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Improving the Teaching and Learning of Mathematics for the Attainment of Millennium Development Goals (MDGs) through the use of Mathematical Games in Makurdi Local Government Area, Benue State, Nigeria.

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Abstract

The paper examined the effect of algebraic game on students' achievement in algebraic linear graphs. A sample of 130 junior secondary three students from two secondary schools in Makurdi Local Government Area were used for the study. Two research questions were asked while two hypotheses were formulated and tested. Algebra Substitution Achievement Test (ASAT), a 20-item instrument was developed by the researchers. The instrument was validated by three experts in mathematics education and two from measurement and evaluation while its reliability was established using cronbach Alpha which gave a reliability index of 0.89. Mean and standard deviation were used to answer the research questions while t-test was used to test the hypotheses formulated at 0.05 level of significance. Results revealed significant difference in the mean achievement scores of students taught algebraic linear graphs using algebra game and those taught using conventional method. It equally showed no significant difference in the achievement scores of male and female students. Based on the findings, it was recommended among others that mathematics teachers be effectively trained to use different educational games when teaching mathematics concepts for problem solving, communication, reasoning and connection skills which are necessary for the attainment of MDGs.

Keywords: *Teaching and Learning, Millennium Development Goals, Mathematical games and Algebraic linear graph.*

1. Introduction

Any where human activities are carried out, there exist mathematics either as arithmetic, algebra, calculus, geometry, trigonometry or statistics that uses signs, symbols and/or proofs to describe relationship(s). Hence Encarta (2007) defined mathematics as the study of relationship among numbers, shapes and quantities. Mathematics as an educational subject is taught primarily for the development of thinking skills and reflections on oneself, environmental and societal issues and organizing one's experiences for possible solution(s) to problems (Lapan & Schram, 1998). On this basis, Otunu-Ogbisi (2009) defines mathematics teaching and learning as the act of imparting and acquiring of skills, knowledge, aptitude, abilities and attitude capable of making the individual functional and productive for effective all round achievement of a nation's developmental goals.

In an attempt to enumerate mathematics application areas, Odumosu, Oluwayemi, and Olatunde (2012) described mathematics as the carpenter's hammer, tailor's tape, artist's pencil, barber's clipper, hair dresser's comb, journalist's pen, broadcaster's microphone, doctor's stethoscope and lawyer's wig. As the list could not end, They further qualified mathematics as an essential ingredient in manufacturing industries and essential tool in economic activities, bride of sciences, chief bride's maid of social sciences, ladies in waiting for engineering, cosmetology of arts and unavoidable servant of management sciences. This is to say that the applications of mathematics to problem areas depend on the understanding of the concepts and the principles of mathematics by the problem solver (National Science Foundation, 2002). However for students to posses the conceptual understanding in different ways, they

should know how and when these different mathematical representations can be used for different purposes. Such presentation could enable the students experience, discover, discuss and reconstruct the socially negotiated nature of mathematics. It therefore means that mathematics can be applied in every facet of life even in the small-scale business enterprises which is the life wire of every economic sector.
Despite the ubiquitous applications of mathematics in both academic and all other human endeavors, research evidence shows that methodology of instruction is a problem (Odili, 1986). Galadima (2002) posit that poor quality instructional technique employed by the teachers is one of the major causes of poor achievement among secondary school students in mathematics. Simeon and Francis (2012) enumerated some of the problems as mathurlurgy (inability to deal with figures); mathematics aversion (mathematics students shying away from class); the use of irrelevant teaching methods and absence of mathematics resource materials. These and many more are problem areas in the teaching and learning of mathematics that militate against students taking career choice in further studies as well as entrepreneur-ship skill development.

Also, Agwagah (2004) stated specifically that traditional mathematics teaching is still the norm in our nation's schools and has continued to dominate the mathematics classroom. In traditional teaching, students acquire mathematical skills by imitating demonstrations by the teacher and the textbook, and they acquire mathematical concepts by absorbing teacher and textbook communications. Furthermore, in traditional mathematics instruction, every day the teacher shows students several examples of how to solve a certain type of problem and then have them practice this method in the class and in homework. This rote memorization is not only ineffective but also seriously stunts students' interest and growth in mathematical reasoning and problem solving skills (Battista, 1999). This teacher directed instruction, rote memorization, drill and verbal recitation, and worksheets completion approaches failed to develop students' generic skills and interest as students are still struggling to understand abstract mathematical ideas or concepts since the approach lacked concrete experiences (Shannon, 2004). As a result, students' achievements in mathematics at both internal and external examinations have been reportedly poor especially in algebraic processes (Obioma, 2005; Galadima & Okogbenin, 2012).

According to West Africa Examination Council (WAEC, 2003; 2005; 2007) Mathematics Chief Examiner reported that:

> In 2003 the candidate's generally demonstrated weakness in word problems which affected most of them in all questions that required them to translate word problems to mathematical expressions. Specifically, it was reported that, candidates' attempts on word problems on linear inequality were poor. They also did not know how to use the curve and a straight line to solve a quadratic inequality. In 2005, the Chief Examiner reported that majority of the candidates could not apply the rules of BODMAS as required of them. Many candidates could not multiply and compare the coefficient of two factors correctly. In areas involving algebraic fractions, majority of the candidates could not clear fractions correctly neither could they remove the decimal in the denominators of such given fractions. In questions on quadratic graph, candidates demonstrated weakness right from completing the table to reading and interpretation of their graphs. The Chief Examiners' Report of 2007 still reported general weakness in reading and solving graphical problems (2003: 150, 2005: 234-235, 2007: 286-287).

The knowledge of these concepts can only be built upon proper understanding of algebraic processes. Lee (2001) and Blanton and Kaput (2005) advocated that students should be involved in algebraic activities which involve working with a variety of algebraic materials. This is because algebra is the language of symbols and relations (Odili, 2006). It is the generalized arithmetic (Kulbir, 2002) which every economic sector need as the medium through which mathematics problems either words or mechanical (Inyang, 2005) are semantically and syntactically translated, written and manipulated to give the desired logic/ answer that is been interpreted for the given situation. It is, therefore, that aspect of mathematics used in

developing what the National Council of Teachers of Mathematics (NCTM) called the four thinking mathematics standards: problem solving, communication, reasoning and connections that are needed most in entrepreneur-ship skill development.

Kurumeh and Imoko (2008) attributed this ugly trend to a very weak mathematics foundation which begins in the primary level and is carried over to the junior secondary, and is culminated in senior secondary. Oteze (2011) posits that the simple cause of mass failure in mathematics performance in most countries of the world including Nigeria is the mathematics educator's tendency not to do what they are supposed to do.

Among other suggestions, the WAEC chief examiner recommended effective teaching that would lead to clear understanding of the various concepts/principles and their applications, and that teachers should allow their teaching to be pleasantly followed by their students. Such concepts teaching should be practical and made to sink into the children's minds. Oteze (2011) instead suggested that mathematics teaching should be structured such that knowledge is built on a foundation already possessed; encourage students to learn by doing, ensuring that learning grows out of useful experiences and experimentations, by effective use of mathematical manipulatives that stimulate cognitive, affective and psychomotor domains' development. Ugama (2011) opined that, the proper and meaningful study of mathematics should assist individual in ordering, organizing and investigating his/her environment. This he added is only possible through active personal experience with material resources. It was the same reasoning while discussing mathematics curricular issues that convinced Aligba and Kurumeh (2008) who posits that, it is worthy of note that no pattern of curriculum implementation can be done effectively without relevant instructional materials to present various mathematics concepts.

Attaining the Millennium Development Goals (MDGs) which in the education sector is to eliminate illiteracy through basic education as well as maintain gender equality in the delivery of instructions in schools is a welcome development. The Universal Basic Education (UBE) programme has enshrined these two goals in their objectives which state to ensuring the acquisition of appropriate levels of literacy, numeracy, manipulative, communicative and life skills, as well as ethical, moral and civic values needed for laying a solid foundation for life-long learning, among others.

In this regard, the mathematics curricular for the primary and junior secondary schools were reviewed, restructured and realigned to needs of the nation's nine year Universal Basic Education (UBE) programme and the need to attain the Millennium Development Goals by 2015 (Obioma, 2007). Interestingly the current mathematics curriculum is not just reviewed, restructured and realigned; it also shifted from teacher-centered approach to students activity-centered. The implication is that the learner must be an active participant in the learning process where the learner learns mathematics in all the three ways identified by Bruner which Odili (2006) emphasized that:

> At concrete level, learners 'know' mathematics in all three ways identified by Bruner. At this level as the learner manipulates objects in the presence of the related symbolism; he develops meaningful comprehension of the symbols which leads him to 'knowing' mathematics enactively. (There is kinesthetic and tactile reinforcement). At this level, learners know mathematics 'iconically; the visual reinforcement of the manipulative activity can later be conjured as mental imagery. And at concrete level, learners 'know' mathematics symbolically, manipulations in the presence of symbols help make the symbols meaningful. However at the semi-abstract/semi-concrete (virtual manipulatives) levels, enactive knowledge is not acquired because there are no objects manipulated (p. 148).

In this view, the UBE mathematics curriculum has place the learner at the centre of learning activities with the hope that such constructivist pedagogies as active learning, use of manipulatives, cooperative learning, and the use of realistic and genuine tasks are emphasized at the expense of traditional methods of teaching. By the use of concrete objects for active learning the cognitive, affective and psychomotor domains of the learners are collectively and simultaneously developed. One of such instructional approach is the mathematical game approach.

Mathematical games also called educational games have been defined as an enjoyable social activity with goals, rules, and educational objectives (Steven & Cary, 1994). Mathematical game approach involved 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. Educators and researchers have recommended the use of educational games in teaching and learning of mathematics because it is found to sustain and develop students' interest and achievement in mathematics. Agwagah (2001) researched on number base using baseboard in junior secondary II, while Bala and Musa (2006) researched on number base game in senior secondary I and find that the number base game was effective in the students' mathematics achievements. As contribution to/and availability of games for use in schools, Ukeje and Obioma (2002) had compiled 53 mathematical games for teaching in both primary and secondary schools. Obodo (2004) treated 20 educational games in his book "Principles and Practice of Mathematics Education in Nigeria" while Agwagah (2001) developed many mathematical games for teaching mathematics in the Primary schools. In this regard, the researchers investigated into the teaching and learning of algebraic linear equations in the junior secondary III using algebraic substitution game to arouse their mathematics thinking which may enhance their achievement in mathematics.

Vast literature concerning gender differences favouring males in mathematics abounds in academic, practitioner and public policy fields. Enquiries into such differences cover cognitive ability, school achievement, attitudes, motivation, participation, course-taking/career choice. However, studies have revealed that gender differences favouring boys in mathematics tend not to appear until high school—in earlier grades, differences are either non-existent or favour girls (Hyde, Fennema, & Lamon, 1990, Han & Hoover, 1994; Ma, 1999).

Etukudo (2002) conducted a study involving all the JSS3 students at Ogba/Egbema/Ndoni Local Government Areas of Rivers State. It was to determine the effect of Computer Assisted Instruction (CAI) on gender and mathematics achievement of junior secondary school students. The result of the posttest analyzed with a t-test statistics at 0.05 level of significant revealed that, the male had a mean of 85.71 and standard deviation of 7.2 as against a mean of 84.9 and standard deviation of 9.25 for the female. He found that, there was no significant difference between the scores of male and female students in the experimental group. He therefore, concluded that the observed gender difference before the CAI lesson is no more because of the effect of the CAI on the students' performance.

In a quasi-experimental study conducted in Gwer-West Local Government of Benue State on Sex Differentials in Students' Achievement and Interest in Geometry using Games and Simulations techniques Achor, Imoko, and Ajai (2010) used 287 senior secondary school (SSS1) students. Their findings revealed that male and female students taught geometry using games and simulations did not differ significantly both in achievement and interest. They therefore recommended mathematics teachers to use games and simulations in teaching mathematics concepts and at the same time paying attention to the learning needs of both male and female students.

Another study by Olagunju (2001) investigated whether sex and age have significant effect on performance in mathematics achievement. The student t-test statistical tool result revealed that the mean scores of boys and girls were (19.55 and 19.34) respectively and the percentages of those that passed the test among all boys and all girls were (83.33% & 80.00%) respectively. Thus the researcher concludes

that there was no significant difference in the achievement of the males and females. The result interestingly revealed significant difference between Junior girls (mean scores of 20.90 & 95% pass) and senior girls (mean score of 17.78 % 65% pass) hence the researcher concluded that girls loss interest in mathematics as they grow older.

In a contrasting view Umar and Momoh (2001) conducted a study on the effects of environment and sex on the mathematics achievement of junior secondary three students in Kwara State. The result revealed that there was significant gender difference between the male and female students in their mathematics achievement due to environmental location.

In the same vain Ogunkunle (2007) investigated the existence of gender difference in mathematics achievement of constructivist and non-constructivist secondary school students in Rivers State. The result revealed among others that there is significant difference between the mean scores of male and female students in the constructivist as well as non-constructivist groups. The researcher hence concluded that, constructivist strategy is laudable in the teaching of mathematics for the benefits of both male and female genders.

This research therefore, investigated among Junior Secondary School Students the extent to which teaching algebraic linear graphs with algebraic substitution game improved their recognizing and describing patterns, constructing physical and/or conceptual models of phenomena; creating symbolic systems to help them represent ideas; manipulate and reflect on ideas; and invent procedures, generalizations or rules to solve problems. Furthermore, the study examined if both male and female students improved their knowledge of algebra due to the usage of algebraic game.

Statement of the Problem

Mathematics is a school subject taught solely for the purpose of developing the learners' habit of effective critical thinking, providing competence in the basic skills, ability to communicate thought through symbolic expressions, ability to differentiate between relevant and irrelevant data, making relevant judgments, among others. As good as the aims sounds, mathematics taught in school is purely for curriculum content coverage at the detriment of students' conceptual understanding (Ogunkule & Okpobiri, 2012). Thus transferring the relevant skills learnt to everyday problem solving areas for individual self sustenance, wealth creation, entrepreneurship and national development which are necessary for the attainment of MDGs has been a difficult task.

Mathematics educators and researchers have therefore advocated among other approaches the teaching of mathematics to lower levels in particular with concrete manipulative to re-direct the mathematics problem solving, communication, reasoning and connections that are needed most in entrepreneur-ship skill development and knowledge transfer in general. This study therefore is to investigate among junior secondary school three students the extent to which teaching and learning algebraic linear graphs with algebraic substitution game has improved their mathematics achievement. Also, will the algebraic game improve both male and female students' achievement in algebra?

Research Questions

The following research questions guided the study

1. What are the mean achievement scores of JSS III students taught algebraic linear graphs using algebraic substitution game and those taught using conventional method?
2. What are the mean achievement scores of male and female JSS III students taught algebraic linear graphs using algebraic substitution game?

Hypotheses

The following hypotheses were formulated for the study and tested at 0.05 level of significance,

1. There is no significant difference between the mean achievement scores of JSS III students taught algebraic linear graphs using algebraic substitution game and those taught using conventional method.
2. There is no significant difference between the mean achievement scores of male and female JSS III students taught algebraic linear graphs using algebraic substitution game.

2. Methodology

The design of this study was quasi-experimental. Specifically, pre-test post-test non-equivalent control group design was adopted. This is because it was not possible to have a complete randomization of the subjects. In order not to disrupt school activities and organization, intact classes were randomly assigned to the experimental and control groups respectively.

The target population for this study was all the JSS III students in Makurdi Local Government Area (LGA) of Benue State. This population was also limited to only public and private Co-educational secondary schools in this LGA. The total Co-educational secondary schools in Makurdi LGA are 47 all together. Out of the 47 Co-educational schools, the study considered only schools with a minimum of two streams in JSS III classes and who have not less than 30 JSS III students per stream. Thus, two schools with 130 students were sampled. The sampling technique employed was multi-stage. A simple random sampling of hart-draw method was used to select the two schools while simple sampling of tossing of coin was used to assign the classes into experimental and control groups. The experimental group was taught algebraic linear graphs using algebraic substitution game while the control group was taught the same topic using convention method.

The instrument for this study was Algebra Simplification Achievement Test (ASAT). The ASAT consists of twenty multiple choice test items with the marking schemes. A total of three mathematics educators and two experts from measurement and evaluation validated the instrument. Their suggestions influenced the final draft of ASAT which was then trial tested before been administered to the students as pre-ASAT and post-ASAT. Post-ASAT is a re-organized version of pre-ASAT so as to minimize testing effect. The reliability index of the validated instrument was established using cronbach Alpha which gave a reliability index of 0.89.

Procedure for the study

Before the commencement of the study, two teachers were trained on the use of algebraic substitution game in teaching algebraic linear graphs. This training lasted for just one day. They served as research assistants who taught the experimental classes while the regular teachers taught the control classes. Six lesson plans were prepared for experimental group based on the use of algebraic substitution game in teaching algebraic linear graphs and another six prepared for teaching the control group using conventional method. Before the commencement of treatment, pre-ASAT achievement test was administered to both groups. The scripts were marked and kept for further analysis.

The treatment lasted for a period of three weeks that was six double lessons of 40 minutes each. At the end of the treatment periods, post-ASAT achievement test was administered to the subjects. Both the pre-ASAT and post-ASAT data collected collated were used for further analysis. The descriptive statistic of mean and standard deviation were used to answer the research questions while t-test was used to test the hypotheses at 0.05 level of significance.

3. Result

The results of findings of the study is presented according to research questions and hypotheses formulated.

Research Question 1

What are the mean achievement scores of JSS III students taught algebraic linear graphs using algebraic substitution game and those taught using conventional method?

Table 1: Mean Scores and Standard Deviations (SD) of Scores of Experimental and Control groups as measured by ASAT.

Group	Type of Test	N	**Mean** $\bar{X}$	SD
Control	Pre-ASAT	63	11.24	2.014
	Post-ASAT	63	13.08	1.843
Experimental	Pre-ASAT	67	11.36	3.029
	Post-ASAT	67	16.43	2.542
Total		130		

The result in Table 1 shows that the pretest mean achievement scores of the control group was 11.24 with a standard deviation of 2.014 where as that of the experimental group was 11.36 with a standard deviation of 3.029. After treatment control group mean achievement scores in the posttest was 13.08 with a standard deviation of 1.843 while the mean achievement scores of the experimental group taught algebraic linear graphs using algebraic substitution game was 16.43 with a standard deviation of 2.542. This means that, the achievement score of students taught algebraic linear equation with algebraic substitution game was higher than that of students taught with conventional method.

Research Question 2

What are the mean achievement scores of male and female JSS III students taught algebraic linear graphs using algebraic substitution game?

Table 2: Male and Female Mean post-test and Standard Deviation as measured by ASAT

Gender	Type of Test	Sex	N	**Mean** $\bar{X}$	SD
Experimental	Post-ASAT	Male	40	15.73	3.457
		Female	27	16.96	2.549
		Total	67		

The findings in Table 2 shows that the mean achievement scores of male students taught algebraic linear graphs using algebraic substitution game was 15.73 with a standard deviation of 3.457 while that of the female students in the same treatment was 16.96 with a standard deviation of 2.549. This means that the female students have an edge over the male in understanding algebraic linear graphs when taught using algebraic substitution game.

Research Hypothesis 1

There is no significant difference between the mean achievement scores of JSS III students taught algebraic linear graphs using algebraic substitution game and those taught using conventional method.

Table 3: t-test of Experimental and Control groups Achievement in Post-ASAT.

Group	Type of Test	N	**Mean** $\bar{X}$	SD	Df	t-Cal	t-Crit
Control	Post-ASAT	63	13.08	1.843	128	8.679	±1.96
Experimental	Post-ASAT	67	16.43	2.542			
Total		130					

From Table 3 the posttest result analysis of ASAT shows that the t-calculated value is (t_{-cal} = 8.679) as against t- critical (1.96) at 0.05 level of significance. This implies that t- calculated is higher than t-critical. Thus the null hypothesis of no significant difference is rejected. Hence there is significant difference between students taught algebraic linear graphs using algebraic substitution game and those taught with conventional method.

Research Hypotheses 2

There is no significant difference between the mean achievement scores of JSS III male and female students taught algebraic linear graphs using algebraic substitution game.

Table 4: t-test of Male and Female Achievement in Post-ASAT

Gender	Type of Test	Sex	N	**Mean** $\bar{X}$	SD	Df	t-cal	t-cri
Experimental	Post-ASAT	Male	40	16.15	2.517	65	-1.282	±1.96
		Female	27	16.96	2.549			
		Total	67					

Table 4 shows that the male students had post-test mean achievement scores of 16.15 with a standard deviation of 2.517, while the female students had post-test mean achievement scores of 16.96 with a standard deviation of 2.549. The calculated t-value is -1.282. This is higher than the critical t-value of -1.96 (going on the negative axis) at the 0.05 level of significance. It follows that the null hypothesis of no significant difference is accepted.

4. Discussion

The result in Table 1 shows that the students in the experimental group had mean achievement scores of 16.43 with a standard deviation of 2.542 on their post-test while the control group had mean achievement scores of 13.08 with a standard deviation of 1.843. The test of hypothesis shown in Table 3 gives a t-calculated (8.679) which is greater than t-critical (1.96). The null hypothesis of no significant difference between the mean achievement scores of students taught algebraic linear graphs using algebraic substitution game and those taught with the conventional method was therefore rejected. This result agrees with the work of Odogwu (2002), Agwagah, (2001), Bala and Musa (2006) and Achor, Imoko, and Ajai (2010) who find that the use of instructional materials (manipulatives) such as games have positive effect on students' academic achievement. Hence with the use of algebraic substitution game, students may understand better and internalize the knowledge of the concept of algebraic linear graphs in particular and algebra in general, such knowledge could be transferred to other mathematics concepts for

higher achievement. Such internalize knowledge could serve as an instrument for entrepreneurships skills for problem solving, communication, reasoning as well as connections/decision making.

Results of the analysis also showed that the mean achievement scores of the male students taught algebraic linear graphs with algebraic substitution game were 16.15 with a standard deviation of 2.517, while the mean achievement scores of the female students taught algebraic linear graphs with algebraic substitution game were 16.96 with a standard deviation of 2.549. The test of hypothesis gives a t-calculated (-1.282) against the t-critical (1.96). Hence we have no reason to reject the null hypotheses of no significant difference. This confirms Hyde, Fennema, & Lamon (1990), Han & Hoover (1994) and Ma (1999) that gender differences favouring boys in mathematics tend not to appear until high school—in earlier grades; differences are either non-existent or favour girls.

5. Recommendations

Following the results of this study, the following recommendations are made

1. Mathematics teachers should be encouraged to use appropriate mathematical games in teaching mathematics topics/concepts in order to link learners' past experiences and daily activities with classroom instructions. This, is believed will enhance problem solving, communications, reasoning and the needed connections in not just better achievement in mathematics, but also self reliance.

2. Game approach can also be applied to other mathematics concepts/topics to arouse interest and made available many simple ways of engaging mathematics learners.

3. Authors of mathematics textbooks are encouraged to simplify more their textbooks by involving game approach in most of the topics.

4. Stakeholders in mathematics education should endeavor to organize workshops/seminars where in-service mathematics teachers could be trained on the use of mathematics games in teaching their students.

5. School administrators should encourage their mathematics teachers by providing necessary financial assistance and approvals for them to attend organized mathematics workshops/seminars.

6. Conclusion

Mathematical game approach has proved itself a neutralizing approach in the issue of gender differences in mathematics achievement tests (Bala & Musa, 2006; Usman & Nwabueze, 2011; Galadima & Okogbenin, 2012). Mathematical games have the capability of catching them young if given proper attention in most mathematics topics.

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