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Original Paper

Effectiveness of Origami-based Instructional Model Approach (Obima) on Secondary School Students' Academic Performance and Interest in Mensuration, Enugu State, Nigeria

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Abstract

The study was conducted to determine the effectiveness of origami-based instructional model approach (OBIMA) on secondary school students' academic performance and interest in mensuration. The population of the study consisted of 2105 SSS III students in 15 government owned secondary schools in Igbo-Etiti local government area of Enugu State, Nigeria. The study was guided by five research questions and five null hypotheses. The hypotheses were tested at $P \leq .05$ level of significance. Multi-stage sampling technique was used to randomly sample 153 students used for the study. Two instruments were developed by the researcher and used for gathering data. One was Mathematics Achievement Test (MAT) instrument containing 15 essay items and the other was Mathematics Interest Inventory Questionnaire (MIIQ) which contains 9 items. The instruments were face validated by experts and their reliability estimates were determined using split-half method which yielded 0.80 and 0.88 for MAT and MIIQ respectively. The data collected with the instruments were analyzed using mean and standard deviation (S.D) to answer the research questions while independents t-test statistic was used in testing the hypotheses ($P \leq .05$). Findings of the study revealed that origami-based instructional model approach is effective in teaching mathematics, especially in sketching roots of mensuration theories. Gender was found not to be a significant factor of variance in mathematics performance, particularly when origami is used in mathematics instruction, among other issues found in the study. It was recommended to teachers to adapt and adopt origami-based instructional model approach in mathematics instruction since the study has shown that the use of origami in mathematics instruction effectively enhances students' interest in mathematics learning.

Keywords

mathematics, origami-based instruction, mensuration, interest and performance

1. Introduction

What mathematics is and its absolute importance are inexhaustible and cannot be overemphasized. Mathematics is a dictionary of all other subjects from science subject to arts, because every subject area apply mathematical expressions and reasoning, to explain concepts, theories, principles, meanings and facts inherent in such area. Mathematics is a phenomenon that has gone beyond explanation of quality, size, shape and order in the universe, to further explain relationships of qualities and number patterns and their applicability in our everyday activities. Tali, Mbwas and Abe (2012) noted that mathematics is the bedrock of knowledge encompassing economic, technology, scientific and social development of any society. According to Okafor (2016), Mathematics is an instrument for scientific, economic, political and human development of all nations. Obviously, mathematics by nature has inevitably attributes to all human activities as in socially, economically, scientifically and politically development of any nation in the world. Ideally, mathematics is a precise tool that can be used by mankind to obtain a clear understanding of the physical world around them. Mathematics is the opium of science that has made phenomental impacts that have enabled technological and scientific invention to be possible for man to function effectively in his immediate environment and even beyond.

Despite the numerous importance of mathematics to humanity, its teaching and learning are bedeviled by incessant reports on students' poor performance on the subject. For instance, the West Africa Examination Council (WAEC) and National Examination Council (NECO) Chief Examiners' reports of (2010-2015) and (2009-2017) respectively clearly indicated that students' performance in mathematics has been persistently poor over the years. Unodiaku (2018) observed that students' achievement and performance in mathematics in both internal and external examinations are consistently reported to be below seventy percent (70%) of candidates who sat for mathematics examination in the West African Secondary School Certificate Examination (WASSCE) during the 2013-2016 for failure to obtain credit level pass on the subject. These reports on students' poor performance on mathematics is a clear indication that mathematics teaching approaches adopted by teachers were not effective. According to Ebesine (2013), the instructional approach adopted by teachers could make learners to develop negative or positive interest towards the learning task. The present state of art is that mathematics teaching is deficient since teachers' approaches to the teaching of the subject neither enhance the interest of the students on studying the subject nor their achievement on the subject. This is a clear indication of scarcity of teaching approach that can positively change the interest of the students towards learning the subject well for enhanced achievement. Probably because of these consistent reports on students poor performance on mathematics that the National Policy on Education (NPE) (F.R.N., 2013) demanded that teaching shall be practical and activity-based. This demand was earlier made by WAEC Chief Examiner (2012) who insisted that teachers should be encouraged to use instructional materials during lessons so as to re-enforce the learning of mathematics concepts. The use of origami-based instructional model approach (OBIMA) which is activity-based becomes paramount in teaching mathematics concepts such as mensuration.

According to Pokhrel (2018), Eriyagama (2018) and Unodiaku (2018) all demanded that activity-based approach should be used in Mathematics instruction, because it is capable of making mathematics teaching to be practically oriented, increase the interest of students and improved their academic performance on mathematics. More critically, making mathematics teaching to be activity-based, is another way of achieving the noble objective of the NPE (FRN, 2013) which demanded that teaching (Mathematics) shall be practical, activity-based, experiential and IT supported. Activity-based learning method appears to be invoking in the recent time in science teaching especially in mathematics, probably because it is psycho-motor oriented. The philosophy of activity-based learning is based on the notion that learning can be best when it is initiated by the surrounding environment and motivated by providing optimum opportunities to learn (Unodiaku, 2018). Ideally, mathematics is among the core school subjects that it's teaching and learning can be gainfully achieved through activity-based learning method. The psychological theory of information processing views learners as active investigators of the environment. Mensuration is an aspect of mathematics that it's teaching and learning is activity-based (enquiry-based), especially when origami-based approach is integrated into its instruction and learning. Activity-based method gives learners opportunity to enquire about concepts, structures, algorithms and synthesis of mathematical formulae. According to Da Ponte (2007), enquiry-based (activity-based) learning improves the quality of mathematics learning by providing learners with multiple examples, receiving quick feedback, using multiple representations, and being involved in the modeling process. Conventionally, teachers teach students areas, surface areas and volumes of solid shapes by writing down formulae for the students to memorize them and apply them in problem-solving. Most of these memorized formulae are easily forgotten because teachers did not show students the structure of the formulae through activity-based learning that can help the student to remember the formulae. The need to use origami-based teaching approach is hereby exemplify to the students on how to arrive at the formulae inherent in mensuration theorems through paper folding and cutting activities thereby making it paramount for quick remembering and internalizing of the formulae as well as gaining interest on the subject.

Measuration is an aspect of mathematics that has been variously reported as being difficult to learn by students and teach by the teachers, probably because proofs of theories are involved in the topic. For instance, Daguplo (2014) observed that the importance of proof was elusive to many students, making them less appreciative in proof-writing activities which increased their difficulties in constructing valid proofs. For many, proofs are just some esoteric, Jargon-filled technical writing that only a professional mathematician would care about (Copper, n.d.). It shows why students failed to appreciate writing proofs and continue to face various difficulties in writing proofs as a method of presenting mathematical truths (Daguplp, 2014). Poor performance in mathematics and problems-solving in proving mensuration theorems in particular can be halted through the teaching of mensuration with origami-based approach which is activity-based and practically oriented.

Origami is the ancient art of paper folding, and it can make an impact in today's education. It is a mechanism of paper folding to transform a flat piece of paper unto mathematical models and sketching proofs of mathematical theorems (Unodiaku, 2018). According to Ainissa (2015), this art form engages students and neatly enhances their skills, including improved spatial perception, logical and sequential thinking. Origami has been shown to be helpful in mathematics particularly for determining geometric construction, algebraic and mensuration formulas as well as increasing visualization abilities (Edutopia, 2016). This is to say that transformation of a flat piece of paper into other origami figure is a unique exercise in spatial reasoning and can strengthen an understanding of mensuration and geometric concepts, formulas, and labels, making them come alive (Edutopia, 2016). Such skills enable students to comprehend, characterize and construct their own vernacular for the world around them (Unodiaku, 2018). These assertions suggests that origami can be modeled to be used in proving mathematical theorems and facts, especially in geometry and mensuration. Ideally, origami in some ways, is an untapped resource for supplementary construction, determining geometric, mensuration and algebraic formulas, and increasing manual dexterity along the way (Ainissa, 2015). This suggests the need to adopt and adapt origami-based instructional model approach that can improve spatial visualization and psychomotor skills of the students using hands-on learning which can help them learn concepts of mensuration proofs that may otherwise be rather abstract.

Literature search concerning gender and academic performance in mathematics exist with varied views and findings. Studies earlier conducted on issue of gender variability in mathematics achievement reported that boys achieved higher mean gain scores in mathematics than their female counterpart (Anaduaka & Olaoye, 2018; Ehiwnrio, Aghamie & Azagbuekwue, 2018; Asante, 2010). However, some literature search reported that female students exposed to mathematics tests with males, performed better than males exposed to the same mathematics tests (Unodiaku, 2015; Hyden & Merzbm, 2009; Agwagah, 1993). The other research findings on gender variability on mathematics test results reported no significant difference in mathematics performance between male and female students (Alonye, 2018; Rigas & Valendies, 2001). These inconsistency reports concerning male and female students' superiority in mathematics tests appear inconclusive. There is need to conduct this study to clarify this notion of inconsistency reports concerning male and female superiority in mathematics tests. It is against this background that the present study is conducted to determine the efficacy of origami-based instructional model approach for effective teaching of measuration to college students to bridge the disparity in performance between the duo.

Literature concerning interest as inhibiting factor to mathematics achievement among students exists with varied views and findings. Interest is believed to be an important factor or variable in mathematics learning, because when one is interested in an activity, one is likely to be willingly or likely to partake in the activity. In that regard, the person in partaking in the activity will involve both his/her body and mind wholly, and can hardly be distracted while undertaking the activity. According to Akpanya (2011), interest is an energizer of learning without which meaningful learning may not take place. Moreso, Chukwu (2001), noted that without interest and personal efforts in learning mathematics by the students, they can hardly achieve well in the subject. Interest in learning (mathematics) can be expressed in different ways by the learner, either positively or negatively. In other words, students' interest to learn (mathematics) can be willingness to learn the subject or dislike to learn it. It becomes pertinent therefore, to use appropriate instrument such as questionnaire that can validity determine the level of the students' interest to participate in learning of the subject, particularly when origami-based instructional model approach is infused into teaching the subject. Ebesine (2013) stated that the instructional approach adopts by teachers could make learners to develop negative or positive interest towards the learning tasks. Obviously, interest is a factor of mathematics achievement' and as such made the study worthwhile to determine the level of students' interest in using origami-based instructional model approach in proving some mensuration theorems.

1.1 Statement of the Problem

Several methods/strategies/approaches have been applied by teachers in teaching mathematics (Poly, 1977) problem-solving strategy; Harbor-Peters (1990) target task for problem-solving; Unodiaku (2011) ethnomatematics teaching materials; Unodiaku (2013) game-based instructional model approach, among others to halt the situation of poor performance of students on the subject. The persistent poor performance of students on mathematics suggests that the methods/strategies/approaches teachers used in the mathematics instruction are ineffective, leading to incessant reports of students' poor performance on the subject. The problem of the study is, how can the origami-based instructional model approach be used for effective teaching of mathematics among college students in Igbo-Etiti Local Government Area of Enugu State, Nigeria? This question posed is the thrust of the present study.

1.2 Purpose of the Study

The main purpose of the study is to determine how possible origami-based instructional model approach can be applied in teaching measuration theorem proofs among senior secondary school students. Specifically, the study sought to determine:

1) How the performance of the experimental group differ from that of the control group before intervention (treatment).

2) How the performance of the experimental group differ from that of the control group after treatment.

3) If there is any difference in the main performance of the gender within the experimental group after treatment.

4) Whether there is any difference in the mean interest ratings of the gender within the experimental group before treatment.

5) How far the interest of the students' change within the experimental group after the treatment (intervention).

1.3 Research Questions

The study was guided by five research questions. These questions are posed as follows:

1) How does the performance of the experimental group differ from that of the control group before treatment?

2) How does the performance of the experimental group differ from that of the control group after treatment?

3) Was there any difference in the mean performance of the gender within the experimental group after treatment?

4) Was there any difference in the mean interest ratings of the gender within the experimental group before the treatment?

5) How far does the interest of the student change within the experimental group after the treatment (intervention)?

2. Hypotheses

The study was guided by five hypotheses. The hypotheses were tested at P .05 level of significance. They are stated as follows:

Ho_1: There is no significant difference between the mean performance test scores of the experimental group and control group before treatment.

Ho_2: There is no significant difference between the mean performance test scores of the experimental group and control group after treatment.

Ho_3: There is no significant difference between the mean performance of male and female students in the experimental group before treatment.

Ho_4: There is no significance difference between the mean interest ratings of the male and female students in the experimental group before the treatment.

Ho_5: There is no significant difference in the mean interest ratings of the male and female students in the experimental group after the treatment.

3. Research Method

Quasi-experimental research design was adopted to carry out this study. Specifically, it is pretest-post-test non-equivalent control group intact class design. The study was carried out in Igbo-Etiti Local Government Area. The population of the study consisted of 2105 SSS III students in the 15 secondary schools in Igbo-Etiti LGA of Enugu State (PPSMB, Nsukka Zonal Office, Statistical Unit, 2020).

Mutli-stage sampling technique was employed. First stage involving using simple random sampling technique to select 4 schools out of 15 schools in the area. The next stage involved using simple random sampling technique to select one intact class from each of the 4 sampled schools. In each of the 4 sampled schools, simple random sampling technique (balloting without replacement) was adopted to assign two classes each to experimental and control groups of 81 and 72 students respectively, bringing the total sample size of 153 students used for the study. The 153 students were composed of 44 males and 37 females in experimental group and 42 males and 30 females in control group.

The research instrument used for data collection were Mathematics Achievement Test (MAT) and Mathematics Interest Inventory Questionnaire (MIIQ) developed by the researcher. The instruments were face validated by experts in Mathematics Education and Measurement and Evaluation areas. The MAT contains 15 essay questions while the MIIQ contains 9 response items. Thereafter, the instruments were trial tested using one intact class of SSS III students that did not form part of the main study. The reliabilities of the instruments were determined using test-retest method which yielded reliability coefficients of 0.8 and 0.87 for MAT and MIIQ respectively. The data collected with the instruments were analyzed using descriptive statistics of mean and standard deviations in answering the research questions posed while research hypotheses were tested using independent t-test statistic at $P \leq .05$ level of significance.

3.1 Materials and Experimental Procedure

Objectives of the study: Required to use origami-based instructional models approach (OBIMA) to verify mensuration theorems:-

1) Curved surface area of cone = πrl

2) Total surface area of a cone = $\pi rl + \pi r^2$ or $\pi r(l + r)$

Experiment: Using origami-based instructional model to verify the theorem that (i) the curved surface area of a cone = πrl, and (ii) the total surface area of a cone = $\pi rl + \pi r^2$ or πr^2 πr $(l + r)$.

Previous Knowledge Required: Circumference of a circle, features of a section of a circle, radii of a sector and arc length of a sector.

3.2 Lesson Plan

Lesson plan was used for teaching the experimental group. The lesson plan only was used for teaching the conventional group (control group) while both the lesson plan and the OBIMA were used for teaching experimental group.

3.3 Experimental Procedure

Paper cutting and folding approach was adopted in the experiment. Pre-existing differences in achievement between the two groups were accounted for through teaching and evaluation of the students. The Mathematics Achievement Test (MAT) was administered to both groups as a pre-test while MIIQ (Section A) was administered to the experimental group before treatment, while MIIQ (Section B) was administered to the experimental group after treatment. The results obtained were used as covariate measure. The teachers who taught both groups were trained by the researcher so as to control the teacher quality variable. The regular class teacher taught experimental group using origami-based instructional model approach (OBIMA) and lesson plan. Both experimental and control groups were taught the same units (verifying mensuration theorem proofs: (i) Curved surface area of the cone = πrl; (ii) Total surface area of a cone = $\pi rl + \pi r^2$ or $\pi r(l + r)$, based on National Curriculum on Mathematics for senior secondary schools (FME, 2015), for two weeks using two contacts of 2 ½ hrs each contact. The students in each group were allowed to be taught in their normal schools and classrooms so as to eliminate horn-thorn effect among the testees.

Experimental procedure was carried out taking the following steps:

Step 1: Gathering materials used: a table, a pair of compass, ruler, pencil, a pair of scissors, cardboard sheets and paper tape

Step 2: Spread a cardboard sheet on a table and hold it firmly by the sides with paper tape (see Figure 1 below).

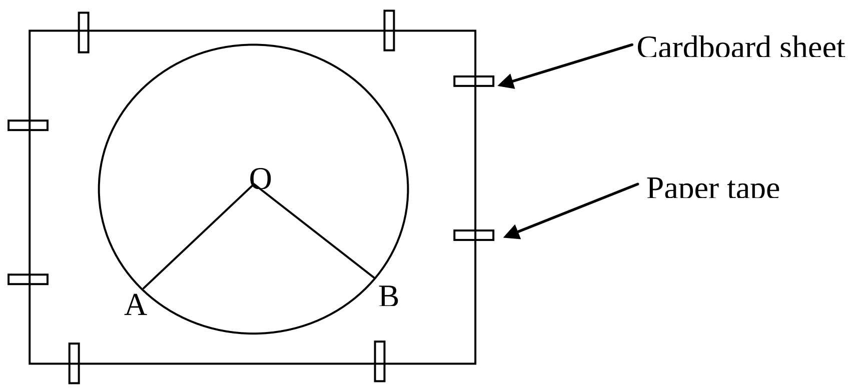

Figure 1. Cutting Out Sector AOB

Step 3: With sharp pencil fix firmly on pair of compass, draw a large circle (see Figure 1), and mark say, O, at the centre of the circle.

Step 4: Use ruler and pencil to draw two radii from the centre 0 to the circle, to produce a sector of a circle (Sector AOB) (see Figure 1). Let the radii meet the circle at point A and B (see Figure 1)

Step 5: Use ruler and a pair of scissors to cut-out the sector AOB (see Figure 2).

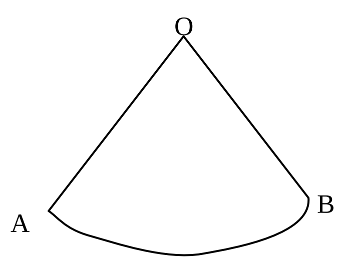

Figure 2. The Sector AOB Cut Out

Step 6: Fold the sector by joining $\overline{AO}$ to align with $\overline{BO}$ or vice versa to form a cone (see Figure 3). Join firmly with paper tape.

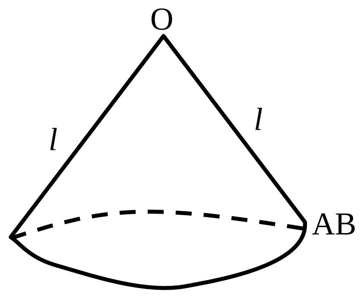

Figure 3. Come Formed with Sector AOB

Step 7: In Figure 3, press two slant sides (*l*) and circular base to coincide to form a sector Top (see Figure 4), where P is now used to replace point AB of the cone.

Step 8: Fold the sector Top formed again, such that $\overline{OT}$ coincide with $\overline{OP}$ making a creed along $\overline{ON}$ (see Figure 5).

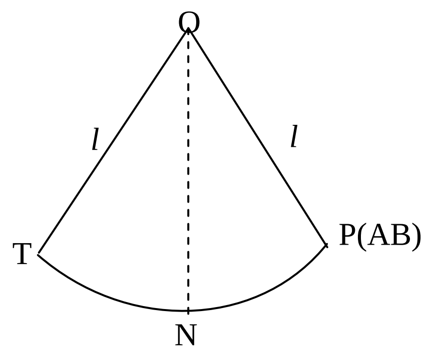

Figure 4. Folding Sector AOB from Vertx O to the Point Making Two Symmetrical Sectors

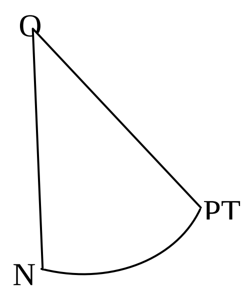

Figure 5. Half of Sector ONPT (OPN) Is Produced

Step 9: Fold the sector TOP to form a creed along $\overline{ON}$ to produce a half of the sector (see Figures 5 & 6).

Step 10: Use the scissors and cut sector ONTP along $\overline{ON}$ to produce two sectors TON and PON (see Figure 7)

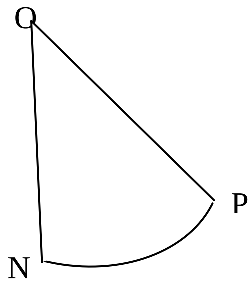

Figure 6. Half of Sector ONPT

Step 11: Open one of the sectors TON or PON, to see that it has formed four even numbers of equal smaller sectors (see Figure 6).

Step 12: Use a pair of compass to cut out the four sectors, numbered 1-4 (see Figure 7).

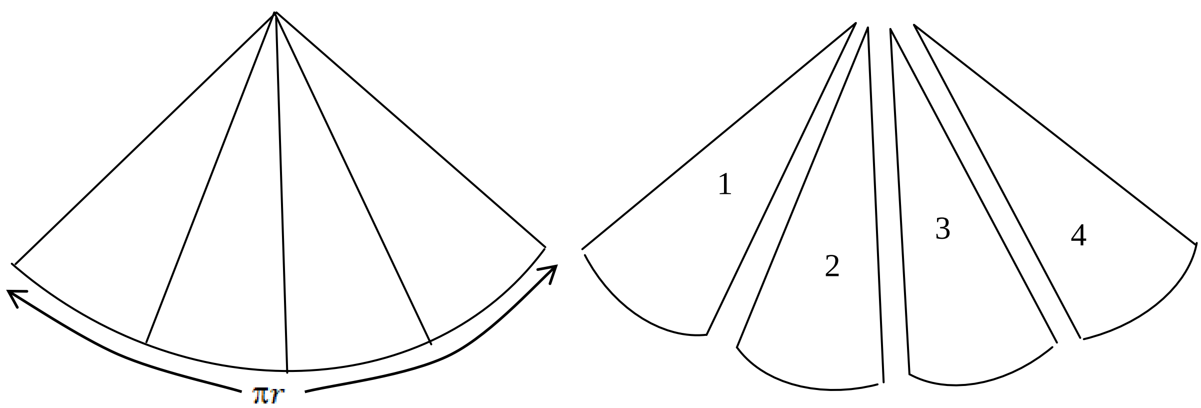

Figure 7. The Cut Out of the Four Sectors Numbered 1-4

Step 13: Turn 2 and 4 upside down and join them firmly with paper tape to get approximately a parallelogram ABCD (see Figure 8) such that $\overline{AB}//\overline{CD}$ and $\overline{AD}//\overline{BC}$. This shows that $\overline{BC} \cong \frac{1}{2}$ of $2\pi r = \overline{AD} = \pi r$.

$\therefore$ Area of a parallelogram = $\frac{1}{2}$ (πrl + πrl) = $\frac{1}{2}$ ($2\pi rl$) = πrl = the curved surface area of the cone = πrl. QED.

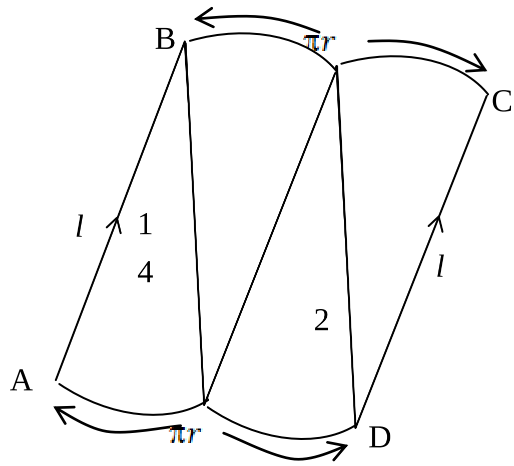

Figure 8. Approximately Parallelogram ABCD Is Formed from the 4 Sectors

It can be deduced from the above proof that total surface area of cone = curved surface area + area of the circular base of the cone = $\pi rl + \pi rl^2$ or $\pi r\ (l + r)$. QED

Students Observed That:

1) The curved surface area of a cone = πrl

2) The base of the parallelogram is approximately half of the circumference of the base of the cone, i.e., ½ $\times$ $2\pi rl$ (see Figures 8 and 9 above).

3) The height of the parallelogram is roughly the slant height (l) of the cone.

4) Therefore, the curved surface area of the cone = area of the parallelogram = πrl.

5) Students observed that paper folding activities can turn a plane surface (sector of a circle) into a curved surface (of the cone) to be approximately πrl.

6) Total surface area of a cone = $\pi rl + \pi r^2$ or πr (l + r).

4. Results

The findings of the study were presented in accordance with the posed research questions and the null hypotheses.

Research Question One: How does the performance of the experimental group differ from that of the control group before intervention (treatment)?

Research question one was answered using Table 1 below:

Research Question Two: How does the performance of the experimental group differ from that of the control group after treatment?

Research question two was also answered using Table 1 below:

Table 1. Means and Standard Deviations (S.D) Test-scores of Subjects in Experimental and Control Groups

Group	N	Pre-test scores (before treatment)		Post-test scores (after treatment)	
		Mean	S.D	Mean	S.D
Experimental (OBIMA)	81	5.71	0.51	3.86	0.49
Control (Conventional)	72	5.68	0.53	2.90	1.05
Mean Difference	153	0.03		0.96	

Result in Table 1 revealed that students exposed to the OBIMA in experimental group have a mean performance score of 5.71 with S.D. of 0.51 while those of the conventional method have a mean performance score of 5.68 with S.D. of 0.53 in pre-test (i.e., before treatment). In post-test, the experimental group have a mean performance score of 3.86 with S.D of 0.49 while those exposed to the conventional method have a mean performance score of 2.90 with S.D of 1.05. The mean difference between the experimental and control groups was 0.03 in the pre-test (before treatment was administered) while in the post-test (after treatment), the mean difference was 0.90 with S.D of 1.05. The mean difference between the experimental and control groups was 0.03 in the pre-test/before treatment was administered) while in the post-test (after treatment), the mean difference was 0.96. These mean differences in both before and after treatment were in favour of those exposed to experimental treatment. These differences in mean (0.03 in pre-test and 0.96 in post-test) were tested for statistically significant difference in the corresponding hypotheses 1 and 2 presented in Table 2 and 3 below.

Hypothesis One: There is no significant difference between the mean performance test scores of the experimental group and control group before treatment.

Table 2. Results of Independent T-test on the Performance of Experimental and Control Groups before Treatment (pre-test)

Group	N	Mean	SD	df	$t_{cal.}$	$t_{crit.}$	$P \leq .05$	Decision
Experimental (OBIMA)	81	5.71	0.51	151	0.36	1.96	0.000	NS*
Control (Conventional)	72	5.68	0.53					

Note. *NS = not significant at $P \leq .05$.

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Table 2 revealed the independent t-test statistic result of students in experimental and control groups who were pre-tested to partial out pre-existing cognitive differences amongst them. From the above Table 2, the result showed that the t-calculated value was 0.36 while the t-critical value was found to be 1.96 (i.e., tcal. = 0.36 > tcrit. = 1.96). Hence, the null hypothesis which stated that there is no significant difference between the mean performance test-scores of the experimental group and control group before treatment was not rejected. This implies that the initial mean difference in performance between the two groups was not statistically significant at $p \leq .05$. That shows, the two groups were sharing equal strength in Mathematics performance before the experimental group was exposed to the treatment.

Hypothesis two: There is no significant difference between the mean performance test scores of the experimental group after treatment.

Table 3. Results of the Independent T-test on the Performance of Male and Female Students on the Experimental and Control Group after Treatment

Gender	N	Mean	S.D	df	$t_{cal.}$	$t_{crit.}$	$P \leq .05$	Decision
Male (Experimental group)	44	21.01	1.021	79	0.164	2.01	0.96	NS*
Female (Experimental group)	37	20.97	1.147					

Note. *****NS = Not significant at $P \leq .05$.

Table 3 shows that after treatment (post-test) among the male and female subjects in experimental group, the t-calculated value was 0.164 while at t-critical value was found to be 2.01 (i.e., tcal = 0.164 < t-crit = 2.01). Hence, the null hypothesis which stated that there is no significant difference between the mean performance of male and female students in the experimental group after treatment was upheld. That means, the mean difference of 0.04 obtained between the two groups and tested, was not statistically significant at $p \leq 0.05$. That means, male and female students in the experimental group shares equal mathematics experience after being exposed to the treatment. This means, OBIMA is effective and capable of placing male and female students on equal pedestal in mathematics performance.

Research Question Four: Was there any difference in the mean interest ratings of the gender within the experimental group before the treatment?

Table 4. Response Scale by Experimental Subjects before Treatment

MIQ SECTION A

S/N	ITEMS DESCRIPTION	SA		A		D		SD		Total		$\bar{X}$		Rmk
		M	F	M	F	M	F	M	F	M	F	M	F	
1	I do not have interest in maths because maths teacher do not use alternative approach such as games or simulations except the usual method of applying formula	10	14	19	16	6	6	9	1	118	117	2.68	3.16	Agreed
2	Teacher do not reward me after solving maths problem correctly	12	15	20	17	8	3	10	2	134	119	3.05	3.22	Agreed
3	I hat maths because I am required to prove maths theorem	13	12	17	18	9	4	5	3	126	113	2.86	3.05	Agreed
4	Maths teacher teaches me maths with variety of methods or strategies thereby making it interesting to me	6	3	10	12	15	15	16	7	110	85	2.27	2.30	Disagree
5	I hate maths because there is no practical aspect to help me remember so many formulas involved in the mathematics	10	8	15	22	9	5	10	2	113	110	2.57	2.97	Agreed
6	I dislike maths because my maths teacher is not teaching me maths in laboratory like physics, biology and chemistry teacher do	7	9	23	20	7	5	13	3	124	109	2.82	2.95	Agreed
7	I do not participate often in	15	10	11	20	9	5	9	2	120	112	2.73	3.03	Agreed

	maths classes because my maths teacher do not take me out for field trip as physics, chemistry and biology teachers do													
8	I do not have interest in maths because teachers do not make the subject an activity-based learning subject	12	13	14	18	8	2	10	4	116	114	2.64	3.08	Agr
9	I do not have interest in maths because teachers do not give me assignments based on practical problem-solving	11	13	16	17	7	2	11	5	114	112	2.59	3.03	Agreed.
	Mean Diff. = 0.29; $\overline{X}_m$ = 2.69; S_m = 0.218l $\overline{X}_f$ = 2.98; S_f = 0.268													

The results of Table 4 shows that the students in the experimental group, before they were exposed to the treatment, agreed that they do not have interest in mathematics, mostly because of teacher's inability to approach the teaching of subject with practical activities thereby failure to make it activity-based learning. The table reveals that the respondents agreed that items 1, 2, 3, 5, 6, 7, 8 and 9 are the reasons why they disliked and do not participate in mathematics classes. However, they disagreed that item 4 is the reason that can make them interesting in mathematics. All the items mean responses are equal to or greater than the criterion mean of 2.50, except item 4 which has low score mean values of 2.27 and 2.30 for males and females respectively. The mean responses of males $\left(\overline{X_m} = 2.69; S.D * (Sm) = 0.218\right)$ and mean responses of females $\left(\overline{X_f} = 2.98; S.D\ (s_f) = 0.268\right)$ and mean difference of 0.29 in favour of females in mathematics before those in experimental group were exposed to the treatment.

Hypothesis Four: There is significant difference between the mean interest ratings of the males and female students in the experimental group before the treatment.

Table 5. Results of the Independent T-test on the Mean Interest Ratings of Male and Female Students in Experimental Group before Treatment

Gender	N	Mean	S.D	df	$t_{cal.}$	$t_{crit,}$	P ≤ .05	Decision
Male (Experimental)	44	2.69	1.021	79	5.27	2.01	0.96	S*
Female (Experimental)	37	2.98	1.147					

Note. *S = Significant at P ≤ .05.

Table 5 shows that before treatment (pre-test) among the male and female subjects in the experimental group, the t-calculated value was 5.27 while the t-critical value was found to be 2.01 (i.e., $t_{cal.} = 5.27 > t_{crit}. = 2.01$). Hence, the null hypothesis which states that there is no significant difference between the mean interest rating of the male and female students in the experimental group before treatment is rejected. That means, there is significant difference in the mean interest ratings of males and females in experimental group before they were exposed to the treatment. The mean difference of 0.29 obtained between the two groups and tested for significance was found statistically significant at p ≤ .05. That means, there is variation in the mean responses of the two groups (males and females) on how far they are interested in mathematics learning.

Research Question Five: How far does this interest of the students vary within the experimental group after the treatment (intervention)?

Table 6. Response Scale by Experimental Subjects after Treatment

MIQ SECTION B

S/N	ITEMS DESCRIPTION	SA		A		D		SD		Total		$\bar{X}$		Rmk
		M	F	M	F	M	F	M	F	M	F	M	F	
1	Teachers use of OBIMA arouses my interest in learning mensuration	18	15	20	14	2	0	4	8	140	110	3.18	2.5	Agreed
2	Teacher's praise to me whenever I get any aspect of the proof correctly, motivates me to learn mensuration proof	15	10	21	19	3	6	5	2	134	117	3.05	2.66	Agreed
3	The use of OBIMA is proving mensuration theorems, improved my ability in proving theorems, thereby	12	13	24	15	0	5	8	4	128	111	2.91	2.52	Agreed

	arousing my interest to learn more												
4	The use of OBIMA has not changed my negative attitude to the study of maths especially mensuration proves	4	4	6	1	11	12	23	20	79	59	1.8	1.34	Disagree
5	I was motivated to lean maths whenever teacher rewards my good performance in mensuration proofs	13	10	16	18	10	7	5	2	125	110	2.84	2.5	Agreed
6	OBIMS make me to develop higher thinking in proving theorems through paper-cutting and folding	16	14	21	11	1	10	6	2	135	111	3.07	2.52	Agreed
7	OBIMA has made it possible for me to understand the structure of mensuration formulae, and so can now internalize and recall them easily	14	18	13	9	12	8	5	2	114	117	2.59	2.66	Agreed
8	Teaching me maths with OBIMA make me to participate activity with great interest in maths class	16	17	11	9	10	6	7	5	124	112	2.82	2.55	Agreed
9	Teacher's use of OBIMA to teach me mensuration has made me to be interested in maths because it is activity-based or practically oriented	15	14	10	12	10	7	9	4	119	110	2.7	2.5	Agreed.

Mean diff = 0.35 $\overline{X_m}$ = 2.77; S_m = 0.4095; $\overline{X_f}$ = 2.42; S_f = 0.4089

The result of Table 8 shows that the students in the experimental group after they were exposed to the experimental treatment, agreed the items in the serial number 1, 2, 3, 5, 6, 7, 8, and 9 are reasons why they developed positive attitude towards the study of mathematics. However, they disagreed on item number 4 as reason for their interest in mathematics after they were exposed to the treatment. All the items means responses are equal to or greater than the criterion mean of 2.50, except item 4 which has low means values of 1.8 and 1.34 for males and females respectively. The mean responses of males ($\overline{X_m} = 2.77; S.D = 0.4095$) and mean responses of females ($\overline{X_f} = 2.42; S.D = 0.4089$) and mean difference of 0.35 in favour of males were obtained. That means males are more interested in maths than females after they were exposed to the treatment. This means difference (0.35) was further tested for statistically significant difference ($P \leq .05$).

Table 9. Results of the Independent T-test on Mean Interest Ratings of Male and Female Students in Experimental Group after Treatment

Gender	N	$\overline{X}$	S.D	df	$t_{cal.}$	$t_{crit.}$	$P \leq .05$	Decision
Male	44	2.77	0.4095	79	1.81	2.01	0.000	NS*
Female	37	2.42	0.4089					

Note. *NS = not significant at $P \leq .05$.

Table 9 shows that after treatment (post-test) the male and female subjects in experimental group had t-calculated value of 1.81 while t-crit value was found to be 2.01 ($t_{cal.} = 1.81 < t_{crit.} = 2.01$). Hence, the null hypothesis which stated that there is no significant difference in the mean interest ratings of the male and female subjects in the experimental group after treatment was not rejected. That means the observed mean difference of 0.35 obtained between the males and females responses after experimental treatment was not statistically significant at $p \leq .05$ significant level. That means the subjects gained positive attitude (interest) in mathematics learning after being exposed to the new treatment (OBIMA). That means OBIMA is effective in bridging the gap in gender bias in mathematics learning and interest.

5. Discussion of Results

Based on the findings of the study, it appears to suggest that the problem of poor performance in mathematics among secondary school students can be tackled through activities-based teaching approaches (FRN, 2013). Obviously, origami-based instructional model approach belongs to such approaches. For instance, this study has clearly demonstrated that the students taught using origami-based instructional model approach had higher mean gain score of 0.96 after treatment than their counterpart taught using conventional method. This finding is in agreement with earlier assertion of WAEC Chief Examiner (2012) that teachers should be encouraged to use instructional materials during lessons so as to re-enforce the learning of mathematical concepts. Moreso, the result indicated that the interest of the students exposed to the treatment changed from negative (before treatment) to positive (after treatment), thereby making the students perform better on the subject after being exposed to the treatment. This finding is in consonance with earlier report of Okafor (2011) that the use of appropriate teaching materials to teach mathematics concepts and principles, arouses students' interest and increase the volume of learnt materials. The mean interest rating of male and female students in experimental group before being exposed to the treatment was significant but after being exposed to treatment there was no significant difference between the two groups (males and females) ($P \leq .05$). This clearly indicate that OBIMA is effective in bridging the gap of gender variability in mathematics achievement tests. However, the origami-based instruction model approach favour males students more than their female counterpart as the result yielded mean difference of 0.35 in favour of male students. The mean difference of 0.35 was further tested and found not satistically significant ($P \leq .05$). This finding is in consonance with earlier reports that girls reached parity with boys in mathematics achievement tests (Hydea & Mertzb, 2009; Aja & Imoke, 2015). However, this finding contradicts earlier reports (Olosunde & Olaleye, 2010; Unodiaku, 2013) that boys performed better than girls in mathematics tests. Moreso, it contributes earlier reports (Ozofor, 2001; Unodiaku, 2015), who all reported that females performed better than males in mathematics achievement tests. These in consistency reports suggest the need for further enquiry to clarify gender superiority in mathematics achievement tests.

6. Conclusion

Based on the findings of the study, it was concluded that origami-based instructional model approach is effective in teaching mensuration theorems proofs. The mean difference in achievement of male and female students was found to be in favour of males. However, the mean difference between both sexes was not statistically significant when origami-based model approach is used in teaching mathematics, especially in proving mensuration theorems. In other words, OBIMA is capable of giving both sexes equal strength in mathematics achievement and interest in studying the subject. The result of the study indicates that OBIMA is capable of bridging the existing gap in mathematics achievement between male and female students.

7. Recommendations

1) Teachers of senior secondary schools students should adopt and adapt origami-based instructional model in teaching mensuration proofs. Through this practical activities in mathematics learning, psycho-motor of the students and their interst in learning mathematics will be encouraged. Hence, students' performance on the subject will be enhanced.

2) Examination bodies such as NECO and WAEC should include questions on mensuration proofs based on the use of origami-based instructional model approach which is practically and activity based.

3) Conferences, seminars and workshops should be organized by ministry of education and other stakeholders in education, for teachers on origami-based instruction and how to apply it in teaching mathematics, especially mensuration proofs.

4) Stakeholders in secondary school mathematics curriculum planning and development and authors of secondary school mathematics textbooks should incorporate origami-based instructional model approach as inclusive approach to be adopted in teaching mathematics especially mensuration proofs, among secondary school students.

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