replaced. Lesson plans for the two experimental groups on the two different methods (PPSM and AGM) were developed by the researcher.

MIIA was validated by lecturers from the Department of Science Education, and Department of Educational Foundations (Measurement and evaluation), Nnamdi Azikiwe University, Awka and Department of Science (Mathematics option), Federal College of Education (Technical), Umunze. The reliability of MIIA was established using Cronbach Alpha method. This is because Cronbach Alpha is suitable for establishing the reliability of polytomously scored items (that is items with multiple ratings). MIIA was administered to the same set of 40 students used for the MATA. The scores generated was used to compute the coefficient of internal consistency of MIIA. The coefficient obtained is 0.82. The experimental groups were taught algebra using polya's problem solving and algebraic games method where students in the classroom were clustered in groups of fives. During the algebraic game approach, the teacher first introduced the lesson, solve one or two problems. The teacher shuffled a pack of cards containing algebraic expressions which are the step by step solutions to questions. The teacher gave to each group a set of cards at random. When a question is posed by the teacher, she calls on each group at random to find a card that is a correct answer to the step in the solution of the question being solved. Group members are required to first solve the question and find from their cards each step to the solution, so that when called, they can easily present the step. The teacher at the end of each lesson presented a general summary of all the important points of the lesson and give students class exercise to solve individually as a mean of evaluating the objectives of the instruction.

The research questions were answered using mean and standard deviation. The null hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 alpha level. The null hypothesis was rejected if the probability value (p-value) is less than or equal to the significant value of 0.05 ($P \leq 0.05$), while the null hypothesis was not be rejected where P-value is greater than 0.05 ($P > 0.05$).

Presentation of Results

Research Question 1: What are the mean interest rating scores of students taught algebra using PPSM and those taught using AGM?

Table 1: Mean Interest Rating Scores of Students taught Mathematics using PPSM and AGM

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
PPSM	52	44.98	9.175	60.13	7.951	15.15
AGM	47	44.36	7.696	59.55	8.433	15.19

Table 1 reveals that the students taught Mathematics using PPSM had a pretest mean interest rating score of 44.98 with posttest mean interest rating score of 60.13 and gained mean interest rating score of 15.15, while those taught using AGM had had a pretest mean interest rating score of 44.36 with posttest mean interest rating score of 59.55 and gained mean interest rating score of 15.19.

Research Question 2: What are the mean interest rating scores of male and female students taught algebra using PPSM and AGM?

Table 2: Mean Interest Rating Scores of Male and Female Students taught Mathematics using PPSM and AGM

Method	Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
PPSM	Male	23	46.65	8.76	60.17	9.02	13.52
	Female	29	43.66	9.43	60.10	7.15	16.44
AGM	Male	22	41.77	6.88	56.95	10.48	15.18
	Female	25	46.64	7.78	61.84	5.35	15.20

Table 2 shows that the male students taught Mathematics using PPSM had pretest mean interest rating score of 46.65 and posttest mean interest rating score of 60.17 with a gain mean interest rating scores of 13.53 while the female students had pretest mean interest rating score of 43.66 and posttest mean interest rating score of 60.10 with a gain mean interest rating scores of 16.44. Table 2 also shows that the male students taught Mathematics using AGM had pretest mean interest rating score of 41.77 and posttest mean interest rating score of 56.95 with a gain mean interest rating scores of 15.18 while the female students had pretest mean interest rating score of 46.64 and posttest mean interest rating score of 61.84 with a gain mean interest rating scores of 15.20.

Hypothesis 1: There is no significant difference between the mean interest rating scores of students taught algebra using PPSM and those taught using AGM.

Table 3: ANCOVA Test of Significance of Difference between the Mean Interest Scores of Students taught Mathematics using PPSM and AGM

Source	SS	df	MS	F	Sig.	Decision
Corrected Model	297.354[a]	4	74.339	1.126	.349	
Intercept	10822.142	1	10822.142	163.901	.000	
Pretest	9.643	1	9.643	.146	.703	
Methods	12.135	1	12.135	.184	.669	Not Sig.
Gender	137.255	1	137.255	2.079	.153	Not Sig.
Methods * Gender	125.484	1	125.484	1.900	.171	Not Sig.
Error	6206.666	94	66.028			
Total	361226.000	99				
Corrected Total	6504.020	98				

Table 3 shows that there is a significant difference between the students' interest in Mathematics, F (1, 94) = 0.184 P > 0.05. Therefore, the null hypothesis was not rejected meaning that there is a significant difference between the mean interest scores of students taught algebra using Polya's problem solving method (PPSM) and those taught using algebraic games method (AGM) in favour of those taught using PPSM.

Hypothesis 2: There is no significant difference between the mean interest scores of male and female students taught algebra using PPSM and AGM.

Table 3 shows that there is no significant main influence of gender on students' interest in

Mathematics, F (1, 94) = 2.079, P > 0.05. Therefore, the null hypothesis was not rejected meaning that there is no significant difference between the mean interest scores of male and female students taught algebra using PPSM and AGM.

Hypothesis 3: There is no interaction effect of instructional methods (PPSM, AGM) and gender on students' interest in algebra.

Table 3 also shows that there is no significant interaction effect of instructional methods and gender on students' interest in algebra, F (1, 94) = 1.900, P > 0.05. Therefore, the null hypothesis was not rejected meaning that there is no significant interaction effect of instructional methods (PPSM, AGM) and gender on students' interest in algebra.

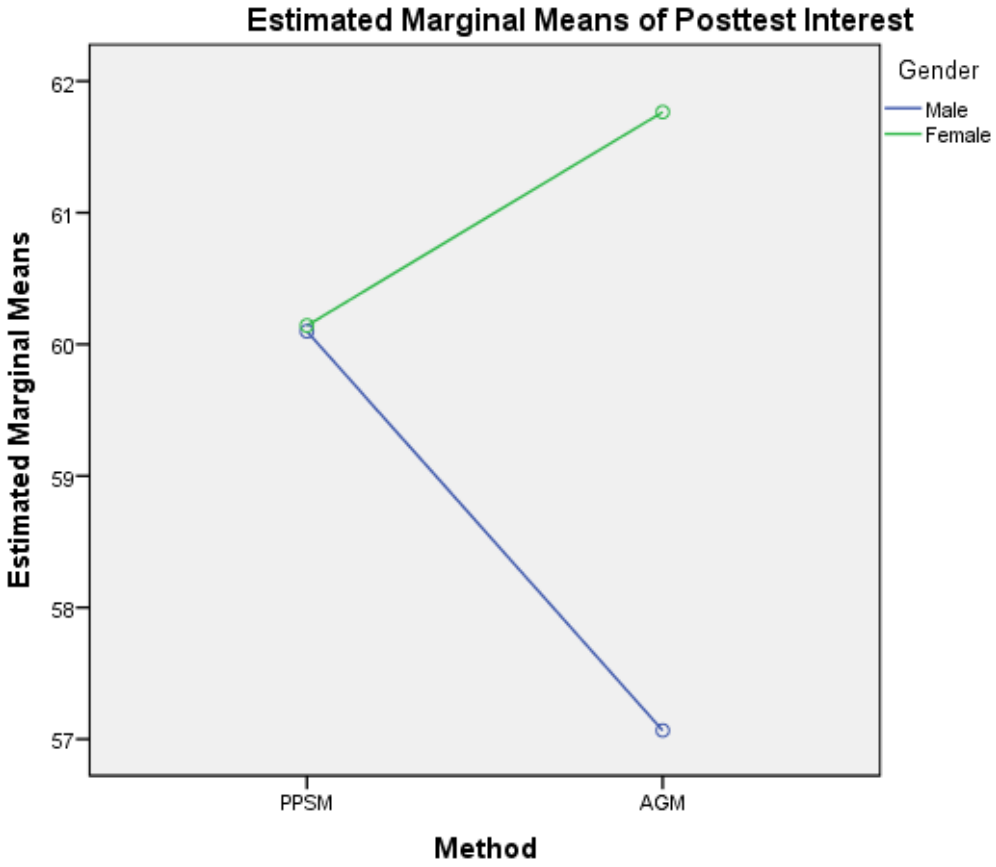


Figure 3: Plot of interaction effect of instructional methods (PPSM and AGM) and gender on students' interest in Mathematics

The plot of interaction effect of instructional methods and gender on students' interest in Mathematics is significant and ordinal. This shows that the instructional methods had the same effect with respect to gender and are therefore gender biased towards the male. Male students taught Mathematics using PPSM had lo mean interest score than female students whereas male students taught using AGM had a lesser mean interest score than the female students.

Discussion of Findings

The findings of the study showed that there was no significant difference between the mean interest rating scores of students taught algebra using PPSM and AGM. The observed

results of the study can be attributed to the importance of competence in skills and perceived competency in fostering student engagement and interest in the learning process. When students possess a belief in their ability to effectively engage in an activity, they exhibit heightened levels of interest and confidence, hence demonstrating a greater inclination to invest effort into the work at hand. The use of PPSM facilitated their acquisition of a systematic approach to effectively solve algebraic problems. On the contrary, AGM diminishes the notion of competitiveness and fosters a more relaxed learning environment that is highly engaging. On the contrary, in situations where students lack confidence in their abilities to effectively partake in an activity, they exhibit reduced inclination to subject themselves to potential unfavourable social comparisons with their classmates. Consequently, they demonstrate decreased likelihood of active involvement in the activity. Social comparisons frequently arise in situations when students engage in individual performances while being observed by their peers or in competitive games.

The provision of choice in instructional experiences is crucial for both arousing and sustaining student interest, while also catering for students' desire for autonomy. Granting students the opportunity to exercise autonomy in decision-making fosters a sense of personal investment in the assigned work. One such approach is to provide students with the autonomy to select their preferred method of problem identification, as exemplified in the PPSM. Another approach involves letting students to choose a card containing a solution, as demonstrated in the AGM. Both the PPSM and the AGM are carefully designed elective teaching approaches that provide students with a range of activity options. In each instance, the meticulous planning provided significant teaching options to students that engendered and maintained their engagement.

The interest of students in a specific activity is determined by various factors, including their personal interests, situational interest, choice, and level of challenge. The construct of individual interest is generally considered to be reasonably stable and is contingent upon the unique personal features and experiences of each student. Situational interest exhibits greater variability and is subject to the influence of the learning environment. The study conducted using PPSM and AGM has shown that students' situational interest was enhanced by the manipulation of cognitive demand or challenge levels, as well as the provision of alternatives to students. The learning experiences in the PPSM and AGM, which necessitated exploration, problem-solving, and higher-order thinking skills (such as the application of skills to novel situations and the synthesis of knowledge from diverse domains), augmented the probability of student interest and engagement in the presented activities.

The findings of the study are in line with the findings of the Ojukwu (2012) that significant effect of Polya's technique on the interest of the students was observed. The findings of the study also supports the finding of Ali (2015), Nnachi, Ugama and Udeh (2019), Ezeugwu, Onuorah, Asogwa and Ukoha (2016) and Asanre, Abiodun, Odupe and Ogendeji (2021) that the use of slide game approach significantly enhanced the interest students more than those in the conventional group.

Conclusion

The findings of this study showed that students taught Mathematics using AGM and PPSM had similar interest in learning mathematics. It is concluded therefore, that both AGM and PPSM significantly enhances students' interest in mathematics.

Recommendations

1. Effort should be made by educational stakeholders to acquaint mathematics teachers on how to use PPSM and AGM in teaching mathematics.
2. Teachers of mathematics should employ the use of AGM for female students who show phobia for mathematics while PPSM should be used for male students of the same category who have phobia for mathematics.

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