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HARNESSING GEOMETRIC MANIPULATIVES AS A REVITALIZATION STRATEGY FOR MATHEMATICS EDUCATION IN NIGERIA

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This study tested out the implication of harnessing geometric manipulatives on the mathematics achievement of secondary school students in Nigeria. An experiment was conducted in Edo State, using a multistage sample of students in three secondary schools. The instruments for the research were a testing instrument, Mathematics Achievement Test (MAT) and a treatment instrument, Simple Improvised Manipulatives (SIM). Statistical analysis of pretest and posttest scores was carried out by means of SPSS computer software. The independent samples t-test was the statistical method adopted. Positive and statistically significant results indicated that geometric manipulatives could be harnessed as a revitalization strategy for mathematics education in Nigeria.

Keywords: Mathematics Education; Geometric Manipulatives; Nigeria.

I. – Introduction

Perennial poor mathematics performance in Nigerian secondary schools has generated an overwhelming need for a review of current teaching and learning strategies. The Mathematical Association of Nigeria (MAN) once declared a War Against Poor Achievement in Mathematics (WAPAM). Unfortunately, WAPAM achieved little in reversing the trend of poor mathematics achievement in Nigerian secondary schools. Thus, this paper aims to proffer a new strategy towards reversing the trend.

To achieve its aim, the remainder of the paper is organized in the following manner. The next section builds up a theoretical framework for the study. Section 3 outlines the investigation methods. Section 4 presents the results. Section 5 concludes the paper.

II. –Theoretical Framework

1. Poor performance in mathematics in nigeria

Poor achievement in mathematics in Nigerian secondary schools has assumed alarming proportions and caused a lot of concern for many years. [Adeniji (1998)] and [Amoo (2001)] have expressed similar tales of woes about low achievement in mathematics in Nigerian secondary schools. This problem is clearly evident in the following table.

Table 1 – Performance in Mathematics in West African School Certificate Examinations (1995-1997)

Year	Entry	Candidates who sat for the exam	Credit 1 – 6	Pass 7 – 8	Fail 9
1995	466971	462273	76080	185931	200262
	%	99	16.5	40.2	43.3
1996	519656	514342	51587	190899	272356
	%	99.07	10.01	37.07	52.9
1997	621844	616923	47252	161526	408145
	%	99.2	7.65	26.18	66.16

Source: Amoo (2001)

From the table, failure in mathematics (F9) increased from 43.3% in 1995 to 52.9% in 1996, and then increased again to 66.16% in 1997. The seriousness of the adverse implications of these results is better appreciated when one glances through the mathematics admission requirements for Nigerian universities, as shown in the next table.

Table 2 – Mathematics Admission Requirements for Nigerian Universities

S/N	Faculty	Number of courses available	Courses needing mathematics	% Needing mathematics
1	Administration	14	11	79
2	Agriculture	36	36	100
3	Arts	56	0	0
4	Education	73	42	58
5	Engineering	53	53	100
6	Law	6	0	0
7	Medical Sciences	15	15	100
8	Science	60	60	100
9	Social Sciences	27	10	37
Total		340	227	67

Source: Joint Admissions and Matriculation Board (1998)

From the table, out of 340 courses available in Nigerian universities in 1999 / 2000 academic session, 227 courses (67%) needed a credit (1-6) pass in mathematics for any student to be considered for admission.

While Table 1 shows that the percentage of students with credit pass in mathematics dropped from 16.5% in 1995 to 10.01% in 1996, and further dropped to 7.65% in 1997, Table 2 shows that, in the faculties of agriculture, engineering, medical sciences and science, all courses required credit pass in mathematics as an admission requirement. It is therefore obvious that, though mathematics is very important in the Nigerian educational system, the performance in mathematics has been very low. This problem of very low mathematics achievement could adversely affect national development, especially in science and technology.

2. *Manipulatives – a plausible panacea for poor performance in mathematics*

According to [National Science Foundation (2002)], manipulatives are materials designed to provide concrete experiences that can help students make the link between mathematical concepts and the real world. They are objects that aid children in visualizing mathematical processes. However, they are also useful in adult education. In the main, improvised geometric manipulatives are made from ordinary cardboard paper. This makes them cheap and easily available. Teachers, and even students, can easily produce a good number of them locally. However, analyzing the effective application of improvised manipulatives, [Ivowi (1999: 483)] has cautioned that the practical nature of science and mathematics needs to be emphasized in order to enhance their functionality as a means of instruction.

If the use of simple improvised geometric manipulatives in this present study is found to be significantly effective in improving mathematics achievement in Nigerian secondary schools, then their widespread use could revitalize mathematics education in Nigeria and, by implication, other developing countries having similar characteristics. For any developing nation, more success in mathematics education would have the long-term effect of greater national development, especially in science and technology.

III – Investigation Methods

To analyze the possibility of harnessing geometric manipulatives as a revitalization strategy for mathematics education in Nigeria, an experiment was conducted in Edo State using a multistage sample [(Eze, 1999: 55)] of students in three secondary schools – Momodu College (MC), Agbede (mixed),
Girls Model Secondary School (GMSS), Ubiaja (girls only), and Immaculate Conception College (ICC), Benin City (boys only).

1. *Research instruments*

The instruments for the research were a testing instrument, Mathematics Achievement Test (MAT) and a treatment instrument, Simple Improvised Manipulatives (SIM). MAT was a multiple-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 (Table 3).

Table 3 – Specifications for MAT

Mathematics Areas	**Recall of Information**	**Understanding Concepts**	**Application 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 on thirty-one students in a pilot test. Kuder-Richardson formula (KR21) was applied to scores in order to measure internal consistency.

The internal consistency coefficient was 0.79; and this 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 0.82 as test-retest reliability coefficient for MAT. Again, this was considered high enough to accept MAT as a reliable research instrument.

The treatment instrument (SIM) comprised 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) and four solid shapes (cube, cuboid, triangular prism, and cylinder).

2. Data collection

Data collection started with a pretest administered to students in an experimental and a control group. The pretest scores were carefully kept aside for future use. After the pretest, ten weeks of teaching followed. During this period, students in the experimental group were taught with SIM; while students in the control group were taught without SIM. Special care was taken to ensure that, in each school, the same mathematics teacher taught the experimental group and the control group. This was to eliminate what is known as the "*teacher effect*". Another teaching precaution was to ensure that whenever one group was having a mathematics class, the other group was occupied by another teacher. This was to ensure that students did not study mathematics in a class that was not theirs. After the pretest and ten weeks of teaching, a posttest was given to all students in the experimental and control groups. The posttest scores were collated for analysis in conjunction with the pretest scores.

Table 4 shows the distribution of students in the experimental and control group in the three schools where the research took place. The experimental group comprised ninety-four students; while the control group comprised ninety-one students.

Table 4 – Distribution of Students in the Experimental and Control Group

Group	ICC	GMSS	MC	**Total**
Experimental Group	36	36	22	94
Control Group	33	35	23	91
Total	69	71	45	185

It is noteworthy that though the validated MAT was used for both pretest and posttest, this was done with three precautions. The first precaution was that MAT was administered to students in two versions. The second version was a rearrangement of the question numbers and alternative answers in the first version. Thus, question 5 with correct answer E in the first version could become question 23 with correct answer C in the second version. The second precaution was aimed at minimizing the chances of obtaining fake scores from students who merely copy from their neighbors. In order to achieve this, question papers were given to students in a checkerboard fashion as illustrated in Table 5. In the table, '1' applies to students taking the first version of MAT, while '2' applies to students taking the second version of MAT.

Table 5 – 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	2	1	2	1	2	1	2	1	2
2	1	2	1	2	1	2	1	2	1

Checkerboard arrangement of question papers guaranteed that each student was surrounded by other students writing a different version of MAT. The third precaution was that no student wrote the same version of MAT for pretest and posttest.

3. Data analysis

Statistical analysis of pretest and posttest scores was carried out by means of SPSS computer software. The independent samples t-test [(Warner, 2008)] was the statistical method adopted. During the data screening process, extreme outliers were identified and expunged from the data set. All the various assumptions of the independent samples t-test were satisfied.

IV. The Results

Table 6 – T-test Results for Pretest Scores

Group	Number of Students	Mean	Standard Deviation	Degrees of Freedom	T-Calculated	T-Critical	Decision
Experimental	94	8.74	5.37	184	0.09	1.96	Insignificant difference
Control	91	8.81	5.18				

Table 6 shows that, at the pretest level, the calculated t value (0.09) was very much below the critical t value (1.96). This also had no effect, as indexed by $?^2$ [(Warner, 2008)]. Therefore, there was no significant difference between the mean score (8.74) of the experimental group and the mean score (8.81) of the control group, implying that the experimental and control groups were equally matched (academically) at the pretest level.

Table 7 – T-test Results for Posttest Scores

Group	Number of Students	Mean	Standard Deviation	Degrees of Freedom	T-Calculated	T-Critical	Decision
Experimental	94	11.70	5.26	184	2.23	1.96	Significant difference
Control	91	9.89	5.77				

Table 7 shows that, at the posttest level, the calculated t value (2.23) was greater than the critical t value (1.96). The effect size, as indexed by ?^{2} [(Warner, 2008)], was .026; this was a medium effect. This implied the existence of a significant difference between the mean score (11.70) of the experimental group and the mean score (9.89) of the control group. The experimental group was statistically superior to the control group in mathematics achievement at the posttest level, suggesting that students taught with simple improvised geometric manipulatives perform better than other students, ceteris paribus.

V. – Conclusion

Based on the finding of this study, persistent poor performance of Nigerian secondary school students in mathematics need not continue indefinitely. There is hope that, with simple, cheap, improvised geometric 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 teaching and learning of mathematics in Nigeria. By implication, massively harnessing them will enhance the nation's development strides in science and technology.

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