Comparative Analysis Of Students' Performance In Geometry Taught Through Manipulative And Conventional Methods Of Teaching: An Implication For Curriculum Development

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Abstract: The paper examined the performances and views of Senior Secondary School Students taught using conventional (textbook) and manipulative methods towards solving exercises related to the circle theorem – the angle that an arc of a circle subtends at the center is twice that which it subtends at any point on the remaining part of the circumference. 168 Students were sampled and divided in to two groups by giving them numbers 1, 2; 1, 2; 1, 2, then all 1s formed group I and all 2s formed group II. Group I were considered as control group to which the conventional (textbook) method was applied during instructions. Thus, the researchers revised the concept of circle, stated the theorem, proved the theorem and then solved examples. Group II were the Experimental group (manipulative group) to which the concept of circle was revised and then the students were asked to draw different circles, mark arcs, draw angle at the center, angle at the circumference then measure the angles drawn. The students were asked to explain what they can infer from the angles measured, and lastly examples were solved. During the second contact, both groups were subjected to solving exercises in the classroom related to the theorem - the angle that an arc of a circle subtends at the center is twice that which it subtends at any point on the remaining part of circumference. At the same time, they were asked to comment freely on the methods used. The solution to the exercises were marked, the scores were analyzed using mean, standard deviation and t- test. Moreover, effect size was computed using Macrucci's method. The results showed that there was significant mean difference between the two methods in favour of manipulative method. Based on the findings, it was recommended that teachers should adopt manipulative method in teaching geometrical theorems.

Keywords: Circle theorem, control group, experimental group, conventional (textbook) method, manipulative method.

I. INTRODUCTION

Despite the relative importance of Mathematics, it is very disappointing to note that the students' performance in the subject in both internal and external examinations has remained consistently poor (Adolphus, 2011). The chief examiners' annual reports in Mathematics in the Senior School Certificate Examinations (SSCE) conducted by the West African Examinations Council (WAEC) and National Examinations Council (NECO) are good testimonies of the Facts that the poor performance is affecting the parents, government and the teachers themselves (Obodo, 2000).

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. Students' mass failure in public mathematics examinations has always been confirmed by the West African Examinations Council's chief examiner's report (WAEC, 2011).

This paper tried to look into two different methods of teaching on proving one of the circle theorems in geometry. The teaching of Geometry has been so influenced by Euclid's work that most secondary students have thought of "proofs" and "Geometry" as synonymous (O'Daffer and Clemens, 1977). A proof can be defined as "the process of reasoning from a set of premises through a series of connected inferences to a conclusion, in such a way that any doubt about the conclusion must be referred back to the premises, rather than to the logical necessity of the inferences" (Driscoll, 1988, p.155). Instead of considering the methods as deductive and inductive methods, the researchers used (conventional) textbook method and the manipulative method. These two methods have been described in the following ways; The conventional (traditional textbook) method of teaching geometry at the middle school level, consists of one unit of formal proofs, contained within general Mathematics text, and taught for a very limited amount of time, (approximately one month) (Shaughnessy and Burger, 1985). The conventional (textbook method) depends heavily on rote-memorization along with worksheets and homework exercises (Suydam, 1985)

The manipulative method (non-traditional) recommended by NCTM (1989) consists of a less formal geometric approach emphasizing the direct use of manipulative materials to study geometric shapes and their translations, reflections, and rotations (Suydam, 1985). Manipulative materials are objects which can be used to represent mathematical concepts. They can be touched, rearranged and moved about. These objects can be devices which are utilized daily, such as measuring instruments or rulers, or they may be specifically designed materials to aid in the instruction of mathematical concepts, such as blocks or geo boards (Kennedy, 1986).

STATEMENT OF THE PROBLEM

There is no doubt that everybody believes mathematics is important; however, many students have a poor mathematics skill which indicates that changes are needed in the methodology of teaching mathematics. Related to the changes, there is a growing consensus around the use of manipulatives in instructional practices. The use of manipulatives can be traced to Piaget's (1952) suggestion that children cannot comprehend abstract mathethematics through explanations and lectures; therefore, they need experiences with models and instruments in order to grasp the mathematical concepts. Lindorth, Reimer & Moyer (2005) and Sherman & Bisanz, 2009 observed that many researchers suggest the use of manipulatives in solving mathematics problems as a result of their positive learning effects on all students, and in particular on struggling students. Depending on the student's identified learning ability, teachers may use appropriate manipulative objects to bring mathematics to life and to make the invisible mathematics concepts visible. Experience with manipulative materials, regardless of the developmental level of the

students, aids in providing a strong foundation for conceptual understanding whether it be counting skills or the understanding of properties and relationships (Moses, 1986). The Van Hieles strongly emphasized the use of manipulatives when teaching geometry to help facilitate the transition from one level to the next (Fuys, Geddes and Tischler, 1988). It is in the light of this assertion that we carried out research work of comparing the achievement of two groups of learners.

OBJECTIVES OF THE STUDY

The main objective of the study is to find the effect of the manipulative method over traditional textbook method.

RESEARCH QUESTION

Is there any significant difference in the mean scores of achievement test of students taught using manipulateve method over those taught using conventional (textbook) method?

HYPOTHESIS

There is no significant mean difference between the geometry achievement test scores of students taught using the manipulative method and those taught using the conventional (text book) method.

POPULATION

The population of the study involves all the senior secondary school students of Katagum Local Government Area consisting of three districts- Azare, Chinade and Madara. Precisely, SSII students of all the secondary schools from Azare, Chinade and Madara districts totalling three thousand and twenty four (3,024) formed the population of this study. (Katagum Zonal Education Authority, 2018).

SAMPLE AND SAMPLING TECHNIQUES

Three schools, one from each of the three districts were randomly selected as the sample schools. The sample of the study consisted of 168 students, 56 drawn from each of the Senior Secondary Schools of Azare, Chinade and Madara districts. The students of two classes were asked to form a line and were given numbers 1,2, 1, 2, 1,2 and instructed that all 1s formed group I (Control group) while all 2s formed group II (Experimental/manipulative group). Both groups had comparable socio-Economic and ethnic background as well as comparable mathematics grades. Both groups had comparable male-female ratios and were instructed by the same teacher.

DELIMITATIONS

The content instructed and tested was limited to angles involving the famous theorem; Angle subtended at the centre of a circle is twice that which it subtends at any point on the circumference.

INSTRUMENTATION

The questions used in assessing the students were drawn from New General Mathematics for West Africa Senior Secondary Book 2.

VALIDITY

The questions were faced validated by senior mathematics Educators from Aminu Saleh College of Education, Azare, Bauchi State Nigeria.

TREATMENT

The control group (Group I) were taught using conventional (textbook) method likely to be deductive method through the following procedure:
- ✓ The theorem – angle at the centre of a circle is twice angle subtend at any point on the circumference was stated
- ✓ The stated theorem was logically proved
- ✓ The theorem was applied in solving examples i.e many examples were solved.

On the other hand, the experimental or manipulative group was a learner centred lesson; the students were asked to use the available manipulatives (pair of compasses, ruler, pencil, protractor etc) and draw different circles with centre O.
- ✓ Locate points A, B and C on the circumference of the circle drawn
- ✓ Asked to join A to O, B to O then A to C and also B to C as well
- ✓ Measure the angles <AOB and <ACB.

II.   ANALYSIS OF THE QUESTIONS ASKED

Apart from the solutions to the questions on circle geometry, the students were asked to express their views on the method of teaching each group was subjected to during the instruction. Their views are shown below;

IS THERE ANY DIFFERENCE BETWEEN THE TEACHING AND THE USUAL WAY YOU ARE TAUGHT IN THE MATHEMATICS CLASS?

Most of the students in group I (those taught using the usual textbook means) responded that they did not see any difference from the way they had been taught mathematics. While some of the responses from group II that were taught through manipulative means stated as follows:
- ✓ The way we were taught was very simple and clear unlike the usual teaching
- ✓ Teaching is different
- ✓ Yes, there is difference between teaching and the usual way.
- ✓ Yes, because in that lesson there are equipment or instrument that help the students to understand
- ✓ Yes, because the method is different, I understand higher than before.

Also, many students in group II simply responded '*yes*' without adding anything.

GIVE ANY TWO DIFFERENCES BETWEEN THE TEACHING AND THE USUAL WAY YOU ARE TAUGHT, (IF ANY).

Majority of group I students responded '*No difference*'. However a student responded, '*expanding solutions and wider or long method when solving, lack of teaching materials like circumference drawer and other mathematical instruments.*'

While Reponses from group II were as follows:
- ✓ You come with materials
- ✓ You always ask questions
- ✓ You taught us how to measure angle with protractor
- ✓ The learning is active
- ✓ There are practical instruments while in the past there were no practical instruments
- ✓ They grouped us in this lesson but in the past they taught us in rows

WHAT PROBLEMS DID YOU HAVE IN THE LESSON?

Majority of the students in both groups responded that there were no problems.

WHAT DO YOU THINK A STUDENT NEEDS TO KNOW BEFORE THE LESSON?

Some students from group I responded that they needed to;
- ✓ Practice
- ✓ do research
- ✓ have more explanation on how to solve problem
- ✓ know main points on the topic
- ✓ open their books and bring out their calculators
- ✓ think *about how to solve circle.*

While, Majority of group II students responded that; '*a student needs to have materials*'.

WERE YOU BUSY DURING THE LESSON?

Majority of group I students taught using deductive process responded '*No*', while majority of group II students responded '*Yes*'.

WAS THE LESSON INTERESTING OR NOT?

Responses from both groups indicated the common answer "*yes very interesting*"

STATE ANYTHING THAT YOU SEE INTERESTING

Some responses from group I were:
- ✓ Asking question and answering it in the way we understand
- ✓ Showing a diagram make me understand the lesson.
- ✓ The teacher smiles a lot
- ✓ The advices given by the teacher were encouraging
- ✓ While responses from group II indicated that:
- ✓ Now we know how to measure a circle
- ✓ The teacher used simple method of teaching

- ✓ The way you come with materials for teaching i.e. ruler, compass, pencils and others
- ✓ There is nothing that I did not want in the lesson, but what interested me in the lesson is that the kind of method of your teaching is good and it makes the student to understand very well. And you are explaining step by step which the learner will understand clearly.
- ✓ The way the lesson was going on was interesting
- ✓ I want everything about the lesson
- ✓ I want to be a good mathematics student that is why I have interest about mathematics
- ✓ I am very happy with the lesson because I have problem on circle geometry, but now I understand it.
- ✓ I am understanding very well
- ✓ I have never done this measurement before
- ✓ Your way of teaching

III. RESULT

Ho_1: There is no significant difference between the geometry achievement test scores of students taught using the manipulative method and those taught using the text book (deductive) method.

Post – test	N	$\bar{x}$	δ	T_{cal}	T_{crit}	df	P	Remark
Group I 0.7325 2..0086	84	4.04 5.46	1.88 1.84	2.881	1.645	166	0.00	Significant
Group II	84	5.46	1.84					

Table 1: t – test on achievement scores of students in circle geometry test

From table 1 above, at α = 0.05 level of significance T_{cal} = 2.881 >T_{crit} = 1.645 at df = 166 showed that there is significant difference between the geometry achievement test scores of students taught using the manipulative method and those taught using the textbook (deductive) method. Also, since the p value = 0.00 is less than the α = 0.05, this shows presence of significant difference.

IV. DISCUSSION

The result revealed that students taught using manipulative method performed better than those taught using conventional (textbook) method. This can be seen from the mean score of the two groups; experimental group has a mean score of 5.46 while the control group has a mean score of 4.04, which shows a difference of 1.42 in favour of the experimental group. The result affirmed the findings of (Nahid, 2013) that the use of manipulatives has direct effect on the students' learning, in particular, on the struggling students; it is also in line with the suggestion of Lindorth, (2005); Reimer & Moyer, (2005); Sherman & Bisanz, (2009) that the use of manipulatives in solving mathematics problems improves the performance of students as a result of their positive learning effects.

Based on the comments by the students, one can infer that group II students were happy with the new method, especially with the expression that materials were used and this made

them interested in the lesson. Also, group II students responded that they were busy during the lesson using the manipulatives. However, group I said that they were not busy that shows they were passive. This could be part of the the the reasons why some students detest mathematics and, geometry in particular.

V. CONCLUSION

The findings of the study showed that students taught with manipulatives have advantages over students taught using the non – manipulative method. Allowing students to experiment, investigate, and play with geometrical ideas and figures has the potential to increase their performances. Neglecting manipulatives make the students passive and slows their spirit of learning.

VI. RECOMMENDATIONS

Based on the findings, we recommend the following;
- ✓ The use of manipulatives in teaching mathematics in general and geometry in particular will make students to be active, interesting and increase their performance in the subject.
- ✓ Parents, Institutions and Government should make provisoins for manipulatives to students for effective teaching and learning Mathematics.
- ✓ Group work should be encouraged while teaching mathematics as against teaching in rows.
- ✓ Teacher friendliness makes learners to feel free and participate actively in the Mathematics lessons.

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