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The Effect of Quadratic Simulation - Games on Students' Achievement and Anxiety Level in Quadratic Equations in Senior Secondary Schools in Kaduna State, Nigeria

Joseph M. Timayi[1], Paul O. Jonah[2]

[1]Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Primary Education Studies, Federal College of Education (Technical) Bichi, Kano State, Nigeria

Email address

timayijoe@gmail.com (J. M. Timayi), onezeepaulo@yahoo.com (P. O. Jonah)

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Abstract

This research examined the effect of Quadratic Simulation-games on students' achievement and anxiety level in senior secondary school mathematics in Zaria Educational Zone of Kaduna State, Nigeria. The study adopted the quasi- experimental and control group; involving pretest and posttest design. The population of the study comprised 80 students randomly sampled from two public secondary schools. The Quadratic Equation Achievement Test (QEAT) and the Quadratic Equation Anxiety Rating Scale Questionnaire (QEARQ) were used to collect data; these gave a 0.83 consistency with the Pearson Product Moment Correlation (PPMC) and a Cronbach Alpha of 0.81 respectively. The research hypotheses which was tested using the t-test was found to be significant at 0.05. The findings from the study revealed that Quadratic Simulation-games led to improved achievement and reduction in students' anxiety in mathematics. The study concluded that teachers' use of Quadratic Simulation-games in the teaching of quadratic equations would go a long way in sustaining and motivating students' interest in learning mathematics. Based on the findings, it was recommended that the Federal Government through the National Mathematical Centre should encourage the development of indigenous simulation - games for our secondary schools and teachers are to step out of the box by searching for, adopting and applying result oriented games useful for teaching and learning of mathematical concepts in a classroom situation.

Keywords

Quadratic Simulation-games, Achievement, Anxiety, Quadratic Equations

1. Introduction

Mathematics is a powerful social entity that plays a key role in sharpening how individuals deal with the various spheres of private, social and civil life (Kajuru & Popoola, 2010). Anxiety for mathematics is a threat to the development of any nation; this is because science, technology and mathematics has become the basic tool for the development of any modern society and a measure of the development of a nation can be ascertained from the quality and quantity of its basic and applied scientific output (Amazigbo, 2000). This view is supported by Uyanga (2008) who asserted that nations at the fore front of modern development are those that have invented enormous resources over considerable time in three major areas which are establishment and nurturing of stable well supported Science, Technology and Mathematics Educational (STME) system, promotion of mass –oriented research in the basic science coupled with long-term strategy of technology and mathematics development and institution of well-anticipated programmes for science, technology and mathematics education of a large scientifically and technologically literate workforce. Amazibo (2000) maintained that mathematics provides the bedrock on which scientific work can be built and that a nation that neither develop a scientifically literate citizenry nor attracts its best minds to the basic sciences is doomed to remain underdeveloped no matter its natural resources.

The existence of students' anxiety for mathematics has been widely reported. Studies such as Beitiku (2002), Rameau and Louime (2007) and Leppavirta (2011) asserted that anxiety for mathematics which is also called mathematics phobia exists among students at various level of education. According to Richardson and Suinn (1972) mathematics anxiety is the feeling of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations. Mathematics anxiety can result from environmental factors such as myths, teachers and parents (Hadfield & Trujillo, 1999). Intellectual factors that bring about mathematics anxiety include learning styles, persistence, self-doubt and dyslexia (Hadfield & Trujillo, 1999; Harper & Daane, 1998). Personality factors such as low self-esteem, shyness and intimidation can lead to mathematics anxiety in students (Fotoples, 2000).

Students' performance in mathematics examinations, in both internal and external, from year to year has not been encouraging (Ale, 2005), this view is shared by Betiku (2001) in Kajuru and Popoola (2010) who pointed out that students performance has fallen below expectation in recent years despite the relative importance of the subject. Agwagah (2001) in Makinde (2012) said that though mathematics is vital to student's future and national development; its study has been ineffective in meeting the demands of national development in Nigeria. Nwabugwu (2012) reported that the Federal Government described the poor performance of students in Nigeria as unacceptable and warns that the trend must be checked if the country has to move forward.

Several studies have investigated the prevalence of learning difficulties in mathematics. Most of these studies concluded that many children have difficulties with mathematics, and a significant number have relatively specific difficulties with mathematics. Others reported that students have difficulties in the acquisition of mathematical concepts. Hence, Akinsola and Animasahun (2007) submitted that an instructional strategy is crucial to the understanding of mathematical concepts, to which Brown (1997) stressed that effective instruction requires the teacher to step outside the realm of personal experience unto the world of the learners.

Some variables responsible for the poor performance of students over the years in mathematics as observed are:

i. Lack of qualified mathematics teachers (Adewumi, 1981; Ali 1985).
ii. Student's lack of interest and negative attitude towards mathematics (Ale, 1989).
iii. Teachers negative attitude and incompetence in certain concepts (Badmus, 1989).
iv. Poor methods of the teaching applied by the teacher in the classroom.
v. Teachers' non-use of relevance instructional materials in the teaching of mathematics concepts.
vi. Anxiety for mathematics (Bryl, 1983; Beitiku, 2002; Popoola & Olarewaju, 2010; Kajuru & Popoola, 2010).

Aremu (1999) in her study observed that the use of games could be effective for the improvement of achievement in mathematics. This is because games provide a unique opportunity for integrating the cognitive, affective and social aspects of learning. Another reason for using games is that it appeals to almost all the senses. In a related study, Orim and Ekweme (2011) posited that the use of games in the teaching and learning of mathematics helps to suppress anxiety for the subject. The researcher is interested in the application of simulation game for the study.

Simulation games according to Basnet (1999) in Obeka (2009) are activities designed to mimic the reality of the external world, within the classroom with the goal of instruction. The major purpose for the use of simulation as demonstrated by Morris and Dean (1974) in teaching is to test the behavior of simple theoretical models, which would otherwise involve tedious calculation, or high level of mathematical expertise. Games are a form of enjoyable play or sport which is bound by rules to achieve specified goals that depend on skill and often involve chance while simulation is a role- playing, which involve people adopting roles in a mock - up of a situation.

Simulation has been shown to be useful not only because of its ability to provide believable numerical answers but also perhaps more importantly because successful simulation require a full understanding of the problem to be solved. Akinsola and Animasahun (2007) in their study on the effect of simulation – games environment on student's achievement in and attitude to mathematics agreed that poor academic achievement in mathematics is partly a function of the teaching method used by the teacher. They reported that simulation-games environment led to improved achievement and positive attitude towards mathematics learning; they concluded that simulation methods will go a long way in sustaining and motivating students' interest in learning mathematics.

Quadratic Simulation as used by the researcher refers to simulation games designed specifically for the teaching and learning of quadratic equation. Quadratic equation is a second order polynomial equation in a single variable say x written as $ax^2 + bx + c = 0$ where a$\neq$ 0. The quadratic equation is very useful in our modern world. Budd and Sanguin (2013) demonstrated about 101 ways the quadratic equation is applied; a few of these are in quadratic curves such as circles, ellipse, hyperbola and parabola. Practically, it is used to predict the motion of the electrons and holes in semi-conductors and in the design of integrated circuits with huge numbers of components which can perform amazingly complex tasks. Such circuits are at the heart of much modern technology, including computers, cars, DVD players and mobile phones. So we can say with justification that without the simple quadratic equation $x^2 = -1$ the mobile phone would never have been invented. Other important areas are: dynamics, astronomy, Chaos systems, micro-chips, quantum theory, radio and in higher mathematics like 2^{nd} order differential equations, complex analysis, infinite series and many more not covered in this study.

2. Statement of the Problem

It has been observed that students find it easier to solve linear equations but have difficulty solving quadratic equations and consequently exhibit anxiety in understanding the concept (Tall, Lima & Healy, 2011). The use of Quadratic Simulation games to teach quadratic equations can lead to the improvement of students' dexterity and better performance learning in our secondary schools. The general poor performance of students in mathematics and their attitudes towards some concepts of the subject are expected to be better. This study investigated the effect of quadratic simulation-games on students' achievement and anxiety level in mathematics in senior secondary schools in Zaria Inspectorate division of Kaduna state.

3. Objectives of the Study

The objectives of the study are to:

i. determine the effect of Quadratic Simulation-games on the academic achievement of students in quadratic equations.
ii. determine the effect of Quadratic Simulation-games on the anxiety level of students in quadratic equations.

4. Research Questions

The following research questions were formulated as a guide to the study:

i. What is the difference in the mean academic achievement of students taught quadratic equations using the Quadratic Simulation and those taught the same concept by lecture method?
ii. What is the difference in the mean anxiety of students taught quadratic equations using the Quadratic Simulation and those taught the same concept by lecture method?

5. Research Hypotheses

H_{01}: There is no significant difference in the academic achievement of students taught quadratic equation t using Quadratic Simulation-games and those taught the same concept by lecture method.

H_{02}: There is no significant difference in the anxiety level of mathematics students taught quadratic equations concept using the Quadratic Simulation-games and those taught the same concept by lecture method.

6. Methodology

The research design adapted for this study is Quasi Experimental and control group design involving pretest and posttest. This design has two groups: the experimental and the control group. Both groups were pretested each on achievement and anxiety ($O_{1_{AN}}^{AC}$) before the administration of treatment; the essence of which was to ensure uniformity and equivalence in achievement and anxiety level of mathematics students. The treatment is the Quadratic Simulation-games (X_1) which was administered to the experimental group only; while the control group were taught using the lecture method which implies no treatment (X_O). A Posttest ($O_{2_{AN}}^{AC}$) was administered after treatment to determine the comparative student's achievement and anxiety level in both groups. Below is an illustration of the research design

$$EG \rightarrow O_{1_{AN}}^{AC} \rightarrow X_1 \rightarrow O_{2_{AN}}^{AC}$$

$$CG \rightarrow O_{1_{AN}}^{AC} \rightarrow X_0 \rightarrow O_{2_{AN}}^{AC}$$

AN = Anxiety
AC = Academic Achievement
EG = Experimental Group
CG = Control Group
X_1 = Treatment (Quadratic Simulation)
X_O = No Treatment (Lecture method)
O_1 = Pre test
O_2 = Post test
Research Design illustration

The population of the study covered all the senior secondary year two (SS2) students of the public secondary schools of Zaria Educational Zone (ZEZ) of the Ministry of Education, Kaduna State. This is made up of twenty-two (22) senior secondary schools with a total enrollment of 2400 students. The study area comprises of two Local Government Areas (LGA) and has the characteristic elements that are of interest to the researcher such as student population; co-education and geographical spread.

Table 1. *EAT BLUE PRINT.*

S/No	Content	Wgt	K	C	A	AN	S	E	Total
			33.5%	13.3%	13.3%	13.3%	13.3%	13.3%	100.0%
1	Factorization	26.7%	3	1	1	1	1	1	8
2	Completing the square	26.7%	3	1	1	1	1	1	8
3	Use of formula	23.3%	2	1	1	1	1	1	7
4	Graphing	23.3%	2	1	1	1	1	1	7
	Total	100%	10	4	4	4	4	4	30

Key:
K = Knowledge
C = Comprehension
A = Application
AN = Analysis
S = Synthesis
E = Evaluation

The sample for the study consists of 80 senior secondary year two (SS2) students selected from two secondary schools in ZEZ. The schools are: Government Secondary School Kofar Jatau, Zaria and Government Commercial College, Sabon-Gari; they are well separated apart to avoid interaction effect of subjects. Sample of school was drawn using the purposive sampling technique while the sample of students was drawn by the use of the random table of numbers (Kerlinger, 1973).

Two instruments were used for collection of data for this study: they are tagged the Quadratic Equation Achievement Test (QEAT) and the Quadratic Equation Anxiety Rating Scale Questionnaire (QEARSQ). QEAT consisted of 30 objective test items developed (based on a QEAT blue print Table) from the quadratic equations while QEARSQ consisted of 25, five point Likert scaled having responses of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD) to measure students' anxiety.

7. Results

The research questions was answered by the comparison of the mean and standard deviation of the experimental and control groups respectively while the hypothesis was tested by the t-test at 0.05 level of significance.

Table 2. *The mean academic achievement of students taught quadratic equation concept using the Quadratic Simulation and those taught using lecture method.*

Groups	N	Mean (X)	Standard Deviation (S.D)
Experimental	38	15.6	9.23
Control	42	12.3	6.1
Total	80		

The mean and standard deviation of the academic achievement of students in the experimental and control group is presented Table 2. From the result, students taught using the Quadratic Simulation have higher mean score of 15.6 as compared to the mean score of 12.3 obtained by students taught using lecture method.

Table 3. *The mean anxiety level of students taught quadratic equation concept using the Quadratic Simulation and those taught using lecture method.*

Groups	N	Mean (X)	Standard Deviation (S.D)
Experimental	38	11.2	7.23
Control	42	18.4	10.31
Total	80		

Table 3 above presents the mean and standard deviation of the anxiety level of students in the experimental and control group. From the result, it follows that students taught using the Quadratic Simulation had a lower mean anxiety score of 14.2 as compared to the mean anxiety score of 18.4 obtained by students taught using lecture method.

Table 4. *T- test analysis of academic achievement in experimental and control groups.*

Group	N	X	SD	Df	t-value	P	Remarks
Experimental	38	15.6	9.23	78	1.96	0.02	Significant
Control	42	12.3	6.1				
Total	80						

Significant at $p \leq 0.05$

From Table 4, it was observed that the t-value was 1.96 while the p value was 0.02 at 78 degree of freedom. Since $p \leq 0.05$, the null hypothesis is rejected. Hence, there is significant difference in the academic achievement of students taught quadratic equation concept using Quadratic Simulation and those taught the same concept by lecture method.

Table 5. *T-test analysis of anxiety level in experimental and control groups.*

Group	N	X	SD	Df	t-value	P	Remarks
Experimental	38	11.2	7.23	78	1.86	0.031	Significant
Control	42	18.4	10.31				
Total	80						

Significant at $p \leq 0.05$

Table 5 results showed that the t-value calculated was 1.86 and the p-value of 0.031 was observed at 78 degree of freedom at 0.05 level of significance. Since the $p \leq 0.05$, the null hypothesis is hereby rejected. This means that the there is significant difference in the anxiety level of mathematics students taught quadratic equations concept using the Quadratic Simulation and those taught the same concept by lecture method.

8. Discussion

The findings in table 4 revealed that there is significant difference in the academic achievement of students taught quadratic equation concept using Quadratic Simulation and those taught the same concept by lecture method. The respective means of the experimental and control groups in Table 2 showed that the experimental group had a higher score than the control group. This implies that the experimental group performed better; this is consistent with the findings of Aremu (1999), Akinsola and Animasahun (2007) and Orim and Ekweme (2011) who reported that mathematical games are effective in the improvement of students' achievement in mathematics.

Also, the result from Table 5 reveals that there is significant difference in the anxiety level of student in the experimental and control group. The mean of the experimental group was lower than that of the control group as shown in Table 3. This means that there is reduced anxiety in the experimental group which was as a result of the treatment. This result is in agreement with the findings of Asby (2009) and Orem and Ekweme (2011) who opined that anxiety is reduced when simulation games are used.

9. Conclusion

The study has shown that Quadratic Simulation Games is effective in the teaching and learning of quadratic equations. This can be extended to other topics in mathematics if the right Simulation- games can be developed. The outcome of this research also revealed that students' anxiety for mathematics was positively affected by the use of Quadratic Simulation. The data collected in this research confirmed that students' poor academic achievement is partly due to the method of teaching used by their teachers. Teachers will need to explore and diversify their teaching method in our secondary school in order to curb the problem of poor performance in the all-important subject of mathematics.

Recommendations

Based on the results of the findings, the following recommendations were made.

1. The Federal Government should encourage the development of indigenous simulation games through the National Mathematical Centre for our secondary schools.
2. Teachers should step out of the box by searching for mathematical games that have produced result for adoption and use in classroom situation.
3. Teachers should engage student in creating their own learning environment. By transferring classroom rules and management to students for their directions, the teacher becomes facilitators of the learning, enabling students to determine the strategies that will motivate them to learn.
4. Teachers should engage students in role playing and cooperative experiences. Knowing how to work cooperatively with one another, to build on the knowledge and experiences of diverge nature of the classroom. This is because bringing different perspective to the thinking and reasoning process in the mathematics classroom, can help students to expand their thinking and explore new approaches to learning mathematics (Brown, 1997).
5. Teachers and students should be encouraged in the use of ICT since some educational games are available online.

Abbreviations

STME: Science, Technology and Mathematics Education
ZEZ: Zaria Educational Zone

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