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Effects of Mathematical Games on Students' Academic Achievement and Retention in Probability in Oron Local Government Area, Akwa Ibom State

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Abstract

This study examined the effects of mathematical games on mathematics students' academic achievement and retention in probability in Oron Local Government Area of AkwaIbom State. It adopted a quasi- experimental research design. A sample of 50 senior secondary 2 students was drawn from a population of 980 students in all the public secondary schools in Oron Local Government Area of Akwa Ibom State using purposive sampling technique. The instruments used for data collection were 20 item Mathematics Achievement Test on Probability (MATP) and Mathematics Retention Test on Probability (MRTP).The MATP and MRTP were subjected to a test-retest method to determine the reliability. MATP and MRTP had reliability coefficients of 0.81 and 0.83 obtained using Pearson Product Moment Correlation (PPMC). The research questions were answered at 0.05 level of significance, using t-test analysis. The findings showed that there is significant effect of mathematical games on students' academic achievement and retention in probability. Male and female students taught probability with mathematical games do not differ significantly. It was recommended amongst others that mathematics teachers should always utilize games in teaching probability.

Keywords: Mathematical games, academic achievement, retention

INTRODUCTION

Mathematics is a compulsory subject at all levels of education in Nigeria. Mathematics is useful in science, social science, business and technological based disciplines. Mathematics plays important role in the scientific and technological development of a nation. The pivotal role of mathematics reflects in its day to day application in most sciences, business, economicsand management studies. Mathematics is an indispensable tool for development of new techniques and concepts; hence its inclusion as a compulsory subject in secondary school curriculum. Mathematics is the science that deals with measurement, relationships, properties of quantities and sets using numbers and symbols. This is why Elaine (2013) sees mathematics as the building block of everything in our lives including arts, money, engineering, mobile devices, architecture

and sports. Mathematics forms the basis of other physical sciences. Thomaskutty and George (2007) examined the versatile nature of mathematics by identifying educational values of the subject; these include aesthetic, moral and practical values. It is on this premise the subject is made compulsory for both primary and secondary schools in Nigeria.

The NERDC (2013) revised curriculum divides mathematics into the following broad themes which are numbers and numeration, algebraic processes, geometry, statistics and introductory calculus. Each of the broad themes has been taught as a collection of rules and procedures which computations are more efficient. Thus, it comes as a little surprise that in a content where mathematical activity is computation, access to tools that can be used to perform many of these functions has historically been restricted, (Nwoke, 2008). This has made both teachers and students perceive some of the concepts in each theme mysteriously, difficult to understand or retain. One of such concepts is probability.

Achievement is the performance of students in school (Nwagba, 2013). According to Bitrus (2014), achievement is a measurement of knowledge gained through educational process usually indicated by test scores, grade point average (GPA) or ranking in class. James and Ovute (2019) see achievement as the learning outcome acquired as a result of test or examination administered to the learner. With all these views, achievement can be described as the end product or outcome of an academic programme.

Sahakyan (2014) sees retention as the learner's ability to recall information of materials learned after a given time lag. Okoro (2011) suggests that retention is the ability to remember things and the action of keeping something rather than losing it. Retention is the ability of students to reproduce the knowledge gained which has been stored in long-term memory over a long period.

Gender is another factor interacting with students' achievement and retention in mathematics. The difference between male and female students has attracted some debates. Ado & Amos (2019) define gender as a social connotation that has a psychological background and is used to refer to specific cultural patterns of behaviour that are attributed to masculinity and feminity. According to Eze and Ezeugo(2019), some researchers in education indicated that male students had higher mean achievement scores than their female counterparts when taught using programmed instruction strategy. According to Edet (2016), there is no significant difference in the academic performance and retention of male and female students in sciences. When students are taught probability with the required teaching and learning resources such as games, there will be no difference between the academic achievement and retention of male and female students in mathematics.

Probability as a Concept in Mathematics

The term probability refers to the study of randomness and uncertainty. In any experiment in which one of the numbers of possible outcomes may occur, the theory of probability provides method for quantifying the chances or likelihoods associated with the various outcomes. The language of probability is constantly used in an informal manner in both written and spoken contexts. The experiment of tossing a fair coin or a fair die is example of random experiment. The development of probability is quite recent, relative to other branches of mathematics. Pascal and Kolmogorov are the pioneers in the field of probability (Adegun and Adegoke 2017). Probability as a branch of mathematics goes back over 300 years where it has its genesis in connection with the analysis of certain games of chance and it has found application in many branches of science and engineering. There are two major ways of defining probability in mathematics. These are; the relative frequency definition and axiomatic definitions.

Mathematical games are instructional resources used by teachers and learners to teach and learn different concepts in probability. Mathematical games are also called probability games. These games are chance instruments and hands-on-activities used for teaching and learning of different concepts in probability. Abonyi, Maduagwuna & Ugoma (2014) describe mathematical game as a type of play that follows a set of rules, aims at definite goal or outcome, and involves competition other players or against barriers imposed by nature. Mathematical games may be used to introduce concepts in mathematics (Okigbo & Agu, 2010). Examples of these games are ludo game, spinner game, joker game and coins. These games provide opportunity for learners to relate theory to practice. When mathematical games are properly used in teaching probability, students become active than the teacher as they investigate, explore, interact and apply what they learn to real life situations. This will eventually enhance their academic achievement and retention in mathematics.

Teaching Probability with Spinner Game

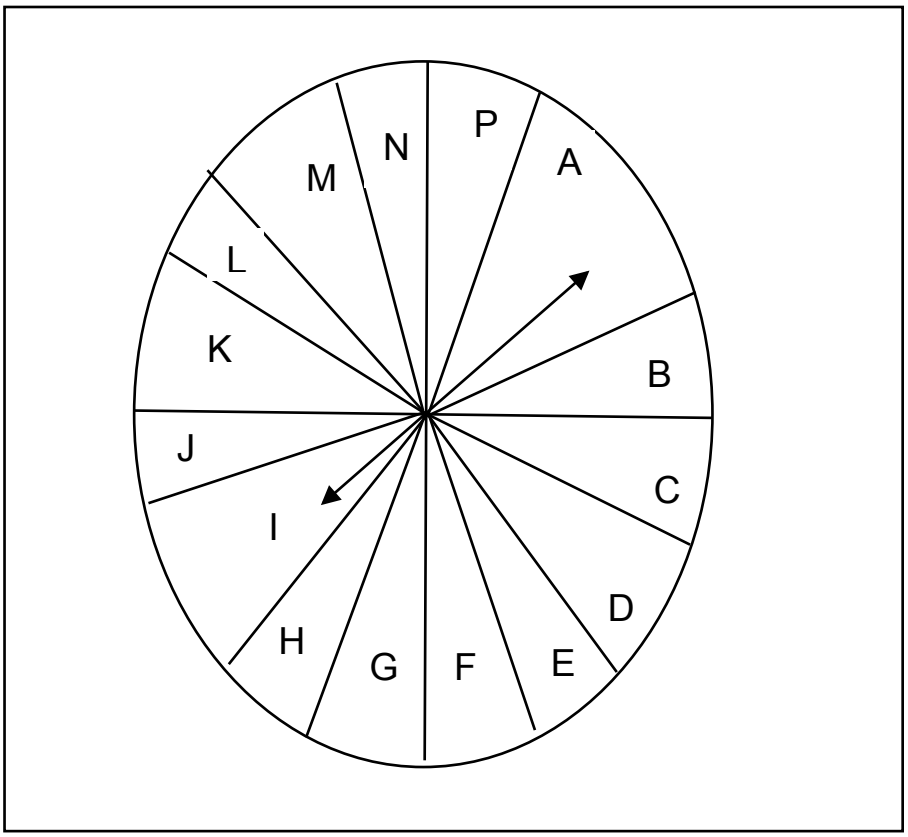

Figure 1: A Diagram Showing Spinner Game.

Spinner game is a mathematical game that has many sections depending on what the teacher desires. Each section of the game is assigned different colours such as red, blue, green, black and yellow. Alternatively, each section can also be assigned letters (A, B, C, D, …, Z) depending on the teacher. The teacher brings spinner game into the classroom, describes how to use it and asks the studentsto spin the game and record the number of timeseach letter appears or comes up. It will be noticed that some letter come up more often than others during spinning. The result is obtained at the letter which the pointer stops after each spin. If the pointer stops at say, B, that is the probabilityof obtaining B is 1/15. The teacher asks the students to obtain the following using the spinner game. (i)Pr(H), (ii)Pr (Consonant) and (iii) Pr (vowel). It will be discovered that each student will be recording different results depending on how fast they spin the game.

Teaching probability with Dice

In a single throw of a fair die, find the following probabilities that; (i) an even number appears (ii) 5 appears(iii) a perfect square appears. The teacher provides die to all the students or group

them, asks them to describe the die. The teacher asks them to toss the die. He asks the students to state the face that appears. He explains that the face that appears is just one out of the six faces of the die. The teacher provides the students or group of students with two dice. He hangs a chart showing the sample space and asks students to draw the table (write 1 to 6 vertically as column and 1 to 6 horizontally as row). The teacher asks the students to add each number in the column to its corresponding row to complete all the boxes as shown below. The teacher asks the students to answer the above questions.

Table 1: Results Obtained From Dice Game

	1	2	3	4	5	6
1	1,1	1,2	1,3	1,4	1,5	1,6
2	2,1	2,2	2,3	2,4	2,5	2,6
3	3,1	3,2	3,3	3,4	3,5	3,6
4	4,1	4,2	4,3	4,4	4,5	4,4
5	5,1	4,2	5,3	5,4	5,5	5,5
6	6,1	6,2	6,3	6,4	6,5	6,6

Teaching probability with coins

In a single throw of a coin, find the probability that (i) a head appears (ii) a tail appears

The teacher presents a coin to the students. Describe the coin to them as having a head and a tail. Ask them to record the fraction of obtaining any of the two faces.

Two coins are thrown at the same time, the probability of finding (i) two heads (ii) at least one tail can be obtained as follows:

(i) Pr (two heads) = 1/4 (ii) Pr (at least one tail) = 3/4

However, many mathematics teachers avoid teaching some concepts in probability (conditional probability, theoretical probability, dependent events) with concrete materials.Consequently, students' understanding and retention of these concepts is in doubt since teachers resort to teaching them abstractly with only chalk and talk. This problem can be reduced or eliminated if the necessary instructional materials are utilised in the teaching and learning of concepts in probability.

In a related and recent study conducted by Akanmu and Adeniyi (2021) on the effects of mathematical games on senior secondary students' academic performance in mathematics in Ejigbo, Osun state, Nigeria. The sample size was 73 students in their intact classes from two schools using simple random sampling technique. Data were collected using Mathematics Performance Test (MPT) and analysed using Analysis of Covariance (ANCOVA) at 0.05 level of

significance. The results revealed that students taught using games performed significantly better than those taught using lecture method.

In another study carried out by Okigbo and Agu (2010) which investigated the effects of mathematical games and instructional analogy on students' achievement in junior secondary school mathematics. A total of 246 junior secondary two (JSS2) mathematics students were involved in the study. It was observed that both games and analogy enhanced students' achievement and retention in mathematics. It was noticed that there was no significant difference between the achievement of male and female students taught mathematics with either games or analogy.

Finally, Adeoye and Ambimbola (2016) carried out a study on effects of senior secondary school students' use of demo kits on their performance in Biology. A quasi experiemtal design (non-randomized, non-equivalent pretest and posttest control group of 2x 2x 3 factorial matrix) was used. Data were obtained from four intact classes in four purposively selected secondary schools. The research instruments were Biology Achievement Test (BAT) and demo kit. Descriptive statistics (standard deviation and mean gain scores) were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the corresponding null hypothesis. Finding from the study revealed that students who learned Biology with demo kit performed significantly better than those that learned it without using demo kits. The study also reported a high retention level in favour of students who learned biology with demo kits.

Statement of the Problem

Studies conducted over the years have shown that lack of instructional materials for teaching mathematics also contribute to students' poor performance in the subject (Adebule and Ayoala 2015). This was confirmed by Bitrus (2014) when analyzing the West African School Certificate Examinations (WASSCE) between 1989 and 2005. The perceived and inherent difficulty associated with various topics in mathematics is responsible for such performancesProbability was not left out as a difficult concept in mathematics.This is confirmed by the Chief Examiner's Report which showed that candidates in 2019 WASSCE had weakness in probability. Some of the reasons for this weakness include poor method of teaching and lack of application of instructional materials in teaching probability. To overcome these setbacks and accelerate students' achievement and retention in learning probability, the researchers found it necessary to conduct a study to determine the effect of mathematical games on mathematics students' achievement and retention in the concept of probability. The question is what is the effect of mathematical games on students' achievement and retention in mathematics?

Purpose of the Study

The purpose of the study is to find out the effect of mathematical game on mathematics students' achievement and retention in concept of probability. Specifically, the study sought to determine:

(i) The difference between mean achievement scores of mathematics students taught the concept of probability using game and charts.
(ii) The difference between mean achievement scores of male and female mathematics students taught the concept of probability using games.
(iii) The difference that between retention mean scores of mathematics students taught the concept of probability using game and charts.

Research questions

To guide they study, the following questions were raised:

(i) What are the mean achievement scores of mathematics students taught the concept of probability using games and charts?
(ii) What are the mean achievement scores of male and female mathematics students taught the concept of probability using mathematical games?
(iii) What are the mean retention scores of mathematics students taught the concept of probability using games and charts?

Research Hypotheses

The researcher raised the following hypotheses to help answer the questions posed.

(i) There is no significant difference between the mean achievement scores of mathematics students taught the concept of probability using mathematical games and charts.
(ii) There is no significant difference between mean achievement scores of male and female mathematics students taught the concept of probability using mathematical games.
(iii) There is no significant difference between the mean retention scores of mathematics students taught the concept of probability using mathematical games and charts.

RESEARCH METHODOLOGY

The research design adopted for this study was pretest, posttest non-randomized control group design. The area of the study was Oron Local Government Area of AkwaIbom State. The population of this study was made up of nine hundred and eighty (980) from all senior secondary two (SS2) students in the five (5) public secondary schools in the study area during 2022/2023 academic session. The sample size was fifty (50) students in their intact classes from two (2) co-educational public secondary schools in Oron Local Government Area of Akwa Ibom State. A purposive sampling technique was used to select the schools for this study.

The instruments used for data collection were Mathematics Achievement Test on Probability (MATP) and Mathematics Retention Test on Probability (MRTP) structured on four options A-D. The instrument consisted of two sections of twenty items. The first section contained the students' details such as serial number, gender, class and school name while the second section consisted of20 multiple choice items with one correct option and three wrong

options. The test was based on a maximum score of twenty (20) marks. Each correct answer was scored 1 mark and incorrect answer was scored 0 marks. The retention test MRTP contained the same questions as MATP but arranged in different order which was used to determine the retention scores of mathematics student on probability.

The instruments were subject to face validation by three experts. To further strengthen the validity of the above instruments, a test- retest method was used to obtain the reliability coefficients of 0.81 and 0.83 for MATP and MRTP respectively using Pearson Product Moment Correlation (PPMC). The instruments were administered on equivalent group of students who were not part of the study. The students assigned as experimental group were taught probability with mathematical games while those in the control group were taught probability without mathematical games. At the end of the lesson, the two groups were given the achievement test (MATP). After three weeks of administration of MATP, retention test (MRTP), a reshuffled form of (MATP), was also administered to the students to determine the level of retention of the concept probability. Finally, scripts were retrieved, marked and data generated were analyzed using t- test analysis at 0.05 level of significance.

RESULTS

Research Questions 1

What are the mean achievement scores of mathematics students taught the concept of probability using games and charts?

Table 2: Mean and Standard Deviation Showing Pretest and Post Test Scores of Students Taught Probability With Mathematical Games and Charts.

		Pretest		Posttest		
Group	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Gain
Experimental	25	6.16	1.59	12.28	2.11	6.12
Control	25	6.40	1.85	8.80	1.70	2.40

Data in Table 2, show the pretest and posttest mean scores of students taught probability using mathematical games to be 6.16 and 12.28 respectively, while those taught with games had 6.40 and 8.80 for pretest and posttest respectively. The mean gain scores show that those taught using mathematical games had best mean score of 6.12 and those taught with charts had 2.40. The difference in the mean scores of these two groups is examined by testing hypothesis one.

Hypothesis 1

There is no significant difference between the mean achievement scores of students taught probability with mathematical games and charts.

Table 3: T – Test Analysis of Mean Achievement Scores of Students Taught Probability With Mathematical Games and Charts.

Group	N	$\overline{X}$	SD	df	t-cal	t- critical	Decision
Experimental	25	12.28	2.11				
				48	6.4	2.01	
Control	25	8.80	1.70				Rejected

Table 3 shows that the calculated t-value which is 6.4 is greater than t-critical value which is 2.01 at 0.05 level of significance. Based on this result, the null hypothesis is rejected. This means that a significant difference exists between the mean achievement scores of mathematics students taught probability with mathematical games and charts.

Research Questions 2

What are the mean achievement scores of male and female mathematics students taught the concept of probability using mathematical games?

Table 4: Mean and Standard Deviation Showing Pretest and Posttest Scores of Male and Female Students Taught Probability With Mathematical Games.

	Pretest			Posttest		
Gender	N	$\overline{X}$	SD	$\overline{X}$	SD	Mean Gain
Male	14	6.29	1.44	12.90	2.47	6.61
Female	11	6.00	1.76	11.82	1.53	5.82

Data in Table 4 indicate that the mean scores of male students taught probability with mathematical games are 6.29 and 12.90 for pretest and posttest respectively, while their female counterparts have 6.00 and 11.82, respectively for pretest and posttest. The mean gain scores of male students taught probability with mathematical games is 6.61 while that of their female counterparts is 5.82. This implies that male students taught probability with mathematical games achieved more than their female counterparts. The difference in the mean scores of the male and female students taught probability with mathematical games is examined by testing hypothesis two.

Hypothesis 2:

There is no significant difference between the mean achievement scores of male and female students taught probability with mathematical games.

Table 5: T-Test Analysis of Mean Achievement Scores of Male and Female Students Taught Probability With Mathematical Games.

Gender	N	$\bar{X}$	SD	df	t-cal	t- critical	Decision
Male	14	12.90	2.47				
				23	1.28	2.07	
Female	11	11.82	1.53				Accepted

Data in Table 5 show that the calculated t-value is 1.28 while the critical t-value is 2.07 at 0.05 level of significance. This indicates that the calculated t-value is less than the t-critical value; therefore, the null hypothesis is accepted. This means that there is no significant difference in the mean scores of male and female students taught probability with mathematical games.

Research Question 3

What are the mean retention scores of mathematics students taught the concept of probability using games and charts?

Table 6: Mean and Standard Deviation Showing Posttest and Retention Test Scores of Students Taught Probability with Mathematical Games and Charts

	Posttest			Retention test		
Group	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Gain
Experimental	25	12.28	2.11	12.44	2.23	0.16
Control	25	8.80	1.70	8.82	1.86	0.02

Table 6 shows the retention mean gain scores of students taught probability with mathematical games had 0.16 while those who were taught with charts had 0.02

Hypothesis 3

There is no significant difference between the mean retention score of students taught probability with mathematical games and charts.

Table 7: T- Test Analysis of Mean Retention Scores of Students Taught Probability with Mathematical Games and With Mathematical Charts

Group	N	$\overline{X}$	SD	df	t-cal	t- critical	Decision
Experimental	25	12.44	2.23				
				48	7.86	2.01	
Control	25	7.88	1.86				Rejected

Table 7 shows that the calculated t-value which is 7.86 is greater than the t-critical which is 2.01 at 0.05 level of significance. Based on this result the null hypothesis is rejected. This implies that a significant difference exists between the mean retention scores of mathematics students taught probability with mathematical games and charts.

DISCUSSION

The results of this study revealed that there exists a significant difference between the mean achievement scores of mathematics students taught probability with mathematical games and those taught with charts. This may be attributed to the fact that mathematical games can stimulate and motivates students' active participation during lessons. This finding is in line with the finding of Akanmu and Adeniyi (2021) on the effects of mathematical games on senior secondary students' academic performance in mathematics which showed that students taught with mathematical games performed significantly better than those who were taught with lecture method. It also agrees with the finding of Adeoye and Abimbola (2016) who found out that students who learned biology with demo kits achieved significantly better than those who learned without the use of demo kits.

The finding of the study on the difference between the mean achievement scores of male and female students taught probability with mathematical games showed no significant difference between the male and female mean achievement scores. This could be attributed to how use of mathematical games stimulates male and female students' interest in learning which might have brought about equal competitiveness. This finding is supported by that of Okigbo and Agu (2010) who found that male and female students improved in their academic achievement when taught with either games or analogy. However, this finding contrasts with that of Nnamani and Oyibe (2016) who reported significant effects of gender on students' performance. The finding of this study on the difference between the mean retention scores of students taught probability with mathematical games and those taught with charts revealed that there exists a significant difference. The students taught probability with mathematical games

had better retention than their counterparts who were taught without mathematical games. The significant effect may be attributed to the utilization of games as instructional resources which makes learning more meaningful. This is in line with the findings of Adeoye and Abimbola (2016) who reported a high retention level in favour of students who learned biology with instructional materials (demo kits).

Recommendations

Based on the findings of this study, the following recommendations are made:

(i) Mathematics teachers should always utilize instructional materials in teaching different concepts in mathematics.

(ii) Teachers should not consider as a significant academic factor in students' achievement and retention, but should motivate both male and female students in their classes for enhanced academic gains.

(iii) There should be mathematics laboratory in all the secondary schools where different mathematical games can be found.

Conclusion

Based on the findings, it is concluded that there is significant effect on students' achievement and retention when taught probability with mathematical games. This is due to the fact that students were actively involved during the lessons. The study also showed that male and female students achieved and retained equally when both gender were taught probability with mathematical games.

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