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Enhancing Senior Secondary School Students' Achievement in Geometry through Origami Instructional Approach

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Abstract

The study was aimed at enhancing secondary school students' achievement in geometry through Origami Instructional Approach. The study was carried out in secondary schools in Owerri municipal council of Imo State, Nigeria. The study was a quasi-experimental type adopting the non-equivalent control group design. The sample for the study consisted of 240 senior secondary II (SS2) students from two purposively selected secondary schools. The instrument for data collection was a researcher made 35-multiple questions titled "Geometry Achievement Test (GAT)". It had reliability coefficient of 0.79 determined using kuder Richardson 20 formula (KR_{20}). The experiment group was taught using Origami Instructional Approach (OIA), while the control group was taught the same topic using the conventional approach. The data generated were analyzed using ANCOVA statistical tool tested at 0.05 level of significance. The result of the study showed that Origami Instructional Approach (OIA) enhanced students' achievement in geometry across gender. Based on the results, it was recommended that Origami should be employed in teaching geometry in secondary schools to enhance students' achievement.

Keywords: Origami, Instructional Approach, Geometry, Achievement

Introduction

Mathematics is a very important subject that cuts across all human activities in the society. The knowledge of mathematics possessed by an individual determines his level of critical thinking ability, intelligence and academic prowess. Mathematics is very essential in our daily life activities and has much regards in the society due to its relevance in industrialization, entrepreneurship, scientific and technological development of any nation (Nwoke, 2017). According to Oloda (2017) Mathematics ideas played a significant role in the revolution of electronics, information technology (IT), the search for energy, ability to measure the effect of environmental hazards and so on. Betiku (2001) indicated that Science, Technology and Mathematics Education (STME) has been widely acclaimed to be the index of measuring any nation's socio economic and geo-political development. Mathematics is seen as science of structure, order and relation that has evolved from counting,

measuring and describing the shapes of object. It deals with logical reasoning and quantitative calculations. Mathematics nurtures the power of reasoning, creativity, abstract or spatial thinking, critical thinking, problem-solving ability and even effective communication skills (The India times, 2013, Nwoke & Nwaneri, 2016). According to Eniayeju (2005) the significance of Mathematics is further strongly expressed through the Federal Government policy of making Mathematics a compulsory subject at both primary and secondary school levels.

Irrespective of the importance and relevance of Mathematics to individual and the nation in general, the students' performance in Mathematics both at internal and external examinations has continued to deteriorate year after year (Galadima & Okogbenin, 2012). According to Kurumeh (2007) students fear and hate Mathematics which results to lack of interest and poor achievement in Mathematics particularly geometry and mensuration. Adegun and Adegun (2013) stated that students generally encountered difficulties in geometry and performed poorly in senior secondary school Mathematics lessons.The problem of poor performance in Mathematics has been severally blamed on Mathematics teachers and their instructional approaches. Obodo (2000) lamented the poor state of Mathematics instruction in Nigeria and averred that the problem of quality of Mathematics instruction and learning are from diverse sources. Cooney as cited in Adolphus (2011) accused teachers to be responsible for the low quality of students' performance in our secondary schools. The trend of poor performance in Mathematics portends great danger for geometric instruction and students further academic pursuit if not arrested.

Geometry is noted to be the study and analysis of shapes and structures (NCTM, 2000). According to Kurumeh, Obarakpo, Odoh and Ikyereve (2016) geometry is seen as a basic and important branch of Mathematics that deals with the study of size, shape and position of 2-dimensional shapes and 3-dimensional figures. Geometry is a branch of Mathematics that deals with points, lines sizes, angles, surfaces, solids and shapes. Geometry is included in most of the school curricula over the world taking into account its considerable benefits and application in life (Arici & Aslan-Tutak, 2013). They further noted that geometry instruction develops students' spatial and perceptual abilities to interpret the dimensionality of the physical world. Jones (2002) noted that shapes and space are taught to foster the learning of higher Mathematics such as mechanics, vector and mensuration. Geometry appears naturally in the structure of the solar system, a geological formation, rocks and crystals, plants and flowers, and even in animals. It is also a major part of the synthetic world such as art, architecture, cars, machines and virtually everything humans create (Fabiyi, 2017). According to Jones (2002) the reasons for including geometry in the school Mathematics curriculum are myriad and encompass providing opportunities for learners, not only to develop spatial awareness, geometrical intuition and the ability to visualize, but also to develop knowledge and understanding of, and the ability to use geometrical properties and theorems.

Despite the importance of geometry, the teaching and learning of this aspect of Mathematics has continued to pose challenges for both teachers and learners. Fletcher and Anderson (2012) noted that at the senior high level, there have been consistent evidences regarding the inability of candidates to tackle questions requiring spatial visualization and geometric reasoning in relation to circle theorems, mensuration and other 3-dimensional problems in core Mathematics. Many researchers have indicated several factors responsible for students difficulty in learning geometry these includes: lack of background knowledge, teachers method of teaching, lack of proof by

students, poor reasoning skill in geometry, lack of visualization, geometric language comprehension, non-availability of instructional materials, gender differences among others (Mason, 2002; Noraini, 2006; Uduosoro, 2011; Telima, 2011; Ayben, 2012 & Fabiyi, 2017).

The National Council of Teachers of Mathematics (NCTM, 2000) calls for continued improvement in methods of teaching Mathematics that engage, excite, and develop Mathematical thinkers. The need for innovative approaches of teaching Mathematics gives way to student centered approaches such as use of manipulatives involving origami as against the conventional teacher centered approach. Manipulatives may play an instrumental role in enhancing geometric reasoning skills of students by creating a suitable context that allows transition from empirical thinking to more abstract thinking. Manipulatives can be useful in facilitating students' progression to higher levels of geometric thinking. Thus, origami, the art of paper folding can be used in teaching geometry considering its manipulative nature (Arici & Aslan – Tutak, 2013).

Tugrul and Kavici, (2002) in Arici and Aslan-Tutak (2013) suggested origami as a useful educational tool considering its several benefits ranging from cognitive to motivational gains. Origami has the potential of enabling students understand Mathematical and geometrical concepts such as angle bisectors, fractions, division, ratio, triangles, polygons, congruence, symmetry among others. Origami could enhance students understanding of some underlying principles associated with geometric concepts. Boakes (2009) indicated that origami activity generates multi modal learning in the form of visual, verbal and kinesthetic learning modes. Gunhan (2014) in a research on learning reveals that such multi-modal learning environment promotes effective geometric reasoning among students with difficult learning styles. Akayuure, Asiedu-Addo and Alebna (2016) stated that origami instruction can help students to visualize, reason and discover fundamental properties of shapes including their geometrical relations and transformations. Arici and Aslan-Tutak (2013) suggested that the origami-based instruction could have an effect on students' geometry achievement and geometric reasoning concerning triangles. Pope and Lam (2011) noted that origami was a good way to enrich school curriculum by providing opportunities for problem solving and creativity. These are indications that origami may be an instructional approach that can enhance geometry knowledge of secondary school students.

Statement of the Problem

The consistent poor performance of students in Mathematics and geometry in particular has constituted a source of worry to parents, educators and government. This situation if allowed to persist, the nation might not attain the level of industrialization it has projected

Based on the foregoing, this study investigated the effect of Origami Instructional Approach (OIA) on senior secondary school students' achievement in geometry.

Purpose of the Study

The main purpose of this study was to investigate the effect of Origami Instructional Approach (OIA) on senior secondary school students' achievement in geometry. Specifically, the study sought to determine:

1. The effect of Origami Instructional Approach (OIA) on students' achievement in geometry.
2. Influence of gender on students' achievement in geometry.

Research Question

The following research questions guided the study:

1. What is the difference between the mean achievement scores of students taught geometry using Origami Instructional Approach (OIA) and those taught using conventional approach?
2. What is the difference between the mean achievement scores of male and female students in geometry?

Hypotheses

The following hypotheses were formulated to guide the study:

$H0_1$: There is no significant difference between the mean achievement scores of students taught geometry using Origami Instruction Approach (OIA) and those taught using traditional approach

$H0_2$: There is no significant difference between the mean achievement scores of male and female students in geometry.

Methodology

The study adopted the quasi-experimental research design applying the pre-test, post-test, non-equivalent control type. This approach was adopted since it was not possible to disrupt the academic programme of the schools used through randomization process.

Group	**Pre-test**	**treatment**	**Post-test**
Experiment	X_1	a	X_3
Control	X_2	-	X_4

Where a = treatment, - = no treatment

The population of the study consists of all senior secondary school II (SS 11) students in the 12 public secondary schools in Owerri West Local Government Area of Imo State. Two schools were purposively selected for the study based on their co-educational characteristics. In each of the two schools selected, two intact classes were randomly assigned to control and experiment groups and this gave a sample total of two hundred and forty students (240) for the study. The sample comprised of one hundred and seventeen (117) females and one hundred and twenty-three (123) males. The control group had one hundred and twelve (112) students with sixty (60) females and fifty-two (52) males, while the experiment group had one hundred and twenty-eight (128) students with seventy-one (71) males and fifty-seven (57) females. Also, the experiment group had eighty-two (82) low

achievers and forty-six (46) high achievers who were classified based on their existing Class assessment records. The instrument for data collection was a researcher made 35–multiple choice questions titled "Geometry Achievement Test (GAT)" it was constructed based on the topics treated with the students from the syllabus. The construction of the instrument was guided by a table of specification. To determine the face and content validity of the instrument, it was handed over to two experts in Mathematics education and a Measurement and Evaluation expert. In determining the face validity, the experts vetted the items of the instrument in terms of clarity of words, language difficulty etc. For the content validity, the experts vetted instrument to ensure the adequacy of the items in measuring the objectives of the study. Their expert judgment guided the restructuring of the instrument where necessary. To determine the reliability of the instrument, 30 copies were administered to students outside the study group but with the same characteristics. The data generated was analyzed using Kuder Richardson 20 ($K\text{-}R_{20}$) formula, this gave a reliability coefficient of 0.79 which was acceptable for the study. The two groups (control & experiment) were administered with a pre-test to determine their placement before the treatment. The control groups were taught some topics in geometry using the traditional instructional approach as outlined in the lesson plan by their regular teachers. The students were taught proof of sum of angles in a triangle (900 and180^0), bisection of angles, line of symmetry, formation of cubes, cuboids. The experiment groups were taught the same topic using Origami Instructional Approach (OIA) as outlined in the lesson plan. They were taught by their classroom teacher who was trained on application of Origami Instructional Approach (OIA) for one week using one hour for four days. The experiment groups were taught the geometric concepts through folding of paper and the teachers guided them to understand the underlying relationships and proofs for other concepts. The origami activities include; proof of sum of angles in a triangle sum up to 180^0 by folding paper, bisection of angles by folding paper, line of symmetry by folding paper, formation of cubes, cuboids by folding paper and making nets, and practiced other relationships. The entire lessons lasted for two weeks after which a post-test was administered to both groups using a re-arranged version of the pre-test and marked over 100 percent. The data generated was analyzed using mean and standard deviation to answer research questions while analysis of covariance (ANCOVA) was used to test hypotheses at 0.05 level of significance.

Results

Research Question 1: What is the difference between the mean achievement scores of students taught geometry using Origami Instructional Approach (OIA) and those taught using conventional approach?

Table 1: Summary of Students' Achievement

Group	N	Pre-test Mean	SD	Post-test Mean	SD	Mean gain	Diff. in mean
Expt.	128	33.06	8.75	53.05	0.33	19.99	
Control	112	32.92	8.63	34.48	8.96	1.56	18.43

Table 1 shows that the experiment group had mean score of 33.06 and standard deviation of 8.75 in the pre-test and mean score of 53.05 and standard deviation of 9.33 in the post-test, the mean gain of the experiment group was 19.99. The control group had mean score of 32.92 and standard deviation of 8.63 in pre-test with mean score 734.48 and standard deviation of 8.96 in post-test, the mean gain of the control group was 1.56. The difference between the mean gain of the experiment and control group was 18.43 in favour of the experiment group.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught geometry?

Table 2: Summary of gender achievements in experiment group

Gender	**N**	**Pre-test**		**Post-test**		**Mean gain**	**Diff. in mean**
		Mean	**SD**	**Mean**	**SD**		
Male	71	33.49	7.60	53.45	7.92	20.04	
Female	57	32.83	7.05	53.09	8.01	20.26	0.22

Table 2 shows that the male students had mean score and standard deviation of 33.41 and 7.60 in pre-test with 53.45 and 7.92 in posttest which gave a mean gain of 20.04 while the female students had mean score and deviation of 32.83 and 7.05 in pre-test with 53.09 and 8.01 in post-test which gave a mean difference of 20.26. These gave a mean score difference of 0.22 in favour of female students.

Hypotheses

$H0_1$: There is no significant difference between the mean achievement scores of students taught geometry using Origami Instruction Approach (OIA) and those taught using traditional approach.

Table 3: Summary of ANCOVA analysis of students' achievement

Source	**Type III sum of squares**	**df**	**Mean square**	**f**	**Sig**
Corrected model	25897.274	6	4316.212	60.508	.000
Intercept	30425.985	1	30425.985	426.535	.000
Covariate	23.800	1	23.800	.334	.564
Method	**22669.605**	**1**	**22669.605**	**317.800**	**.000**
Gender	**170.435**	**1**	**170.435**	**2.389**	**.124**
Ability	**17.401**	**1**	**17.401**	**.244**	**.622**
Error	16620.576	233	71.333		
Total	502418.000	240			
Corrected Total	42517.850	239			

Table 3 shows that f calculated was 317.800, p-value (0.000) is less than 0.05. Based on the result, the null hypothesis is rejected and alternative accepted. This implies that there is a significant difference between the mean achievement scores of students taught geometry using Origami Instructional Approach (OIA) and those taught using traditional approach.

$H0_2$: There is no significant difference between the mean achievement scores of male and female students taught geometry.

Table 3 shows that f-calculated value was 2.389, p-value (.124) is greater than 0.05. Based on the result, the null hypothesis is upheld.

Discussion of Findings

The result of the study revealed that Origami Instructional Approach (OIA) is effective in enhancing students' achievement in geometry as students taught geometry using Origami Instructional Approach had higher mean achievement scores than those taught using traditional approach. Further statistical analysis indicated a statistically significant difference between the mean achievement scores of students taught geometry using Origami Instructional Approach (OIA) and traditional approach. This outcome is suspected to have resulted due to activity-based nature of the instructional approach. This result is in line with Arici and Aslan-Tutak (2013), whose results about geometry achievement revealed that there was a statistically significant change in geometry achievement scores of students, who received origami-based instruction from pre-test to post-test time, and Boakes (2006) who sees origami as a powerful tool to teach mathematics concepts, particularly in geometry. The result is also in agreement with Obi, Agwagah and Agah (2014) which showed that the use of origami in teaching geometry will help students to retain the things they have learnt and in turn improve achievement in mathematics.

The result of the study revealed a slight difference in the achievement of male and female students taught geometry using Origami Instructional Approach (OIA) in favour of the female students. However, further analysis indicated no statistically significant difference between the mean achievement scores of male and female students taught geometry using Origami Instructional Approach (OIA). This result is in agreement with Ajai and Imoko (2015) which showed no significant difference between the achievements mean scores of male and female students taught algebra using problem-based learning strategy.

Conclusion

The study investigated the efficacy of Origami Instructional Approach (OIA) in enhancing students' achievement in Geometry at secondary school level. The result of the study revealed that Origami Instructional Approach (OIA) enhanced students' achievement in geometry and reduced gender gap associated with mathematics achievement. This is an indication that, Origami Instructional Approach (OIA) is a very effective measure of teaching Geometry at secondary school level.

Recommendations

Based on the results, the following recommendations are made:

1. Mathematics teachers at the secondary school level should be exposed to the use of activity based instructional approach such as Origami Instructional Approach in teaching Mathematics to enhance students' achievement.
2. The government, stake holders and school managers should organize workshops, seminars and symposium to train teachers on innovative approaches of teaching Mathematics to enhance students' achievement.
3. The government should establish Mathematics laboratory in secondary schools where Origami Instructional Approach will be applied when teaching geometric concepts.

References

Adegun, I. K. & Adegun, B. O. (2013). Student and teaches views of difficult areas in mathematics syllabus. Basic requirement for science and engineering education. *Journal of Education and Practice*, 4(12), 235 – 243

Adolphus, T. (2011). Problems of teaching and learning of geometry in secondary schools in Rivers State, Nigeria. *International Journal of Emerging Science*, 1(2), 143 – 152

Ajai, J.T. & Imoko, 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.

Akayuure, P. Asiedu-Addo, S. K. & Alebna, V. (2016). Investigating the effect of origami Instruction on pre-service teachers' spatial ability and geometric knowledge for teaching. *International Journal of Education in Mathematics, Science and Technology*, 4(3), 32 – 38

Arici, S.& Aslan-Tutak, F. (2013). The effect of origami-based instruction on spatial visualization, geometry achievement and geometric reasoning. *International Journal of Science and Mathematics Education*, 13, 179 – 200

Aysen, A. (2012). Misconceptions in geometry and suggested solutions for seventh grade students. *International Journal of New Trends in Arts, Sports and Science Education. 1(4), 1 – 13*

Betiku, O. F. (2001). Causes of mass failure in mathematics examination among students. *Commissioned paper presented at Government secondary, Karu, Abuja Science Day*

Boakes, N. J. (2009). Origami Instruction in the middle school mathematics classroom: its impact on spatial visualization and geometry knowledge of students. *RMLE: Research in Middle Level Education*, 32(7), 1 – 11

Eniayeju, A. A. (2005). Training and retention of mathematics teachers in Nigeria in Ale, S. O. & Adetula, L. O. (Eds), *Reflective and intellectual position papers on mathematics education issues.* Abuja: Marvellous Ventures Ltd.

Fabiyi, T. R. (2017). Geometry concepts in mathematics perceived difficult to learn by senior secondary school students in Ekiti State, Nigeria. *IOSR Journal of Research & Method in Education*, 7(1), 88 – 90

Fletcher, J. A. & Anderson, S. (2012). Improving students' performance in mensuration at the senior high school level using geometer sketch pad. *International Journal of Science and Mathematics Education*, 6(1), 63 – 79

Galadima, I. & Okogbeni, A. A. (2012). The effect of Mathematical games on academic performance and attitude of senior secondary students towards mathematics in selected schools in Sokoto State ABACUS, *J. Math Assoc Nig*, 37(1), 30 – 37

Gunhan, B. C. (2014). A case study on the investigation of reasoning skills in geometry. *South African Journal of Education*, 34(2) 1- 19

Jones, K. (2002). Issues in the teaching and learning of geometry in: Liudo A. (Ed). *Aspects of teaching secondary mathematics perspectives on practice*. London: Routledge Falmer

Kurumeh, M. S. (2007). Effect of ethnomathematics approach on students intest in geometry and mensuration. ABACUS: *J. Maths Assoc Nig*, 31(1), 35 – 44

Kurumeh, M. S.; Obarakpo, J. S.; Odoh, O. O. & Ikyereve, R. O. (2016). Enhancing senior secondary school students' achievement in geometry through the utilization rusbutt problem solving model in Keffi metropolis, Nasarawa State, Nigeria. *Merit Research Journal of Education and Review*, 4(6), 060 – 070

Mason, M. (2002). The Van Hiele levels of geometric understanding. Retrieved from *http://jwilson.coe.uga.edu/EMAT8990/GEOMETRY*

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics.* Reston, VA

Noraini, I. (2006). *Teaching and learning of mathematics: making sense and developing cognitive abilities.* Perak:utusan Publishing sdn Bhd

Nwoke, B. I. (2017). Enhancing secondary school students' achievement in Mathematics using peer tutoring instructional approach. Abacus, *the Journal of Mathematical Association of Nigeria*, 42(1), 297 – 303

Nwoke, B. I. & Nwaneri, M. O. (2016). Effect of improvised instructional materials on senior secondary school students' achievement and retention in Mathematics. *International Technology Research Journal (INTERJ)*, 4(1), 1 – 9

Obodo, G. C. (2000). *Principles and practice of mathematics education in Nigeria*. *Enugu*: General Studies division, University of Science and Technology Pub

Obi,C.N., Agwagah, U.N.V. & Agah, J.J. (2014). Effect of Origami on Students' Retention in Geometry. *IOSR Journal of Research & Method in Education (IOSR-JRME)* 4(5),46-50.

Oloda, F. S. S. (2017). Gender environment and parents' socio-economic status as determinant of students performance in Mathematics periodic tests and terminal examination in Ondo State secondary schools. Abacus: *The Journal of Mathematical Association of Nigeria*. 42(1), 166 – 172

Pope, S. & Lam, T. K. (2011). Origami and learning mathematics. In P. Wang Iverson, R. J. Lang & M. Yim (Eds), Origami *fifth international meeting of origami science, mathematics and education (SOSME).* Boca Ratou: CRC Press

The Times of India (2013). *The importance of maths in everyday life times of India.* Indiatimes Com/city

Telima, A. (2011). Problems of teaching and learning of geometry in secondary schools in River State, Nigeria. *International Journal of Emerging Science*, 1(2), 2011, 143-152.

Uduosoro, U. J. (2011). Perceived and actual learning difficulties of students in secondary school mathematics. *International Multidisciplianry Journal*, Ethiopia, 5(5), 357 – 361