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MATHEMATICAL VISUALIZATION AND SENIOR SECONDARY SCHOOL STUDENTS' PERFORMANCE IN SOLVING REAL-WORLD PROBLEMS

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Abstract
The research investigated the effect of mathematical visualization on the academic performance of senior secondary school students' in solving real-world problems. The study incorporated two objectives. Pretest, posttest quasi-experimental design that presented one experimental and one control group was used. Simple random sampling technique was used to draw 176 government-owned senior secondary school two (SS2) students from a population of two thousand five hundred and ten. The instrument used for data collection was a validated instrument titled Mathematical Visualization Achievement Test. The instrument was 0.83 reliable using Kuder-Richardson Formula 21. The experimental group was taught how to solve real-world problem with mathematical visualization while the control group was taught with deductive teaching method. Analysis was done with mean, standard deviation and analysis of covariance at 0.05 significant level. The result showed that there was a significant difference between the performance of students taught with mathematical visualization and those taught without mathematical visualization. However, there was no significant difference between the students taught with mathematical visualization based on gender. It was recommended that Mathematics teachers should incorporate mathematical visualization when teaching students Mathematics.

Keywords: Real-life problem, mathematics, visualization, performance, students

Introduction

The subject matter of Mathematics deals with parameters such as numbers, counting, patterns, measurement, estimation, calculation, shapes, logic, numerical operations and relationships. The usefulness of Mathematics to the development of man and the society has paved way for it to be accorded a compulsory subject at the primary and secondary levels of education. Its application is seen in everyday activities of an individual's potentiality and the entire nation. It is also the key to other science subjects and vocational endeavor. Salman and Ameen (2014) opined that Mathematics problem-solving requires specialized skills which are practical and involves a unique linkage between Mathematics, communication and the environment. It also embraces many important concepts, skills and ideas which aid in the development of the logical, creative and reasoning abilities of students (Okechim & Nyelle, 2019).

Furthermore, 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. This therefore makes it imperative for the all-round implementation and evaluation of the Mathematics curriculum to be well articulated.

The teaching of Mathematics in schools is not carried out haphazardly, but rather it is done by adhering to laid down educational principles and practice. There are principles which govern the teaching and learning of mathematical concepts in schools. These principles are derived from the nature of Mathematics and the scholarly learning theories. Hilbert (2016) posited that the four principles of teaching and learning Mathematics are the principle of concreteness, necessity, abstraction and application. This indicates that Mathematics should be taught with relevant and appropriate instructional materials and methods to unravel the abstractions which are imbedded in Mathematics concepts for application in the solution of problems in the society. The use of instructional materials for Mathematics classroom delivery makes clearer the Mathematics concepts been taught. These principles uphold that Mathematics should be taught to bring about the relatedness of that which is taught in Mathematics and the real-world situations. This depicts the applicability of Mathematics, knowing how, why and when to apply mathematical skills.

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The main focus of teaching mathematics to students is for them apply the mathematical knowledge to tackle problems in real-world scenario. Hence, we talk about real-life application of mathematics. The use of mathematical relationships in everyday life is essential. Mathematics matters in the everyday life ranging from the minute matters to the huge matters of life The practical application of mathematics in our day to day activities is very important because it allows the students to apply what they have learnt in the classroom in many different situations that arise within their daily activities. The various real-world problems where mathematics is applied everyday are cooking, budgeting, interior design, construction, decision making, weather forecast, marketing, industries, science and technology. Ibekwe (2018) posited that through real-world applications students can understand more and make connections from classroom to real-world effortlessly.

Saronwal (2018) posited that one of the most effective method to appreciate mathematics is by its mental visualization. Mathematical visualization is the key skill required to make connections from classroom to real-world problems. Mathematical visualization has the power to engage students, get their attention and also unravel how Mathematics is relevant in their daily activities. Everybody needs logical reasoning to excel in the mathematical content taught in school. However, it takes mathematical visualization to apply the learnt Mathematics content to solve problems in real-life scenarios. The world we live in is full of information that can be solved mathematically. It is visualization that can be put into work to translate mathematical concepts to everyday use to solve of problems. Abstract Mathematics concepts are understood when students have the ability to see how they work and how they can be used practically to solve problems that emanate from their environments.

Visualization has to do with how information can be communicated and presented for the sole purpose of decision making. Visualization helps to bridge the gap between the mathematical data and its usage to solve problem in real-world situations. It means the ability of one to see a problem situation and understand it. This therefore, indicates that visualizing a problem or object requires the mental manipulation of various helpful alternative methods and links that can be used to salvage the situation. Visualization means making a mental note and link of what the situation at hand look like. Visualization in mathematics can be intimidating especially for students that were not taught how to visualize. Mathematical visualization is important in solving real-life problems because it enhances students' attention and keeps the problem-solver focused. Teaching visualization can improve academic achievement of students of any age grade. Waren (2012) opined that teachers need to define visualization for students and teach the skill. Mathematical visualization can be taught by breaking down it down into the various skillsets. Students therefor must learn how to make mental representations of numbers, place values, size, notations, symbols, shapes, diagrams. estimation, proportion and directed numbers.

To visualize mathematically means to picture what the problem situation at hand looks like mentally. The process of visualization intimidates some students and thus frustrating. Presmeg (2020) defined a visual image as a mental sign which depicts visual or spatial information for relating or connecting variables. The spatial abilities, visual mental imagery, mathematical processing of students are the elements that helps students to succeed in solving real-world problems. Visualization has to do with the practice of imagining how and what mathematical concepts can be used to solve problems in the environment. Visualization is a process that directs the subconscious of the problem solver to be aware of how mathematics can be applied or connected to situations in order to reach an end goal which is already known in the mind. The process of visualization consistently reminds and keeps the problem solver on track. It also helps to develop the brain and thinking facility. Moe (2021) opined that there are two types of visualization, namely process and outcome.

Visualization is the key element to expanding and inputting mathematical idea to solve real-life problems (Kadiunz, & Yerushalmy, 2015). Mathematics teachers should teach mathematics in such a way that students will be encouraged and be able to recognize that Mathematics permeates the world in which we live. International Baccalaureate (2008) stated that teachers are expected to teach Mathematics to encourage students become self-reliant when the need arises to solve problems in and outside the school setting. To this end, the option becomes teaching Mathematics for transfer of learning and connectivity.

Statement of the Problem

The subject matter of Mathematics helps students to make sense of the world and solve a myriad of real-world problems. The skill that helps students to communicate learnt Mathematics concepts to real-world situations is mathematical visualization. A student that lack the skill of mathematical visualization will find it difficult to connect

mathematical principles and theories to the everyday life. When students are taught how to visualize mathematically, it makes them see Mathematics from a different and new perspective. It therefore lies in the onus of the teacher to guide and engage students meaningfully in mathematical visualization. It has been observed that so many senior secondary school students that perform excellently in Mathematics achievement tests struggle with the application of learnt Mathematics concepts to solve real-world problems. The concern then becomes how this observed phenomenon can be addressed. Could it be that students lack the skill of mathematical visualization that has the capability to help them make the required connection? The researcher thus examined the effect of mathematical visualization on senior secondary school students' performance in solving real-world problem.

Objectives of the Study

1. Determine the performance of students taught how to solve real-world problem with and without mathematical visualization.
2. Ascertain the performance of the male and the female students taught how to solve real-world problem with mathematical visualization.

Research Questions

1. What is the difference between the performance mean score of students taught how to solve real-world problem with and without mathematical visualization?
2. What difference exists between the performance mean score of the male and the female students taught how to solve real-world problem mathematical visualization?

Hypotheses

H_{O1}: There is no significant difference between the performance mean score of students taught how to solve real-world problem with and without mathematical visualization

H_{O2}: No significant difference exists between the performance mean score of the male and the female students taught how to solve of real-world problem with mathematical visualization.

Materials and Method

The quasi-experimental research design which presented one control and one experimental group was used. Intact classes in which the subjects were not randomized were used. A simple random sampling technique was used to draw a sample of one hundred and seventy six (176) senior secondary two (SS2) students from a population of two thousand five hundred and ten (2,510) students in Port Harcourt Local Government Area of Rivers State Nigeria.

A twenty item multiple-choice question was used to collect data. This set of multiple-choice questions was the instrument for the study. The instrument was named Mathematical Visualization Achievement Test (MVAT). The instrument was prepared to measure the ability of senior secondary school students to solve real-life problems using mathematical visualization. The real-world problems were extracted from domestic activities, buying and selling, distance-time and simple interest. All test items were posed to depict real-world situations that students can solve by applying mathematical visualization. The total mark for MVAT was 100. The instrument was face and content validated by two experts in mathematics education. Kuder-Richardson Formula 21 (KR-21) was used to obtain an internal consistency of 0.83 for the instrument. The experimental and control groups were pre tested using MVAT. This was followed with the treatment of the two groups. The experimental group was taught how to use mathematical visualization to solve problems related to real-life situations while the control group was not taught how to mathematically visualize but rather taught with deductive teaching method. After the treatment, both groups were post tested using a parallel MVAT in which the test items were reshuffled to reduce memorization by students. Mean and standard deviation and analysis of covariance were used for statistical analysis at 0.05 significant level.

Results

Table 1: Mean and standard deviation on performance of students taught how to solve real-world problem with and without mathematical visualization

		Pretest		Post-test		Performance Gain	
Group	**N**	**Mean**	**S.D**	**Mean**	**SD**	**Mean**	**SD**
DMV	80	45.28	12.63	76.04	14.72	30.76	12.66
DTM	96	46.71	13.11	65.92	10.25	19.21	11.93

Key: DMV= Deductive & Mathematical Visualization, DTM = Deductive Teaching Method

Table 1 is a presentation of the analysis of data of students who were taught solution to real-world problem with mathematical visualization in the experimental group and those taught with deductive teaching method in the control group. The students who were taught with mathematical visualization had a performance mean gain of 30.76, SD = 12.66 while those taught with deductive teaching method had a performance mean gain of 19.21, SD = 11.93. Thus,

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the analyzed data in table 1 revealed that students taught how to solve real-world problem with mathematical visualization performed better than students that were taught with deductive teaching method.

Table 2: Mean and standard deviation on the performance of the male and the female students taught how to solve real-world problem with mathematical visualization

			Pretest		Posttest		Performance Gain	
Group	**Gender**	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
DMV	Male	32	48.05	9.74	79.05	14.63	31.00	14.25
	Female	48	42.56	13.43	73.81	15.10	31.25	10.74

Table 2 is a presentation of the analysis of data of the male and the female students who were taught how to solve real-world problem with mathematical visualization in the experimental group. The male students who were taught with mathematical visualization had a performance mean gain of 31.00, SD = 14.25 while their female counterpart in the same experimental group had a performance mean gain of 31.25, SD = 10.74. Thus, the analyzed data in table 2 revealed that the female students taught how to solve real-world problem with mathematical visualization performed better than the male students that were taught with same mathematical visualization.

Table 3: Summary of ANCOVA on the difference in the performance of students taught how to solve real-world problems with and without mathematical visualization

Dependent variable : Posttest						
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	544.245	2	272.122	21.932	.000	.343
Intercept	49746.236	1	49746.236	4.010	.000	.271
Group	255.453	1	255.453	32.600	.000	.069
Pretest	360.587	1	360.587	4.651	.035	.404
Error	1637.681	173	12.407			
Total	52544.202	176				
Corrected Total	2181.926	175				

Table 3 presented the summary of ANOVA on the difference between the performance of students taught soling real-world problems with mathematical visualization and those taught with deductive teaching method. From the tabular presentation, it was revealed that there is a significant difference exists between the performance of students taught real-world problem with mathematical visualization and those taught with deductive teaching method ($F_{1, 173}=32.600$, $p=.000$; $p<.05$, Partial eta squared =.069). Hence, H_{O1} was rejected.

Table 4.: Summary of ANCOVA on the difference between the performance of the male and female students taught how to solve real-world problem with mathematical visualization

Dependent Variable: Posttest						
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	129.224	2	103.681	12.031	.295	.101
Intercept	27458.229	1	27458.229	2.552	.000	.828
Pre test	134.605	1	134.605	.715	.407	.030
Gender	158.852	1	158.852	1.684	.195	.072
Error	677.871	77	10.758			
Total	28558.781	80				
Corrected Total	803.224	79				

a. Group = MVS

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Table 4 presented the summary of ANOVA on the difference between the performance of the male and the female students taught how to solve real-world problems with mathematical visualization. From the tabular presentation, it was revealed that there is no significant difference between the performance of the male and the female students taught real-life problem with mathematical visualization ($F1, 77 = 1.684$, $p=.195$; $p>0.05$, Partial eta squared = .072). Hence, H_{O2} was retained.

Discussion of Findings

From the analyzed data it was deduced that the students who were taught with mathematical visualization had a performance mean gain of 30.76, SD = 12.66 while those taught with deductive teaching method had a performance mean gain of 19.21, SD = 11.93. Thus, the analyzed data in table 1 revealed that students taught how to solve real-world problem with mathematical visualization performed better than students that were taught with deductive teaching method. This agrees with the finding of Anyanwu (2014). When subjected to statistical analysis, it showed that the students that were taught with the incorporation of mathematical visualization had a higher performance mean score than those that were taught with just deductive teaching method. This result agrees with the research findings of Rabi, Fengqi, Aziz & Ihsanullah (2022) which showed Microsoft mathematics visualization impacted positively on students' academic skills. This finding is also in line with the finding of Tiwari, Obradovi, Rathour, Mishar & Mishra (2021).

The analyzed data in table 2 revealed that the female students taught how to solve real-world problem with mathematical visualization performed better than the male students that were taught with same mathematical visualization. When this result was statistically tested, it was revealed that there is no significant difference between the performance of the male and the female students taught real-world problem with mathematical visualization. This result is in consonance with that of Anyanwu (2014). However, this disagrees with the research finding of Zudok (2017) which showed that the male students taught with visualization had a higher performance than their female counterpart and there was not significant.

Conclusion

This study concluded that instruction carried out with deductive teaching method incorporated with mathematical visualization enhanced the performance of students in solving real-world problems which they always come across in their day to day activities.

Recommendations

Recommendations that were based on the findings which can be used to improve students' mathematical visualization of solving real-world problems were stated as follows:

1. Mathematics teachers should endeavor to incorporate during classroom instruction, mathematical visualization that students' can develop to solve real-world problems that emanate from their environment.
2. Mathematical visualization should be taught to both male and the female students since it helps to expand their visualization horizon..

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