COMPARATIVE EFFECTS OF USING PUZZLES AND PROBABILITY KITS ON STUDENTS' ACHIEVEMENT AND INTEREST ON PROBABILITY IN YENAGOA, NIGERIA

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Abstract

This study compared the effect of Using Puzzles and Probability Kits on Students' Achievement on Probability in Nigeria. A quasi-experimental research design was adopted for the study. The population consisted of all senior secondary school two (SS2) students with a total number of 25,672 students. The sample consisted of 109 students, from two schools in Yenagoa Local Government Area of Bayelsa State. A group of students were taught probability using crossword puzzle games while the other group was taught probability using probability kit. The instruments used for data collection were Probability Interest Scale (PIS) and Probability Achievement Test (PAT) with reliability coefficient of 0.87 and 0.76 respectively. The scores obtained were analysed using mean, standard deviation and Analysis of Covariance (ANCOVA) at .05 level of significance. The results revealed that the mean interest and achievement scores of students taught probability using crossword puzzle is higher than that of those taught using probability kits. However, there was no significant mean difference in the interest and achievement of students taught probability using crossword puzzle games and those taught probability using probability kit. Based on the findings of the study, therefore, it was recommended that teachers should use both crossword puzzle games and probability kits in teaching probability in order to enhance interest and achievement of students.

Keywords: *Puzzles, Kits, Achievement, Interest, Probability*

Introduction

The chief goal of science education in any nation is to instil in its citizens appropriate scientific and technical abilities critical to its economic competitiveness and address of its national needs. Nation can make progress and prosperity without scientific knowledge and skilled manpower. Measures therefore, need to be taken to illuminate the minds of the youths with modern science and technology. Science teaching is considered the vehicle through which such knowledge is converged to people. Mathematics teaching is one aspect of science

education that cannot be ignored if it must be said that any meaningful and holistic venture into science teaching has been attempted.

The specific objectives of mathematics teaching include the development and use of mathematical investigative skills (Kumar, 2017). Through this, students are given the opportunity to apply mathematical knowledge and problem-solving techniques to investigate and solve real-life problems, generate and/or analyse information, find relationships and patterns, describe these patterns mathematically as general rules, and justify or prove them. As it applies to knowledge and understanding, the objectives include that at the end of the general mathematics course, students should be able to demonstrate understanding of all concepts from the five branches of mathematics namely: number, algebra, geometry and trigonometry, discrete mathematics, and statistics and probability (Federal Government of Nigeria (FGN), 2007).

Probability is a part of mathematics that reflects the chance or likelihood that a particular event will occur. Durrett (2013) defines probability as the expected frequency of the occurrence of an event, among events of a like sort. They are usually expressed as proportions ranging from 0 to 1, although they may also be expressed as percentages that range from 0% to 100%. The probability theory provides a means of getting an idea of the likelihood of occurrence of different events resulting from a random experiment in terms of quantitative measures ranging between zero and one (LaMorte, 2016). Hence, a probability of 0 indicates that there is no chance that a particular event will occur, while a probability of 1 indicates that an event is certain to occur. Whereas, probability of 0.45 or 45% indicates that there are 45 chances out of every 100 that a particular event will occur.

Some commonly used terms in the study of Probability which facilitate precision and efficiency in communication on the subject include:

– Mutually exclusive events: this is interpreted to mean two or more events that cannot occur simultaneously. That is, the occurrence of one invariably prevents the occurrence of the other(s). For example, night and day cannot coexist simultaneously. It cannot be night and at the same time be day, hence, night and day are mutually exclusive events.

– Independent and dependent events: two events are independent when the occurrence of one does not have an effect on the other. It indicates the fact that if trials are made one by one, then one trial is not affected by the other. Also, that one trial never describes anything about the other trials.

– Equally likely events: events are equally likely when they have an equal chance of occurring. Simply put, a number of events are equally likely when one of such events is not likely to occur more than the others. For equally likely events, if one does not occur then others are not considered as likely to occur.

– Simple and compound events: in simple events, we think about the probability of an event occurring or not occurring. For instance, if a coin is tossed once, we think about the occurrence of either a head or a tail. On the other hand, when we consider the joint

occurrence of two or more events, we begin to think of compound events. Unlike simple events, here, more than one event is taken into consideration. For example, if the coin above is tossed say twice, we may begin to think of a head occurring twice in both tosses, a head occurring in the first toss and a tail occurring in the second toss, a tail occurring in the first toss and a head occurring in the second toss or tails occurring in both tosses, then we would have begun talking of compound events (Abdulcarismo, 2009).

Probability theory has its application in many areas of the field of engineering as well. In environmental engineering for example, issues related to environmental risk assessment include among others health effects, impact on natural resources or man-made structure due to pollution, change in climatic conditions and water quality of streams. Different parametric, non-parametric and empirical models are used to address these issues, and probability methods play a role in (i) the estimation of these model parameters, (ii) determination of dependencies among variables and (iii) estimation of uncertainties (Batenero, 2016). Failure in structural engineering can cause excessive monetary loss, injury and death, therefore, extremely low rate of failure is assured in designs. Safety factors are determined by considering risk or probability of failure.

The concept of "low-probability high-consequence" risks events is the key issue in the design of complex structures such as, offshore structures, nuclear plants and high exposure public structures (Liu & Nagumey, 2011). Sources of uncertainty in structural engineering lie among others in the magnitude of load, strength of structural material and number of load cycles until fatigue failure. For instance, determination of maximum wind effect, consideration of earthquake force and others. are uncertain and their assessment requires probability methods. Similar reasoning applies for assessment of strength of structural material and number of load cycles until fatigue failure as well. In structural design, Probabilistic Structural Design Optimization (PSDO) is able to handle uncertainties in material properties, geometry, loadings, boundary conditions, and mathematical simulation. Different standards of acceptance are developed based on the probability concepts. This is helpful to ensure that the standards should not be too stringent or too lax (Wilensky, 2014).

Sales forecasting and risk evaluation are practical uses for probability distribution in businesses (Haataja, 2016; Vale, 2009). It is used in sales forecasting to predict the future level of sales. Although it is essentially impossible to predict the precise value of a future sales level, however, businesses still need to plan for future events. Using a scenario analysis based on probability can help a company frame its possible future values in terms of likely sales level in a worst-case and best-case scenario. In doing so, the company can base its business plans on the likely scenario, but still be aware of the alternative possibilities.

In risk evaluation, consider a company contemplating on entering a new business line. If the company needs to generate say, $500,000 in revenue in order to break even and their probability distribution tells them that there is a 10% chance that their revenues will be less than $500,000, the company will have a rough idea what level of risk they are facing and decide whether or not to pursue that new business line (Vale, 2009). Other areas of meaningful application of the concept of probability include psychometrics in psychology,

biology and computer science. One would argue that there is hardly any discipline that doesn't apply the concept of probability somewhere along its ranks, thus, the need exists to ensure that the concept is sufficiently grasped if we will have well rounded personnel optimally discharging responsibilities in their respective fields.

Students' achievement and consequent performance on the concept of probability have been observed. It has been this researchers' experience while assessing the readiness of candidates for WAEC examinations, to notice that most of them shy away from questions on probability; this is an indication that they have not achieved enough on the concept. WAEC Chief Examiners' Report 2012 and 2017 reported that the performance of candidates in general mathematics were not encouraging. It could be argued that a contributory effect to these is the poor knowledge of students on the concept of probability. The WAEC Chief Examiners' Report (2017) suggested that teachers should give equal attention to all topics in the syllabus, and stop specializing in teaching some topics.

Learning mathematics can prove to be a highly complex cognitive task that can be very imposing on students since it requires a lot of effort from them (Ogochukwu, 2010). Hence, these students need some kind of motivation to cope through the rigours of learning the subject. Interest in a particular subject or concept spurs students to learn such subject frequently and with ease. This could be why Dewey (1913) in his Classical Analysis, theorized that interest-based learning is much more beneficial than effort-based learning. He justified this position when he stated that "life is already full of uninteresting things that have to be faced; demands are continually made and situations have to be dealt with which present no features of interest. Unless one has had previous training in devoting himself to uninteresting work, unless habits have been formed at attending to matters simply because they must be attended to irrespective of the personal satisfaction they can afford, character will break down or avoid the issue when confronted with the serious matters of life". Mathematics is a serious matter of life. It is for this benefit that mathematics educators seek a release for students, in the form of instructional strategies that are stimulating and interesting.

In the opinion of Mohammed and Charles (2017), the key strategy of mathematics teaching should focus on keeping the students' interest on mathematics. A characteristic feature of the modern education system is the continuous search for more attractive and effective methods and forms of working with students. Among the various trends and modernization of educational systems, concepts which favour active involvement of learners in some way occupy a special place. The active participation of students is what is emphasized in recent educational activities. In the bit to address this problem, the study used student centre activities to determine their effects on interest and achievement of students.

Puzzles can be used in teaching mathematics. They are very beneficial and can improve children's mental state in many ways than we can expect (Ebele & Sam, 2015). Mathematical Puzzles make up an integral part of recreational mathematics. They do not usually involve competition between players; instead, the solver must find a solution that satisfies the given conditions in order to solve the puzzle. Puzzles provide the opportunity for learners to learn and enjoy at the same time. They make learning fun. Okigbo and Okeke (2011) stated that

exposing children to puzzles is highly beneficial for a good number of reasons such as– introducing them to intellectual humour, improves their comprehension and creativity, expands their vocabulary, it gives them the opportunity to teach themselves, as well as helps them to create and strengthen bonds within peers.

Introducing puzzles in teaching sharpens students' critical thinking and problem-solving skills (Chernoff, & Sriraman, 2014). Puzzles as a resource creates the opportunity for the teacher to create, capture, increase and retain the interest of the learners in the topic being studied, and develop their problem-solving and teamwork skills. Dewey (1913) surmised that people will not readily involve in a particular activity unless such an activity is satisfying and rewarding–in other words, when such an activity interests them. This forms the basis of using puzzles in mathematics teaching; puzzles get students interested in learning mathematics. The activities so presented by the manipulation of puzzles are enjoyed across gender, and may well improve the performance of both male and female students in probability if effectively used to teach the concept.

Orji and Sumbabi, (2010) investigated the Effects of Two Puzzle-based Instructional Strategies on Primary School Pupils' Learning Outcomes in Social Studies in Ondo State, Nigeria. The study revealed that pupils who were exposed to puzzle-based instructional strategies exhibited greater academic performance than their counterparts who were not exposed to it. Ezeugwu, Onuorah, Asogwa and Ukoha (2016) in their study titled effects of game-based instructional technique on achievement and interest of students in Algebra at the basic educational level found that the use of Game-based instructional technique in teaching affects students' achievement and interest in Algebra.

The use of a wide variety of manipulatives in mathematics teaching has a long traditional and solid history. They do not only allow students to construct their own cognitive models for abstract ideas and processes, they also provide a common language with which to communicate these models to the teacher and their peers (Omeodu & Charles-Owaba, 2020). Manipulatives are concrete objects that can be viewed and physically handled by students in order to demonstrate or model abstract concepts. These include colour counters, place-value disks, Cuisenaire rods, fraction tiles, number-base blocks, foam geometric solids kits, algebra tiles, pattern blocks classroom kits and probability kits. Probability Kits are a class of concrete manipulatives which include a variety of spinners, dice, playing cards, boards, pawns and coins, which is used in teaching the concept of probability.

According to Joseph, (2016) the history of manipulatives for mathematics teaching extends at least two hundred years, with each innovation and research emphasizing the importance of authentic learning experiences and the use of concrete tools as an important stage in development of understanding. In addition to aiding cognitive process, manipulatives have the advantage of engaging students and increasing both interest in, and enjoyment of mathematics. Probability instruction through concrete activities makes students' reason as it tends to draw their focus to real life applications of theoretical instruction. Siong-Hoe (2011) examined manipulatives and simulations on learning skills and on students' experimental

probability achievement. He concluded that manipulatives improved achievement in experimental probability.

Problem of the Study

The achievement of students in mathematics has been quite unsatisfactory over the years in Nigeria particularly in Bayelsa State. The external examination bodies such as the West African Examination Council (WAEC) and the National Examination Council (NECO) have repeatedly reported the poor performance of students in mathematics. The picture emerging from research reports, Chief Examiners' reports and WAEC and NECO SSCE results (2010-2020) show that the students have major and consistent difficulty in solving mathematical problems that involves probability. Students' low success levels in mathematics have been a source of worry for a long time in many countries, Nigeria inclusive. There are a lot of factors said to be affecting students' achievement in probability, one of these according to Adolphus (2011), Omeodu and Charles-Owaba (2019), is the conventional pattern of teaching mathematics which has been identified as being ineffective. In addition, other reasons pointed out by different scholars, Ado (2018), Orji and Sumbabi, (2010) are poor learning interest and assimilation of mathematics ideas, concepts, principles, processes and teachers' failure to use appropriate and stimulating teaching methods are responsible for students' low achievement in probability in Nigeria.

Though, much attention has been directed towards the study of mathematics at the primary and secondary levels of education as to improve students' achievement and interest; regrettably, this has not given the required result of improved achievement in our schools. In a bid to overcome the problem associated with the learning of probability, mathematics educators have resorted to the use of developed Puzzle-based Instructional Strategies. Orji and Sumbabi, (2010), Ezeugwu, Onuorah, Asogwa and Ukoha (2016) reported that the use of mobile application-based pedagogy in the teaching and learning of probability and other aspects of mathematics in other countries have yielded improved results. There is a dearth of empirical evidence on the teaching of probability using mobile application instructional technique to enhance students' achievement and interest in probability. Therefore, the problem of the study is to investigate the comparative effects of using puzzles and probability kits on students' interest and achievement on probability in Yenagoa, Nigeria.

Purpose of Study

The purpose of this research was to investigate the comparative effects of using puzzles and probability kits on students' interest and achievement on probability in Yenagoa, Nigeria. The study sought to achieve the following specific objectives.

1. Compare the mean interests of students taught probability using crossword puzzle games and those taught using probability kit.

2. Compare the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit.

Research Questions

1. What is the difference between the mean interests of students taught probability using crossword puzzle games and those taught using probability kit?

2. What difference exists between the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit?

Hypotheses

1. There is no significant difference between the mean interests of students taught probability using crossword puzzle games and those taught using probability kit.

2. There is no significant difference between the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit.

Research Methods

The pre-test post-test quasi-experimental design was used for this study. All public secondary schools in Yenagoa local government area formed the population of the study. The population consisted of all senior secondary school two (SS2) students with a total number of 25,672 students. Two intact classes were randomly selected from two schools which were also drawn randomly from the thirty-four public secondary schools in Yenagoa local government area in the 2020/2021 academic session. The intact classes were randomly assigned into two groups; Group A (puzzles approach) and Group B (probability kit approach). The total sample of the study was one hundred and nine (109) students in the groups.

The instruments used for data collection were Probability Interest Scale (PIS) and Probability Achievement Test (PAT). PIS consisted of two sections; Section A contained demographic information while Section B contained fifteen (15) items with Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) as options to be responded to. PAT also consisted of two sections; Section A contained demographic information while Section B of the Probability Achievement Test (PAT) contained forty (40) multiple choice test items on the concept of probability, with each question having four options with only one correct option.

The instruments were validated by two secondary school mathematics teachers, a lecturer from the Department of Science Education and an expert of Tests, Measurement and Evaluation from Niger Delta University, Amassoma. Their criticisms, comments and corrections made the final instrument. The instruments were trial-tested on 30 students in a school from the population that did not form part of the sample. This was done to establish the reliabilities. The instruments were administered once to the students. Data obtained from the administration of PIS was analysed using Cronbach Alpha reliability coefficient formula while those from the administration of PAT were analysed using Kuder Richardson formula 20. A reliability of 0.87 was obtained for PIS while 0.76 was obtained for PAT. The instruments were thus considered reliable for the study.

The regular Mathematics teachers from the two schools were used as research assistants. The pretest and pre-interest was administered to the students by their teachers before treatment commenced. A group of students were taught probability using crossword puzzle games while the other group was taught probability using probability kit. The teaching lasted for two weeks for both groups. After teaching, the reshuffled Probability Achievement Test (PAT) and Probability Interest Scale (PIS) were administered in both groups as post-test and post interest. The scripts were collected, marked and recorded. The scores obtained were analysed using mean, standard deviation and Analysis of Covariance (ANCOVA) at .05 level of significance.

Results

The results are presented in tables based on the research questions and hypotheses.

Research Question One

What difference exists in the mean interests of students taught probability using crossword puzzle games and those taught using probability kit?

Table 1

Marginal Estimated (Adjusted) Mean and Standard Deviation of Students' Post-interest Scores Using Pre-interest Scores as Covariate.

Resources	N	$\bar{X}$	SD
Probability Kit	56	34.45	9.59
Crossword Puzzle	53	38.34	2.70

As shown in Table 1, the adjusted mean interest scores of students taught probability using probability kits is 34.45 while that of those taught probability using crossword puzzle is 38.34. It can be inferred from the adjusted mean scores that, the difference between the students taught probability using probability kits and those taught probability using crossword puzzle is 3.89 in favour of those taught using crossword puzzle. This implies that the mean interest score of students taught probability using crossword puzzle is higher than that of those taught using probability kits.

Research Question Two

What difference exists between the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit?

Table 2

Marginal Estimated (Adjusted) Mean and Standard Deviation of Students' Posttest Scores Using Pretest Scores as Covariate.

Resources	N	$\bar{X}$	SD
Probability Kit	56	26.49	5.39
Crossword Puzzle	53	26.60	4.35

As shown in Table 2, the adjusted mean achievement score of students taught probability using probability kits is 26.49 while that of those taught probability using crossword puzzle is 26.60. It can be inferred from the adjusted mean achievement scores that, the difference between the students taught probability using probability kits and those taught probability using crossword puzzle is 0.11 in favour of those taught using crossword puzzle. This implies that the mean achievement score of students taught probability using crossword puzzle is higher than that of those taught using probability kits.

Hypothesis One

There is no significant difference between the mean interests of students taught probability using crossword puzzle games and those taught using probability kit.

Table 3

Analysis of Covariance of Students' Post-interest Scores Using Pre-interest as Covariate.

Source of Variation	SS	df	MS	F_{cal}	P-value$_{cal}$
Pretest	767.74	1	767.74	9.09*	.00
Resources	411.99	1	411.99	4.88*	.03
Residual	8956.72	106	84.50		
Total	10136.44	108	93.86		

*= Significant at .05 level of significance

As shown in Table 3, the analysis of the pre-interest scores of students is significant since the calculated F-value (9.09) and its corresponding P-value (.00) is less than the significant level (.05), indicating the groups were not statistically equivalent. The initial equivalent of the two groups is however addressed by analysis of covariance that would regress the pre-interest and post-interest scores of the students. The table also showed that the calculated F-value (4.88) and its corresponding P-value (.03) of resources is less than the significant level (.05). Therefore, the null hypothesis is rejected. This implies that there exists significant difference between the mean interest scores of students taught probability using crossword puzzle games and those taught using probability kit.

Hypothesis Two

There is no significant difference between the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit.

Table 4: Analysis of Covariance of Students' Posttest Scores Using Pretest as Covariate.

Source of Variation	SS	df	MS	F_{cal}	P-value$_{cal}$
Pretest	209.26	1	209.26	6.48*	.01
Resources	0.30	1	0.30	0.01NS	.92
Residual	3423.50	106	32.30		
Total	3633.06	108	33.64		

*= Significant at .05 level of significance. NS= Not Significant at .05 level of significance

As shown in Table 4, the analysis of the pretest scores of students is significant since the calculated the calculated F-value (6.48) and its corresponding P-value (.01) is less than the significant level (.05), indicating the groups were not statistically equivalent. The initial equivalent of the two groups is however addressed by analysis of covariance that would regress the pretest and posttest scores of the students. The table also showed that the calculated F-value (0.01) and its corresponding P-value (.92) of resources is greater than the significant level (.05). Therefore, the null hypothesis is not rejected. This implies that there is no significant difference between the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit.

Discussion

The findings on the difference between the mean interest scores of students taught probability using crossword puzzle games and those taught using probability kit indicated a significant difference in favour of students taught probability using crossword puzzle games. The findings could be attributed to students being seriously engaged in playing the crossword puzzle game which may have given them their required excitement. The puzzles as a resource may have created the opportunity for the teacher to capture, increase and retain the interest of the learners in the topic. The finding of the study is in agreement with that of Ezeugwu, Onuorah, Asogwa and Ukoha (2016), who found that the use of Game-based instructional technique in teaching affects students' achievement and interest in Algebra.

The findings on the difference between the mean achievement scores of students taught probability using crossword puzzle games and those taught using probability kit indicated a non-significant difference. The findings could be attributed to both resources being students centred. The use of the two resources may have allowed students to construct their own cognitive models for the concept and given them a better understanding. The finding of the study is contrary to that of Orji and Sumbabi (2010), who revealed that pupils who were exposed to puzzle-based instructional strategies exhibited greater academic performance than their counterparts who were not exposed to it.

Conclusion

It can be concluded from the findings that in order to enhance students' interest in probability crossword puzzle games is more preferable to manipulatives such as probability kits. However, both crossword puzzle games and probability kits are good in the enhancement of students' achievement in probability.

Recommendations

The following recommendations are made based on the findings:

1) Teachers wanting to enhance students' interest in probability should go with crossword puzzle games.

2) Parents Teachers Associations, the government and other philanthropic organisations should help provide these resources (crossword puzzle games, probability kits) for teachers in teaching the concept of probability.

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