

Effect of Scratch Programming Language (SPL) on Achievement in Geometry among Senior Secondary Students in Ibadan, Nigeria

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Abstract

The knowledge of Mathematics is germane to the scientific and technological development of nations all over the world. In addition to this, the integration of Information and Communication Technology (ICT) cum advances in pedagogy have made educators all over the world to adopt innovative approaches that are ICT-inclined to enhance students' acquisition of mathematical skills and also to enhance their academic achievement. In view of this, this study determined the effect of Scratch Programming Language (SPL) on achievement in Geometry among senior secondary one (SS 1) students in Ibadan North Local Government Area of Oyo State, Nigeria. The study adopted the pretest-posttest control group quasi-experimental research design. The participants were 116 (75 males and 41 females) Senior Secondary School students in two intact classes from two public schools in Ibadan North Local Government Area. The instruments used for data collection were Students Achievement Test in Geometry (SATG) (with a reliability coefficient of 0.75) and Instructional Guide or Manual for the use of Scratch Programming Language (IGUSPL). Data were analysed using Analysis of Covariance (ANCOVA). Results revealed that there was a significant main effect of treatment on students' achievement in Geometry ($F_{(1, 111)} = 124.80$; $p < 0.05$, partial $\eta^2 = 0.53$). Gender also had a significant main effect on students' achievement in Geometry ($F_{(1, 111)} = 20.25$; $p < 0.05$, partial $\eta^2 = 0.15$). It is therefore, recommended that teachers and curriculum developers should adopt the use of Scratch Programming Language (SPL) for teaching Geometry for improved achievement in this aspect of Mathematics.

Keywords: gender difference, Scratch programming language, students' achievement in Geometry, senior school mathematics.

INTRODUCTION

Mathematics is one of the core subjects that is globally recognized and crucial at the secondary education level because of its relevance to Science and Technology. It is a subject that develops students' ability to think critically and evolving body of knowledge as well as a way of perceiving, formulating, and solving problems in many disciplines (Odili, 2012). Thus, Mathematics is seen as the foundation of the scientific and technological knowledge vital toward the socio-economic development of any nation (Eze, 2007; Alamu, 2011). Mathematical knowledge is needed by everyone to efficiently and intelligently function in his or her world as it is an integral part of everyone's life (Ogunleye, 2009). More so, it affects almost every field of human endeavour, because it has application in a number of operations that take place in homes, offices, industries, agricultural outlets, decision-making processes, businesses, governance, and architecture, among others (Anaduaka & Okafor, 2013). This centrality of Mathematics presupposes that proficiency in Mathematics is essential for the generality of the society in any nation, Nigeria inclusive.

The Nigerian Mathematics curriculum has some concepts such as number base system, logarithms, statistics, and geometry, to mention a few. However, the concept of geometry serves as the basis for learning Mathematics. The properties and relationships of angles, curve, lines and shapes, are the concerns of Geometry. It aids the understanding of other aspects of Mathematics because Geometry helps to develop logical skills, problem-solving and spatial understanding (Sunzuma, Masocha & Zezekwa, 2013). Geometry focuses on the study of size, shape, and position of 2-dimensional shapes which is also called plane shape. A plane shape is a geometrical object with length and width/breadth and 3-dimensional shape which is also called solid shape. It is a geometrical object with length, breadth, and height.

The teaching and learning of Geometry is essential in both primary and secondary school Mathematics as it makes available to students a vital source of visualization which aids the understanding of statistics, arithmetic and algebraic concepts (Mamali, 2015). The importance of the application of Geometry could not be over-emphasized as it is useful in various fields of knowledge such as Architecture, Geography, Computing, Engineering, Geographic Information systems, star maps, and Space Travel Art. Geometry is concerned with the development of students' cognitive, affective and psychomotor skills, such as investigating, criticizing, creative thinking and self-expression (Jacob, Decl, Kajuru, Musa & Bala, 2017).

Despite the relevance of Geometry, students perform poorly in the subject matter. The Chief Examiners' Reports for the West African Senior Secondary Certificate Examination (WASSCE) from 2014 to 2018 show that students have weaknesses in Geometry. Many factors have been responsible for this poor achievement in the subject. These factors include teaching method, teacher factors, student factors, among many others (Surya & Syahputra, 2017). Among these factors, teacher factor and teaching strategies are the most prevalent (Prendergast & Donoghue, 2014; Ogunleye, 2013 & 2014). Though, other factors include learners' interest, wrong perception, fear, unqualified teachers, and lack of incentives for teachers, inappropriate teaching strategies among others. And many times,

government, at various times had tried diverse interventions like in-service programmes for Mathematics teachers, workshops, seminars and conferences, but all to no avail. Also, the majority of previous studies have focused on how some instructional strategies affect students' progress and achievement in Geometry. These include think-pair-share, regulated-learning strategies, cooperative strategy. In Kurumeh's (2007) study, it was opined that generally, students have phobia for Mathematics and this results in lack of interest and poor achievement in Mathematics particularly geometry and mensuration.

One way to learn Geometry is through Computer Programming, which is another aspect of computer studies curriculum being taught in schools. This therefore means that Geometry can be learnt by exposing learners to computer programming. Programming languages, which are artificial notational languages that are developed and utilized in preparing coded instructions on the computer. Programming languages can be used to solve problems such as Science, Art and Mathematics. Programming language can be categorized into various types such as block-based and text-based (Resnick et. al, 2009). Programming in this environment takes the form of dragging blocks into scripting and snapping them together to form scripts. It prevents syntax error but retaining the practice of assembling program instruction by program instruction. Text-based programming involves writing codes and it takes time to learn because of the syntax attached to it (Weintrop & Wilensky, 2017). It has been observed that males are more found in the programming field than females, and seem to have more confidence in writing computer programming. This is why there is the need to explore disparity issues that bother on gender differences in computer programming.

Gender is an important factor in achievement. Variations in gender differences in educational outcomes which include achievement and attitude towards acquiring Mathematical knowledge are founded situations (Ifamuiwa, 2003). According to Okeke (2001), gender disparity is across social, economic, political, and economic development, education, and particularly in science subjects. Reports have shown that gender is one of the cogent predictors of students' conducts and there has been a difference between the achievement of boys and girls (Adegoke, 2003; Ojo, 2003; Olowojaiye, 2004).

STATEMENT OF THE PROBLEM

Mathematics is compulsory for all science courses and it is a compulsory subject for admission into degree programmes in any science related courses. The value of Mathematics lies in its being useful for different purposes, in economics, in engineering, technology pure and applied sciences among others. Despite the usefulness of Mathematics, reports have shown that students have poor achievement in the subject and this has affected their performance in the subject. One aspect of Mathematics that has been found to be give students problem is Geometry which has to do with shapes and figures. Efforts to address the problem have led scholars and researchers to look for strategies that can be used to mitigate the poor performance and simplify Mathematics for students so that their performance can improve. However, most of these strategies did not focus specifically on Geometry neither did they focus on Scratch Programming Language which is the strategy used in this paper. Studies have shown that Scratch programming is very facilitative for student learning in different subjects such as

Mathematics but its effect on student achievement in Geometry has not been given much deserved attention especially among students in Ibadan. This is why this study determined the effect of Scratch Programming Language (SPL) on Geometry achievement among senior secondary schools one (SS 1) students. The moderating effect of gender was also determined.

OBJECTIVES

The objectives of the study were to:

1. Determine the main effect of treatment (Scratch Programming Language) on students' achievement in Geometry.
2. Determine the main effect of gender on students' achievement in Geometry.
3. Determine the interaction effect of treatment and gender on students' achievement in Geometry.

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance:

- HO1: There is no significant main effect of treatment (Scratch Programming Language) on students' achievement in Geometry.
- HO2: There is no significant main effect of gender on students' achievement in Geometry.
- HO3: There is no significant interaction effect of treatment (Scratch Programming Language) and gender on students' achievement in Geometry.

LITERATURE REVIEW

Mathematics, as a secondary school subject, has been found as the foundation of all science –related professions and it plays a crucial role in science and technology development (Adolphus, 2011). This makes Geometry relevant among secondary school students. In spite of the significance of the concept, Sunzuma, Masocha and Zezekwa (2013) reported that most students recorded poor achievement in this aspect of Mathematics. Fabiyi (2017) confirmed that the abstract and complex nature of the concept contribute to the poor achievement among the learners. Furthermore, Esan (2015) conducted a study that identified poor teaching methods and inadequacy in instructional materials as factors responsible for mediocre achievement in Geometry. It could be concluded that good methods to teach the concept are to be explored in order to assist these students overcome the problem of unimpressive achievement in Geometry. This is in tandem with Hamish (2017) who reported that students performed very well in Geometry when good methods of teaching such as laboratory and experimental methods were used compared with traditional methods where most students normally memorize information rather than engaging in activities that will help them in their thinking skills. The foregoing establishes that a scientifically proven laboratory method is essential at this juncture to help improve the teaching of Mathematics to the students.

Ikhwkwa and Usifoh (2016) also buttressed the above facts when they reported that the experimental approach enabled students to perform better in Geometry against the conventional one. Against this

backdrop, Ogunleye (2007) and Ajai and Okwu (2013) found that the use of information technology devices like computer, Video CD-ROM and over-head projectors are effective devices for stimulating students to actively and independently learn in collaboration with other students. On this premise, it is established that one way to learn Geometry is through programming language. BASIC, C, C++, COBOL, JAVA, FORTRAN, PASCAL, have long been known and widely accepted programming languages.

Programming languages can be used to solve problems of Mathematics. Scratch Programming Language, can be specifically used to solve the problem associated with Geometry. Scratch Programming Language is visual, block-based and has an interactive interface strategy that could enhance students' achievement in Geometry. Forster, Forester and Lowe (2018) reported that Scratch programming improved Geometry learning very significantly. Muhammed (2017) also found that significant differences existed between the experimental group and the control group, with the former outperforming the latter. The present study also looks into the significant contributions of gender to achievement in Geometry. Etukudo (2002) also reported significant gender differences amongst male and female students in which boys had a mean score of 65.3 while girls recorded 52.9 in Mathematics. According to Hartley and Sutton (2013), females are academically superior in the area of Mathematics achievement than males. It can be drawn from the foregoing that various studies have shown that programming language such as Scratch Programming Language has impact on education.

METHODOLOGY

This study adopted the pretest-posttest control group quasi experimental research design. The population comprised all Senior Secondary School one students in Ibadan North Local Government Area of Oyo State. Two schools were selected in the study using the purposive sampling technique. This was done so that schools with computer gadgets for the implementation of the strategy (Scratch Programming Language) could be selected. The participants involved in the study were 116 Senior Secondary School One (SS1) students in two intact classes. The participants were randomly assigned to treatment and control groups. The participants for treatment group were fifty-eight (58) students and another fifty-eight (58) students for control group. The participants were one hundred and sixteen (116) in total, comprising of seventy-five (75) boys and forty-one (41) girls. The instruments for data collection were Students' Achievement in Geometry Questionnaire (with a reliability coefficient of 0.75) and instructional guides.

The study took one week for pretest administration, six weeks for treatment administration (three hours per week) during which the students in the experimental group were exposed to Scratch Programming Language strategy while the control group was taught Geometry using the conventional method. This was followed by one week of posttest administration. Data gathered in the study were analyzed using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The dependent variable in this study was the students' achievement in Geometry. The independent variable was the Scratch Programming Language strategy while the control variable was the traditional method of teaching Geometry.

RESULTS

H₀₁: There is no significant main effect of treatment on students' achievement in Geometry.

As shown in Table 1, there was significant main effect of treatment on students' achievement in Geometry ($F(1, 111) = 124.80$; $p < 0.05$, partial $\eta^2 = 0.529$). The effect is 52.9%. This indicates 52.9% of the total difference in students' achievement in Geometry is due to the significant main effect of the treatment. Hence, hypothesis 1 was rejected.

Table 1: Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1681.927	4	420.482	43.254	0.000	0.609
Intercept	1367.683	1	1367.683	140.689	0.000	0.559
Pre-Achievement	228.778	1	228.778	23.534	0.000	0.175
Treatment	1213.257	1	1213.257	124.804	0.000*	0.529
Gender	196.874	1	196.874	20.252	0.000*	0.154
Treatment x Gender	12.497	1	12.497	1.286	0.259	0.011
Error	1079.065	111	9.721			
Total	23929.000	116				
Corrected Total	2760.991	115				

R Squared = 0.61 (Adjusted R Squared = 0.60) * denotes significant $p < 0.05$

H₀₂: There is no significant main effect of gender on students' achievement in Geometry.

Table 1 revealed a significant main effect of gender on students' achievement in Geometry ($F(1, 111) = 20.25$; $p < 0.05$, partial $\eta^2 = 0.15$). The effect is 15.0%. This means that 15.0% of the total variation in students' achievement in Geometry is as a result of the significant main effect of gender. Hence, hypothesis 2 was rejected. This indicates that gender affected students' achievement in Geometry.

Table 2: Estimated marginal means for post-achievement by treatment and control group

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Scratch Programming Language (SPL)	17.33	0.45	16.45	18.21
Conventional method (CM)	10.53	0.42	9.69	11.36

H₀₃: There is no significant interaction effect of treatment and gender on students' achievement in Geometry.

Table 1 indicated a higher adjusted post-achievement mean score for females in Geometry (15.47) than their male counterparts (12.39). Hence, Female > Male. Table 1 also indicated no significant interaction effect of treatment and gender on students' achievement in Geometry ($F(1, 111) = 1.29$; $p > 0.05$; partial $\eta^2 = 0.01$). Thus, hypothesis three was not rejected.

Table 3: Estimated Marginal Means for Post-Achievement by Gender

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	12.39	0.38	11.65	13.14
Female	15.47	0.53	14.42	16.52

DISCUSSIONS

a) Scratch Programming and Students' Achievement in Geometry

Findings from the report of the study showed a significant main effect of treatment on Geometry achievement. Scratch Programming Language (SPL) has a significant effect on students' achievement in Geometry. In other words, students who were exposed to SPL achieved better in Geometry than students in the control group. The effectiveness of Scratch Programming Language on achievement may be due to interaction with the computer and ease of use of the programming language which contains more direct instruction than other programming languages which makes it easier for users to learn through exploration. Scratch has a graphical interface and a better learning environment that motivates users to learn and have the opportunity to work individually on the computer and affords every student to interact with the computer at their own pace and allows learners to individualize their learning. These findings are in agreement with that of Colon and Romo (2016) that Scratch programming language improves students' achievement. This finding also corroborates the findings of Otrell-Cass, Forret and Taylor (2009), Boyer (2010), Park and Shin (2014), Korkmaz (2016), Muhammed (2017) and Lowe, Forster and Foerster (2018), who reported that Scratch programming improved the reading comprehension skills of elementary school pupils.

b) Gender and Achievement in Geometry

Findings also showed a significant main effect of gender on achievement in Geometry, suggesting that female students are more likely to use Scratch programming language and perform better in Geometry than male students. This could be because girls were more sensitive, attractive to colour and interactive environment than boys. These findings corroborate those of Guven and Kosa (2008), Yang and Chen (2010), Barrie and Adleberg (2013) who reported significant effect of gender on Geometry. This finding disagrees with Akinyemi (2013) who reported that there is no significant effect of gender on pupils' competence in LOGO programming language and Halat (2006) who reported no significant main effect of gender on learning outcome in Geometry.

c) Interaction Effects of treatment and Gender on Achievement in Geometry

Finding also revealed that there was no significant two-way interaction effect of treatment and gender on students' achievement in Geometry. This is in line with the findings of Danjuma (2015) who reported that though the experimental group performed better than the control group, yet there was no significant interaction effect of treatment and gender.

CONCLUSION AND RECOMMENDATIONS

Reports of this study have established that Scratch Programming Language (SPL) is effective in increasing students' achievements in Geometry as against the traditional/conventional strategy. Also, SPL significantly improved students' achievement in Geometry because it provides enjoyable learning opportunities to study various mathematical areas such as Geometry, Probability among others and ease of use which could lead to improved academic achievement. The study has proved that Scratch Programming Language is a strategy that is potent to effect better achievement in Geometry.

Based on the findings of the study, it is recommended that:

1. Teachers in Secondary Schools should integrate the Scratch Programming Language strategy into Geometry classroom as it is an effective and viable alternative to the traditional approach to teaching and learning.
2. Mathematics Teachers and Educators should be adequately sensitized through Workshops, Seminars, and Conferences on Scratch Programming Language and its integration in Mathematics education.
3. Curriculum planners and developers in Nigeria secondary schools should emphasize the essence to continuously utilize innovative approaches such as Scratch Programming Language in improving learning.

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