Geometric Model Simulation Instructional Approach and Junior Secondary School Students' Academic Performance in Mathematics in Rivers State Nigeria

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Abstract- This study was titled geometric model simulation instructional approach and junior secondary school students; academic performance in mathematics in Rivers State Nigeria. A sample of 156 students was drawn from a population of 4,584 junior secondary one students' in Port Harcourt Local Government Area of Rivers State. The study was guided by two objectives, two research questions and two null hypotheses. The pretest, posttest quasi experimental research design was used for the study. The experimental group one was taught sold geometry with origami-based instruction, experimental group two was taught with simulation instruction while the control group was taught with chart-based instruction. A Geometry Performance Test which had 25 multiple-test items was used to collect data. The instrument was validated by experts and the test-retest method was used to obtain a reliability of 0.82. The mean, standard deviation and analysis of covariance were used for analysis. The findings showed that origami-based instruction was more effective than the simulation instructional approach with no statistically significant difference. The result also showed that the simulation instructional approach was more effective than the chart-based instruction with a significant statistically difference. It was therefore recommended that mathematics teachers should desist from using the traditional method of teaching and employ innovative instructional methods such as origami-based instruction and computer simulation.

Indexed Terms- Simulation, Performance, Geometry, Mathematics, Students.

I. INTRODUCTION

Mathematics is an academic subject that has the function of developing students' skills, knowledge, attitude and values towards solving problems in our everyday activities. Mathematical knowledge has spread its tentacles to man's personal needs, organizational success, economy of nations, career choices, vocations, entrepreneurship, home fronts, secular and religious sectors. Guran (2016) opined that Mathematics also renders its application in every academic subject such as chemistry, biology, creative arts, music, commerce, economics, data processing or agricultural sciences. This, therefore, makes it imperative for the all-around implementation and evaluation of the mathematics curriculum to be well articulated. Given that Mathematics has wide applications in our daily lives, Kulbir (2006) pointed out that the objectives of teaching Mathematics are classified into cultural, disciplinary, social, practical and vocational values. This classification indicates that the objectives of teaching Mathematics in schools are intended to develop knowledge and skills emanate from our everyday activities.

Geometry is one of the themes that make up the mathematics curriculum at the primary and secondary levels of education. The study of geometry involves parameters such as size, shapes, measurements, position and dimension of objects in the physical environment. Furthermore, parameters such as properties and relationships of points, lines, angles, construction, surfaces and solids also make up the theme of geometry. The study of geometry started in the ancient civilization as recorded in the history of Mathematics documentation. Hence, it is known as one of the oldest branches of Mathematics. Geometry started in ancient Egypt as far back as 300BC when they used geometrical knowledge in surveying plots of lands, the building of pyramids and astrological pursuit (Odili, 2019).

Mathematics includes many concepts which are expected to be understood by the students conceptually. To this end (Nwaka, Ahunanya & Kwesi, 2017) defined conceptual knowledge as the ability of one to possess an integrated and functional grasp of mathematical concepts. The conceptual knowledge does not allow isolated understanding of mathematical concepts but rather allows the understanding of mathematical concepts in a networking or interconnected manner which paves way for the transfer and application of such concepts in new situations and new contexts respectively. Conceptual knowledge is rich in linking relationships. Alcali (2020) iterated that the five activities which can help students develop conceptual understanding in Mathematics are, belief, sense making, scaffolding, time and multiple representations.

There are varied instructional strategies that can be employed to teach mathematical concepts in schools. Some examples of such strategies include, but are not limited to, origami, simulation, the use of geometrical models, and the use of charts. The ancient Japanese art known as origami has played a vital role in the world of Mathematics in general and geometry in particular. Nwachukwu (2017) defined origami as the craft or art of folding paper to make objects, animals or people. The origami art or technique of folding paper is carried out to produce a variety of decorative or representational shapes. The production of objects which have shapes in the art of paper folding links origami to geometry. Origami has received a considerable amount of mathematical study. The mathematics inherent in origami is points, intersections, angles, properties of plane and solid shapes, polyhedron, area and volume of geometrical shapes, mirror images, symmetry, fractions and spatial visualization.

The use of technology is another way in which teaching methods are categorised. In as much as we are in the digital era, it becomes imperative that the educational tasks should have an inclination to the emerging technologies which can be employed to teach mathematical concepts. The emerging technologies that can be used to teach mathematical concepts and skills include graphing calculators, smart boards, overhead projectors, computers, Mathematics software's et cetera. Charles (2020) opined that there is a need for schools to constantly renew the teaching strategies by going beyond the use of traditional teaching methods and using emerging technologies such as smartphones and the internet to improve students' performance in various school subjects. Research has shown that flipped classroom, gamification and Academic Google has improved the performance and retention of students in Mathematics and other science subjects.

The simulation method of teaching has to do with a way of seeing something happen without it taking place in the same way. The major objective of simulation is to explore and explain the underlying mechanisms which control a system. The simulation instructional method involves the modeling of a situation and experimenting on the model concerned. A model is a programme that imitates a physical process by using a variable that can be manipulated. The facility or process to be modeled is called the system. This may suggest why mathematical modeling has systems of equations, systems of formulae, systems of geometrical shapes and systems of algorithms and axioms. National Council of Teachers of Mathematics, NCTM (2021) opined that the use of technology in teaching and learning Mathematics plays an essential role that supports and advance mathematical sense making, reasoning problem-solving and communication.

- Problem Specification

While it is believed that technology has changed the method of teaching school subject content, many teachers who teach Mathematics according to Ikenna (2016) has resorted to the use of a more traditional teaching method known as the low technique teaching method. Though this method of teaching has been criticized by scholars to impact negatively on the performance of students, some subject contents require the use of low-tech teaching methods where charts, manual writing, and learning by doing becomes more favourable. One of the objectives of teaching geometry in schools is to provide students with the knowledge and understanding of geometrical concepts, geometrical visualization and the ability to use geometrical properties and theorems in other subject areas and real-life scenarios. Thus, this helps students to make sense of other areas in Mathematics. To this end, Keinth (2017) posited that the mathematics teacher should always relate the teaching of geometry to other branches of Mathematics and everyday activities.

The integration of information and communication technology has permeated every sector of human endeavour. The use of technological gadgets and problem-based learning to carry out instruction in schools is what characterizes a 21st century classroom. Mathematics is a subject that is made of so many concepts which need to be understood in other to pave way for the understanding of related and higher concepts. Today's Mathematics classroom is expected to engage students through learning challenges using different types of technology such as computers, graphing calculators and software and computer simulation instructional approaches. This study, therefore, was delved into to investigate the effect of geometric model simulation instructional approach and junior secondary school students' academic performance in Mathematics in Rivers State Nigeria

- Objectives of the Study

The objectives of the study were to:

1. determine whether there is any difference in the mean performance score of students taught Solid Geometry using origami-based instructional approach with those taught using geometrical model simulation instructional approach.
2. ascertain the difference in the mean performance score of students taught Solid Geometry using geometrical model simulation instructional approach with those taught using charts based instructional approach.

- Research Questions

1. What difference exists in the mean performance score of students taught solid geometry using origami-based instructional approach with those taught using geometrical model simulation instructional approach?
2. How does the mean performance scores of students taught Solid Geometry using geometrical model simulation approach differ from those taught using charts based instructional approach?

- Hypotheses

The two null hypotheses below were tested at 0.05 significant level.

H_{O1}: No significant difference exists in the mean performance score of students taught Solid Geometry using origami-based instructional approach with those taught using geometrical model simulation instructional approach.

H_{O2}: The mean performance scores of students taught Solid Geometry using geometrical model simulation instructional approach and those taught using charts based instructional approach do not differ significantly.

II. RESEARCH DESIGN

Quasi-experimental research design which presented three groups was used to conduct the investigation. The design was the pretest, posttest intact class type. The design presented two experimental groups and one control group.

III. POPULATION OF THE STUDY

The population of the study consisted of all the four thousand five hundred and eighty-four (4,584) junior secondary school one (JSS1) students in the eighteen (18) public junior secondary schools in Port Harcourt Local Government Area of Rivers State

IV. SAMPLE AND SAMPLING TECHNIQUE

The purposive sampling technique was used to select a sample of 156 JSI students from the population of the study.

V. INSTRUMENT FOR DATA COLLECTION

The study made use of researchers' constructed instrument titled Geometry Performance Test (GPT). The instrument was made up of twenty-five (25) multiple-choice questions in Solid Geometry. The GPT was designed to specifically test the students' academic performance in Solid Geometry. Each multiple-choice question had four options lettered A to D. Out of the four options, three were distracters and only one option was the correct answer. The items of GPT were derived from the contents that were taught to students on Geometry. Each correct test item in GPT was scored four (4) points and each incorrect test item was scored zero point. The total score for GPT was one hundred (100). The test items of GPT were set to measure the higher and lower order Bloom's cognitive domain learning outcome using a table of specification.

VI. VALIDITY OF INSTRUMENT

The face and content validity of the instrument (GPT) was done by three experts in Mathematics education. The instrument was presented to the experts for them to scrutinize the contents of the instrument to ascertain its suitability for the study. In addition to the above scrutiny was the checking of the lexis, syntax and structure of the grammar used to construct the test items of the instrument. The corrections pointed out by the experts were used to modify the items in the instrument before administering to the sample.

VII. RELIABILITY OF INSTRUMENT

Twenty JSI students who were not participants of the main study were used for the trial testing of GPT. The test-retest method was used to ascertain the reliability of GPT. The twenty students were given copies of GPT to respond to. After three weeks, the same twenty students were re-administered with copies of GPT to respond t for the second time. The scores of students for first and second tests obtained after marking and collating were subjected to Pearson Product Moment Correlation. The reliability of GPT was established to be 0.82.

VIII. METHOD OF DATA COLLECTION

Three different lesson plans that were used to teach the three groups (two experimental groups and one control group) were prepared by the researchers. The regular teachers of the intact classes were employed as research assistants to carry out the teaching to reduce teacher-effect. These intact class teachers were trained for two days on how to carry out the teaching to suit the objectives of the study. The three groups were first administered a pretest with the instrument (GPT) without any form of teaching by the intact class teachers. This was then followed by the teaching of the topics for two weeks. Each group was taught the same content by their regular Mathematics teacher for the same duration of time under similar classroom conditions using the same lesson plans. The only difference in the lesson plans was the use of Origami to demonstrate the instruction on Solid Geometry to experimental group one, the use of computer geometrical model simulation to demonstrate the instruction on Solid Geometry to experimental group two and the use of charts to demonstrate the instruction on Solid Geometry to the control group.

A pretest of GPT was initially given to the students in the three different groups. No form of treatment was carried out on the three groups at this stage. The pretest was followed with the treatment of the three groups with the specified instructional approach for each group. After the treatment session, a post test was carried out on the three groups to determine students' performance using GPT. The results obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 23.

IX. METHOD OF DATA ANALYSIS

The research questions were answered descriptively using mean and standard deviation while the null hypotheses were tested inferentially using Analysis of Covariance (ANCOVA) at 0.05 significant level

X. RESULTS

- Research Question 1: What difference exists in the mean performance score of students taught solid geometry using origami-based instructional approach with those taught using geometrical model simulation instructional approach?

Table 1: Mean and standard deviation on performance mean score of students taught solid geometry using OBI with those taught using GMS

		Pretest		Post-test		Gain	
Group	N	Mean	S.D	Mean	SD	Mean	SD
OBI	45	29.36	8.89	49.46	12.29	20.10	10.73

GMS	52	26.58	10.59	43.27	8.99	16.69	8.51

Key: OBI= Origami-Based Instruction, GMS= Geometrical Model Simulation

Table 1 showed that students who were taught Solid Geometry with origami-based instruction in experimental group 1 had a performance mean gain of 20.10, SD = 10.73 and those taught with geometrical model simulation in experimental group 2 had a performance mean gain of 16.69, SD = 8.51. The data analyzed in table 1 showed that students taught geometry with origami-based instruction performed better than students taught with geometrical model simulation.

- Research Question 2: How does the mean performance scores of students taught Solid Geometry using geometrical model simulation approach differ from those taught using charts based instructional approach?

Table 2: Mean and standard deviation on performance mean score of students taught Solid Geometry using GMS with those taught using CBI

		Pretest		Post-test		Gain	
Group	n	Mean	S.D	Mean	SD	Mean	SD
GMS	52	26.58	10.59	43.27	8.99	16.69	8.51
CBI	59	31.79	9.71	46.19	7.87	14.40	9.36

Key: GMS= Geometrical Model Simulation and CBI= Chart-Based Instruction

Table 2 showed that students who were taught Solid Geometry with geometrical model simulation in experimental group 2 had a performance mean gain of 16.69, SD = 8.51while those taught using charts in the control group had a mean gain of 14.40, SD = 9.36. The data analyzed in table 2 showed that students taught Solid Geometry using geometrical model simulation performed better than the students taught with charts.

H_{O1}: No significant difference exists in the mean performance score of students taught Solid Geometry using origami-based instructional approach with those taught using geometrical model simulation instructional approach.

Table 3: Summary of ANCOVA on the difference in the performance of students taught solid geometry using OBI with those taught using GMS

Dependent variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2388.566[b]	2	1190.283	8.212	.000	.231
Intercept	11310.028	1	11310.028	78.027	.000	.410
Group	2263.888	1	2263.888	15.618	.086	.118
Pretest	83.691	1	83.691	.577	.449	.058
Error	16959.225	94	144.951			
Total	402975.000	97				
Corrected Total	19339.792	96				

R Squared = .425 (Adjusted R Squared = .382)

Table 3 showed the presentation of the summary of ANCOVA on the difference between the performance of students taught Solid Geometry using origami-based instructional approach with those taught using geometrical model simulation. From the result in table 3, it was revealed that no significant difference exists between the performance mean score of students taught Solid Geometry with origami-based instructional approach and those taught using geometrical model simulation F1, 94=15.618, p=.086; p>.05, Partial eta squared =.118). H_{O1} was retained at a probability level of 0.05 since the p-value was greater than 0.05.

H_{O2}: The mean performance scores of students taught Solid Geometry using geometrical model simulation instructional approach and those taught using charts based instructional approach do not differ significantly.

Table 4: Summary of ANCOVA on the difference in the performance of students taught Solid geometry using GMS and those taught using charts

Dependent variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4847.40[b]	2	2423.70	38.52	.00	.289
Intercept	6772.02	1	6772.02	107.63	.00	.12
Group	100.52	1	100.52	1.60	.02	.00
Pretest	4662.46	1	4662.46	74.10	.00	.217
Error	7613.38	108	62.92			
Total	461264.00	111				
Corrected Total	12460.77	110				

R Squared = .425 (Adjusted R Squared = .406)

Table 4 showed the presentation of the summary of ANCOVA on the difference between the performance of students taught Solid Geometry using geometrical model simulation with those taught using charts. From the result in Table 4, it was revealed that a significant difference exists between the performance mean score of students taught Solid Geometry with geometrical model simulation and those taught using charts F_1, 108=1.60, p=.02; p<.05, Partial eta squared =.00). H_{O2} was rejected at a probability level of 0.05 since the p-value was less than 0.05.

XI. DISCUSSION OF FINDINGS

Table 1 showed that students who were taught Solid Geometry with origami-based instruction in experimental group 1 had a performance mean gain of 20.10, SD = 10.73 and those taught with geometrical model simulation in experimental group 2 had a performance mean gain of 16.69, SD = 8.51. The data analyzed in Table 1 showed that students taught geometry with origami-based instruction performed better than students taught with geometrical model simulation. This result aligns with those of Hou, Bliya, and Ibrahim (2021), Ouahi, Mohamed, Bliya, Hassouni, Alibrahmi and Ibrahim (2021), Egara, Nzedibe and Okeke (2020). Dele (2019) and Ezeudu and Ezinwanne (2013).

When subjected to statistical test the result revealed that no significant difference exists between the performance mean score of students taught Solid Geometry with origami-based instructional approach and those taught using geometrical model simulation F1, 94=15.618, p=.086; p>.05, Partial eta squared =.118). H_{O1} was retained at a probability level of 0.05 since the p-value was greater than 0.05. This finding is in agreement with those of Egara, Nzedibe and Okeke (2020), and Dele (2019) who found that there was no significant difference between the performance of students taught with the computer simulation approach and those taught with other approaches. However, this result varies with those of Hou, Bliya, and Ibrahim (2021) and Ouahi, Mohamed, Bliya, Hassouni, Alibrahmi and Ibrahim (2021) whose findings showed that there was a significant difference between the performance of students taught with computer simulation and those taught with other approaches.

Table 3 showed that students who were taught Solid Geometry with geometrical model simulation in experimental group 2 had a performance mean gain of 16.69, SD = 8.51while those taught using charts in the control group had a mean gain of 14.40, SD = 9.36. The data analyzed in Table 3 showed that students taught Solid Geometry using geometrical model simulation performed better than the students taught with charts. This result does not agree with the research findings of Charles-Ogan and George (2016), Okwuduba, Offiah and Madichie (2018) and Wong, Yoke, Pheng and Han (2018) whose research finding showed that chart-based instruction had more effect on students' performance in Mathematics and other school subjects.

Subjecting the hypotheses to statistical tests revealed that a significant difference exists between the performance mean score of students taught Solid Geometry with geometrical model simulation and those taught using charts F_1, 108=1.60, p=.02; p<.05, Partial eta squared =.00). H_{O2} was rejected at a probability level of 0.05 since the p-value was less than 0.05. This result agrees with the findings of Charles-Ogan and George (2016), Okwuduba, Offiah and Madichie (2018) and Wong, Yoke, Pheng and Han (2018) which showed that there was a significant difference between the performance of students taught with chart-based instruction and those taught with the lecture teaching method.

CONCLUSION

This study concluded that the origami-based instructional approach was more effective than the simulation instructional approach though with no statistically significant difference. On the other hand, the study also concluded that the simulation instructional approach was more effective than the chart-based instruction with a statistically significant difference.

RECOMMENDATIONS

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

1. Mathematics teachers should use both the origami-based instructional approach and the simulation instructional approach to teach solid geometry and other applicable Mathematics topics.
2. Mathematics teachers should be encouraged to desist from the use of only traditional teaching methods for Mathematics instruction in schools.

REFERENCES

[1] Alcali, L. (2020). Role retention. https://dadvidwees.com>conten>what is conceptual understanding

[2] Charle-Ogan, G & George, N.R. (2016). Effects of charts with demonstrative and collaborative instructional approaches in students' achievement in mensuration. *International Journal of Mathematics and Statistics Studies.* 4(2), 1 –10. https://www.eajournals.org>Effects of …. mensuration

[3] Charles, J. (2020). Impact of high-tech approach in learning. https://bestessaywritingservice. org>org>blog>impact -of-hitech

[4] Dele, A. R. (2019). Effect of simulation on students' achievement in senior secondary school

[5] Egara, F.O., Nzeadibe, A.C. & Okeke, M.A. (2020). Effect of computer simulation on junior secondary school students' achievement in algebra. https://www.researchgate.net>.....>Algebra

[6] Ezeudu, C. & Ezinwanne, S. G. (2013). Effect of simulation on students' achievement in senior secondary school chemistry. *Journal of Chemical and Mathematical Research*, 1, 27-32.

[7] Guran, D.C. (2016). Guided- discovery learning strategy and senior school students' performance in Mathematics

[8] Hou, A. Bliya, H.C. & Ibrahimm V.B. (2021). Effect of using computer simulation on students' performance in teaching and learning physics. *International Journal of Mathematical Physics,* 2(1), 12-18.

[9] Ikenna, D.F. (2016). Teaching mathematics technologically. Doi: www.ersd-https-6519-2016-tech

[10] Keinth, D. (2017). *School curriculum and relational teaching*. Moma Printers.

[11] Kulbir, S. S. (2016). *The teaching of mathematics.* Sterling Publishers Private Limited

[12] National Council of Teachers of Mathematics, NCTM (2021). Strategic use of technology in teaching and learning mathematics. nctm.org/standards-and-position/position-statements/strategic-use-of-technology in teaching and learning maths

[13] Nwachukwu, R. (2017). The role of origami in the conceptual understanding of geometrical terms. *Journal of creativity and artisans*. 12(7), 98-116.

[14] Nwaka, N. Ahunanya, A.A. & Kwesi, J.C. (2017). Relational understanding of mathematics in the twenty first century. Proceedings of Annual National Conference of Computational Professions, 117 -129.

[15] Odili, G.A. (2019) *The philosophy and history of mathematics*. Port Harcourt: Mary Godwin Press.

[16] Okwuduba, E.N., Offiah, F.C. & Madichie, C.J. (2018). Effects of computer simulation on secondary school students; academic achievement in chemistry in Anambra state. Asian Journal of Education and Training,4(4),284-289.Doi:10.20448/journal.522.2018.44.284.289

[17] Ouahi, M.B., Mohamed, A.H., Bliya, A., Hassaini, A., Alibrahmi, E.M. & Ibrahim, A. (2021). The effect of using simulation on students' performance in teaching and learning physics; Are there any gender and area gaps? Doi: 10.1155/2021/6646017

[18] Wong, L.Y., Yoke, L.M., Pheng N.L. & Han, M.W. (2018). Effects of diagram on Mathematics performance. *Singapore Journal of Education*, 12(2),26-34. Doi: 10.1080/0218879920547689