EFFECTS OF TEACHING USING SCRATCH PROGRAMMING LANGUAGE ON STUDENTS' PROBABILITY ACHIEVEMENT AND INTEREST IN BAYELSA STATE

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Abstract

The study investigated the effect of scratch programming language on students' academic achievement and interest in probability content of mathematics curriculum. A total of two hundred and eighty-nine (289) senior secondary class two (SSII) mathematics students were involved in the study. Three research questions and hypotheses guided the study. The study employed non-equivalent pretest, post-test control group design. A researcher's developed Probability Achievement Test (PAT) and Probability Interest Inventory (PII) was used for the study. Data collected were analyzed using mean scores, standard deviation and analysis of co-variance (ANCOVA). Findings from the study shows that students who were taught probability using scratch programming language achieved higher than those taught with conventional approach. The use of scratch programming language favored both male and female students. Finally, the use of scratch programming language increases the interest of students in probability. It was recommended that the use of scratch programming language should be incorporated into the mathematics curriculum and its use be encouraged at all level.

Keywords: *Scratch Programming Language, Students' Achievement, Interest, Probability Introduction*

Introduction

Nigeria, like other countries all over the world, strives for academic excellence because without a sound and quality education, no country would develop. Not only will a country not develop but if at all there is an iota of development, sustainability becomes imperative. Hence, education is synonymous with sustainable development. In pursuance of this, the National Policy on Education (NPE, 2014) spells out the place and importance of many subjects taught in Nigerian schools and made some subjects mandatory because whatever the course of study a child decides to go for in the higher education, the subjects remain compulsory starting from primary and secondary and tertiary level of education. One of such subjects is Mathematics.

Mathematics is a logical science upon which other sciences like chemistry, physics, biology and geography depends. It is considered a basis for social life and the exploration of the entire universe. Mathematics is a precursor of scientific discoveries and inventions. Mohamed (2010) sees it as one of the oldest fields of study in the history of mankind that forms the most central components of human thought. To Odili (2006), mathematics represents the superb and sublime product of reason as well as the upper limits of what one hopes to attain in all rational domain. Mathematics is a very vital subject in our daily lives. No society can survive without the use and application of mathematics. No wonder, Shafi and Areelu (2010) asserted that without mathematics there is no science and without science there is no technology and without technology there is no modern society.

The current Nigeria Mathematics Curriculum for secondary schools designed by the Nigerian Educational Research and Development Council (NERDC, 2016) presents mathematics as a school subject under five (5) distinct themes, viz-a-viz;

1. Number and Numeration
2. Geometry
3. Algebra
4. Introductory Calculus
5. Statistics and Probability

Probability which is the focus of this study is a branch of mathematics that deals with calculating the likelihood of a given event's occurrences, which has a number between zero and one (Orji & Sumbabi, 2010). Graham (2017) submitted that probability is a branch of mathematics used to understand chance and to collect, organize, describe and analyze numerical data. It is used to analyze games of chance, genetics, weather, prediction, election results and a myriad of other everyday events. Bantenero (2016) stated that to adequately function in society, citizens need to overcome their deterministic thinking and accept the existence of fundamental chance in nature and this can only be made possible by the teaching of probability. Also, Prat (2005) submitted that probability as an integral part of mathematics curriculum is of great importance to learners, because the progressive nature that follows the use of technology, spread of empirical science in the society, the use of data to communicate information and modern decision-making system are all influenced by projected outcome based on estimated probabilities.

Gold (2009) reported that in spite of the importance of probability to man and National development, students continue to see it as abstract and difficult to understand. Toh (2010), Yildiz and Baltaci (2015), Baltaci (2016), Vivian and Masitah (2018) submitted that students find it difficult in understanding and interpreting probability related questions during examinations. Also in another vein, Garfield (2005), Konold and Kazak (2008) reported that lack of understanding of the basis of probability is the cause of the difficulties encountered by students learning basic data analysis.

Among several explanations, Chernoff and Srirman (2014) outlined reasons why students find it difficult to grasp the fundamental ideas of probability as; lack of basic mathematics skills, teaching method, lack of interest, anxiety. Vivian and Masitah (2015) admitted that students are weak in probability because they have weak foundations in rational number. Baltaci (2016) while examining causes of difficulties in probability content, admitted that students answer questions in intuition rather than logic, while making sense of the probability concepts. Bantero, Chernoff and Engel (2016) noted that a large majority of students prefer the memorizing of formulae rather than making effort to understand the basis of probability content. They further noted that nurturing negative attitude towards this content and the non-use of teaching materials by teachers are major reasons behind poor performance and lack of understanding. Batenero (2016) identified wrong approach, poor linkage that exist between the natural and the academic languages of probability and the poor linkage that exist between intuition of chance and quantitative literacy; as challenges of teaching probability.

Different teaching and learning methods have been experimented to motivate and increase learner's interest in probability content of mathematics curriculum: cooperative learning and peer interaction (Jone, 2009), learning via videos (Esteban & Tejero, 2000), internet based instruction (Utts, 2003), Geometer's sketchpad (Almegdadi, 2005) and graphing calculator (Norini, 2006; Siong-Hoe, 2011), cultural games (Adullarismo, 2009), teacher and student based instruction on probability achievement (Joseph, 2016), integrating real-word problem solving and innovation dimension (Vivian et al., 2015), problem solving based learning (Jamilah, 2017), game-tournaments (Joseph, 2016). Also, in order to resolve this sort of problems, Watson (2006) emphasized the adoption of an experiment-based mindset of teaching with student-centered approaches which will help students comprehend the theoretical aspect of probability.

Imoko and Agwagah (2006) defined interest as a subjective feeling of concentration or persisting tendency to pay attention and enjoy some activity or content. Oxford Advanced Learner's Dictionary (2018, p.910) defined *interest* as the feeling of one whose attention or curiosity is particularly engaged by something. Interest is an important variable in learning because when one becomes interested in an activity, one is likely to be more deeply involved in that activity.

Abdulcarismo (2009) submitted that some children may be intellectually and physically capable they may never learn until their interest is stimulated. Once the students' interest are stimulated, they will continue to learn as long as the teacher is capable of sustaining their interest in the subject matter. McPhan (2008) opined that interest is the mother of attention; once there is direct interest, attention is guaranteed and learning is assured. Ebele & Sam (2015) reported that low interest in mathematics emanates from anxiety and phobia. Phobia has been observed in Abdulcarismo (2009) to be an academic sickness whose virus has not yet been fully diagnosed for an effective treatment in the class and the symptoms of this phobia are usually expressed on the faces of mathematics students in their classes.

Scratch is a program with interactive features used to create stories, games, and animations, art and music and share all of these creations with others in an online community (http://scratch.mit.edu/). Scratch was developed at the MIT Media Lab and it consists of reusable pieces of code, which can easily be combined, shared, and adapted. It was created to help students think more creatively, reason systematically, and work collaboratively, all of which are essential skills required for the 21st century (Resnick, 2007). The software was first released in 2007 while Scratch 2.0, which is its second current major version, came out in 2013. In this study, we deemed Scratch 2.0 as the most appropriate option to adopt, due to the fact that there is very little research on how coding learning environments could be used as a tool for developing concepts related to the stochastic.

Imoko and Agwagah (2016) reported that females achieved significantly better than males in mathematical activities as a result of instructions in mathematics reading. This is supported by Salau (2011). There are still some reports which do not agree with any of the above stance. Galadima and Okogbenin (2012) reported that both male and female performances are at per after exposing them to some mathematics activities. In respect to the above reports on gender parity or disparity in mathematics achievement, there is need for further investigation on gender issue as it relates to probability achievement, especially, when the students are exposed to certain

approaches like the use of probability apparatus in the teaching and learning of the probability content in mathematics curriculum.

Conventional teaching approach is described as teacher centered and didactic with learners simply listening, copying notes, doing classwork and doing assignments. It allows some interactions between the teacher and the students in terms of asking and being asked questions on the topic of discussion. Dotun (2015) reported that the conventional methods of teaching mathematics are no longer adequate to meet the demand of modern mathematics. He further stated that in order to develop the skills reiterated in the National Policy of Education and provide practical experience of abstract mathematical concepts like probability, a strategy for teaching and suitable platform to use such platform is the need of the day.

Statement of the Problem

Many studies suggested that most students are weak in probability content at all levels because they have weak foundations in problem solving and difficulties in understanding abstract concepts (Garfield, 2012; Salau, 2011). Research has shown that one way to improve the teaching process is by introducing good teaching aides (Esteban et al., 2000).

Scratch programming language was designed and constructed to help students develop interest by reducing the abstractness associated with probability. In view of these significant role of probability apparatus, the question therefore is; How effective is the use of probability scratch programming language in enhancing students' interest and achievement in probability content in secondary schools in Bayelsa State?

Purpose of Study

The aim of this study is to determine effect of scratch programming language on students' achievement and interest on probability content in Mathematics. Specifically, the study sought to compare:

1. Mean achievement scores of students taught probability using scratch programming language and those taught using conventional methods.
2. Mean achievement scores of male and female students taught with scratch programming language and conventional method.
3. Mean interest scores of students taught probability using scratch programming language and those taught using conventional methods.

Research Questions

The following research questions guided the study:

1. What is the difference in mean achievement scores of students taught probability using scratch programming language and those taught with conventional teaching method?
2. What is the difference in mean achievement scores of female and male students taught probability using scratch programming language and those taught with conventional teaching method?
3. What is the difference in mean interest scores of students taught probability using scratch programming language and those taught with conventional teaching method?

Research Hypotheses

Ho_1: There is no significant difference in the mean achievement scores of students taught probability using scratch programming language and those taught with conventional teaching method.

Ho_2: There is no significant difference in the mean achievement scores of male and female students taught probability using scratch programming language.

Ho_3: There is no significant difference in the mean interest scores of students taught probability using scratch programming language and those taught using conventional teaching method.

Scratch programming Language as Used in the Study

It consists of reusable pieces of code, which can easily be combined, shared, and adapted. The basic tools in are;

i. Sprite: it serves as the cursor upon which actions and commands are noticed.
ii. Stage: the space where the actions are observed.
iii. Block pallet: these are the commands in block form showing the sequence of events

The app uses an activity-based strategy by creating avenue for users to explore the relationship between events that will enhance a seamless journey to the world of probability.

Classroom Setting Adopted

This study adopted a blended classroom setting which involves the use of whiteboard and marker with computers and application projected on a screen.

Equipment used in the Study

The following equipment were used;

a. Laptops with the scratch 2.0 version installed

b. Projector for demonstration
c. Lesson plan on the content to be taught
d. Source of power supply
e. Whiteboard and marker

Specific Phases Involved in the Instructional Guide

The instructional guide involved the following specific phases listed below:

i. **Introduction**: The teacher introduced the basics of the lesson using the whiteboard and marker.
ii. **Presentation and implementation of the strategy**: The teacher presents a step-by-step approach on how the games were used for contents to be taught respectively. Details on how to manipulate the cursor on the stage for enhanced understanding were shown. The students were allowed to interact with the application by using it to solve problem under the guidance of the teacher.
iii. **Feedback**: The students recorded their observations and solutions to problems solved in their notebooks and were given time to probe the process.

Evaluation of Learning Outcomes: Teachers evaluated the students' performance through the traditional mode of allocating marks on methods (M), bonus (B) and accuracy (A) as presented in their various notebooks.

Methodology

A pre-test, post-test, non-equivalent control group quasi–experimental design was adopted for the study. The choice of this design, allows investigation of intact groups in real-life classroom setting, since it was not possible to randomly assemble students for any intervention during school hours so as to avoid artificial conditions. The population for this study was all the mathematics students in Bayelsa State. A sample of two hundred and eighty-nine (189) second year senior secondary school (SS2) students were used for the study. The two co-educational Federal Government Colleges (FGC, Odi and FSTC, Tungbo) were purposively selected, because they are the only schools with the Knowledge-Based Centers, where the functional computer laboratories with the scratch programming language are available. Also, SS2 class was purposively selected because there was no impending external examination that could distract students from full participation in the study and the content used was meant for them as contained in the senior secondary mathematics curriculum. In each school, there are 4 classes (2

science classes and 2 arts classes) making a total of 8 classes in both schools selected for the study. Simple random sampling by flipping of the coin was used to select one out of the two science classes and one out of the two arts classes from each school, thereby making it a total of four classes to participate in the study. Allocation of the classes into experimental and control group was done by random sampling through balloting, which resulted to two (2) classes assigned to experimental group and the other two (2) to the control group. All the two hundred and eighty-nine (289) SS2 students in the four streams of the selected schools formed the sample of the study. The instructional tools consisted of the instrument which is a Probability Achievement Test (PAT), Probability Interest Inventory (PII), Marking Guide, scratch programming language and Lesson Packages. The instruments were validated by two (2) lecturers from Mathematics Education Unit of Science Education Department and one (1) expert of measurement and evaluation, all of Federal University, Otuoke. Their suggestions and corrections formed the final draft used in the study.

Probability Interest Inventory (PII) was developed by the researcher from vocational interest and other interest inventory. The PII was a researcher-made, questionnaire that was used to help students express their feelings towards mathematics generally and probability in particular. It consists of two sections. Section A sought general information about respondents, while Section B bothered on their interest in probability. The PII is a 15-item inventory with a five-point response type of *"Strongly Agree",* if you like it very much to engage in the activity; *"Agree",* if you like to engage in it; *"undecided"*, if you like to neither like nor dislike it; *"Disagree",* if you dislike engaging in the activity and "*Strongly Disagree"*, if you very much dislike engaging in it. Like very much, like, neither like nor dislike, dislike and dislike very much all had values of 5, 4, 3, 2 and 1 respectively.

The Probability Achievement Test (PAT) consisted of twenty (20) multiple choice items, which covers experimental probability, theoretical probability, mutually exclusive events; tree-diagram and independent events. The instrument was developed based on Bloom's Taxonomy. Each item had four options (A–D) which comprised three detractors and one correct option. The principle of item analysis, item difficulties and effectiveness of detractors were followed. The questions on knowledge in the PAT constituted four (4) items which are 1, 2, 3 and 7 of the total questions. This was to enable the researcher to determine the extent to which concepts learnt using probability apparatus could be easily recalled or remembered. Questions on application in the

PAT constituted of 8-items which are 4, 5, 8, 10, 11, 12, 15 and 20 of the total items. This was to enable the researcher determine the extent to which the students can apply the acquired knowledge, when taught probability apparatus. Questions on comprehension are 6, 9, 13, 14, 16, 17, 18 and 19 of the total items. This was to enable the researcher determine the students' ability to comprehend, when taught probability apparatus.

The researcher scored the instrument of which each correct option was scored 5 marks, which totals 100% at maximum. The instrument and tools were trial tested using four classes from other schools that did not participate in the research but were of equal status with the schools sampled. The reliability coefficient was computed using Kudder-Richardson (K-R_{20}) and reliability coefficient of 0.72 obtained was considered appropriate for the study. The Cronbach Alpha (α) was used to estimate the internal consistency of the PII. The choice of Cronbach Alpha (α) method was based on the fact that responses of the items in the instrument were not dichotomously scored. In other words, the responses do not entail right or wrong, pass or fail answers but the level of agreement or disagreement with each statement of the given items on the instrument. The reliability test on PII yielded coefficient of internal consistency of 0.8 which indicates that the reliability is very high and was therefore appropriate for the study.

The scratch programming language was used to teach the probability content of the SS2 Mathematics Syllabus (NERD, 2016) for three (3) weeks involving four (4) contacts of one hundred and forty (140) minutes each week.

Six regular teachers were engaged. The PAT and PII were administered as pre-test and the teachers taught the experimental group with probability apparatus and lesson packages after the pre-test and the control group was taught without the probability apparatus but with the lesson packages only. The reorganized version of PAT and PII were administered as post-test in both control and experimental group.

Research Question One

What is the difference in mean achievement scores of students taught probability using scratch programming language and those taught conventional method?

Table 1: Mean Achievement Scores, Standard Deviations and Adjusted Mean Scores of the Experimental and Control Group in probability

Group	No. of Cases	Pre-Test		Post-Test		Mean Difference
		Mean	Standard Deviation	Mean	Standard Deviation	
Control	156	41.81	6.54	59.92	9.37	18.11
Experimental	142	40.91	7.48	82.17	7.81	46.26

Source: Fieldwork, 2022.

The result shows that the control group had a mean achievement score of 41.81 and standard deviation of 6.54 while experimental group had a mean and standard deviation of 40.91 and 7.48 respectively. Similarly, in Post-PAT, mean achievement score and standard deviations of control group are 59.92 and 9.37 respectively, while mean achievement scores and standard deviation of experimental group are 82.17 and 7.81 respectively. The mean difference between Pre-PAT and Post-PAT for control and experimental groups are 18.11 and 46.26 respectively. This implies that students taught probability using scratch programming language performed better than those taught with the conventional teaching method.

Research Question Two

What is the difference in mean achievement scores of female and male students taught probability using scratch programming language?

Table 2: Mean Scores, Standard Deviations and Mean Differences of Male and Female Students Taught Using the scratch programming language

TYPES OF TEST	SEX			
	Male		Female	
	Mean	S.D.	Mean	S.D.
Pre-MAT	47.76	5.51	43.30	4.30
Post-MAT	79.60	7.30	77.17	7.81
Mean Difference	31.84		34.57	

Source: Fieldwork, 2022.

The result shows that the male students had a mean achievement score of 47.76 and standard deviation of 5.51 in Pre-PAT while the female students had a mean and standard deviation of 43.30 and 4.30 respectively. Similarly, in Post-PAT, mean achievement score and standard

deviation of male students are 79.60 and 7.30 respectively, while mean achievement scores and standard deviation of the female students are 77.17 and 7.81 respectively. The mean difference between Pre-PAT and Post-PAT for male and female students are 21.84 and 21.87 respectively. This implies that male and female students improved when taught probability using scratch programming language.

Research Question 3

What is the difference in mean interest scores of students taught probability using scratch programming language and those taught with conventional method?

Table 3: Mean Interest Scores, Standard Deviations and Mean Difference of Students Taught Using scratch programming language

TYPES OF TEST	SEX			
	EXPERIMENTAL		CONTROL	
	Mean	S.D.	Mean	S.D.
Pre-PII	2.15	0.965	2.29	0.813
Post-PII	4.44	1.241	2.92	0.838
Mean Difference	2.29		0.63	

Source: Fieldwork, 2022.

The result shows that the students in the experimental group had a mean interest score of 2.15 and standard deviation of 0.965 in the Pre-PII while students in control group had a mean interest score and standard deviation of 2.29 and 0.813 respectively. Similarly, in Post-PII, mean interest score and standard deviation of students in experimental group are 4.44 and 1.241 respectively, while mean achievement scores and standard deviation of students in urban area are 31.92 and 8.38 respectively. The mean difference between Pre-PII and Post-PII for students taught in experimental and control group are 2.29 and 0.63 respectively. This implies that the interest of students taught probability using scratch programming language improved better than those taught using conventional teaching method.

Hypotheses Testing

Ho_1: There is no significant difference in the mean achievement scores of students taught probability using scratch programming language and those taught with conventional teaching method.

Table 4: Analysis of Co-variance (ANCOVA) for Students' Overall Scores by Instructional Approach and by Gender

Source of Variance	Sum of Squares	Df	Mean Square	F_{cal}	F_{crit}
Covariates	2524.168	1	2524.168	46.163	
Effects	9723.314	2	4861.657	88.911	
	9714.530	1	9714.530	177.662	3.84
Methods	2.003	1	2.003	0.037	3.84
Gender					
2 Way Interaction	44.954	1	44.954	0.822	3.84
Method* Gender					
Explained	12292.437	4	3073.109	56.202	
Residual	4702.465	86	54.680		
TOTAL	16994.901	96	188.832		

Source: Fieldwork, 2022.

Summary of data analysis presented in table 4 shows that the main effect, teaching approach has F-calculated value of 177.662 and it is greater than the table value of 3.84 at 0.05 level of significance. This is based on 1-degree of freedom for numerator and 267-degree of freedom for denominator. Thus, the null hypothesis is rejected. This implies that the difference in the mean achievement scores of students taught probability using scratch programming language and those taught using conventional teaching method is statistically significant.

Ho_2: There is no significant difference in the mean achievement scores of male and female students taught probability using scratch programming language.

Table 4 shows that the Gender has F-calculated value of 0.037, while the critical value is 3.84. This means that the null hypothesis is accepted at 0.05 level of significance. That is the difference in mean achievement scores between male and female students taught with scratch programming language is not statistically significant.

Table 5: Analysis of Co-variance (ANCOVA) for Students' Overall Scores by Instructional Approach and Interest Scores

Source of Variance	Sum of Squares	Df	Mean Square	F_{cal}	F_{crit}
Covariates	24588.883	1	2458.883	51.259	
Main Effects	15889.857	2	7944.928	165.622	

Methods	15788.883	1	15788.883	329.140	3.84
Location	73.681	1	73.681	8.536	3.84
2 Way Interaction Method* Interest scores	19.210	1	19.210	0.400	3.84
Explained	18367.950	4	4591.987	95.726	
Residual	4125.435	86	47.970		
TOTAL	22493.385	96	249.926		

Source: Fieldwork, 2022.

Ho_3: There is no significant difference in the mean interest scores of students taught probability using scratch programming language and those taught using conventional teaching method.

The summary of ANCOVA in table 5 shows that the mean interest scores of experimental groups have F-calculated value of 8.536, which is greater than the table value of 3.84. This implies that the null hypothesis is rejected. That is the difference in mean interest scores of students taught probability, using probability apparatus and those taught using conventional method is statistically significant.

Discussion of Findings

The result of this study reveals that students in the experimental group improved in achievement more than those in the control group which may be attributed to the use of the treatment via scratch programing language. This finding is in agreement with the findings of Abdulcarismo (2009), Okechukwu et al. (2010), Ugwanyi and Agwagah (2011) who reported that the performance of students exposed to scratch programing language is significantly different from those taught probability using the conventional teaching methods. On the other hand, the result disagrees with the report of Ezeamenyi (2010) who stated that the achievement of students exposed to treatment is not significantly different from those that were not exposed to treatment.

In addition, the result shows improved achievement scores of both male and female students in post-PAT which may be attributed to the effective students' involvement in the instructional process. The non-significant difference in the mean achievement scores is an indication that the

scratch programing language reduces gender differences. This gender parity in the achievement of the experimental group is in line with the findings of Ado and Charles-Owaba, (2022) and Memeh (2016) which reported that there is no significant difference between achievement levels of boys and girls taught probability via ICT-aided instructional strategy. It also agrees with the Vale (2009), Imoko and Agwagah (2006), Anyagh and Okwu (2010) who stated that there is no significant difference between achievement levels of male and female mathematics students when the appropriate teaching strategy is used.

Finally, the findings of this study shows that the scratch programing language increases the interest of students in probability. Result from table 3 for research question three shows that there was a higher mean interest score for the group taught using the scratch programing language over the group taught using the conventional method. This was further confirmed by the result in table 5 for research hypothesis three which intends to find out if there exists a significant difference between the mean interest scores of the two groups. The analysis revealed that the difference in mean interest scores between the two groups was statistically significant. Thus, this reaffirmed the findings of Abdulcarismo (2009), Almegdadi (2015) and Arsaythamby (2013), who reported that the use of the right teaching resources increases students' interest.

Recommendations

In view of the findings of this study, the following recommendations are deemed pertinent;

1. More aids should be developed and used by teachers to teach probability content to reduce its abstractness.
2. Ministry of Education should embark on in-service training, seminars and workshop to acquaint the already serving teachers with the skills needed to use scratch programing language.
3. Pre-service mathematics teachers should be trained and encouraged to use the scratch programing language.
4. Curriculum planners and textbook authors should help provide guidelines in their teachers' guide on the use of scratch programing language.

Conclusion

The study has established that the use of scratch programing language improves the students' achievement and interest in probability content. Furthermore, scratch programing language also helps to bridge the gap between male and female students' achievement in probability content.

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Appendix