GEOMETRIC MODEL SIMULATION INSTRUCTIONAL APPROACH AND JUNIOR SECONDARY SCHOOL STUDENTS' RETENTION IN SOLID GEOMETRY IN RIVERS STATE NIGERIA

[1] **Dr. Arokoyu, Abosede A.**

[2] **Ndubisi, Esther Ekene**

[1, 2] Department of Curriculum Studies and Educational Technology

Faculty of Education, University of Port Harcourt

Abstract

This study was titled geometric model simulation instructional approach and junior secondary school students; retention in solid geometry in Rivers State Nigeria. The sample used for the study was 156 students that were drawn from a population of 4,584 junior secondary 1 students in Port Harcourt Local Government Area of Rivers State. Two objectives, two research questions and two null hypotheses were formulated for the study. The 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 and a Geometry Retention Test which had 25 multiple-test items each was used to collect data. The instrument was validated by Mathematics educators and the test retest method was used to obtain a reliability of 0.82. The mean, standard deviation was used to answer the research questions while analysis of covariance was used to test the null hypotheses at 0.05 significant level. The findings showed that origami-based instruction improved the retention of students in solid geometry than the simulation instructional approach with no statistically significant difference. The result also showed that the simulation instructional approach improved the retention of students than the chart-based instruction with a significant statistically difference. It was therefore recommended that Mathematics teachers should embrace the use of paper folding and computer simulation to teach solid geometry concepts

Keywords: *Solid Geometry, Simulation, Retention, Model.*

Introduction

A critical aspect that concerns all stakeholders of Mathematics education is the method by which the classroom instruction is presented. Koren (2019) posited that the application of diverse teaching methods in education help to improve students' learning in schools. Teaching methods are the procedures that the teacher puts in place to enable students' learning. It is the primary role of teachers to pass knowledge unto the students under the umbrellas of the school. This may suggest why Zawadi (2020) opined that the type of teaching method employed by teachers to teach Mathematics has a huge impact on the performance of students in the subject. The teaching method which the Mathematics teacher employs to carry out classroom instruction depends not on the feelings of the teacher but rather on some factors of the nature of the subject, the topic to be taught, the nature of the students, the class size and the availability of instructional resources.

It is when a teacher understands the needs of the students that he/she can choose the most effective method for classroom instruction. The teaching methods are generally classified into four namely: the teacher-centered, the learner-centered, the high-tech and the low-tech. The teacher-centered teaching method is describing the teacher as the authority during the classroom interaction while the learners are deemed as empty vessels which are to be refilled with knowledge from the authority. The teaching of Mathematics does not embrace the teacher-centered since it creates an interface during classroom instruction. Ehiwario, Aghamie and Azagbaekwue (2019) affirmed that Mathematics is a subject that can be effectively taught to improve students' performance and retention by employing the student-centered teaching method which emphasizes the students taking responsibility for their learning through problem-solving and inquiry strategies. Innovative methods of teaching involve new ways of teaching or carrying out classroom instructions and interactions which will lead to students' mastery of taught content which paves way for meaningful learning to take place.

Every theme in the Mathematics curriculum has roles it plays on the students and the society at large. The study of geometry in Mathematics helps students to develop visualization skills and critical thinking skills due to the very contents of this theme in the Mathematics curriculum. When students study geometry in schools, it also develops problem-solving skills and deductive reasoning. Ihekwe (2018) posited that knowledge that students gain from geometry also develops their conjecturing skills which lead to success in logical arguments. The above assertion, therefore, makes it imperative that teachers of Mathematics should present geometry in such a way that it stimulates curiosity and exploration that will enhance students' learning and their attitudes towards Mathematics in general and geometry in particular.

One of the objectives of teaching Mathematics is to use mathematical knowledge to solve problems in the environment. Employing mathematical knowledge to solve problems implies the application of the learnt mathematical knowledge in real life scenarios. The application of any learnt knowledge or skill calls for the mastery and retention of that which was learnt. The question of how newly learnt mathematical concepts subsequently goes into the activity of solving problems becomes of utmost importance to Mathematics educators. Retention of learnt mathematical knowledge, therefore, is very crucial to the students as well as all stakeholders of Mathematics education. There is an increasing concern as to what methods of teaching are most appropriate for Mathematics students. Barida (2013) posited that the use of innovative instructional strategies is the answer to improving the performance and retention of students in Mathematics. Retention simply means the ability to acquire and continue to possess or retain something. Retention of learnt mathematical concepts by students, therefore, becomes the threshold by which the application of concepts comes to play. Students' performance and retention in Mathematics has continuously been researched by Mathematics educators to see how the improvement on them can help solve the individual, economic, organizational and societal problems because it is retention that paves way for the transfer of learning.

Jones, Jones and Vermette (2019) opined that promoting student understanding for transfer is the hallmark of effective Mathematics instruction. Edukake (2017) asserted that in education, transfer of learning refers to learning in one context and applying it to another. It is when learning in a particular context impacts on performance or exhibition of skills in another context or with other related situations. It is of importance to note that the concept of learning differs from the ultimate context of the application. When a student applies the skills and knowledge learnt in Mathematics to other situations, transfer of learning is said to have taken place. No student can transfer a mathematical concept that he/she has no possession of.

Transfer of learning represents much of the very central basis of the educational system. Mathematics is a subject that requires that most of its learnt concepts be applied to other subjects as well as beyond the developmental tasks of students outside the school. This is what makes the need for the transfer of learning to be more evident. The main focus of transfer of learning is on the kind of initial learning that enables subsequent transfer. On this note, it becomes imperative to relate transfer of learning in Mathematics to teaching Mathematics for transfer.

In this 21st century, the teaching and learning of Mathematics have gone beyond the use of talk chalk. It, therefore, becomes imperative that programmes of teacher education and professional development be continually updated in knowledge to meet the demands of the present day and its applications to support learning. Dick and Hollebrands (2021) posited that in a balanced Mathematics program, the strategic use of technology boosts Mathematics teaching and learning. The use of technological simulation to teach mathematical concepts has the potential to develop students' understanding, stimulate their interest and make them mathematically proficient. The above can only take place when teachers use technology strategically. Simulation is role playing in which learners perform the role in an artificially created environment (Sharma, 2018). Simulation is otherwise known as a modeling in Mathematics is a novel and classic method of mathematical concepts. A simulation activity is a teaching and learning process that is designed to reflect a real situation or system. Hafey (2016) opined that simulation activities engage students more than other activities in the classroom instructional process. It consists of a set of activities that seek to replicate real contexts either physically or by use of a technological simulator. A simulator is a device or computer program that performs simulation when any model is implemented, thus the method is also known as a simulator.

The two types of simulations which is used for mathematical modeling are concept and process simulations. Ashton (2021) posited that just as 3D shapes can be drawn physically, they can also be drawn by using software such as GeoGebra. Properties of solid shapes, volume and surface area of solid shapes can be simulated using the computer for them to visualize the spatial properties embedded in solids. The simulation of geometrical shapes can also be done with the use of presentation software such as PowerPoint. Thus, simulation can rotate the model in 360^0 directions for a total visualization of all perspectives of the concept under consideration.

Problem Specification

Several research findings have revealed that students' Mathematics performance in both internal and external examinations have continuously been poor in Nigeria at all levels of education. Charles-Ogan (2016) deliberate that the poor performance of students in Mathematics cuts across every country. The major cause of students' poor performance in Mathematics is a weak foundation in Mathematics which was attributed to the mathematical weakness that elementary school teachers possess. At the public elementary school level in Nigeria, it has been observed that one Mathematics teacher manages one class and teaches all the subjects to the students in that classroom. Given that these factors impact the performance of students in Mathematics, there is, therefore, an urgent need to tackle these challenges in other to improve the retention of students in Mathematics. The use of modern technology and paper folding, therefore, becomes an option. Students love any activity that is technologically-based. Students also love any activity that involves learning in a fun manner and creativity. It is against this backdrop that the researchers investigated the effect of geometric model simulation instructional approach on junior secondary school students' retention in solid geometry.

Objectives of the Study

The objectives of the study were to:

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

Research Questions

The following were the formulated research questions that directed the study.

1. What difference exist in the mean retention 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 retention scores of students taught Solid Geometry using geometrical model simulation instructional approach differ from those taught using charts based instructional approach?

Hypotheses

These two null hypotheses were tested at a significant level of 0.05.

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

H_{O2}: There is no significant difference in the mean retention scores of students taught Solid Geometry using geometrical model simulation approach differ with those taught using charts based instructional approach.

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.

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

Sample and Sampling technique

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

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.

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.

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.

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 first administered to the three groups without any form of teaching. This was followed by the teaching of solid geometry concepts to the three groups using the specified approach for each group. A reshuffle posttest was thereafter administered to the three groups to ascertain their performance in the taught contents. After three weeks of administration of posttest, the GPT was reshuffled and was tagged GRT which is Geometric Retention Test and was administered to the students as post-posttest to test retention. The results obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 23.

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

Results

Research Question 1: What difference exists in the retention mean 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 Retention mean score of Students taught Solid Geometry using OBI with those taught using GMS

		Post-test		**Post-Posttest**		**Difference**	
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
OBI	45	49.46	12.29	60.84	11.54	11.38	8.45
GMS	52	43.27	8.99	50.46	10.97	7.19	6.02

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 retention mean gain of 11.38, SD = 8.45 and those taught with geometrical model simulation in experimental group 2 had retention mean gain of 7.19, SD = 6.02. The data analyzed in table 1 showed that students taught geometry with origami-based instruction had higher retention than students taught with geometrical model simulation.

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

Table 2: Mean and Standard Deviation on Retention mean score of Students taught Solid Geometry using GMS with those taught using CBI

		Post-test		Post-Posttest		Difference	
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GMS	52	43.27	8.99	50.46	10.97	7.19	6.02
CBI	59	46.19	7.87	48.34	12.64	2.15	1.47

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 retention mean gain of 7.19, SD = 6.02 while those taught using charts in the control group had a mean gain of 2.15, SD = 1.47. The data analyzed in table 2 showed that students taught geometry using geometrical model simulation had higher retention than the students taught with charts.

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

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

Dependent variable: Post-Posttest

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	64921.864[b]	2	21640.621	241.437	.010	.513
Intercept	2907.461	1	2907.461	32.438	.000	.410
Group	5522.501	1	5522.501	61.613	.102	.238
Posttest	4447.951	1	2223.976	24.812	.574	.064
Error	12548.573	94	89.633			
Total	533433.000	97				
Corrected Total	77470.438	96				

R Squared = .642 (Adjusted R Squared = .715)

Table 3 showed the presentation of the summary of ANCOVA on the difference between the retention of students taught Solid Geometry using origami-based instructional approach with those taught using geometrical model simulation. From the result, it was revealed that no significant difference exists between the retention mean score of students taught Solid Geometry with origami-based instructional approach and those taught using geometrical model simulation F1, 94=61.613, p=.102; p>.05, Partial eta squared =.238). H_{O1} was retained at a probability level of 0.05 since the p-value was greater than 0.05.

H_{O2}: There is no significant difference in the retention mean scores of students taught Solid Geometry using geometrical model simulation approach differ with those taught using charts.

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

Dependent variable: Post-Posttest

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	3249.27[b]	2	1624.636	11.539	.000	.286
Intercept	1090.645	1	1090.645	7.746	.005	.134
Group	2.577	1	2.577	.018	.038	.000
Posttest	3239.168	1	3239.168	23	.000	.289
Error	8025.311	108	140.795	006		
Total	227875.000	111				
Corrected Total	11274.583	110				

R Squared = .821 (Adjusted R Squared = .734)

Table 4 showed the presentation of the summary of ANCOVA on the difference between the retention of students taught Solid Geometry using geometrical model simulation and those taught using charts. From the result, it was revealed that a significant difference exists between the retention mean score of students taught Solid Geometry with geometrical model simulation and those taught using charts F_1, 108=2.577, p=.038; p<.05, Partial eta squared =.00o). H_{O2} was rejected at a probability level of 0.05 since the p-value was less than 0.05.

Discussion of Findings

Table 1 showed that students who were taught Solid Geometry with origami-based instruction in experimental group 1 had a retention mean gain of 11.38, SD = 8.45 and those taught with geometrical model simulation in experimental group 2 had retention mean gain of 7.19, SD = 6.02. The data analyzed in table 1 showed that students taught geometry with origami-based instruction had higher retention than students taught with geometrical model simulation. This is not in agreement with the findings of Ezeudu and Ezinwanne (2013), Osaro (2017) and Hou, Bliya and Ibrahim (2021) whose research findings revealed that students taught with computer simulation had higher retention than the students taught with traditional and other teaching methods.

When subjected to statistical test, it was revealed that no significant difference exists between the retention mean score of students taught Solid Geometry with origami-based instructional approach and those taught using geometrical model simulation F1, 94=61.613, p=.102; p>.05, Partial eta squared =.238). H_{O1} was retained at a probability level of 0.05 since the p-value was greater than 0.05. This finding agrees with the result of Osaro (2017) which showed that there was no significant difference between the retention of students taught with the computer simulation approach and those taught with the lecture method.

Table 2 showed that students who were taught Solid Geometry with geometrical model simulation in experimental group 2 had retention mean gain of 7.19, SD = 6.02 while those taught using charts in the control group had a mean gain of 2.15, SD = 1.47. The data analyzed in table 2 showed that students taught geometry using geometrical model simulation had higher retention than the students taught with charts. This finding is in line with those of Obafemi and Onifade (2019), Kpaniku (2017), Ederinko, Kofi and Gullain (2019), and Igwe (2020). Table 4 showed the presentation of the summary of ANCOVA on the difference between the retention of students taught Solid Geometry using geometrical model simulation and those taught using charts. From the result, it was revealed that a significant difference exists between the retention mean score of students taught Solid Geometry with geometrical model simulation and those taught using charts $F_{1, 108}=2.577$, p=.038; p<.05, Partial eta squared =.00o). H_{O2} was rejected at a probability level of 0.05 since the p-value was less than 0.05. This result aligns with the findings of Kpaniku (2017) whose findings showed that there was a significant difference between the retention of those taught with computer simulation and those taught without computer simulation. However, the finding of Ederinko, Kofi and Gullain (2019) disagrees with this finding.

Conclusion

This study concluded that the origami-based instructional approach improved the retention of students in solid geometry than the simulation instructional approach though with no statistically significant difference. On the other hand, the study also concluded that the simulation instructional approach improved the retention of students in solid geometry than the chart-based instruction with a statistically significant difference.

Recommendations

1. Mathematics teachers should embrace the use of paper folding and computer simulation to teach mathematics concepts since they enhance students' retention in the taught concepts.
2. The Ministries of Education should equip the public schools with technological gadgets to enable the mathematics teachers to integrate technology in Mathematics teaching for enhancing students' performance.

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