

**INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL SUSTAINABILITY****Impact of Manipulation of Symbols by Upper Basic Education Students in Performance and Retention of Algebraic Processes**Umar Sodangi<sup>1</sup> Suleiman Bashir<sup>2</sup> Khadijat Anike Oyeibanji<sup>3</sup><sup>1&2</sup> Department of Science Education, Faculty of Education, Federal University Gusau, Zamfara State.<sup>3</sup> Department of Economics, Federal College of Education (Technical) Gusau, Zamfara State.

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**ABSTRACT**

The study focused on the use of instructional materials for effective teaching and learning of mathematics at upper Basic Education Level. The use of shapes was employed to introduce the teaching of algebra to upper Basic Education Junior Secondary School One (JSSI) students. Quasi-experimental (Pre-test Post-test Non-equivalent control group design) was used for the study. The instrument used for the study was Algebraic Performance and Retention Test (APRT). The Performance Test was used as Pre-test, Pre-test and Retention-test. Researchers self-constructed two-dimensional shapes were used as manipulative skills for the teaching and learning of algebra. Two intact classrooms of JSSI were randomly selected out of the private schools in Gusau metropolis. Mode of instruction was randomly assigned to the classes using simple random technique of balloting. A sample size of 180 students were involved in the study comprising of 90 for experimental and 90 for control groups. The teaching and scoring were made by the researchers while the items, lesson plan and marking guide were all validated by the experts in mathematics education from the Federal University, Gusau. The findings of the study show that students taught algebra using manipulating skill performed better than those taught using conventional method. Also, students in the manipulative group retained the algebra contents more than those in the conventional group. More so, there was no significant difference in the mean achievement scores of male and female student's algebra for both teaching methods. Similarly, there was no significant difference in the mean retention scores of male and female students in algebra for both teaching methods.

**Keywords:** manipulation, performance, retention, algebraic processes, students.

**1.0 INTRODUCTION**

Mathematics is a tool for service to humanity because it is used in all aspects of human daily activities. Suleiman and Abdullahi (2015), Suleiman and Umar (2018), and Olasesan (2019) states that mathematics plays a paramount role in scientific, technological, commercial and entrepreneurial areas for any nation development. Teaching and learning of the subject in most schools is in dismal state due to lack of qualified and enough mathematics teachers, poor method of teaching, lack of adequate use of instructional materials. Students find it difficult to learn some of the topics taught by their teachers while some teachers too find it difficult to teach some topics adequately in the classroom. This is linked to the lack of qualified teachers, method of instruction and use of instructional materials.

Due to the poor state of teaching and learning the subject in Nigeria, students performs poorly in

**1.1 Introduction of the Background**

mathematics, most especially in public examinations like West African Examination Council (WAEC), National Examination Council (NECO) and Joint Admissions and Matriculation Board (JAMB) (Suleiman, 2010, Adebola and Ajilogba 2013, Suleiman and Umar 2018, Ahmad and Haruna, 2020). This poor performance in mathematics might be due to students' inability to retain what they have learnt.

Azuka (2009 in Ugwuayi (2016) opined that methods of instructions that promote student's active participation through activities do enhance their learning and retention of what they learnt. Therefore, for any classroom teacher to maximize retention ability in his students, he needs to make the lessons students-centered and concrete. This is in line with (Obodo 1990, Ezeugo 1999 and Bashir and Umar 2020) who indicated that teaching

mathematics concepts especially algebra that is being regarded as abstract should be taught using practical methods. Algebra is the most important area of mathematics and provides the language by which mathematics becomes the universal tool for most other subjects such as the sciences, economics, business, statistics and even sports. The power of algebra is illustrated by its ability to describe generalizations. For instance, when you draw a circle, you know that its diameter is twice the length of its radius ( $d = 2r \rightarrow r = \frac{d}{2}$ ).

Manipulating symbols is an important algebraic skill and we need to develop this in our teaching and learning situations. This manipulating skill can be developed in the students by making the lesson an activity with specific values in which letter symbols represent something tangible. Involving students to manipulate shapes is a technique that enhances active participation in the lesson. This method involves use of recognizable quantities such as areas of shapes to represent some symbols like  $x$  and  $y$ .

Students manipulating shapes is like using game approach in mathematics instruction. The procedure is by using skills and or chance under specified rules of four basic operations of addition, subtraction, multiplication and division and has a

The main purpose of this study is to construct two geometrical shapes to represent  $x$  and  $y$  symbols and many other shapes to be manipulated by students by adding, subtracting or multiplying them and to investigate the effects of this manipulating skills in enhancing students learning and retention of algebraic concepts. Specifically, the study sought to:

- i. Construct some geometrical shapes for manipulation

The following research questions were answered in this study.

- i. What are the mean performance scores of students taught algebra using manipulative skill and those taught by the conventional method?
- ii. What are the mean retention scores of students taught algebra using manipulative

winner. Agwagah (2001) stated that a game is said to be mathematical structure. The manipulation activities can be individual, pairwise, group or class tasks.

The argument is frequently heard that boys obtain better results than girls simply because mathematics has been regarded as a masculine subject. In line with this assertion Harbor-Peters (2004) conducted a research to ascertain the effect of new approach on the performance of SS1 students on writing the proof of trigonometry identities. The result also indicated that differences between the performance of male and female students could be taken care of using good methods, materials and teaching strategies. Harbor-Peters advised that there is need to work to reduce this gap and encourage all students to persevere and succeed in mathematics in order to retain more women in mathematics. Sam-Kayode, Bolagun, Fatoki (2019), Umar (2021) and John, Felix and Umar (2021) stated further that, Nigerian society is structured to discourage women from pursuing courses that are mathematics and science related. They further indicated that the dominance of men in these fields (mathematics and science) this could be as a result of its complexity and thoroughness requiring more brain tasking activities and perseverance to get results.

### 1.2 Purpose of the study

- ii. Find out if differences exist in the students' learning and retention of those taught algebra with the manipulation skills and those taught with conventional method.
- iii. Find out if differences exist in the students learning and retention of students taught algebra using manipulation skills based on gender.

### 1.3 Research question

- skill and those taught by the conventional method?
- iii. Does difference exist in mean performance and retention mean scores of male and female students taught using manipulative skills?

### 1.4 Hypothesis

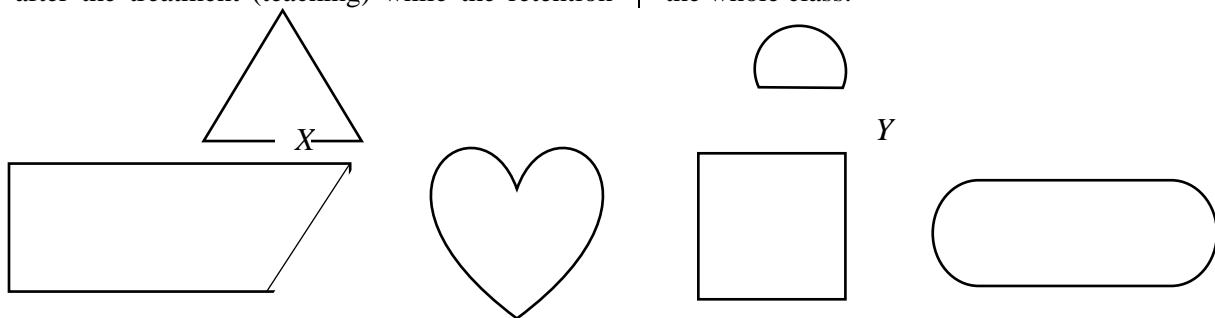
The following hypothesis were formulated and tested at 0.05 level of significance.

- i. There is no significant difference in the mean achievement scores of students taught algebra using the manipulative skill and those taught using conventional method.
- ii. There is no significant difference in the mean retention scores of students taught algebra

## 2.0 METHODOLOGY

The study adopted quasi experimental design using non-equivalent control groups design or pre-test and post-test non-randomized was used in this study. Intact classes were randomly assigned to the two treatments group by balloting. The groups were given the same pre-test before the experiment and post-test after the experiment. One group was The samples of the study comprised of all selected intact classes of the 2020/2021 academic sessions from schools in Gusau metropolis selected by balloting during the study. Gusau was for used because it had the highest of schools in the state and consisted of both single sex and co-educational schools. Because gender was a variable in this

The instrument used for this study was Algebraic Achievement and Retention Test (AART). It consists of ten items on simplification of algebraic expressions using grouping and factor methods. The instrument was used for pre, post and retention tests. The pretest was administered to determine the equivalence of the students on knowledge of algebra. Post-test was administered immediately after the treatment (teaching) while the retention



## 2.4 Lesson plan

Lesson plans were developed by the researchers. The experimental group lesson plan was developed based on teaching of algebra using Algebraic Manipulating Skill Shapes (AMSS) coupled with and without activities for the students and the control group lesson plan was written using conventional teaching

using the manipulative skill and those taught using conventional method.

- iii. There is no significant difference in the mean retention scores of male and female students taught algebra using manipulative skills

## 2.1 Research design

taught using manipulative skill and the other taught using conventional method. It was considered appropriate for this study, because classes were used instead of randomly composed samples.

## 2.2 Sample

study, a purposive sampling was adopted in sampling. Two upper basic education (JSS 1) selected private secondary schools in Gusau town of Zamfara state. The two intact classes were randomly assigned treatment using simple balloting.

## 2.3 Instruments

test was rearranged post-test which was administered three weeks after the post-test. The reliability coefficient based on Cronbach alpha formula was determined as 6.8. The researchers constructed some geometrical two-dimensional shapes called Algebraic Manipulative Skill Shapes (AMSS). These shapes are manipulated by students as activities either individually, pairwise, groups of the whole class.

approach. The lesson plan was validated by one mathematics educator and one lecturer of measurement and evaluation from the university.

### 3.0 RESULTS

The results of the analysed data were presented according to research questions and hypotheses.

#### Research Question 1

What are the mean performance scores of students taught algebra using manipulative skill and those taught by the conventional method?

**Table 1: Mean Achievement and Standard Deviation Scores of Students in Manipulative Skill and Conventional Method**

Method	N	Pre-test		Post-test		Mean Difference
		X	SD	X	SD	
Manipulative	90	2.29	1.39	4.02	1.59	1.73
Conventional	90	2.06	1.30	2.33	1.71	0.38

Table 1 shows the pre-test and post-test mean achievement scores and standard deviation of students in both manipulative skill and conventional method. In Table 1, the mean Pre-test scores of the manipulative skill and conventional method are 2.92 and 2.06 respectively, with a standard deviation of 1.39 and 1.30 respectively.

There is no significant difference in the mean achievement scores of students taught algebra

While the mean Post-test scores of the manipulative and conventional are 4.02 and 2.33 respectively, with a standard deviation of 1.59 and 1.71 respectively. The result reveals the mean difference of pre-test and post-test scores of the manipulative skill and conventional method are 1.73 and 0.38 respectively. The manipulative skill was significant in improving students' achievement.

#### Hypothesis 1

using the manipulative skill and those taught using conventional method.

**Table 2: Analysis of Covariance of Students' Scores in the Manipulative Skill and Conventional Method Achievement Test in Algebra Due to teaching strategies.**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17.371	2	5.780	3.572	.000
Intercept	27.786	1	27.786	16.854	.000
Pre	12.283	1	12.283	7.450	.095
Group	4.409	1	2.204	1.337	.000
Error	141.784	86	1.649		
Total	586.000	90			
Corrected Total	159.156	89			

Table 2 shows that the value of the significance of F (1.33) on achievement is 0.00 compared to 0.05 alpha level already set. Since the probability value associated with F is lower than the set alpha of 0.05, the null hypothesis of no significant difference in the mean achievement scores of students taught algebra using the manipulative and those taught

using the conventional approach was therefore rejected. There is a significant difference in the mean achievement scores of students taught algebra using the manipulative skill and those taught using the conventional teaching strategy

#### Research Question 2

What are the mean retention scores of students taught algebra using manipulative skill and those taught by the conventional method?

**Table 3: Mean Retention Scores and Standard Deviation of the Manipulative Skill and Conventional Method**

Method	N	Post-test		Retention-test		Mean Difference
		X	SD	X	SD	
Manipulative	90	4.02	1.59	6.53	2.59	6.53
Conventional	90	2.33	1.71	4.22	2.67	1.89

Table 3 shows the post-test and retention-test mean achievement scores and standard deviation of students in both manipulative skill and conventional method. In Table 3, the mean Post-test scores of the manipulative skill and conventional method are 4.04 and 6.53 respectively, with a standard deviation of 1.59 and 1.71 respectively. While the mean Retention-test scores of the manipulative and conventional are 6.53 and 4.22 respectively. There is no significant difference in the mean retention scores of students taught algebra using the

6.53 and 4.22 respectively, with a standard deviation of 2.59 and 2.67 respectively. The result reveals the mean difference of post-test and retention-test scores of the manipulative skill and conventional method are 6.53 and 1.89 respectively. The manipulative skill was significant in improving students' achievement.

### Hypothesis 2

manipulative skill and those taught using conventional method.

**Table 4: Analysis of Covariance of Students' Retention Test on Algebra in the Manipulation and Conventional Method due to Teaching Strategies**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17.371	2	5.780	3.572	.019
Intercept	27.786	1	27.786	16.854	.000
Retention	12.283	1	12.283	7.450	.008
Post Test	4.409	1	2.204	1.337	.000
Error	141.784	86	1.649		
Total	586.000	90			
Corrected Total	159.156	89			

Table 4 shows that the value of significance of F (1.33) on mean retention scores is 0.00 against  $\alpha$  level already set at 0.05. Since the probability value associated with F is higher than the set alpha of 0.05, the null hypothesis of no significant difference in the mean retention scores of the Manipulative skill and Conventional method is therefore not rejected. Although students in the Manipulative skill had higher mean retention difference than those in the Conventional in the algebra content taught, the difference was not significant.

### Hypothesis 3:

There is no significant difference in the mean achievement scores of male and female students taught algebra using the manipulative skill and those taught using the conventional method

**Table 5: Analysis of Covariance of Male and Female Students' Retention Test on algebra in the Manipulation and Conventional Method due to Teaching Strategies**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	20.321	2	10.160	3.572	.003
Intercept	30.278	1	30.278	18.973	.000
Retention	10.126	1	10.126	6.346	.0014
Gender	7.358	1	7.358	4.611	.035
Error	138.835	86	1.596		
Total	586.000	90			
Corrected Total	159.156	89			

From the ANCOVA result on Table 5, it is observed that the value of significance of F (4.61) on the mean achievement scores of students in the teaching methods for gender is 0.03. Since the probability value associated with F is lower than that of  $\alpha$  set at 0.05, the null hypothesis of no significance difference in the mean achievement scores of male and female students taught algebra using the methods was therefore rejected. This implies that, there was significant difference in the mean achievement scores of male and female students taught algebra using the Manipulative skill and Conventional method.

#### 4.0 DISCUSSIONS OF FINDINGS

In table 1, the mean difference achievement score of the manipulative skill in the Post-test was 1.75. This is higher than the Post-test mean difference achievement scores of 0.38 for the conventional method. This shows that the manipulative skill used in teaching algebra content improved the students' achievement. Also, table 1 reveals that difference in achievement of students was statistically significant among students taught algebra in the manipulative skill. This finding was further confirmed by the result presented on table 2, which shows that teaching strategies are significant factors determining students' achievement in algebra. Thus, students who were taught algebra using the manipulative skill achieved better than those taught using the conventional method. The implication is that the mode of instruction used in teaching algebra are capable of producing effects on students' achievement.

These findings appear to justify previous studies such as Olasesan (2019), Suleiman & Umar (2018), Suleiman & Abdullahi (2015), and Ifeanacho (2012), where experimental aspect improved students' achievement. This finding is also in agreement with previous studies such as Fawowe (2010), who noted that appropriate methods lead to students' improvement in mathematics achievement.

This shows that students in the manipulative skill appeared to retain the algebraic content taught more than those of the conventional method. This difference in retention scores between the manipulative skill and conventional method is found significant at 0.05 level of significance in favour of the manipulative skill as can be seen on Table 3. The result reveals that the mean differences of manipulative are 6.53 and 1.89 respectively.

The retentive effect of the manipulative skill can be seen from the fact that it enhances meaningful learning. The meaningfulness of the mode of presentation facilitated the encoding of the learnt concepts into memory. The constant practice of both previous and present concepts adopted by the manipulative skill is capable of causing overlearning which is found to be responsible remembering and enhance retention. Contrary to this result, Table 5 reveals the ANCOVA result tested at 0.05 level of significance that gender is not significant in students' retention in algebra. This implies that though a difference was found in the

mean retention scores of male and female students in the manipulative skill and conventional method, but the difference was not significant. This result agrees with the study of Eze (2011), Harbor-Peters (2004) and Umar (2021) who found that gender was not significant on students' retention in mathematics content taught. Based on this, it can then be appreciated that the teaching strategies are capable of bridging the gap between male and female students' retention and consequently achievement in algebra.

## 5.0 CONCLUSION

The following conclusions are made based on the result of the analysis of data in this study:

- i. The use manipulative skills approach significantly improved students learning of algebraic process by upper basic education one (JSSI) students.
- ii. Students taught using manipulative skills retained the algebraic process higher than their counterparts taught using conventional methods.

Gender difference in students' performance in algebraic process was not significant. Gender disparity in students' retention in algebraic was not significant. This implies both male and female students in manipulative skill group retained the algebraic process content more than their counterparts

## 6.0 RECOMMENDATION

The following are recommended for effective teaching and learning of mathematics at upper basic education level.

- i. Mathematics teachers to learn how to produce and use improvised instructional materials for teaching of mathematics
- ii. Teachers of mathematics need to be sent for in-service training on how to teach the subject in a meaningful manner to students at that level.
- iii. Students need to be engaged with series of classroom activities for the purpose of active participation by the students.

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