How Manipulatives Affect the Mathematics Achievement of Students in Nigerian Schools

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Mathematics is a very important subject in Nigeria. Yet, for more than twenty years, mathematics education in Nigeria has been in a sorry state. Mathematics achievement has been very low and frustrating. So far, every effort made to save Nigerian education from the devastating effect of persistent poor mathematics achievement has failed. An experiment to address the problem of poor achievement in mathematics in Nigerian high schools was carried out in Edo State of Nigeria. Eighteen simple improvised geometric manipulatives were made from ordinary cardboard paper. The manipulatives were used in teaching students in experimental group. There was a control group of students which did not study with manipulatives. Scores were collected from mathematics test taken by students in both experimental and control groups. Statistical analysis showed that students in the experimental group (who were taught with manipulatives) were clearly better than students in the control group who were not instructed with manipulatives.

Introduction

Federal Republic of Nigeria (2004) National Policy on Education made mathematics compulsory in all classes in grade schools and high schools. In fact, in grade school and high school, every child must study mathematics everyday the child goes to school in Nigeria. The National Policy on Education also made it compulsory for students to pass mathematics at the end of junior high and the senior high school levels of education in order to continue their educational career. It is therefore necessary that mathematics be taught effectively in Nigerian schools. Another reason for desiring effective mathematics teaching in Nigerian schools is that mathematics is very much needed for undergraduate admission into universities in Nigeria (see table 1 below).

Table 1: Mathematics Admission Requirements for Nigerian Universities 2004-2005

S/N	*Faculty*	*Number of Courses Available*	*Courses Needing at Least Credit in Mathematics*	*% of Courses Needing at Least Credit in Mathematics*
1	*Administration*	*21*	*16*	*76%*
2	*Agriculture*	*46*	*46*	*100%*
3	*Arts*	*65*	*0*	*0%*
4	*Education*	*72*	*36*	*50%*
5	*Engineering*	*68*	*68*	*100%*
6	*Law*	*7*	*0*	*0%*
7	*Medical Sciences*	*21*	*21*	*100%*
8	*Science*	*79*	*79*	*100%*
9	*Social Sciences*	*36*	*21*	*58%*
	Total	***415***	***287***	***69%***

Source: Joint Admissions and Matriculation Board (2004) Universities Matriculation Examination Brochure (2004-2005).

Table 1 shows that 69% (more than two-thirds) of the university courses available need mathematics as entry requirement. In the courses concerned, a candidate must pass mathematics at credit or distinction level, and also offer mathematics at the Universities Matriculation Examination (UME) before being considered for admission. Out of nine faculties, four faculties (Faculty of Agriculture, Faculty of Engineering, Faculty of Medical Sciences, and Faculty of Science) require credit or distinction level pass in mathematics for all courses before candidates can qualify for further screening for admission. In spite of this great need for high achievement in mathematics, mathematics achievement has remained very low for many years. Lassa (1981) pointed out the sorry state of mathematics education in Nigeria. Lassa's warning did not stop the continuous high failure in mathematics and its resulting frustration of students and embarrassment of teachers. Ale (1989) declared that the

Mathematical Association of Nigeria was launching a War Against Poor Achievement in Mathematics (WAPAM); but WAPAM has not succeeded in solving the problem of poor achievement in mathematics in Nigerian high schools. Ale (2003), in his capacity as Director of the National Mathematical Center, Abuja, Nigeria, launched a Mathematics Improvement Program. Yet, the sad situation persists. To show how serious the situation is, Amoo (2001) brought out the following table (table2).

Table 2: Performance In Mathematics in West African School Certificate Examination 1995-1997

Year	**Entry**	**Candidates Who Sat for Exam**	**Credit or Distinction 1 – 6**	**Pass 7 – 8**	**Fail 9**
1995	466971 %	462273 99.0	76080 16.5	185931 40.2	200262 43.3
1996	519656 %	514342 99.1	51587 10.0	190899 37.1	272356 52.9
1997	621844 %	616923 99.2	47252 7.7	161526 26.2	408145 66.2

Source: *Amoo (2001)*

In 1995, only 16.5% of high school students passed mathematics at the credit or distinction needed as a precondition for admitting students into majority of university courses. In 1996, the percentage fell further to 10.0%, only to fall again to 7.7% in 1997. Outright failure (Fail 9) in high school final year mathematics examination rose from 43.3% in 1995 through 52.9% in 1996 to 66.2% in 1997. This shows that nearly two-thirds of final year students in Nigerian high schools failed mathematics in 1997! These results are obviously not encouraging. They frustrate not only the students affected, but also other students. Mathematics teachers in Nigerian high schools as well as parents, guardians, and government are not happy about this persistent poor performance in mathematics. According to Ibuot (2000), a leading teacher, Okubodejo, said that:

Government has not been happy with the performance of students in mathematics in recent times because of students' poor performance… Mathematics is the bedrock of the sciences and technology … Without mathematics it would be difficult for the nation to move forward.(Page 5).

A vivid description from Aborisade (2001) shows that,

For many Nigerian students in secondary schools, mathematics is a loathsome subject… At the mention of the subject, some students curse and hiss. To those students who detest the subject, the mathematics teacher is an archenemy. He is unpopular simply because the subject is unpopular. A recently conducted research to know what is responsible for learners' hateful attitude to mathematics gave the reason to be lack of proper motivation and high cost of books. (Page 48)

Both Ale (1989 p.27) and Amazigo (2000 p.24) have identified teaching problems and lack of instructional materials as major factors responsible for poor performance in mathematics. As a contribution to the struggle against poor achievement in mathematics, an experiment was performed in Edo State, Nigeria, using three high schools – Momodu College, Agbede (mixed), Girls Model Secondary School, Ubiaja (girls only), Immaculate Conception College, Benin City (boys only). Simple improvised geometric manipulatives were utilized in the experiment. Manipulatives, according to National Science Foundation (2002), are materials designed to provide concrete experiences that can help students make the link between mathematical concepts and the real world. Also, Langa (2002) sees manipulatives as any objects that aid children in visualizing mathematical process. Ivowi (1999 p.483) explains that "the practical nature of science and mathematics is being emphasised in order to make them functional."

Statement of the Problem

In full recognition of the importance of mathematics, the Federal Government of Nigeria has made mathematics compulsory in all Nigerian grade schools and high schools. Since government spends a lot of money on education, it is disappointing to see a high percentage of students continuously failing mathematics for more than twenty years. In spite of efforts made by the Mathematical Association of Nigeria and the National Mathematical Centre, Abuja, Nigeria, the problem has persisted. Improving achievement in mathematics is desirable. As a matter of fact, it is necessary in order to produce more students who can acquire enough mathematics education to carry Nigeria confidently to the forefront of scientific and technological research and development in this twenty-first century. As a contribution towards solving the longstanding problem of low achievement in mathematics in Nigerian high schools, an

experimental research study was carried out in Edo State, Nigeria. The experiment aimed to test the effect of eighteen simple geometric manipulatives, made from ordinary cardboard paper, on the mathematics achievement of students in Edo State.

Objective of the Study

The study aims to find out how simple improvised geometric manipulatives affect mathematics achievement of high school students. Specifically, the study wants to determine if mathematics achievement in Edo State high schools in Nigeria will improve as a result of using improvised geometric manipulatives in classroom teaching and learning.

Significance of the Study

Once it is ascertained that improvised geometric manipulatives improve mathematics achievement at the high school level, teachers and students will be encouraged to use improvised manipulatives as one possible means of fighting failure and frustration in mathematics teaching and learning. There is a more important reason for encouraging the use of improvised geometric manipulatives (if they are effective enough to improve mathematics achievement). If more students pass mathematics, mathematics can become a more solid springboard for economic, scientific and technological development.

Research Question

To what extent does the use of improvised geometric manipulatives improve the achievement of students in mathematics?

Research Hypothesis

There is no significant difference between the mathematics achievement of students taught with simple improvised geometric manipulatives and students taught without manipulatives.

Research Methodology

Population, sample, instrument, data collection and analysis shall be discussed under research methodology.

Population

All students in 287 high schools in Edo State of Nigeria constitute the population for this study.

S*ample*

Stratified random sampling, using a table of random numbers, led to the choice of Momodu College, Abgede (a mixed school), Girls Model Secondary School, Ubiaja (girls only) and Immaculate Conception College, Benin City (boys only). A random choice of class was done by simple ballot with JSS1, JSS2 JSS3, SSS1, SSS2, SSS3 written, one each, in six pieces of paper of equal size. After folding the papers and throwing them on a wide floor, one of them was picked up. It was JSS2. Another simple ballot was conducted with two equal pieces of paper, with A written on one paper, and B written on the other paper. The papers were folded and thrown into an envelope. After closing and shaking the envelope, one of them was taken out. Before picking the paper, it was decided that the chosen paper should be for the experimental group while the remaining paper would be for the control group. B was the choice for experimental group. So JSS2B became the experimental group while JSS2A was the control group in all the three schools chosen.

Instrument

The instrument for this research consisted of a testing instrument, Mathematics Achievement Test (MAT) and a treatment instrument, Simple Improvised Manipulatives (SIM). MAT was a mutiple-choice type of achievement test, which was used for both pretest and posttest. To construct MAT, a table of specifications (or test blueprint) was drawn up for sixty-eight test items (see table 3 below).

Table 3: Specifications for JSS2 Mathematics Achievement Test

Mathematics **Areas**	**Recall of Information**	**Understanding Concepts**	**Applications of Concepts**	**Total**
Geometry	5	13	8	**26**
Algebra	3	7	4	**14**
Statistics	3	7	4	**14**
Number and Numeration	3	7	4	**14**
Total	**14**	**34**	**20**	**68**

Writing of test items was followed by face and content validation, then item analysis. The face and content validation reduced the items from sixty-eight to sixty-one while item analysis reduced the test items from sixty-one to fifty-two. The fifty-two surviving items were administered to thirty-one students in a pilot test. The students wsere in JSS2 in Obiaruku Grammar School, Obiaruku, Nigeria. Kuder-Richardson Formula (KR21) was applied to scores in order to measure internal consistency. The internal consistency coefficient was 0.79. It was considered high enough to accept MAT for research. A test-retest of students, with an interval of three weeks, yielded scores that were paired and analyzed to obtain 0.83 as test-retest reliability coefficient for MAT. Again, this was high enough to accept MAT as a reliable research instrument. The second type of research instrument was made up of Simple Improvised Manipulatives (SIM). SIM had eighteen different geometrical shapes constructed from ordinary cardboard paper. Four shapes were triangles – equilateral triangle, isosceles triangle, right-angled triangle and scalene triangle. Six shapes were quadrilaterals – square, rhombus, rectangle, parallelogram, trapezium and kite. There were four other plane shapes - pentagon, hexagon, circle and semi-circle. Cube, cuboid, triangular prism and cylinder were the four solid shapes in Simple Improvised Manipulatives (SIM).

Data Collection and Analysis Techniques

Data collection started with a pretest administered to students in both experimental group and control group. The pretest scores were carefully kept for future use. After pretest, ten weeks of teaching followed, during which only the experimental group was treated with Simple Improvised Manipulatives (SIM). In other words, during the ten weeks that followed the pretest, students in the experimental group were taught with simple improvised manipulatives while control group students were taught without using manipulatives. Special care was taken to make sure that, in each school, the same mathematics teacher taught the experimental group (JSS2B) and the control group (JSS2A). This was to eliminate what is known as the "teacher effect". Another teaching precaution was to make sure that, each time one group (JSS2A or JSS2B) was having a mathematics class, the other group was occupied by another teacher. For example, when JSS2A was studying mathematics, JSS2B must be studying mathematics under a teacher, so that JSS2B students could not study mathematics in JSS2A classroom. In the same way, whenever JSS2B was having a mathematics lesson, a teacher kept JSS2A occupied with another subject. These two precautions were in operation throughout the ten weeks of teaching. After the pretest and ten weeks of teaching, a posttest was given to all students in experimental group as well as control group. The posttest scores were collected for analysis in conjunction with pretest scores. It is noteworthy that the validated Mathematics Achievement Test (MAT) was used for both pretest and posttest with several precautions. The first precaution was that MAT was administered to students in two versions. The second version of MAT was a rearrangement of the numbers and alternative answers in the first version. Thus, question number 5 with correct answer E in the first version of MAT could become question number 23 with correct answer C in the second version of MAT. The second precaution was to minimize the chances of obtaining fake scores from students who merely copy from their neighbours. To carry out this precaution, question papers were given to students in a checkerboard fashion (see table 4 below).

Table 4: Checkerboard Arrangement of Question Papers.

1	**2**	1	2	1	2	1	2	1	2
2	1	2	1	2	1	2	1	2	1
1	2	1	2	1	2	1	2	1	2
2	1	2	1	2	1	2	1	2	1
1	2	1	2	1	2	1	2	1	2
2	1	2	1	2	1	2	1	2	1

1. First Version Test 2. Second Version Test

Checkboard arrangement of question papers guarantees that students writing a different version of test surround every student. Also, desks were separated far enough to prevent any student copying diagonally from students writing the same version. The third precaution was that no student wrote the same version of MAT for pretest and posttest. Statistical analysis of pretest scores was carried out by the computer, using t test (see tables below).

Findings

Table 5A aove shows the number of students in experimental group (JSS2B) and control group (JSS2A) in the three schools where the research took place. The experimental group had a total of ninety-four students while the control group as ninety-one students altogether.

Table 5A: Number of Students in Experimental and Control Groups

	Immaculate Conception College, Benin City	Girls Model High school, Ubiaja	Momodu College Agbede	**Total**
Group JSS2 B	36	36	22	**94**
Group JSS2 A	33	35	23	**91**
Total	**69**	**71**	**45**	**185**

Table 5B: t – Test Analysis of Pretest Scores of Experimental and Control Groups

Group	**Number**	**Mean**	**Standard Deviati**	**df**	**Calculated t value**	**Critical t value**
Experimental (JSS2B)	94	8.74	5.37	184	.09*	1.96
Control (JSS2A)	91	8.81	5.18			
Decision on Hypothesis			***Accept Hypothesis***			

* Not significant at .05 level.

Table 5B shows that, at the pretest level, the calculated t value (.09) is very much below the critical t value (1.96) at .05 level of significance. Therefore, there is no significant difference between the mean score (8.74) of the experimental group and the mean score (8.81) of the control group.

This implies that the experimental and control groups were academically equal in mathematics achievement at the pretest level.

Table 5C: t – Test Analysis of Posttest Scores of Experimental and Control Groups

Group	Number	Mean	Standard Deviation	df	Calculated t value	Critical t value
Experimental (JSS2B)	94	11.70	5.26	184	2.23*	1.96
Control (JSS2A)	91	9.89	5.77			
Decision on hypothesis			**Reject hypothesis**			

* Significant at .05 level.

At the posttest level, the calculated t value (2.23) is greater than the critical t value (1.96) as shown in table 5C above. This implies that a significant difference exists between the mean (11.70) of the experimental group and the mean (9.89) of the control group. The experimental group is now clearly superior to the control group in mathematics achievement at the posttest level. Thus, the research hypothesis (claiming no significant difference) has to be rejected in favor of the experimental group with much higher posttest mean score than the control group. This goes to show that students taught with simple improvised geometric manipulatives performed much better than other students.

Definition of Key Terms

Control Group	Students who were taught without using manipulatives.
Credit	B or C grade
Df	Degrees of freedom.
Distinction	A grade

Experimental Group--Students who were taught with simple improvised geometric manipulatives.

Item	Question.
JSS	Junior secondary school (junior high school).
Manipulatives	Instructional materials that learners can easily handle to help them visualize and understand mathematical ideas.
Secondary School	High school
SSS	Senior secondary school (senior high school).

Recommendations

1. Nigerian government should make it a point of duty to arrest the present persistent poor performance in high school mathematics. Poor performance in high school mathematics has disturbed Nigeria for many years. It is inimical to national development.
2. The use of simple, improvised manipulatives for mathematics teaching and learning should be introduced in our schools, and entrenched in our curriculum. This should assist educational development in particular, and national development in general.
3. To sustain democracy and develop this country to a high level, our federal, state and local governments should invest massively in education, especially mathematics education which is the basis for development in science and technology.

Conclusion

The result of this research study has shown that the persistent poor performance of our high school students in mathematics for many years, need not continue indefinitely. There is hope that, with simple, cheap, improvised manipulatives, the situation can be changed for the better. With ordinary cardboard paper, teachers and students can construct and use simple geometric manipulatives to improve mathematics teaching and learning. Better mathematics results will follow; and better-trained students will come out of Nigerian high schools. Such students will be more equipped for national development, especially in the fields of science and technology where mathematics is a necessity, and not a luxury. Moreover, better mathematics education due to improvement in mathematics achievement, will raise the educational quality of Nigeria and lead the country to sustainable development. In this age of the computer, the website and the Internet, education needs to improve so that Nigeria will not be left behind by other nations in this highly competitive and dynamic world.

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