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Research Paper

Gamification on Senior Secondary School Students' Academic Performance and Retention in Simultaneous Equations in Port Harcourt

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Abstract
This study investigated gamification on senior secondary school students' academic performance and retention in simultaneous equations in Port Harcourt. The study adopted a pretest–posttest quasi-experimental design, which is a partly true experimental design, aimed at establishing a cause–effect relationship between gamification and students' learning outcomes. The population of the study comprised all 4,584 Senior Secondary One (SS1) students in 38 public senior secondary schools in Port Harcourt Metropolis. Using a purposive sampling technique, two public senior secondary schools were selected, and a sample size of 139 SS1 students was used for the study. Data were collected using two researcher-developed instruments: the Simultaneous Equation Performance Test (SEPT) and the Simultaneous Equation Retention Test (SERT). The data obtained were analyzed using appropriate statistical tools. Findings revealed that students taught simultaneous equations using the gamification method performed significantly better than those taught using the conventional expository (lecture) method. Furthermore, students exposed to gamification demonstrated significantly higher retention of the concepts compared to their counterparts in the lecture method group.

Keywords: Gamification, Academic Performance, Retention, Simultaneous Equations

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I. Introduction

Mathematics is all around us, in all we do. It is the constructing block for everything in our day to day lives, along with cellular devices, computers, software, art, money, engineering and even sports. Mathematics is one of the core subjects offered by students in all level of education. Mathematics is a subject that deals with numbers, shapes, logic, quantity and arrangements. Mathematics is viewed as a central part of the curriculum in education systems around the world; therefore, it has a significant impact on students' success and future (Fadlelmula, 2022). Mathematics teaches to solve issues primarily based totally on numerical calculations and discover the solutions. Mathematics has long been a challenging subject for many students. According to Odo (2021), Mathematics is a group of related sciences, including geometry, calculus and algebra which focuses on the study of number, space, shape and quantity and how they interrelate using specialized notation.

The importance of simultaneous equation in Mathematics and applications cannot be overemphasized. Simultaneous Equations is used in linear programming an important topic in operation research and business applications, word problems, indices and logarithms, arithmetic and geometric progression and so on. Simultaneous Equations are a set of two or more algebraic equations that share variables and are solved simultaneously. It can also be solved or taught with other methods such as elimination method and graphical method. This study is based on the substitution and elimination method. Traditional teaching techniques frequently make students struggle to have interaction and foster a deep knowledge of mathematical concepts. According to Iribiri (2020), the traditional teaching pedagogy does not promote the development of reflective and collaborative skills or teamwork skills needed for students to collaborate and communicate effectively in a cross-functional team.

Gamification, with its incorporation of game-like factors including competition, rewards, and interactivity, gives a promising avenue to make Mathematics extra fun and accessible. A gamified learning

environment is a relatively recent teaching strategy, intrinsically engaging, that can push students to learn. The teacher is tasked with creating a gamified atmosphere that engages and entertains the learner while simultaneously teaching through role play and other strategies that tap into the learners' natural motivation.

Gamified learning involves incorporating elements commonly found in games, such as point systems, rewards, levels, leader boards, competition, and storytelling, into the learning process to enhance engagement, motivation, and improve the overall learning experience (Covrig et al., 2023). Game-based learning is regarded as a variant of experiential learning that offers a prospective resolution for enhancing their problem-solving abilities and tackling student motivation through the augmentation of their degree of engagement.

Mathematics plays a vital role in educational measurement and evaluation. Thus, Mathematics is a necessary tool for effective and qualitative functional education in the national and human developments. The teaching and learning of Mathematics is currently in a challenging stage because of the constant poor achievement of students in both internal and external examination results.

II. Statement of the Problem

One of the primary problems facing most secondary schools in the Nigerian society today is poor performance of students and lack of retention in Mathematics. During teaching and learning, students see Mathematics as one of the most difficult subjects and abstract looking in nature. Most times this is due to poor methods and strategies of teaching which can translate to students' and lack ability to retain. The method of teaching Mathematics in Schools have been identified as key factors contributing to lack of interest in Mathematics among the students, which in turn could be responsible for the poor performance in the subject.

Despite its importance, Mathematics is the subject students viewed as being the most difficult to understand and pass. Students cannot achieve excellent results except the best methods of teaching and learning of Mathematics are discovered and used appropriately. The abstract nature of Mathematics as a subject scare many students. Mathematics could be related to real life situations and taught practically to bring changes in the negative perception of the subject as being difficult. Akande (2017) in support of practical approach opined that practical activities enable learners to acquire the relative experience that links learning to environment on their own through the process of thinking, thereby causing positive changes in their activities. Thus, the use of games in the teaching and learning of Mathematics is aimed to bring an improvement of the academic performance and retention of students in Mathematics.

Aim and Objectives of the study

The aim of this study is to investigate Mathematics Students' Academic Performance and Retention using Gamification in Port Harcourt Metropolis, Rivers State. The objectives were:

1. examine the effect of gamification and expository method on students' performance in simultaneous linear equations.
2. ascertain the effect of gamification and expository method on students' retention in simultaneous linear equations.

Research Questions

The following research questions are raised and shall be answered in this study:

1. What is the effect of gamification and expository method on students' performance in simultaneous linear equations?
2. What is the effect of gamification and expository method on students' retention in simultaneous linear equations?

Hypotheses

Six null hypotheses were formulated to guide the study and were tested at 0.05 level of significance:

1. There is no significant difference between students' taught using gamification and those taught using expository method in their performance in simultaneous linear equations.
2. There is no significant difference between students' taught using gamification and those taught using expository method in their retention in simultaneous linear equations.

III. METHODOLOGY

The research design that was used was a pretest, post-test quasi experimental design which is defined as partly true experiment, having the aim to establish an effect relationship between an independent and dependent variable. The reason for using this design was because the investigation was carried out on students who are human and whose internal and external influences were not under the control of the researcher. The second reason for choosing this design was because this type of design does not involve randomization of subjects but rather intact classes were used. This design presented two groups. One group was tagged experimental group while the other group was tagged control group.

The population of the study consist of all the four thousand five hundred and eighty-four (4,584) senior secondary one (SS1) students in the Thirty-eight (38) public senior secondary schools in Port Harcourt Metropolis of Rivers State

The sample for this study comprised of one hundred and thirty-nine (139) senior secondary one (SS1) students in public schools in Port Harcourt Metropolis of Rivers State. The purposive sampling technique were used to draw two schools from the 38 senior secondary schools in Port Harcourt Metropolis of Rivers State.

The instruments that were used to collect data for this study were titled, "Simultaneous equation Performance Test (SEPT)" and "Simultaneous equation Retention Test (SERT)". The instrument, SEPT consisted of twenty-five (25) multiple-choice questions in Simultaneous equations. Each test item of SEPT had four options from which students were asked to select only one correct answer by circling.

The instrument, SEPT was subjected to face and content validity. The validation were carried out by the researcher's supervisors, two experts from Mathematics Education and experts in measurement and evaluation.

The reliability of the instrument was carried out using Kuder-Richardson (K-21). Thirty (30) students in SS1 who were from a school that did not participate in the main study were used to ascertain the reliability of SEPT and SERT. The thirty students were administered with SEPT without any form of teaching. The tests was marked in percentage by the researcher and coded for analysis. The sets of test scores from the thirty students was analyzed using the Kuder Richardson estimates (K-21). A reliability coefficient of 0.79 was obtained.

In order to obtain permission to use the schools and facilities for the research, the researcher obtained a letter from the Head of Department, Curriculum Studies and Educational Technology, Faculty of Education, University of Port Harcourt, to the authorities of the two schools used for the research.

The Mathematics teachers of the schools were used as the research assistants to carry out the teaching and administer the performance test so as to reduce teacher-effect. The two intact class

The three sets of tests administered to each of the experimental and control group were subjected to statistical analysis with the aid of Statistical Package for Social Sciences (SPSS) software version 23.
Mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 significant level.

Results and Analysis

Research Question 1

What is the effect of gamification and expository method on students' performance in simultaneous linear equations?

Table 1: Mean scores of students' performance in simultaneous linear equations classified by methods.

Method	n	PRE TEST		POST TEST		Mean
		Mean	SD	Mean	Std. Deviation	Gain
Gamification	66	28.24	7.84	55.58	12.36	27.34
Expository Method	73	26.90	6.87	49.53	9.54	22.63

Table 1 showed that the students in the gamification group had a pretest mean score of 28.24, post-test mean score of 55.58 with a mean gain of 27.34 while the expository method group had a pretest mean score of 26.90, post-test mean score of 49.53 with a mean gain of 22.63. From the table, the findings shows that students in the gamification group had higher performance score than those in the expository method group, which indicate that students' in the gamification group perform better than the students' in the expository method group.

Research Question 2

What is the effect of gamification and expository method on students' retention in simultaneous linear equations?

Table 2: Mean scores of students' retention in simultaneous linear equations categorized by methods.

Group	n	POST TEST		POST-POST TEST		Mean
		Mean	Std. Deviation	Mean	Std. Deviation	Gain
Gamification	66	55.58	12.36	69.67	11.97	14.09
Expository Method	73	49.53	9.54	58.14	10.61	8.61

Table 2 indicates that the students in gamification group had a retention mean again of 14.09 with a post-test mean score of 55.58 and a post posttest mean score of 69.67 against retention mean again of 8.61 with post-test mean

score of 49.53 and a post posttest mean score of 58.14 for expository method group respectively. This revealed that gamification group enhances students' retention and the students in the group retained better than the students in the expository method group.

Hypotheses

H_{01}: There is no significant difference in the performance of students taught simultaneous equation with gamification and the expository method

Table 3: Summary of Analysis of Covariance (ANCOVA) of performance scores of students taught simultaneous linear equations using different methods.

Dependent Variable: PostTest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2425.457[a]	2	1212.729	10.771	.000	.137
Intercept	15757.650	1	15757.650	139.958	.000	.507
PreTest	1160.304	1	1160.304	10.306	.002	.070
Methods	1044.125	1	1044.125	9.274	.003	.064
Error	15311.981	136	112.588			
Total	399440.000	139				
Corrected Total	17737.439	138				

a. R Squared = .137 (Adjusted R Squared = .124)

Table 3 shows the summary of ANCOVA of students' performance in simultaneous linear equations using gamification method and expository method. Table 3 shows that there is significant difference in the performance of students taught simultaneous linear equations using gamification method and expository method ($F_{1, 136} = 9.274$, $p = 0.003 < 0.05$), partial eta squared = 0.064 for the effect of method on students' performance in simultaneous linear equations. The null hypothesis is therefore rejected at 0.05 level of significance. The partial eta squared value indicates that instructional method had a small effect on the students' performance in simultaneous linear equations.

Table 3b: Summary of Post Hoc Analysis of students' performance in simultaneous linear equations.

Dependent Variable: PostTest

(I) Methods	(J) Methods	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Gamification	Expository Method	5.511*	1.810	.003	1.932	9.090
Expository Method	Gamification	-5.511*	1.810	.003	-9.090	-1.932

*. The mean difference is significant at the .05 level.

Table 3b showed the summary of Post Hoc Test using the Scheffe pairwise comparison on the difference in the performance mean score of students taught simultaneous linear equations using gamification method and expository method. Table 3b indicated that the test between Gamification and expository method was statistically significant (MD = 5.511, $p = 0.003$; $p < 0.05$) and in favour of gamification instructional method. Also, the test between expository method and gamification method was also statistically significant (MD = -5.511, $p = 0.003$; $p < 0.05$) and in favour of Gamification method.

H_{02}: There is no significant difference in the retention of students taught simultaneous equation with gamification and the expository method

Table 4: Summary of Analysis of Covariance (ANCOVA) of retention scores of students taught simultaneous linear equations using different methods.

Dependent Variable: PostPostTest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13174.741[a]	2	6587.371	101.249	.000	.598
Intercept	3865.504	1	3865.504	59.414	.000	.304
PostTest	8567.017	1	8567.017	131.677	.000	.492
Methods	1656.086	1	1656.086	25.454	.000	.158
Error	8848.280	136	65.061			
Total	584476.000	139				
Corrected Total	22023.022	138				

a. R Squared = .598 (Adjusted R Squared = .592)

Table 4 shows the Summary of Analysis of Covariance (ANCOVA) of retention scores of students taught simultaneous linear equations using different methods. Table 4 revealed that there is significant difference in the

mean retention score of students taught simultaneous linear equations using different methods (Gamification and Expository method) ($F_{1, 136} = 25.454$, $p = 0.000 < 0.05$), partial eta squared = 0.158 for the effect of method on students' retention in simultaneous linear equations. The null hypothesis is thus rejected and the alternative hypothesis accepted. The partial eta squared value indicates that instructional method had a large effect on the students' retention in simultaneous linear equations.

Table 4b: Summary of Post Hoc Analysis of students' retention in simultaneous linear equations using different methods (Gamification and Lecture Method).

Dependent Variable: PostPostTest

(I) Methods	(J) Methods	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Gamification	Expository Method	7.173*	1.422	.000	4.361	9.984
Expository Method	Gamification	-7.173*	1.422	.000	-9.984	-4.361

*. The mean difference is significant at the .05 level.

Table 4b showed the summary of Post Hoc Test using the Scheffe pairwise comparison on the difference in the retention mean score of students taught simultaneous linear equations using different methods (Gamification and Expository Method). Table 4b indicated that the test between Gamification and Expository Method was statistically significant (MD = 7.173, $p = 0.000$; $p < 0.05$) and in favour of Gamification instructional method. Also, the test between Expository method and Gamification method was also statistically significant (MD = -7.173, $p = 0.000$; $p < 0.05$) and in favour of Gamification method.

IV. Discussion of Findings

The findings of this study show that students in the gamification group had higher performance score than those in the expository method group which indicate that students in the gamification group perform better than the students in expository method group. Additionally, hypothesis testing assured a significant difference in the performance of students taught simultaneous equations using gamification and expository method. The findings support Akande (2017) whose findings revealed that students taught with the use of game had a greater mean score than their counterpart taught without the use of game; Alio and Anibueze (2017) also discovered that students that were taught with Mathematics Scrabble game performed better in achievement scores than their counterparts taught with expository method. The result revealed that there is significant difference in the performance of students taught simultaneous linear equations using gamification method and lecture method and in favour of Gamification method and it is in consonance with the finding of Ochihu (2022) study which show that there is significant difference in the mean performance scores of students in Mathematics using gamification, mastery learning and conventional Strategies; Akanmu and Adeniyi (2021) also revealed that the use of Mathematical Games has a significant positive effect on the academic performance of the students in Mathematics; El-nady (2020) study concluded that there were statistically significant differences in the overall performance and in all creative thinking skills in favor of the experimental group; Akande (2017) who results of hypotheses testing revealed that there was a significant difference between the students taught with mathematical game and their counterparts taught without the use of mathematical game; Sam-Kayode and Salman (2015) shows that a significant difference in the performance of Students exposed to Ludo game than those exposed to the Conventional method.

The findings revealed that Gamification group enhances students' retention and the students in the group retained better than the students in the Expository Method group. Also, the hypothesis test confirmed that there was a significant difference in the retention of students taught with gamification and those taught with expository method. The findings is in line with Ochihu (2022); Putz and Treiblmaier (2019) results indicate that gamification is an effective tool to increase students' knowledge retention in the short term, but not necessarily in the long term; Pechenkina et al. (2017) which revealed that gamified mobile learning app increased students' retention; Egara and Mosimege (2023) shows students taught algebra using computer simulation had considerably higher average retention scores compared to learners taught utilizing the traditional method. The result also revealed that there is significant difference in the mean retention score of students taught simultaneous linear equations using different methods (Gamification and Expository Method) and Post hoc analysis shows that it favoured Gamification method and it is in consonance with the finding of Egara and Mosimege (2023) revealed that a significant gender difference occurred in the mean retention scores of students taught algebra concepts utilizing computer simulation; Ochihu (2022) which revealed that there is significant difference in the student' s mean retention scores in Mathematics taught using gamification, and mastery learning than conventional Strategies; Farid, Zahra, Asghar, Farshad and Hasan (2012) shows a significance difference between the two groups in the retention of the concepts,

with the game-based learning group scoring higher than the traditional learning group. The result debunk Putz and Treiblmaier (2019) who found that there was no significant effect of gender.

V. Conclusion

Students in the Gamification group performed and retained significantly better than their counterparts in the expository method group. Gender also had a statistically significant effect on students' performance while being taught simultaneous linear equations using Gamification and Expository method while Gamification and Lecture method favored the female. Gender also had no statistically significant effect on students' retention while being taught simultaneous linear equations using Gamification and Expository method but the male students retained better than the female students. The results show interaction between the instructional strategy and gender in terms of students' performance and no interaction between the teaching strategies and Gender on students' retention of the concept of simultaneous linear equations but Statistical testing revealed that there is no significant interactions between the teaching strategies and Gender for students' performance and retention.

VI. Recommendations

The following recommendations are made based on the research findings:

1. Teachers should use Gamification based instructional strategies to enhance teaching and learning in schools.
2. Gamification-based instructional strategy should be incorporated in the Mathematics curriculum for the pre-service teachers' programme

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