The Effect of Ethnomathematics on Junior Secondary School Students' Achievement and Retention in Geometry in Benue State, Nigeria: A Corona Virus Pandemic Case Study

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Abstract: **Training programmes in Nigeria at secondary school level concentrated more on foreign knowledge without considering the various cultures and traditions of the different tribes that make up these secondary schools. This paper therefore examined the effect of ethnomathematics on Junior Secondary School students' achievement and retention in geometry in Benue State, Nigeria: a corona virus pandemic case study. Quasi-experimental of non-equivalent control group design was adopted in this study. Two research questions guided the study and two null hypotheses were formulated and tested at 0.05 level of significance. The 25-item Geometry Achievement Test (GAT) was used for data collection. The instrument was administered to 30 students for trial testing and subjected to test re-test reliability estimate to obtain the reliability coefficient of 0.71. Simple random sampling was adopted to select two schools out of the 35 Junior Secondary School two (JSS2) students' population of 7242. Intact classes from the two schools were purposively selected to obtain a sample of 137 JSS2 students and were randomly assigned to experimental (N=72) and control (N=65) groups. The experimental group was handled by the informal school research assistants while the usual class teachers handled the control group via radio in line with corona virus (Covid 19) safety guide lines. Students were pre-tested to ascertain initial entry point, after six weeks post-test was administered to the two groups for achievement and two weeks later the retention test was carried out. Mean and standard deviation were used to answer the research questions, while the Analysis of Co-variance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings from the statistical analysis showed, significant difference on achievement (F1,136 =711.461) and retention (F1,136 =2.923) of students' in favour of those taught geometry with ethnomathematics compare with those taught with the lecture method.**

Keywords: **Ethnomathematics; Achievement; Retention; Geometry. Junior Secondary School Students**

I. INTRODUCTION

Mathematics is an important human endeavour and has many educational values aside from its technological importance. First, it offers a vast number of structures such as numbers, algorithms, shapes, ratios, functions and data that are useful in understanding physical realities. Secondly, mathematics is a human activity built upon intuitive understandings, cultures and agreed conventions that are not eternally fixed and that its frontier is covered by many unanswered questions. Thirdly, mathematics encourages settling arguments by evidence and proof. Finally, mathematics demonstrates how important it is to subject a familiar thing to detailed study and to study something that seems hopelessly intricate (Abonyi, 2016; Kurumeh, 2006).

Owing to the importance of mathematics, every society has an instinctive kind of mathematical knowledge - that is ways of counting, measuring, relating, classifying and inferring. Unfortunately, much of this knowledge has been ignored in the formal school mathematics curriculum. To a large extent educators do, in fact, determine who studies school mathematics and by extension, who will have careers in mathematics and what the legitimate products of mathematics will be. This is worsened by the present idea of Joint Admission and Matriculation Board (JAMB) granting admission to students to enter courses for which they never applied nor are qualified. University Heads of Department leaving their trained careers to become administrators' overnight. Therefore, groups about whom educators are uninformed are bound to receive inequitable treatment in learning. While professional inequities also exist in deciding who will be recognized - credentialed, published, awarded foundation grants and other honours - perhaps the greatest injustice is in encouraging dependency by doing for others what they can do better for themselves. In this way, considerable resources have been consumed by many for personal gain without making any appreciable positive impact on the conditions of those for whom they speak. The persistence of these inequities often lies in the politics of gender, race, tribalism and ethnicity.

The Benue people which comprise the Tiv, Idoma, Igede and Etulo tribes practiced river valley agriculture along several of the rivers that descend from the Cameroon Mountains. They are engaged in all types of farming and had quite mathematical artwork. Some indication of Benue people's understanding of geometry can be seen in the lines and figures they created in their farms. It is still not clear what the lines represent, but there are connections between many of

the lines and ritual of the Benue people. They did not use a writing system as we know in foreign cultures.

Moreover, the subject of how the Benue people created and maintained complexity in terms of society, government, and economy without communication through what we would consider a writing system is one of active debate. The Benue people represent a mathematically based system of information keeping that could well have served in place of writing. Furthermore, it is also worth to note that the Benue people made use of oral tradition, whereby information, history, and social practice are passed along via oral descriptions. From their number words we can deduce that the Tiv people for instance counted in bases other than ten. That is they don't use a decimal system. Counting in the Tiv culture is done from 1,2,3,4,5,6,7,8,9,10,20,40,60,80,100,200 and so on. That is base twenty.

It is against this background that in mathematics education, ethnomathematics is referred to as the study of the relationship between mathematics and culture(Kurumeh, 2006); often associated with "cultures without written expression". It may also be defined as "the mathematics which is practiced among identifiable cultural groups" (D'Ambrosio, 1984). It refers to a broad cluster of ideas ranging from distinct numerical and mathematical systems to multicultural mathematics education(Malloy, 1997). The goal of ethnomathematics is to contribute both to the understanding of culture and the understanding of mathematics and mainly to lead to an appreciation of the connections between the two.

The term "ethnomathematics" was introduced by the Brazilian educator and mathematician Ubiratan D'Ambrosio in 1977 during a presentation for the American Association for the Advancement of Science. Since D'Ambrosio put forth the term, many researchers - D'Ambrosio included - have struggled with its meaning ("An etymological abuse leads D'Ambrosio to use the word *ethno* to refer to Ethnic" or "cultural context" and *mathema* to mean "to explain" or "to know" or "understand" and *tics* from "techne"). Omenka, (2013) defined ethnomathematics to include the documentation and study of cultural related learning style. In his submission, Masingila, (1997) examined how people learn and use mathematics in distinct cultures and in everyday situations within cultures. In this context, Masingila, (1997) think of culture as acquired knowledge transmitted among groups. It is shared meaning but not necessarily consensus. It includes taken-for-granted values and beliefs seen in what people do, what they know, and the tools they use (Malloy, 1997). From this concept of culture, race is not a proxy for culture and "ethno" in ethnomathematics is not a proxy for ethnic.

Since ethnomathematics is oriented to the masses and the multitude of ways in which mathematical ideas are used on a regular basis in the community, the concept expands our understanding of what mathematics is and of who creates it. In ethnomathematics the focus is on the concepts and techniques actually used by a cultural group rather than the possible mathematical theories available (Abonyi, 2016). The concepts and techniques are usually learned without formal schooling but are actively transmitted from one generation to another. Through this cultural interaction, there develops an instinctive kind of common mathematical knowledge among adults and children who belong to the same cultural group (Gilmer, 1985).

An ethnomathematics curriculum would develop from activities in the learners' surroundings and move seamlessly into the formal school as the process of inducting young people into mathematical aspects of their culture. A mathematics curriculum oriented to the ethnomathematics of the learners' culture would respond to the needs of increasing numbers of students who feel like failures for not understanding something few of them will ever use but without which there is the perception of a bleak future for them. If we acknowledge that mathematics is not culture free, then mathematics educators might be transmitting the values of a single culture (foreign culture) while teaching children of many cultures in the same classroom. What are the consequences of mathematics learning for children whose cultural experiences are being ignored? The consequences might be mass failure and disaffection with the subject owing to cultural conflicts or school failure, since students develop different models for understanding mathematics based upon their cultural backgrounds and experiences.

In geometry, students study sizes, shapes and positions of shapes and figures (Kurumeh, 2006). However, geometry is used daily by almost everyone. We use geometry to explore spatial sense and geometric reasoning. Geometry is therefore found everywhere: in art, architecture, engineering, robotics, land surveys, astronomy, sculptures, space, nature, sports, machines, cars, agriculture and much more. Since the people of Benue State are predominantly farmers and their social organization and traditional life is completely egalitarian the need for this study in this period of corona virus (Covid 19) pandemic is increasing. Furthermore, they are the best storytellers in Africa with geometric and artistic marks good for ethnomathematics that need to be investigated. They are known for their dance craft, poetic creativity and general aesthetic profundity. Benue Music and Communication is also full of geometric instruments for the researchers' investigation. It is against these backdrops that this study determined the effect of ethnomathematics on Junior Secondary School students' achievement and retention in geometry in Benue state considering all the safety protocols of covid 19 pandemic.

Theoretical Basis of the Study

Ethnomathematics which is the main focus of this study stems from constructivist theories in its formation and emphasizes on the development of social skills that enhance learning. This study was not only based on knowledge and learning but on the culture and social skills which stimulates learning.

Vygotsky (1978) postulated his socio-cultural theory which looks at the role culture and social interaction play in the cognitive development of children. He feels social interaction influences cognitive development and observes that as the child interacts with his social environment, he acquires knowledge which becomes the content of his thinking. Through this interaction, the child acquires the means of thinking from the culture he lives, which to Vygotsky are the cognitive tools needed for development. Vygotsky believes there should be no room for the traditional, teacher-centered approach to education. The theory does not expect teachers to do the cognitive work on behalf of the learner, rather, it suggests a situation in which the teacher presents a problem to be solved, and is willing to engage the learner in active and meaningful learning. The teacher therefore, acts as a facilitator of knowledge, leaving children to discover on their own. The theory calls for active teaching and learning through engagement of the learner in meaningful activities from their cultures. According to him without comprehension, teaching and learning is useless and fruitless as it cannot result in the retention of information.

The implication of the theory for mathematics education is that it emphasizes that an alternative teaching method such as ethnomathematics should be used to encourage children's cognitive development especially in a pandemic situation that warrant social distancing and geometric shapes like squares, rectangles, trapezoids, parallelograms and triangles among others. The ethnomathematics which the present study used could provide learners the opportunity to learn the values of more than one culture and share it as they interact with one another during ethnomathematics activities. The mathematics concepts, selected for the present study were perimeter and area of a square, a rectangle, a parallelogram, a trapezium and a triangle which are all within the formal operational level. Others include symmetries, volume of cylinders, angle properties of parallel lines, angle at the point of intersecting straight lines and at a point. The JSS 2 students found it challenging as many of the concepts are beyond their level of competence while they must have come in contact with some foundational concepts to the topics. This is in line with Vygotsky's idea that learners should be provided with learning activities that are ahead of their level of competence but within their zone of proximal development, in order to promote cognitive growth.

The theory of Vygotsky therefore, provides a convincing framework for the present study as it recognizes the child as being active and in a culture. This is so as it pays much attention to the social and cultural influences on the child's cognitive development which plays a significant role in the cognitive development than on the physical maturation of the child. The learner'svalues of their cultures are shared instead of foreign cultures as they interact with others who help to provide perspectives for cognitive growth. The theory therefore, forms a base on which this study can be anchored.

Research Questions

The following research questions were answered in the study:

1. What are the mean achievement scores of JSS2 students taught geometry using ethnomathematics and those taught with lecture method?
2. What are the mean retention scores of JSS2 students taught geometry using ethnomathematics and those taught with lecture method?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance

HO1: There is no significant difference between the mean achievement scores of JSS2 students taught geometry using ethnomathematics and those taught using lecture method.

HO2: There is no significant difference between the mean retention scores of JSS2 students taught geometry using ethnomathematics and those taught using lecture method.

II. METHODOLOGY

The design adopted for the study was Quasi-experimental, specifically non-equivalent control group design. The study was carried out in Benue State having the total population of 35 schools with 7242 Junior Secondary School two (JSS 2) students for the 2019/2020 corona virus pandemic academic session. In this design, intact non-equivalent classes were used because it was not possible to complete randomization of the subjects. Simple random sampling and purposive sampling were used in selecting the sample for the study. Simple random sampling was adopted to select one educational zone out of the three zones from which one local government area (LGA) was selected. Two schools were purposively selected from the LGA due to the availability of qualified informal mathematics teachers and students having written Basic Education Certificate Examination (BECE) for at least five years. A sample (N =137) of JSS2 students of two streams intact classes each from the two schools were selected by simple random sampling and the schools randomly assigned to experimental (N=72) and control (N=65) groups.

The main instrument used in this study to collect data was the 25-item Geometry Achievement Test (GAT) which was used for pretest, posttest and retention where items were reshuffled to have three similar forms of the instrument. The reliability coefficient of 0.71 for the GAT was determined using test re-test reliability estimate hence instrument was used for data collection in the study. Mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Experimental Procedure

The qualified informal mathematics teachers used as research assistants, made up of farmers, weavers and traders were invited to the sampled school to assist in teaching using ethnomathematics for the experimental group. The farming

teachers took the intact experimental group class to the school farm for their lessons for two weeks. These research assistants directed the students to first weed their farms in various plane shapes. Then make big heaps that divide the entire farm in the middle according to the counting base of their tribes. The Tiv tribe members made a twenty heap per a line according to their base twenty mode of counting. This followed by the making of smaller heaps to produce several lines emanating from the big heaps such that the perimeters and areas of the various portions of land so weeded were measured. The total number of heaps at length side was multiplied with the total number of heaps at the width side to obtain the areas of the squares, rectangles, trapezoids, parallelograms and triangles putting into consideration a height were needed. The other tribes in the experimental group also made their farms according to the base in their cultures respectively. Similarly, the perimeters of these different farms was obtained by adding up the number of heaps that made up the sides of the squares, rectangles, trapezoids, parallelograms and the triangles so made.

The weavers also took this same experimental group class for their lessons the third and the forth weeks. Under the shade of trees the weaving teachers were sited. They watched over the group, but at the same time their bodies were subtly swaying and their hands were busy moving threads. These teachers were weaving. As they talk among themselves, calculations were occurring: 40 × 2, 20 × 2, 10 × 2 among others. On their weaving tools symmetric patterns of geometric and animal figures were slowing emerging, produced from years of experience in counting and understanding symmetric properties. The procedures they follow have been instructed to the students verbally as has been done for thousands of years, and they follow it precisely, almost subconsciously. They were doing mathematics. They were calculating pairs of threads in blocks of tens (10, 20, and so on) and determining which colors of threads must go in which places so that half of emerging figures will be exactly copied across an axis of symmetry. These teachers and some students, who had already learnt this act of weaving, were not writing down equations or scratching out the calculations on a notepad. Remarkably, the weaving was done from memory.

The concept of symmetry was also demonstrated further by allowing students who were plated to confirm their hair styles from a mirror thereby enabling the teachers to explain in details the geometry concept or symmetry properties in terms of lines, rotations and so forth. The cultural part of this is to ask questions like: What can we deduce from the lines or symmetry properties used in a particular cultural group? How do the farmers or weavers know how to construct the patterns in order that they have such symmetry? And how do the weavers knew how to obtain the widths from the threads? The numbers of threads to be counted in each step of a weaving process was often complicated and must be decided upon ahead of time. The weaver must know in advance what the entire pattern will look like. Once the process starts, what was remarkable was that the weaver does the counting of threads mentally. These were the kind of questions that helped the students to retain what was thought permanently.

The remaining two weeks of the experimental class period were taken by the traders. Using a basin of local cassava flour (gari), the traders demonstrated the volume of a cylinder to be the number of times the conical section of the gari can go in to the entire basin of the gari by slicing it off the basin and knowing its measure and multiplying by six. This was clearly discovered that in any cylinder the volume is six times the area of the conic section.. Next the traders demonstrated the concepts of the Greek symbol pie to mean how many times the length of the diameter of a circle will go into the distance round the circle edge of any instrument they are using in measuring in the market**.** This shows that any measuring instrument in any market chosen as a means of measurement are the same.

Research Question One

What are the mean achievement scores of JSS2 students taught geometry using ethnomathematics and those taught with lecture method?

Table 1: Mean and Standard Deviation of Pretest and Posttest Scores

Group	N	Pre-Test Mean	SD	Post-Test Mean	SD	Mean Gain
Ethnomathematics	72	40.38	5.897	72.61	6.029	32.23
Lecture	65	40.36	2.976	41.66	7.224	01.30
Mean Difference		00.02		30.95		30.93

Results in Table 1 showed that the post-test mean achievement scores of the ethnomathematics group was 72.61with standard deviation of 6.029, while that of lecture method was 41.66 and standard deviation of 7.224.The mean difference between the two groups for the pre-test and post-test were 0 and 30.95 respectively. The mean gains for the ethnomathematics group was 32.23 and that of lecture method group was 01.30. This showed that the mean gain of 30.93 between ethnomathematics and lecture method groups was in favour of the experimental group.

Hypothesis One

HO1: There is no significant difference between the mean achievement scores of JSS2 students taught geometry using ethnomathematics and those taught using lecture method

Table 2: Analysis of Covariance on the Mean Achievement Scores of Students taught Geometry using Ethnomathematics and Lecture Methods.

Source of Variation	Sum of Squares	Df	Mean Square	F	P	Eta Squared
Corrected Model	32779.653	2	16389.826	374.553	0.001	.848
Intercept	5657.710	1	5657.710	129.294	0.001	.491
PRETEST	58.047	1	58.047	1.327	0.251	.010
METHOD	31132.338	1	31132.338	711.461	0.001*	.842
Error	5863.618	134	43.758			
Total	498352.000	137				
Corrected Total	38643.270	136				

* = Significant at P ≤ 0.05

From Table 2, the result showed that the main effect of the ethnomathematics and lecture method on achievement indicated by F value of 711.461 (F1,136 =711.461) is significant. Therefore, the null hypothesis is rejected. There is a significant difference in the mean achievement scores of students taught using ethnomathematics and those taught using lecture method**.**

Research Question Two

What are the mean retention scores of JSS2 students taught geometry using ethnomathematics and those taught with lecture method?

Table 3: Means and SD of Retention Scores for Experimental and Control Groups

Group	N	Pre-Test Mean	SD	Retention Test Mean	SD	Mean Gain
Experimental	72	40.38		79.36	6.206	42.50
Control	65	40.36		33.20	2.756	07.16
Mean Difference		00.02		46.16		35.34

Table 3 revealed that the mean retention scores of the students taught geometry using ethnomathematics was 79.36 with standard deviation of 6.206, while mean retention scores of students taught using lecture method was 33.20 with standard deviation of 2.756. The difference between the mean retention scores of students taught using ethnomathematics method and lecture method was 46.16. The mean gains for the ethnomathematics method and lecture method on retention scores were 42.50 and 7.16 respectively**.** The mean gain difference of 35.34 indicates that the retention ability of the two groups is in favour of the ethnomathematics method.

Hypothesis Two

There is no significant difference between the mean retention scores of JSS2 students taught geometry using ethnomathematics and those taught using lecture method.

Table 4: Analysis of Covariance on the Mean Retention Scores of Students taught geometry using Ethnomathematics and Lecture Method.

Source of Variation	Sum of Squares	df	Mean Square	F	P	Eta Squared
Corrected Model	72793.281	2	36396.640	1.515E3	0.001	.958
Intercept	6407.271	1	6407.271	266.742	0.001	.666
PRETEST	2.263	1	2.263	.094	0.759	.001
METHOD	70208.310	1	70208.310	2.923E3	0.001*	.956
Error	3218.748	134	24.021			
Total	528336.000	137				
Corrected Total	76012.029	136				

* = Significant at P ≤ 0.05

From Table 4, the result showed that the main effects of the ethnomathematics method and lecture method on retention indicated by F value of 2.923 (F1, 136 =2.923) is significant. Hence, the null hypothesis is rejected. Therefore, there is a significant difference in the mean retention scores of students taught using ethnomathematics and those taught using lecture method.

III. DISCUSSION OF FINDINGS

Result of this study showed that mean achievement scores of students taught geometry using ethnomathematics differ

significantly from the mean achievement scores of those taught using the lecture method and that there is a significant difference in favour of the experimental group. The finding is in agreement with Omenka (2013) who indicated significant achievement difference in the mean scores of students using ethnomathematics to affect a conceptual change strategy. Kurumeh, (2006) equally reported positive significant difference in students' achievement scores that were exposed to the ethnomathematics strategy. These could be that, as students focus was on the concepts and techniques actually used by their cultural group rather than the possible mathematical theories available, they gained more knowledge. The idea of considering mathematics to be too abstract was also put away. By so doing the students' had greater understanding of the materials being learned. Their cultural interaction also helped the students to develop an instinctive kind of common mathematics knowledge that could be handed over to their next generation.

This study also revealed that the mean retention scores of students taught geometry using ethnomathematics was higher than that of those taught using lecture method. On retention test, although the experimental group was superior in achievement, the control group was more homogeneous in their scores as observed in the lower value of the standard deviation. This could be as a result of instructions from the teachers only which improved the students' cultural interactions and retention**.**

The finding of this study also supports that of Achor et.al. (2009) who revealed that ethnomathematics is superiority to the lecture method in enhancing students' retention ability. Their findings confirmed that students who were subjected to the ethnomathematics were able to retain the concepts of locus more than those students who were taught using the conventional method. Similarly, Igboko and Ibeneme (2006) posit that the retention scores obtained by the experimental group were higher than the control group. Ethnomathematics therefore, allows the interplay of thought and action with a consequential development of creative and cultural background which could possibly enhance achievement and retention. These findings are completely in line with the finding of the present study.

Moreover, using ethnomathematics during corona virus pandemic period (that distancing from each other during leaning)conforms better to the covid 19 protocols all over the world than the non- ethnomathematics method that love overcrowding in the class room leading to school lock down has solved the big problem of schooling even during lock down periods of covid 19.

Based on the findings of this study, the following recommendations were made:

1. Students should strive to comply with all covid 19 protocols in the learning of geometry to avoid closure of schools in a pandemic.
2. Mathematics Teachers should also strive to use Ethnomathematics methods in teaching of geometry to improve students' achievement and retention.
3. Periodic government sponsored in-service training, in form of long vacation training programmes, workshops, conferences and seminars on the nature, scope and use of ethnomathematics should be organized for Junior Secondary School mathematics teachers in Benue State
4. Curriculum planners and authors of mathematics textbooks should generally reflect the background of a typical Nigerian society. This method of instruction should reflect our education background, culture and philosophy. This will help to generate interest in the learning of mathematics, which is said to be the "foundations of modern mathematics
5. Ethnomathematics should be used in a corona virus pandemic periods to develop students' skills for economic growth.

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