Efficacy of Constructivist's Teaching Method in Proving Mensuration Theorem: Implications for Nigeria Senior Secondary School Students

Unodiaku, Stanislus Sochima
Department of Mathematics and Computer Education, Enugu State University of Science and Technology (ESUT), Nigeria
unodiakustanley@gmail.com

Abstract: The study was conducted to determine the efficacy of the constructivist's teaching method (CTM) on teaching proof of mensuration theorem: a panacea for senior secondary school students' interest and achievement. The population of the subjects was 3095 SSS II students composed of students in secondary schools in the Agbani Education zone of Enugu State. Four research questions and four null hypotheses guided the study. Multi-stage sampling technique was used for the study, based on which 197 students composed of 95 males and 102 females were randomly sampled. Data was collected using Mathematics Achievement Test (MAT) and Mathematics Interest Inventory Test (MIIT). The Cronbach alpha statistic and test-retest methods were used in determining the reliability estimates of the MAT and MIIT respectively which yielded 0.89 and 0.91 respectively. The data obtained with the instruments were analyzed with descriptive statistics (mean and standard deviation) in answering the research questions. The findings of the study clearly showed that CTM is effective in enhancing students' achievement and interest in mathematics learning, especially in proving mensuration theorems. Those exposed to the treatment performed significantly higher than those exposed to the expository method after the treatment. Moreso, those in the experimental group showed a significant difference in mean interest rating in Mathematics than those in the control group after the treatment (post-test). These recorded significant mean differences in achievement and interest of the students after they were exposed to the treatment showing that CTM is responsible for such enhanced increase in performance of the students and their interest. The observed no significant mean difference in performance and interest between male and female subjects shows that CTM is capable of bridging the existing gap in performance and interest in mathematics between males and females.

Keywords: *Constructivist, Mensuration, mathematics, Mathematical Proof, Cylinder and Cardboard Sheets.*

1. Introduction

Over a long period of time now, Mathematics Education researchers have been working relentlessly to determine the best method to reverse the trend of poor performance of students on the subject. For instance, WAEC Chief Examiner (2016) reported that candidates' performance in Mathematics was generally poor; many of the candidates do not apply Mathematical principles correctly and others left their final answers as improper fractions. Previously, WAEC Chief Examiners also reported that candidates' performance in Mathematics is declining and getting worse every year, even though the rate of failure in all subjects appeared to have declined when compared to previous years (WAEC, 2013 & 2014). These seemingly incessant reports on students' poor performance in Mathematics by WAEC Chief Examiners were strongly anchored on teachers' failure.

To use activity-based teaching methods in mathematics instruction to enhance students' achievements in mathematics (Eriyagama, 2018; Pokhrel, 2018; Unodiaku, 2018; FRN, 2013; and Daponte, 2007). For instance, National Policy on Education (NPE), FRN (2013) recommended that to fully realize the goals of education in Nigeria and gain from its contributions to the national economy, the government shall take adequate measures to ensure that mathematics instruction shall be practical, activity-based, experiential and IT-supported. Moreso, in Sri Lanka, primary school Mathematics teachers are encouraged to use activity-based teaching methods (Eriyagama, 2018). According to Unodiaku (2018), activity-based learning appears to be widely used in the recent time in teaching and learning science subjects, particularly mathematics subject. The clarion call/recommendation of activity-based learning upheld that learning can be best.

When it is initiated by the surrounding environment and motivated by giving the learners maximum opportunities for learning to enable them to build or create their meanings and knowledge. Constructivist teaching method belongs to such activity-based in so far, the methods can practically demonstrate an alternative way of proving the mensuration theorems one of which states that the volume of a sphere (in terms

of its radius) is $\frac{4}{3}\pi r^3$. According to Daguplo (2014), the importance of mathematics proofs was elusive to many learners, which make them less appreciative of proof writing activities which increased the difficulties they have in understanding and constructing valid proofs. Many students see mathematics proofs as just some esoteric, jargon-filled technical writing that only a professional mathematician would care about (Daguplo, 2014). For some students, proof writing is a mathematical trick and manipulation that can be learned by memorization only. Some believed that no number of proofs can show how mathematical formulas can be remembered. The above assertions show the negative conceptions students have about learning mathematical proofs of theorems.

The above mindset of the students made them fails to understand and appreciate writing mathematical proofs, thereby losing an insightful understanding of rudiments, concepts and algorithms of mathematical theorems. This situation leads to poor achievement in mathematics among 21st-century learners on mathematics. It is against this notion that the present research on the efficacy of the constructivist teaching method (CTM) on students' performance achievement and interest in mathematics is carried out. According to Kelly (1991), constructivism is a philosophy of education that says that people learn based on their experience, and not by hearing someone give a lecture. Twomey (1989) views constructivism using four principles: learning, in an important way, depends on what we already know; new ideas occur as we adapt and change our old ideas; learning involves inventing ideas rather than mechanically accumulating old ideas and coming to new conclusions about new ideas which conflict with our old ideas. Piaget (1977) believes that learning occurs by active construction of meaning than by passive recipience.

This is to say that a constructivist mathematics teacher and a constructivist mathematics classroom exhibit a number of discernable qualities markedly different from a traditional or normal mathematics instruction classroom. Constructivist mathematics classrooms ought to be democratic, interactive as well as student-centered to enable students to be active and autonomous learners (Resen Blatt, 1978). The constructivist classroom is quite unlike a traditional classroom where the expository method is used and in which students have limited participation. The teacher is the central focus of the students for information transfer and learning is achieved by repetition and memorization whereas, in a constructivist classroom, the student's active participation is encouraged. In the context of proving the mensuration theorem practically, the students are encouraged to learn through the constructivist teaching method (CTM). This research claimed CTM can be modeled and used in teaching and learning proofs of mensuration theorems and formulae, particularly in demonstrating how to arrive at the mensuration theorems and formulae, practically in tenet with the demands of the constructivist's teaching method (CTM).

Problem Statement: The poor achievement of students exhibit in mensuration and mathematics, in general, has been attributed to their inability in understanding and construct proofs of mensuration theorems practically. The difficulty students exhibit in understanding and constructing proofs of mensuration theorems was linked to teachers' use of conventional methods in teaching proofs of mensuration theorems. It could be that teachers are not hands-on with the availability of new method that is practically oriented and activity-based. Due to the paucity or non-availability of the method for teaching and learning proofs of mensuration theorems (formulae) that can encourage active participation and interaction among students in mathematics classes that this study is conducted to determine the efficacy of the constructivist teaching method and interest in proving that the volume of a sphere is $\frac{4}{3}\pi r^3$. The problem of the study put in question form is, how far can the constructivist method of teaching and learning mathematics enhance students' achievement and interest in mathematics?

Objectives of the Study: The major objective of the study is to find out if a constructivist teaching method (CTM) when used as an alternative method to the Expository method, can enhance students' achievement and interest in mathematics learning. Specifically, the study was geared towards investigating:
- If there is a mean difference in the performance of students exposed to the CTM (Experimental treatment) and those exposed to the Expository method before and after treatment.
- If there is a mean difference in the performance of male and female students when exposed to the experimental treatment before and after treatment.

- If there is a mean difference in interest rating in mathematics between male and female students exposed to the experimental treatment before treatment.
- If there is a mean difference in interest rating in mathematics between male and female students exposed to the experimental treatment after treatment.

Research Questions: The study was guided by four research questions as follows:
- What is the mean difference in mathematics performance between students taught with the CTM and students taught with the Expository method before and after treatment?
- What is the mean difference in mathematics performance between male and female students taught with the experimental treatment before and after treatment?
- What is the mean difference in mean interest ratings in mathematics between male and female students taught mathematics using experimental treatment before treatment?
- What is the mean difference in mean interest ratings in mathematics between male and female students taught mathematics using experimental treatment after treatment?

Hypotheses: Four research hypotheses were formulated and were tested at a 5% significant level. They were stated as follows:
Ho$_1$: CTM has no significant effect on students' academic achievements in mensuration before and after treatment.
Ho$_2$: CTM has no significant effect on male and female students' academic performance on mensuration.
Ho$_3$: CTM has no significant effect on male and female students' interest in mensuration before treatment.
Ho$_4$: CTM has no significant effect on male and female students' interest in mensuration after treatment.

2. Materials and Experimental Procedure

Materials used in the conduct of the Experiment were as follows: Cardboard sheets, a pair of compasses, scissors, a ruler, a pencil, liquid gum or paper tape, and a football made of rubber (of any desired size). **Lesson Plan:** Both the experimental and expository methods groups were taught with a lesson plan while the experimental group was taught with CTM in addition to the lesson plan.
Pre-Requisite Knowledge: At the Junior Secondary School level, the students have been taught the volume of cylinders and the volume of a sphere and their properties and their use in problem-solving. The students have gained the previous knowledge that: (i) Vol. of Cylinder = $2\pi r^2 h$ (ii) $\theta h = 2r$.

Experimental Procedure: The procedure used was the art of paper-cutting and folding; cutting rubber balls into two halves and perforating another ball (2nd ball) of the same size as the one cut into two halves. In both experimental and control groups, the subjects in the two groups were taught the same content, by regular class teachers (without any advanced organizer) and subjected to the same pre-testing. This pre-testing of both groups helped to partially out pre-existing differences in mathematics knowledge among the students. Mathematics Achievement Test (MAT) which the researcher developed and subjected to experts for validation was used to pre-test the testees and the scores obtained were used as a covariate measure. The teachers that taught both experimental and control groups were briefed by the researcher to partially out pre-existing differences between the subjects. The purpose of the training was to control teachers' quality variables. Regular class teachers of those in the experimental group were used to teach them using CTM and lesson plans. The Control group (Expository) was taught by their regular class teachers without using any advanced organizer but were taught the same unit which is verifying that the volume of a sphere is $\frac{4}{3}\pi r^3$. The lessons lasted for three weeks and each week two contacts were made with 2 hours for each contact. The procedure for the experiment was organized by taking the following steps below:
Step 1: Cut one of the two identical rubber balls into two halves to form two equal hemispheres (see fig. 1 below). On the other ball, make a small opening on the hollow sphere where you can fill it with sand (see fig. 2 below).

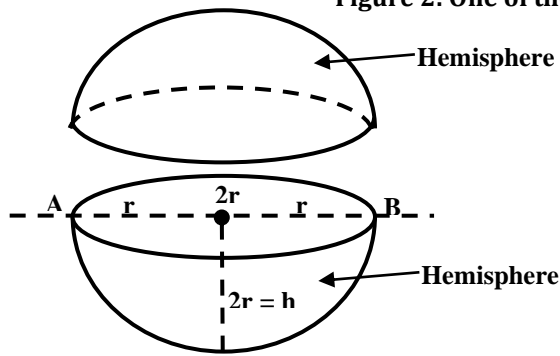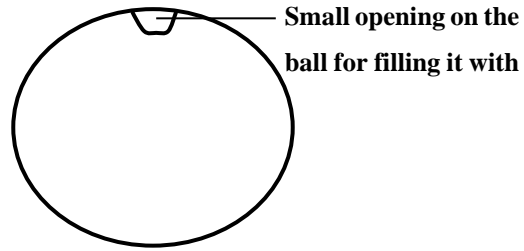**Figure 1: One of the Balls is cut into Halves to form 2 Hemispheres.**
Figure 2: One of the Balls with a Small Opening Made on its Top

On one of the hemispheres, use a ruler and measure the diameter AB i.e. 2r. Note here that half of the diameter (2r) gives the radius (r) of the ball used in the experiment. **Step 2:** Spread two rectangular cardboard sheets on a table and firmly hold them on the table with paper tape (see Fig. 3).

Figure 3: Two Rectangular Sheets Spread on a Table and Firmly Held with Paper Tape
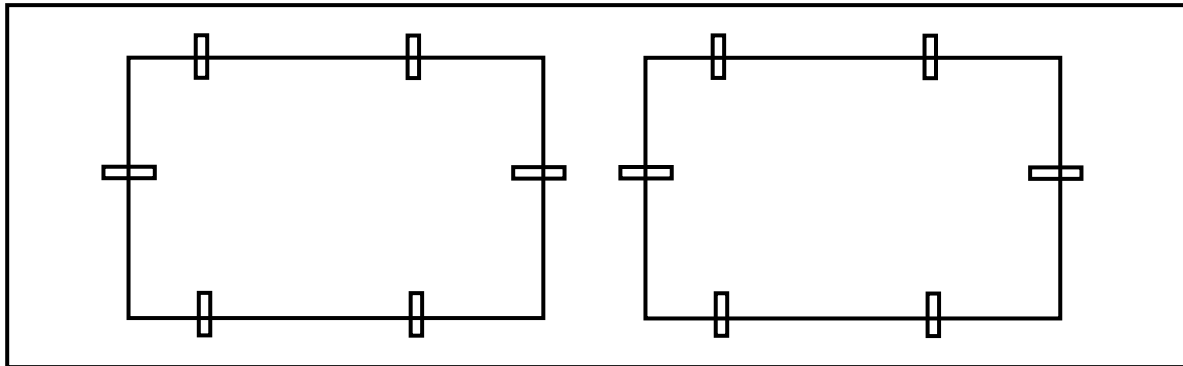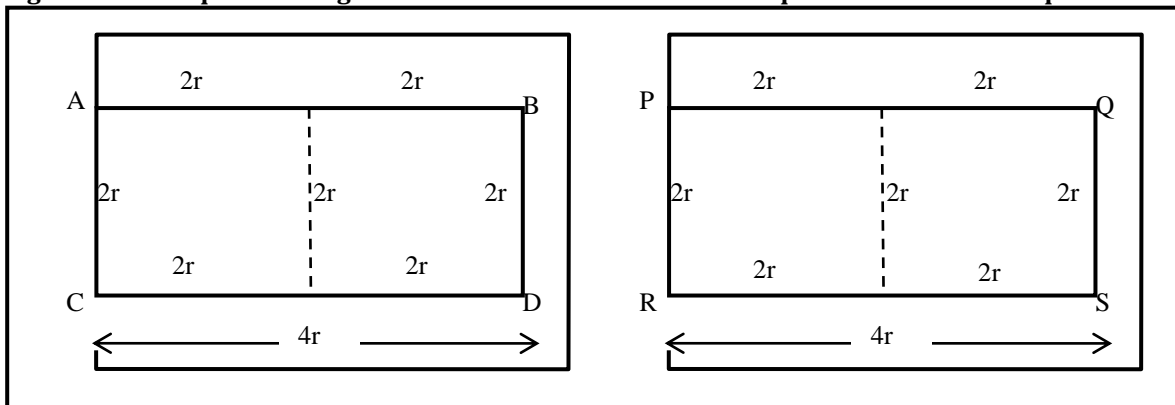

Figure 4: Two Equal Rectangular Diameters Divided into Two Equal Halves to Form Squares

Step 4: Cut rectangles ABCD and PQRS of breath 2r and length 4r. Then, fold them to form cylinders of the same heights and diameters all equal to 2r (ensuring that the edges do not overlap) as shown in Fig. 4.

Figure 5: Two Cylinders Formed with the Two Equal Rectangular Sheets in Fig. 4 Above

Cylinder A   Cylinder B
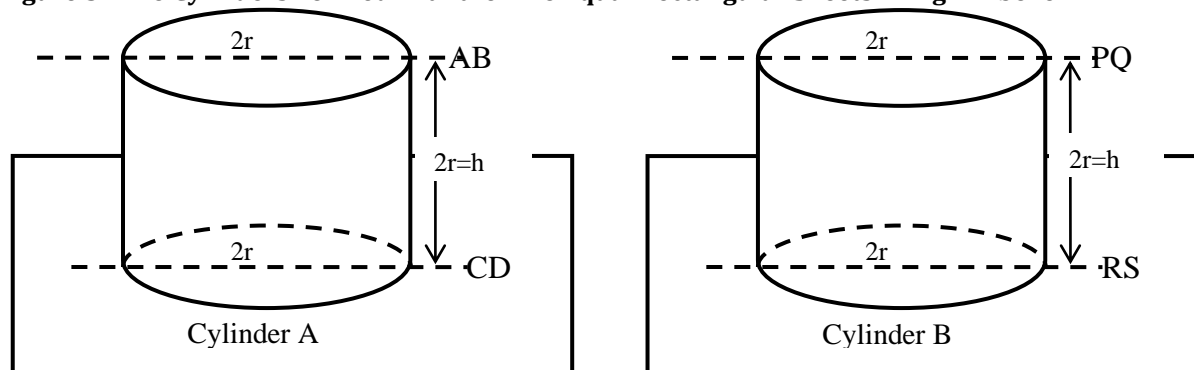
Step 5: Fill the hollow sphere of the ball of Fig. 3 above with sand once and empty it into one of the two cylinders, say cylinder A. You can replicate the experiment with Cylinder B
Step 6: Fill the hollow sphere of the ball of Fig. 3 above again (i.e. second time) with sand and empty it into Cylinder A. You can replicate the experiment with Cylinder B or more cylinders as you may desire.
Step 7: Finally, fill the hollow sphere of the ball of Fig. 3 above again (i.e. third time) and empty it into the remaining space of Cylinders A. You can do the same in Cylinder B. This third time can now make the cylinders to be filled up to the brim.

Observations
- The students observed that after the second time of emptying the sphere filled with sand into the cylinders, the cylinders were not yet completely filled.
- The students observed that after the third time of emptying the space filled with sand into the gender, the cylinder become completely filled with the brim.
- The students observed that the total number of times the pouring of the sphere filled with sand into cylinder A to make it completely filled with the brim was three times.
- Moreso, the students observed that the total number of times the pouring of the sphere filled with sand into cylinder B is three times also.

The students, therefore, concluded that:
3 times the vol. of sphere = 2 the vol. of cylinder = $2\pi r^2 h$ (known from previous knowledge)

$$= 2 \times 2\pi r^2 h$$
$$= 4\pi r^2 h \text{ (since h = r (radii)}$$

The volume of the sphere $= \frac{4}{3}\pi r^3$ QED (by dividing both sides by 3).

3. Methodology

The quasi-experimental research design of pre-test post-test non-equivalent intact class type was adapted in the conduct of the experiment. It was composed of one each of the experimental and groups. Those respondents in the experimental group were taught a lesson plan on mensuration. The lesson plan used was developed by the researcher from the National Mathematics curriculum for senior secondary schools, science and technology (2013). The research was conducted in Agbani Educational Zone, Enugu State. The population of the study is made up of 3095 SSS II students schooling at government-owned secondary schools in the zone (PPSMB, statistical unit, 2022). The study adopted a multi-stage sampling technique in sampling the subjects. The first stage adopted a simple random sampling technique in which 6 schools out of the 44 schools were randomly sampled. The second stage also adopted a simple random sampling technique to draw two intact classes from each of the 6 schools which yielded 12 SSS II, intact classes. This yielded 197 subjects composed of 95 males and 102 females. The third stage involved using a simple random sampling procedure to randomly assign the subjects to treatment and expository groups which yielded 113 subjects in the experimental group (composed of 65 males and 48 females) and 84 in the control group (composed of 46 males and 38 females). The instruments used for collecting data were MAT and MIIT.

Both instruments were developed by the researcher, subjected to experts for validation and used for data collection. Cronbach alpha statistic was applied in obtaining the MAT reliability estimate of 0.89 while the test-retest method was used to establish the reliability estimate of MIIT was obtained test-retest method which yielded 0.91. The samples used in establishing the reliability of the instruments were not used again in the main study. The MAT is a test instrument that covers all the aspects of mensuration taught with regard to the proof of the theorem that the volume of a sphere is $\frac{4}{3}\pi r^3$. The MAT is a 50 marks practical method of proving the theorem that the volume of a sphere is $\frac{4}{3}\pi r^3$ instrument developed for SSS I students. The MIIT was organized into sections A and B. Section A consists of the Bio-data of the respondents while Section B contains information on the research problem. A Likert scale type of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) was adopted in determining the response options of the respondents, concerning their feelings on the use of CTM in proving the mensuration theorem. Mean scores ranging from 3.50 and above = SA; 2.5 to 3.4 = A; 1.50 to 2.4 = D; and 1.40 and below = SD.

The reliability estimates of the instruments were also determined by administering them to SSS II students in a school that did not participate in the main research but was from a school with the same population characteristics as the one used in the main study. The data obtained from this administration was adopted in determining the reliability efficiency of the MAT computed with KR_{21} statistic which yielded 0.89 and Cronbach coefficient alpha statistic for the MIIT which yielded 0.91. The statistical coefficients of the instruments were therefore considered reliable. The pre-MAT, pre-MIIT, post-MAT and post-MIIT were administered to all the SSS II students in the two groups. However, in the post-MAT, the students in the experimental group were tested with CTM. Both the treatment and expository groups were tested at the same time to prevent students from discussing the test items, leakage of the items or exchange of ideas about test conditions. The researcher administered the pre-MIIT to sampled schools. Thereafter, the pre-MIIT and pre-MAT were retrieved from the respondents the same day by the research assistants. At the end of each teaching, the post-MAT and post-MAT were administered to the students in their normal classroom environment.

Each item was in essay format and so was scored based on skills obtained correctly by the testees while taking steps in proving the theorem. That is to say that marks are awarded to the steps as students demonstrate practically in proving the theorem. Data collected were analyzed with descriptive statistics (mean and SD) in answering the research questions while the hypotheses were tested at 0.05 level of significance using ANCOVA statistics.

4. Result

Data for the study obtained with the instruments were presented in line with the posed questions and the null hypotheses.

Research Question One: What is the mean difference in mathematics performance between students taught with the CTM and students taught with the expository method before and after treatment?

Table 1: Mean Achievement Scores and Standard Deviations (Sd) of Respondents Exposed to the Treatment and those Exposed to the Expository Method (before and after treatment)

Teaching Method	Type of Test	N	Mean	SD
Constructivist Teaching method (CTM) (Experimental)	Pre-MAT (Before)	113	37.87	7.59
	Post-MAT (After)	113	38.56	8.36
	Mean difference		0.69	
	Pre-MAT (Before)	84	37.85	9.91
Expository method (Control)	Post-MAT (After)	84	37.82	10.44
	Mean difference		0.03	
Mean Post-test difference			0.74	

In table 1 above, the mean pre-MAT test score for the CTM group was 37.87 with an SD of 7.59. Pre-MAT score (before treatment) for the Expository method group was 37.85 with an SD of 9.91. The post-MAT score for

those exposed to CTM was 38.56. The post-MAT (after treatment) score for those exposed to the Expository method was 37.82 with an SD of 10.44. From the mean test scores of the two groups, the mean post-test difference was 0.74 in favor of the Experimental groups (CTM group), meaning that the CTM group made a higher mean gain score than the Expository group. To determine whether the observed mean difference between the groups in the achievement test scores of the subject after treatment (post-test) is statistically significant, hypothesis one was therefore tested at a 0.05 level of significance. Hypotheses one and two were answered using Table 2 below:

Ho$_1$: There is no significant effect of CTM on students' academic achievement in mensuration before and after treatment.

Ho$_2$: There is no significant effect of CTM on male and female students' academic achievement in mensuration.

Table 2: Summary of ANCOVA Results on Students' Achievement by Pre-Test, Post-Test and Instructional Method

Source of Variation	Type III Sum of Squares	DF	Mensuration	F	Sig.	Dev.
Covariates	1003.257[a]	1	1003.257	8.134	.000	S
Pre-test	2005.152	1	2005.152	16.257	.081	NS
Main effects	3021.199	2	1510.6	12.247	.000	NS
Post-test	46082.663	1	4376082.663	373.611	.022	S
Method	44101.146	1	44101.146	357.546	.000	S
Gender	2309.794	1	2309.794	18.726	.086	NS
Pre-test by method	2014.039	1	2014.039	16.329	.104	NS
Post-test by method	4561.029	1	4561.029	36.978	.190	NS
Error	23682.061	192	123.344	-	-	-
Residual	72604.029	4	18151.007	147.158	.000	NS
Total	**97500.863**	**196**	**497.453**			

a. R^2 = .483 (Adjusted R^2 = .461). b. Computed using α = .05.

The dependent variable (pre-test was found not statistically significant since 0.08 was higher than 0.05. The null hypothesis was accepted: that means before the students were exposed to the treatment they were performing equally in mathematics. Table 2 above reveals that the covariance is not significantly the same as the dependent variable. Thus, a significant value of 0.000. However, the significance of the dependent variable (post-test) in the two methods is 0.000. Since this value is less than 0.05, the level of significance, the null hypothesis is rejected. This result reveals that there is a statistically significant difference in the mean achievement test scores of those students' taught mensuration in the experimental group and control group after treatment. The significant difference must be due to the new method (CTM) used which enabled the experimental group to perform higher than the Expository method group. Table 2 shows that gender has F$_{cal.}$ val. of 18.726 and significant. at .086. This significant value of .086 is greater than 0.05 and so the null hypothesis is rejected. This means that is no significant mean difference in the performance of male and female subjects exposed to the treatment. Gender by method interaction was significant at 0.190, This significant value was more than the level of significance. In so far (0.190) is greater than the significant level of 0.05, the null hypothesis is accepted. This means when CTM is used in Mathematics instruction, the male and female students' performances will be at the bar.

Research Question Two: What is the mean difference in mathematics performance between male and female students taught with the experimental treatment before and after treatment?

Table 3: Mean Achievement Test Scores and SD Based on Gender

Teaching Method	Gender	N	Type of Test	Mean	SD
	Male	95	Pre-MAT	61.13	3.05

Constructivist teaching method		102	Post-MAT	59.27	3.26
			Mean Gain	-1.86	
			Pre-MAT	60.62	3.17
	Female		Post-MAT	62.05	3.01
			Mean Gain in post-test	2.78	

Table 3 reveals that the means of male and female subjects who were pre-tested before the constructivist teaching method was applied were 61.13 and 60.62 with SD of 3.05 and 3.17 respectively. This result reveals that both the male and female students exposed to CTM performed almost at the same level of knowledge in mathematics before they were exposed to the treatment, although the males had a little higher mean score of 0.51. However, the mean achievement test scores in mathematics of the male and female students in the post-test of the CTM group are 59.27 and 62.05 with standard deviations of 3.26 and 3.01 and a mean difference in means of 2.78 in favor of females. The result shows that the female subjects exposed to the CTM improved upon their performance which made them perform higher than males must be due to the new method used, while the males showed a mean decline of -1.86, meaning that after the pre-test score of 61.13, their mean score reduced to 59.27 in post-test. To find out the statistically significance of this finding, hypothesis 2 was further tested at a 5% level of significant level (see table 2 above).

Research Question Three: What is the mean difference in the mean interest ratings in Mathematics between male and female students taught mathematics using experimental treatment before treatment?

Table 4: Mean Interest Scores and SD by Experimental Subjects (Male and Female) before Treatment

S/N	Items Description	Male			Female		
		Mean ($\underline{X}$)	SD	**Rmk**	Mean ($\underline{X}$)	SD	**Rmk**
1	I hate Maths because it does not involve practical activities, thereby making it look abstract.	3.50	1.486	SA	3.31	1.561	A
2	Maths teacher dominates the whole teaching process, thereby making the lesson more of a lecture in nature.	3.31	1.511	A	2.93	2.003	A
3	I hate Maths because I ended up memorizing formulae that I do not know how they were formulated, thereby making me forget them easily.	2.51	1.413	A	3.42	1.131	A
4	Maths class does not give me an opportunity to exchange ideas collaboratively with my colleagues while the lesson is going on.	2.55	0.968	A	3.07	1.513	A
5	The time allotted to Maths is too short, thereby making it difficult for me to be an autonomous learner through practical activities.	3.46	0.994	A	3.10	1.042	A
6	I lost interest in Maths because there is no student-teacher interaction in the teaching-learning process.	2.82	1.601	A	2.90	1.025	A
7	I do not have an interest in Maths because I am only required to identify my teacher's constructions rather than giving me room to construct my own meaning.	3.66	1.636	SA	2.82	1.717	A
8	I do not like Maths, because I am not allowed to share responsibilities with my teacher.	2.98	0.678	A	3.03	1.263	A
9	I am interested in Math because I was allowed to share decision-making with my teacher	1.20	2.013	SD	1.33	2.001	SD
10	I love Math because my teacher and I demonstrated mutual respect for each other.	2.30	2.442	A	0.461	1.431	SD

Total	**3.881**	**1.4158**	**3.033**	**1.6319**
Difference in means	**0.848**			

The results of Table 4 show that the students exposed to the experimental treatment (CTM) group, agreed that they do not have an interest in Math because it was not practically oriented; Math teacher dominates the whole process; Maths learning was by memorization of formulae; no collaborative learning with colleagues/classmates; no student-teacher relationship; no sharing at responsibilities or decision making with the teacher. However, the students agreed that they dislike Maths because they were not allowed to share decision-making with their teacher and that their teacher and themselves do not demonstrate mutual respect for each other. The table shows that the respondents agreed that items 1, 2, 3, 4, 5, 6, 7, and 8 are the reasons why they hate mathematics and therefore lose interest in studying the subject. The items' mean are all higher than the criterion mean of 2.50, except items 9 and 10 which have means of 1.20 and 1.33 for males and females respectively. The respondents strongly disagreed on the items as being the reason for their love of mathematics. The mean and SD of males responses $(X_m = 3.881;\ SD_m = 1.4158)$ and mean and SD of females responses $(X_f = 3.033;\ SD_f = 1.6319)$ and mean difference of 0.848 which favored males with regards to the rate of their interest in Maths learning before they were exposed to the treatment. The difference in means of 0.848 was further tested for a statistically significant difference at α = 0.05 significant level in hypothesis three.
Hypothesis Three: There is no significant effect of the constructivist teaching method on male and female students' interest in mensuration before they were exposed to the treatment.

Table 5: Results of the Independent T-Test on the Mean Interest Ratings of the Male and Female Subjects in the Experimental Group, Before the Treatment

Gender	N	Mean	SD	DF	t_{cal}	t_{crit}	Decision
Males in the Experiment group	65	3.881	1.4158	111	2.886	1.96	Reject Ho
Females in the Experiment group	48	3.033	1.6319				

Table 5 above indicates that the t-test calculated (2.886) is greater than the t-critical value (1.96). Thus, the hypothesis was rejected. This result means that within the experimental group there is a significant difference between the male and female students' interest in mathematics learning. The result clearly indicates that male and female students exposed to the treatment differ significantly in different levels of interest in learning mathematics. The mean interest of males (3.881) is higher than the mean interest of females (3.033) which shows that males are far more interested in learning mathematics than their female counterparts. **Research Question Four:** What is the mean difference in mean interest ratings in Mathematics between male and female students taught mathematics using the experimental treatment after treatment?

Table 6: Mean Interest scores and SD by Experimental Subjects (Males and Females) After Treatment

S/N	Items Description	Male Mean (X)	SD	RMK	Female Mean (X)	SD	RMK
	I love Maths because it is student-centered.	2.59	0.146	A	2.50	0.808	A
	I am interested in Maths because I can learn the subject.	2.99	1.103	A	3.14	1.092	A
	I love Math because the activities in it are interactive.	3.03	0.644	A	3.08	1.103	A
	I love Maths because my classroom environment provides me with meaningful learning experiences through practical activities unlike before.	2.78	0.863	A	2.71	0.798	A
	I can now construct my own knowledge and skills out of experiences and interactions with my classmates.	3.11	1.201	A	3.15	1.043	A
	I have come to love Maths because I can be involved in deciding my own learning.	2.88	1.053	A	3.02	0.801	A

My own reasoning skills can now develop since I can arrive at mathematical formulae practically.		3.05	0.771	A	3.12	1.270	A
I am interested in learning Math because I have control over my thinking.		3.31	0.698	A	3.25	1.008	A
I cannot still remember the formulae even after I have practically demonstrated how to obtain the formulae.		1.32	1.004	D	1.11	0.964	D
I love Maths because I have the opportunity to carry out practical activities in the Math laboratory like my counterparts in Physics, Chemistry and Biology		2.30	1.018	D	2.17	1.301	D
Grand Mean		**2.736**	**0.8411**		**2.725**	**1.0189**	
Difference in means		**0.011**					

The results of the Table show that after the subjects were exposed to the treatment, they agreed that they have now developed an interest in mathematics learning because Math teaching is student-centered; practically oriented; students can learn Maths co-operatively with their classmates; Maths activities are interactive; the practical activities provides them with meaningful learning experiences; their interaction with their classmates can now enable them to construct their own knowledge and skills they can now remember Maths formulae because they can arrive at the formulae practically; they have control over their own learning now and can be involved in deciding their own learning. The table shows that the respondents agreed that items 1,2,3,4,5,6,7, and 8 are the reasons why they are interested in learning mathematics and therefore like learning the subject. All the mean values of items 1 to 8 are greater than the criterion means of 2.50, except items 9 and 10 which have mean scores below 2.5 in both male and female respondents. The mean and SD of male responses $\left(X_m = 2.736;\ SD_m = 0.8411 \right)$ and mean and SD of female responses $\left(X_f = 2.725;\ SD_f = 1.0189 \right)$ and mean difference of 0.011 in favor of males and the rate of their interest in mathematics After they were exposed to the treatment. The difference in means of 0.011 was further subjected to a statistically significant difference at $p \leq .05$.

Hypothesis Four: There is no significant effect of the constructivist teaching method on male and female students' interest in menstruation after treatment.

Table 7: Analysis of the Independent T-Test on the Mean Interest Ratings of Male and Female Students in the Treatment Group the Students Were Exposed to Treatment

Gender	N	Mean	SD	DF	t_{cal}	t_{crit}	Decision
Males in Experimental group	65	2.736	0.8411	111	0.061	1.96	Accepted Ho
Females in Experimental group	48	2.725	1.0189				

Table 7 above revealed that the t-test statistic value of 0.601 is less than the t-critical value of 1.96. Thus, the null hypothesis was not rejected. That means that within the experimental group there is no significant difference between the male and female students' mean interest ratings in mathematics. This clearly shows that in the experimental group both male and female students share an equal level of interest in Learning Mathematics due to the treatment.

Summary of the Findings: The findings were summarized below:
- Before treatment (pre-test), students in the treatment (CTM) group scored a higher mean gain score of 0.02 than students in the expository method group. This mean difference of 0.02 was tested for a significant difference in means and the test showed no significant difference ($P \leq .05$).
- After treatment (post-test), students exposed to the treatment (CTM) scored a higher mean gain score of 0.74 than their counterparts exposed to the expository method. This means the difference of 0.74 which was further tested for statistically significant difference and was found significant ($P \leq .05$). This significant difference must be due to the new method used which led to an increase in the mean gain score (performance).

- The experimental group, before treatment (pretest), achieved a higher mean score than females with a mean gain score of 0.51. This mean difference of 0.51 was further tested for statistically significant mean difference and was found to be statistically significantly different at P ≤ .05.
- Moreso, in the experimental group, after treatment (posttest), the females performed higher than males with a mean gain difference of 1.43. The mean gain difference of 1.43 was further tested for statistically significant difference and was found statistically not significantly different at P ≤ .05. That means gender is not a significant factor of variance when CTM is used. That means males and females exposed to the treatment shared equal strength in Mathematics performance when CTM is used in mathematics instruction.
- The mean difference between the interest ratings of male and female students before they were exposed to treatment was 0.848 in favor of males. The difference in means in interests rating was further tested for statistically significant difference and was found statistically significant at P ≤ .05. This means that before the students were exposed to the treatment, they have different interests in mathematics learning.
- The mean difference between the interest ratings of male and female students after the treatment was administered to the subjects was 0.011 in favor of male. The difference in means in interest rating was further tested for statistically significant difference (P ≤ .05) and no significant mean difference. This change in interest rating after the administration of the treatment must be due to new method used which thereby brought male and female students' interest in Mathematics to bar.

5. Discussion and Conclusion

The discussion section was organized in accordance with the findings of the study. The result of research question one showed that in the post-test, the treatment group outperformed those taught with an expository method with a mean post-test difference of 0.74 in favor of those exposed to the CTM. This result shows that CTM is effective in teaching mathematics. Insofar constructivist teaching method is activity-based, practically oriented and student-centered, the result is confirmed by earlier demands of Blogspot (2018), Samanta and King (2018) and FRN (NPE, 2013), who all advocated that the activity-based method should be used in teaching mathematics because the activity-based method makes the teaching of mathematics practical and experiential. This mean difference of 0.74 was subjected further to a statistical test to determine how significant the mean difference was. The mean difference (0.74) was found statistically significant difference (P ≤ .05). Research question two revealed that in the pre-test (before treatment), males had a little higher mean gain of 0.51 than their female counterparts. However, in the post-test, within the treatment group, the females achieved higher than their male counterparts with a mean gain score of 2.78.

This finding corroborated earlier reports (Hydea & Merzb, 2009; and Unodiaku, 2015) all found that female students performed better than their male counterparts in mathematics achievement tests. However, the finding contradicts earlier reports (Asante, 2010; Olasunde and Oladeye, 2010; and Unodiaku, 2018) all found that males achieved higher mean gain test scores in mathematics than females. These contradicting reports on gender superiority in mathematics achievement is appearing inconclusive. The difference in mean (2.78) between male and female subjects was further subjected to statistically significant difference and was found no significant difference (P ≤ .05). Research question three showed that males were more interested in studying mathematics before they were exposed to the treatment with a mean difference of 0.848 in favor of the males. The interest difference in mean of 0.848 was further tested for a statistically significant mean difference (P ≤ .05). That means before the subject (in the Treatment group) was exposed to the treatment, the males and females in the group (Experimental group) were tested for difference in mean interest in mathematics (without treatment) and the result showed that there was a significant difference in the mean interest ratings of male and female. Although in the experimental group before treatment males showed more interest in mathematics than females, the mean was found statistically not significant (P ≤ .05).

work a huge success. More crucially the typist, Miss Chika Ugwu who typed the manuscript with minimum supervision and a high degree of accuracy is hereby acknowledged.

References

Agwagah, U. V. N. (1993). Instruction in Mathematics Rending as a factor in Students' Achievement and Interest in Word Problem-Solving. Unpublished Ph.D. Thesis, UNN.

Ajai, J. T. & Imoke, I. I. (2015). Gender Differences in Mathematics Achievement and Retention Scores: A Case of Problem-Based Learning Method. *International Journal of Research in Education and Science* (IJRES), 1(1), 45–50.

Asante, K. O. (2010). Sex Differences in Mathematics in Ghana. Retrieved from https://www.org/periodical=2010/218771338/html.

Da Ponte, J. P. (2007). Investigations and Explorations in the Mathematics Classrooms. ZDM – *The International Journal of Mathematics Education*, 39, 419–430.

Daguplo, M. S. (2014). The determination of students' difficulties in proving geometrical propositions using exploratory factor analysis. *Journal of Educational and Human Resources Development,* 2, 1–8.

Diane, F., Halpera, Camilla, P., Benbou. & Morton Ann Gernsbacher. (2020). The Science of Sex Differences in Science and Mathematics. www.ncbi.nlm.nih.gob.

Eriyagama. (2018). Activity-based teaching methods for, *better living in primary mathematics classrooms,* 2(2). www.worldccess.org.article-3.

Federal Republic of Nigeria (FRN). (2013). National Policy on Education, Lagos: NERDV Press.

Ganley, C. M. & Lubienski, S. T. (2016). Mathematics Confidence, Interest, and Performance: Examining gender patterns and reciprocal relations. *Learning Individual Differences,* 41, 182–193, dio:10.1016/j.lind.2016, 01.002.

Guo, J., Parker, P. D., Marsh, H. W. & Morim, A. J. (2015). Achievement, Motivation and Educational Choices: a Longitudinal Study of Expectancy and value using a multiplicative perspective. Dev. *Psychol*, 51, 1163–1176, dio:10.1037/a0039440.

hydea, J. S. & Merzb, J. E. (2009). Gender, Culture and Mathematics Performance. Retrieved from http://tetvideo.madso.com/uw/gender.

Kelly, G. A. (1991). The Psychology of Personal Constructs: Volume one-A Theory of Personality. London: Routledge.

Marshall, Lisa. (2018). Math Myths: Are Boys Really Better at Maths? www.webmd.com.

Olusunde, G. R. & Olaleye, O. O. (2018). Effect of Concept Mapping on Senior Secondary School Students' Performance in Mathematics. *Journal of Mathematics Education,* 1(1).

Piaget, J. (1977). The Development of thought: Equilibration of Cognitive Structures. (A Rosing Trans). New York: The Viking Press.

Pokhrel, T. R. (2018). Activity-based math instruction: Experiences in addressing the 21st Century Skills. www.semanticscholar.org.

Post Primary Schools Management Board (PPSMB). (2022). Statistical Unit. Agbani Education Zone.

Rosen Blat, L. (1978). The reader, the text, the poem: The transactional theory of the literary work. Carbondale, II: Southern Illinois University Press.

Samarita, C. & King, E. M. (2018). 6 Key Insights into the data and information Education leaders want. Mist http://www.bookings.edu.

Susana, R., Isabel, P. & Antonio, V. (2019). Gender differences in Maths motivation: Differential Effects on Performance in Primary Education. www.frontiersin.org>articles>full.

Twomey Fosnot, C. (1989). Enquiring teachers, enquiring learners: A Constructive approach for teaching. New York: Teachers College Press.

Unodiaku, S. S. (2015). Comparative Study of Mathematics Potentials of Single-Sex Secondary Schools in Enugu State. *International Journal of Education, Michael Okpara University of Agriculture, Umudike,* 1(1), 121–128.

Unodiaku, S. S. (2018). Teaching Geometrical and Mensuration Proofs with Origami-Based Instructional Model Approach among Senior Secondary Schools' Students: in Abacus, *The Journal of Mathematical Association of Nigeria,* 43(1), 14–24.

WAEC Chief Examiner's Report. (2016). Yaba, Lagos State.