Effect of Mathematical Manipulatives on Upper Basic One Students' Interest in Algebra in Kwande Local Government Area, Benue State

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Abstract - *This paper sees interest as a mother of attention and prerequisite for meaningful learning that if generated and sustain in students' study of algebra will positively affect their study of mathematics in general. Thus, the paper examined the effect of mathematical manipulatives on Upper Basic Education One students' interest in algebra. Two research questions were asked and two research hypotheses formulated and tested. Algebra Interest Inventory (AII), a 30-item instrument was developed by the researchers. The instrument was validated by five experts, two in mathematics education, one in measurement and evaluation and two mathematics teachers. The reliability of AII was computed using Cronbach Alpha (α)and it reliability coefficient (r) was 0.95. Research questions were answered using mean and standard deviations while hypotheses were tested using analysis of covariance (ANCOVA) at 0.05 level of significance. The results of this study showed that, students taught using mathematical manipulatives developed more interest ($\overline{X} = 3.33$) in algebra than those taught using conventional method ($\overline{X}$ = 2.12). There was no gender difference observed between male and female students in the experimental group. From the results it was concluded that though the use of manipulatives in learning algebra improved students' interest, the teacher need a repertoire of knowledge on* effective *presentation of mathematical manipulatives before the active learning opportunities and self facts discovery expected from students can effectively stimulate students' learning needs. Recommendations were made among others on the need for seminars and workshops to create awareness among mathematics teachers, mathematics educators and curriculum planners to integrate manipulatives as an instructional approach in mathematics teaching and learning process.*

Keywords: *Algebra, Mathematical Manipulatives, Upper Basic Education One, Students' interest, Gender difference*

INTRODUCTION

One of the primary goals of mathematics education is to enhance students' ability to reason deductively. This explains while the problem of knowledge to capture students' interest in mathematics is of growing concern to practitioners and researchers in ongoing efforts to improve students' interest in mathematics especially algebra. Literature has shown that algebra is an important branch of mathematics used indeed for everyday life [1]. It is the language through which most of the mathematics is communicated. This means that understanding algebra implies understanding the semantic and the syntax of mathematics problem solving. This is while Education Alliance [2] posits that, regardless of mathematics skills before high school, taking algebra in the middle school is strongly related to achievement gains in high school mathematics.

Despite the importance of algebra, many students see algebra as the area where mathematics abruptly becomes a non understandable, confusing world Artique & Assude [3]. One of the reasons according to Glass [5] and MacGregor [6] is that, what students learn in algebra classroom is a collection of rules to be memorized and steps to be followed having no logical coherence, very little connection with previously learned arithmetic, and no applications in other school subjects or in the outside world. Explicitly, Obodo [16], Abakporo [14], Imoko & Agwagah [13] and [4] mentioned inappropriate teaching method, teachers' attitude, and employment of unqualified mathematics teachers among others as some of the reasons while students lack interest in learning algebra. Literature has shown that while effective teaching methodologies and resources are of paramount importance, the key to impacting student's academic performance lies in increasing the student's interest in a particular mathematics topic [12]. That means interest is the prerequisite for learning that brings understanding in mathematics.

Interest according to Obodo [16] is the feeling of intentness, concern or curiosity about an object. Harbor-Peters [11] see interest as a subjective feeling of intentness or curiosity over something. Therefore the feeling manifested in an activity is the interest shown in that particular activity or event. Interest is a very strong factor in the teaching and learning of mathematics. The degree and direction of attitude towards mathematics are largely determined by the kind of interest developed by the students [16]. It is therefore based on interest that the expectations related to algebraic proficiency, the coherent connection of the concept of algebra across the secondary school years, and for instruction that makes these connections may better be actualized. This is because with interest, the students can have: (i).The ability to work flexibly and meaningfully with formulas or algebraic relations—to use them to represent situations, to manipulate them, and to solve the equations they represent. (ii). A structural understanding of the basic operations of arithmetic and of the notational representations of numbers and mathematical operations (for example, place value, fraction notation, exponentiation) (iii). A robust understanding of the notion of function, including representing functions (for example, tabular, analytic, and graphical forms); having a good repertoire of the basic functions (linear and quadratic polynomials, and exponential, rational, and trigonometric functions); and using functions to study the change of one quantity in relation to another; (iv).The desire to know how to identify and name significant variables, model quantitative contexts, recognize patterns, and use symbols, formulas, and functions to represent those contexts.

The aforementioned proficiency could better be achieved if the students' interest is won in learning mathematics. This is because interest is a mother of attention, once there is direct interest, attention is guaranteed and learning is assured. With this challenge in mind, the researchers efforts is geared towards finding ways of teaching algebra that allow students to learn and generate genuine interest in algebra. As such, this study used attractive mathematical manipulative (Algebra Tiles, Counters & Base Ten Block) in teaching and learning mathematics at the concrete and formal operational stages.

Manipulatives, according to National Science Foundation [15], are materials designed to provide concrete experiences that can help students make the link between mathematical concept and the real world. For the purpose of this study, the researchers define mathematical manipulatives as any material designed for teaching and learning that can actively engage students in mathematics learning process to foster conscious and unconscious thinking. This differs from instructional materials in the sense that, instructional materials are designed for teaching that actively engage the teacher in demonstrating a mathematical concept before his or her students.

A quasi-experimental study conducted by Galadima and Okogbenin [9] sought to examine the extent to which the use of mathematical games can lead to students' improved interest. Results of the t-test posttest analysis revealed improved interest by the students in the experimental group in learning mathematics. However, there was no significant gender difference among the experimental group male and female students' interest ratings. The researchers taught solution to quadratic equations using completing the square method in SS2. This is a class approaching their final examination level. The current study taught a foundation class, specifically the fundamentals of algebra in Upper Basic One (JSS1) Education level students.

In a quasi-experimental study conducted by Usman and Nwabueze [19] to find out whether the use

of Area Tiles (manipulatives) approach might bring some improvement in students' interest in mathematics. The study revealed that there was no significant difference in the interest of male and female students in learning mathematics using Area Tiles (manipulatives) approach. The researchers did their work with a higher form of algebra (quadratic equations) in SS1. However, this study is for a lower class (JSS1) which serves as a foundation level for the entire secondary education level mathematics.

Concerning gender differences in students' interest in mathematics, literature reveals conflicting findings. While some found no significant gender difference when manipulatives were used in teaching and learning mathematics [7-9] find significant difference in interest between male and female students taught geometry using games and simulations.

The centrality of manipulatives in children's mathematics learning is rooted in Jean Piaget's cognitive development theory. According to Piaget, cognitive development is the process by which environmental experiences and biological maturity determine how a child constructs knowledge [17]. By environmental experiences, Piaget is of the view that children's mathematics understanding begins with their active involvement with the concrete objects around their world. The major implication of Piaget's theory is adaptation of instruction to the learner's developmental level (biological maturity). In this regard, concrete manipulatives (Algebra Tiles, Counters and Base 10 Blocks) are used in the study whose subjects are at concrete operational stage (Upper Basic Education One students) with age bracket 7 to 11 years. This considered the fact that, at concrete operational stage, children can only effectively carry out mental operations with concrete objects.

Also, according to the mere exposure theory of communication, simple ***repeated*** exposure to the communication can influence attitudes, provided that the people have not developed negative feeling to the ***message*** (Zajonc, 1968) as cited in Toh [18]. Thus, the researchers suggests that repeated exposure of students to concrete manipulatives that allow them manipulate and construct simple algebraic sentences, can be used to introduce the students to the world of algebra in particular and mathematics in general. It is believed that, the process of repeated exposure of the students to concrete manipulatives will reduce their fear of using letters to represent numbers. This is supported by Bednarz [10] who posits that successful learning of algebra has to be built upon students' experience with arithmetic. This is to say that, continuity between algebra and arithmetic can be achieved through a gradual increasing change of reasoning procedures. Therefore there is the need for Upper Basic Education One students to use concrete manipulatives and present the physical counting and representation of integers and algebraic variables associated with the arithmetic operations of addition, subtraction, multiplication and division.

Statement of the Problem

Interest is considered as the mother of attention and a prerequisite for meaningful learning and understanding. This is while researchers throughout the past decade have stated that it is the role of the educator to provide students with an environment that actively engages them in learning. However, students' interest in studying algebra has not been encouraging as reported by examination bodies like WAEC. Though use of manipulatives as teaching/learning approach has been proved effective, yet teachers tend not to use them due to lack of education and confidence of their effectiveness to increase learning.

Though several methodologies have been employed, however the key to impacting student's academic performance lies in increasing the student's interest in the subject. This study therefore explored the effects of mathematical manipulatives on Upper Basic Education One students' interest in algebra in Kwande Local Government Area, Benue State, where such study has never been carried out. Also, will the use of mathematical manipulatives improve both male and female students' interest in algebra?

OBJECTIVES OF THE STUDY

The primary purpose of this study was to determine the efficacy of using mathematical manipulatives on students' interest in algebra in Upper Basic Education One in Kwande Local Government, Benue State. The specific objectives of the study were to determine whether the Upper Basic Education One students improved on their interest in algebra when taught using mathematical manipulatives; determine whether the Upper Basic Education One male and female students' interest in algebra improved when taught using mathematical manipulatives.

Ho_1: There is no significant difference between the mean interest ratings of students taught algebra using mathematical manipulatives and those taught using conventional method.

Ho_2: There is no significant difference between mean interest ratings of male and female students taught algebra using mathematical manipulatives.

METHOD

This study adopted quasi-experimental, non-randomized pre-test pos-test control group design. Intact classes were sampled for both experimental and control groups to avoid disrupting school activities, hence the subjects involved were not randomly selected into the said study groups. Sample of 312 out of 625 JSS1 students, from four out of 65 Upper Basic Education Level schools in Kwande L.G.A of Benue State was used. A multi-stage sampling technique was adopted so as to fulfill the criteria for selection. Four schools that had at least two streams were selected by balloting. A further simple random sampling of toss of a coin was performed between the four schools selected, and schools "A" and "C" were selected as experimental group while schools "B" and "D" were selected as control group respectively. Thus the total for experimental group was 154 students (male =89, female =65) and that of the control group was 158 students (male=96, female=62).

The instrument for this study was Algebra Interest Inventory (AII). The AII consists of twenty multiple choice test items. A total of three mathematics educators and two experts from measurement and evaluation validated the instrument. The validated AII instrument was trial tested and it coefficient of internal consistency measure was 0.95 using Cronbach alpha.

Procedure for the study

Before the commencement of the study, two teachers from the experimental schools were trained using the ten lesson plans prepared for teaching the experimental group on the use of Algebra tiles, Base 10 Blocks and Counters in teaching and learning the topics under algebraic processes. This training lasted for one week. These trained teachers served as research assistants who taught the experimental classes while the regular teachers taught the control classes in their respective schools using ten lesson plans prepared by the researchers for teaching the control group using conventional method.

The treatment lasted for a period of four weeks that was ten double lessons of 40 minutes each. At the end of the treatment periods, Post- AII was administered to the subjects. Pre- AII and Post-AII data was collected, collated and analyzed using descriptive statistic of mean and standard deviation for answering research questions, while Analysis of Covariance (ANCOVA) was used in testing the hypotheses at 0.05 level of significance.

RESULTS

Table 1. Mean interest ratings of students taught algebra using mathematical manipulatives and those taught using conventional method

	Tests	Mean	S. Dev
Experimental (n=154)	Pre-AII	1.82	0.94
	Post-AII	3.33	0.70
Control (n =158)	Pre-AII	1.81	0.94
	Post-AII	2.12	1.08
Post-AII Mean Diff.		**1.21**	

Table 1 shows that in pre-AII, the mean interest ratings of students in the experimental group was 1.82 with standard deviation of 0.94, while those of students in the control group was 1.81 with standard deviation 0.94.

In the post-AII, students in the experimental group had mean interest ratings of 3.33 with standard deviation of 0.70, whereas students in the control group had mean interest ratings of 2.12 with standard deviation of 1.08. The Post-AII mean interest ratings difference between experimental and control group is 1.21. This indicates that the experimental group improved on their interest more than the control group.

Research Hypothesis 1

There is no significant difference between the mean interest rating of students taught algebra using mathematical manipulatives and those taught algebra using conventional method.

The result of analysis of covariance for this hypothesis is presented in Table 2.

Table 2: Summary of One-Way ANCOVA Result of Experimental and Control Groups on Pre-AII and Post-AII

Source of Variance	Sum of Squares	df	Mean Square	F_{cal}	Sig.
Corrected Model	55190.68	2	27595.34	355.48	.00**S**
Intercept	12589.12	1	12589.12	162.17	.00**S**
Pre-AII	37640.68	1	37640.68	484.88	.00**S**
group	12886.94	1	12886.94	166.01	.00**S**
Error	23987.31	309	77.63		
Total	1787986.00	312			
Corrected Total	**79177.99**	**311**			

S- Significant at 0.05 level of probability

The result of Table 2 shows that P = .00 < .05 level of significance. That is, there is statistically significant difference between mean interest ratings of students taught algebra using mathematical manipulatives and those taught using conventional method as measured in algebra interest inventory. The result shows a higher increase in students' interest in algebra in the experimental group more than the control group in the study. Hence, the null hypothesis H_{01} is rejected. Thus, the result is an indication that, learning algebra with mathematical manipulatives improved students' interest in algebra more than conventional teaching method.

Table 3. Means and Standard Deviations of Experimental Group Male and Female Students' Responses on Algebra Interest Inventory

		Mean	S. Dev
Male (n=89)	Pre-AII	0.92	0.27
	Post-AII	1.67	0.93
Female (n=65)	Pre-AII	0.90	0.26
	Post-AII	1.66	0.93
Post-AII Mean Diff		0.01	0.00

Table 3 shows the mean ratings of the experimental group according to gender. The result shows that in pre-AII, the mean interest ratings of male students in experimental group was 1.81 with standard deviation of 0.72, while the mean interest ratings of the female students was 1.80 with the standard deviation of 0.72. In the post-AII, the mean interest ratings of the male students ranging was 3.53 with standard deviation of 0.50, while the female students mean interest rating was 3.52 with standard deviation of 0.50.

The male and female students Pre-AII mean interest rating difference was 0.01, whereas their Post-AII mean interest rating difference was also 0.01. This shows that both male and female students in the experimental group who were taught algebra using manipulatives improved statistically on their interest.

Research Hypothesis 2

There is no significant difference between mean interest ratings of male and female students taught algebra using mathematical manipulatives.

The ANCOVA result for this hypothesis is presented in Table 4.

The ANCOVA result as presented in Table 4 shows that the main effect (gender) in the table is P = .671 > .05 level of significance. This implies that there is no significant difference between the mean interest ratings of male and female students taught algebra using mathematical manipulatives as measured by their mean interest ratings in algebra interest inventory (AII). The result proves the closeness of the male and female rating means and standard deviations of Table 3. From the result of Table 4, it therefore implies that the null hypothesis H_{02} of no significant difference is retained.

DISCUSSION

The result in Table 1 shows that the experimental group improved on their interest more than the control group. The finding is an indication that, concrete manipulative as minds-on, hands-on and students' activity-centered approach has a positive impact on students' interest in learning algebra. The finding on the concrete manipulatives and conventional teaching approaches indicates that the use of concrete manipulatives has reduced the effect of just been a passive listener and observer on the students. Hence we conclude that teaching and learning algebra using mathematical manipulatives improved students' interest in the subject.

Table 4. Summary of ANCOVA for Experimental Group in Algebra Interest Inventory According to Gender

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13947.51	2	6973.76	147.42	.00**S**
Intercept	4490.87	1	4490.87	94.93	.00**S**
Pre-AII	13853.52	1	13853.52	292.85	.00**S**
gender	8.55	1	8.55	.18	.67**NS**
Error	7237.85	151	47.31		
Total	648186.00	154			
Corrected Total	**21185.36**	**153**			

S- Significant at 0.05 level of probability; NS- Not significant at 0.05 level of probability

The result of test of hypothesis in Table 2 affirms that, there is statistically significant difference between the mean interest rating of students taught algebra using mathematical manipulatives and those taught using conventional method. Based on the guiding research question 1 which was transcended to research hypothesis 1, the null hypothesis of no significant difference was rejected. The implication is that, teaching algebra using concrete manipulatives improved students' interest more than using conventional method. This is because the use of concrete manipulatives as creative approach provides students with opportunity to actively participate in the lesson by engaging them in conscious and unconscious thinking. This finding is consistent with the earlier reports of Usman and Nwabueze [19] who found that students' interest in learning quadratic equations with Area Tiles (manipulatives) increased significantly.

The results of the experimental group mean interest ratings of male and female students in Table 3 is an indication that given active learning opportunities such as use of mathematical manipulatives, the issue of academic gender disparity may be eventually extinguished. The test of hypothesis result in Table 4 is an affirmation that both male and female students in the experimental group who were taught algebra using concrete manipulatives improved equally statistically significant on their interest. This means that, concrete manipulatives has an equally positive impact on both male and female students' interest hence, the null hypothesis 2 of no significant difference was retained. This result supports the findings of Galadima and Okogbenin [9] who found no significant gender difference between the mean interest scores of male and female mathematics students taught solution to quadratic equations by completing the square method using game.

CONCLUSION AND RECOMMENDATION

It is evident that teaching mathematics using mathematical manipulatives approach significantly improved students' interest with no gender difference. However, the mathematics teacher must be a repertoire of use of manipulatives before he/she can impact effectively in the students. It is only by teacher's effective presentation of mathematical manipulatives that the active learning opportunities and self facts discovery expected from students can effectively stimulate students' learning needs.

It is recommended that the National workshops and seminars should be organized to show classroom teachers how to use manipulatives in different mathematics areas. Such workshops, seminars and conferences could alert mathematics teachers about the limitations and drawbacks in the use of manipulatives.

School authorities should encourage their mathematics teachers by way of organizing in house workshops on use of manipulatives in teaching different algebraic concepts in particular, and mathematics topics in general. This is because manipulatives do not teach for themselves as such teachers require a repertoire of creative knowledge to be able to teach with manipulatives in different mathematics topics.

Teacher trainers should be able to inculcate in student teachers the use of mathematical manipulatives by way of making them to write and present term paper every session on different mathematics topics.

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