

COMPARATIVE EFFECTIVENESS OF GAMIFICATION AND TRADITIONAL METHODS IN ENHANCING STUDENTS' ACHIEVEMENT IN ALGEBRAIC CONCEPTS

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Abstract

This mixed-methods study compared the effectiveness of gamification and traditional methods on secondary school students' achievement in algebraic concepts in Oshimili South Local Government Area, Delta State. Using a quasi-experimental design, 320 Senior Secondary School One students from four schools were assigned to gamification, $n = 160$, and traditional, $n = 160$, groups. The experimental group was taught algebra for eight weeks using points, badges, leaderboards, and challenges, while the control group used lecture and practice methods. Data were collected through an Algebra Achievement Test [AAT], a Gamification Engagement Questionnaire [GEQ], and semi-structured teacher interviews. The AAT had a reliability coefficient of 0.82 using Kuder-Richardson 20. Data were analyzed using mean, standard deviation, one-way ANOVA with Tukey HSD post-hoc, and partial eta squared for effect size. Findings showed that the gamification group had a significantly higher mean gain, 8.8%, than the traditional group, 2.6%, $F(1, 318) = 38.44, p < .001, \eta^2 = .108$, indicating a medium effect. Gender had no significant influence on achievement in the gamified setting, $F(1, 158) = 0.18, p = .672, \eta^2 = .001$. Teachers perceived gamification as effective with a large practical effect, $\eta^2 = .351$, though not statistically significant due to sample size. The study concludes that gamification enhances algebra achievement and engagement more than traditional methods. It is recommended that mathematics teachers be trained in gamification strategies, gamified elements be integrated into the curriculum, and further studies examine long-term impacts.

Keywords: algebraic concepts, gamification, students' achievement, traditional methods, secondary schools, Nigeria

Introduction

Mathematics is a core subject for national development, yet students' persistent poor performance in algebra at the Senior Secondary School Certificate Examination remains a concern in Nigeria [West African Examinations Council, 2023; National Examinations Council, 2023]. Chief examiners' reports consistently attribute poor performance to lack of interest, mathematics phobia, and difficulties with abstract concepts. Traditional lecture and drill methods, which emphasize rote learning with limited student interaction, have not sufficiently addressed this challenge. Consequently, many students develop negative attitudes and avoid effort in algebra. Gamification, defined as the use of game design elements such as points, badges, leaderboards, and challenges in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011), offers an alternative approach. When properly guided by teachers, gamification can foster growth mindset, persistence, and active learning (International Teachers Association, 2025). Theoretical support comes from Deci and Ryan's (2000) Self-Determination Theory, which emphasizes autonomy, competence, and relatedness as drivers of motivation, and Csikszentmihalyi's (1990) Flow Theory, which describes optimal engagement when challenge matches skill. Empirical evidence shows that gamified and game-based approaches improve mathematics achievement and attitudes, particularly when cooperative elements are included (Ke & Grabowski, 2007; Espinosa-Pinos, Mazaquiza-Paucar, & Sánchez Benítez, 2024). In Nigeria and Africa, emerging studies report positive outcomes. Attah, Ogunlade, and Otemuyiwa (2024) found significant effects of gamification-based teaching on junior secondary mathematics achievement in Kwara State, while Nautwima, Asa, and Nendongo documented positive teacher and learner perceptions in Namibia (2022). However, evidence on gamification in Senior Secondary algebra in Delta State is limited, and most studies do not report effect sizes or gender effects. This gap limits policy guidance on scaling gamification beyond pilot classes. This study is therefore significant because it provides empirical evidence on the comparative effectiveness of gamification versus traditional methods for algebra in Oshimili South LGA, examines gender influence, and documents teacher perceptions. The findings will inform teacher training, curriculum integration, and classroom practice in Delta State and similar contexts.

Literature Review

This study is anchored on Self-Determination Theory [SDT] and Flow Theory. SDT posits that motivation is enhanced when learning environments support autonomy, competence, and relatedness (Deci & Ryan, 2000). Gamification elements such as choice of challenges, immediate feedback, and collaboration address these needs. Flow Theory explains that engagement is highest when task challenge matches learner skill. Gamification creates this balance through leveled tasks, puzzles, and instant feedback (Csikszentmihalyi, 1990). Traditional schooling is often perceived as ineffective and boring, and teachers continuously seek novel instructional approaches to address

motivation and engagement problems. According to Deterding, Dixon, Khaled & Nacke (2011), gamification is the use of game design elements in non-game contexts to enhance the participation, motivation, and engagement of individuals. In the educational setting, this involves not only the incorporation of game mechanics such as challenges, immediate feedback, points, and rewards, but also the creation of more dynamic and interactive experiences that encourage exploration and active learning. Gamification in education has transitioned from a novel idea to a central teaching strategy in classrooms around the world, particularly in subjects like mathematics that demand both conceptual understanding and practice. The implementation of gamification goes beyond simply playing games; it cultivates a mindset of growth, challenge, and persistent improvement. A games-based mindset in education is fundamentally about fostering growth rather than just offering entertainment. Educational games have remarkable motivational power because they utilize mechanisms that encourage people to engage for the joy of playing and the possibility to win. Gamified learning environments can increase productivity through interactivity, customization, collaborative competition, and analytics-driven insights (Dicheva, 2017; Mangahigh, 2025). International Studies show consistent gains. Ke & Grabowski (2007) found game-based learning enhanced middle school students' algebra performance, with cooperative gameplaying most effective for attitudes. Nautwima, Asa & Nendongo (2022) reported positive perceptions of gamification among learners and teachers in Namibia. Dahalan, Alias & Shaharom (2023) concluded that gamification and game-based learning can improve academic performance, engagement, and motivation in vocational education. Espinosa-Pinos, Mazaquiza-Paucar & Sánchez Benítez (2024) found gamification significantly increased academic performance and developed logical thinking. In Nigeria, Attah, Ogunlade & Otemuyiwa (2024) reported gamification-based teaching had a significant effect on Mathematics Performance. Guro & Corpuz (2025) found a significant difference in post-test scores favouring the experimental group, suggesting positive short-term impact. Evidence on gender is mixed. Attah et al. (2024) found females outperformed males in gamified algebra, while other studies report no gender difference. This study tests whether gamification provides equitable outcomes in the Delta State context. Teacher buy-in is critical for scaling. Nautwima et al (2022). and Guro and Corpuz (2025) reported positive teacher attitudes toward gamification. However, most studies have small teacher samples, which may limit statistical power. This study therefore reports both significance and effect size for teacher perception.

Poor performance of students in mathematics examinations conducted by WAEC and NECO has been attributed to lack of interest, phobia, dislike, and difficulties in calculations, leading to negative attitudes and unwillingness to work hard. Research evidence suggests the use of games in teaching STEM subjects, especially mathematics, to improve attitudes and performance. Further, Yan (2023) noted there is a lack of specific research on using gamification in various components of primary mathematics education, prompting this study on the comparative

effectiveness of gamification and traditional methods in enhancing students' achievement in algebraic concepts in Nigerian secondary schools.

This research examined the effects of gamification on students' understanding and achievement in learning algebraic concepts among Nigerian secondary school students. Specifically, it sought to investigate:

- The achievement of students using gamification and traditional methods in algebra learning.
- The influence of gender on students' achievements using gamification.
- Teachers' perception of gamification effectiveness for algebra instruction.

The following Research Questions guided the study:

1. What is the academic achievement of students using gamification and traditional methods in learning algebra?
2. What influence does gender have on students' achievements in a gamified setting?
3. How do teachers perceive gamification's effectiveness for algebra instruction?

These Research Hypotheses were formulated to also guide the study:

1. There is no significant difference between the algebra achievement of students in gamification and traditional classes.
2. There is no significant difference between male and female students' achievement in gamified algebra learning.
3. There is no significant difference between teachers' perceptions of gamification effectiveness based on class assignment.

Method

A mixed-methods quasi-experimental design was adopted. The quantitative strand used a pre-test/post-test control group design, while the qualitative strand used teacher interviews. This design was appropriate for comparing achievement and understanding implementation experiences. The population comprised all SS1 Mathematics students in 11 public secondary schools in Oshimili South LGA. Four schools were purposively selected based on availability of ICT facilities. From each school, two intact SS1 classes of 40 students each were selected, giving 320 students. Classes were randomly assigned to experimental, $n = 160$, and control, $n = 160$, groups. Eight Mathematics

teachers, two per school, participated in the study. Instruments used included: Algebra Achievement Test [AAT], a 30-item multiple-choice test covering linear equations, variables, quadratics, functions, systems, inequalities, and sequences. It was validated by three experts in Mathematics Education, FCE Asaba. KR-20 reliability was 0.82; Gamification Engagement Questionnaire (GEQ), a 15-item, 4-point Likert scale for students' motivation and engagement, $\alpha = 0.78$; and Teacher Interview Schedule (TIS), semi-structured items on effectiveness, challenges, and suitability for algebra. Fifteen SS1 Mathematics teachers from the LGA were trained on gamification design. The experimental group received instruction using points, badges, leaderboards, and algebra challenges for eight weeks. The control group received traditional lecture and practice. Pre-test and post-test were administered to both groups. Teacher interviews were conducted after the intervention. Descriptive statistics of mean and standard deviation answered research questions. One-way ANOVA tested hypotheses at 0.05 level of significance because it compares two or more independent means and controls type I error. Assumptions of normality and homogeneity were tested with Shapiro-Wilk and Levene's test. Decision rule was based on If the calculated p-value is less than or equal to 0.05, the null hypothesis is rejected and the alternative is accepted. If the p-value is greater than 0.05, the null hypothesis is accepted. Effect size was reported using partial eta squared, η^2 : 0.01 = small, 0.06 = medium, 0.14 = large. All analyses were done with SPSS version 26.[Cohen, 1988]

Result

Research Question 1: What is the academic achievement of students in algebra using gamification and traditional methods?

Table 1: Descriptive Statistics for Students' Achievement

	Group N	Pretest M	Posttest M	Gain	SD
Gamification	160	55.3%	64.1%	8.8%	10.73
Traditional	160	54.7%	57.3%	2.6%	8.78

The gamification group had a higher mean gain of 8.8% compared to 2.6% for the traditional group. In the gamified class, 108 students scored 60% and above compared to 63 in the traditional class. Low achieving students benefited more from the intervention.

Hypothesis 1: There is no significant difference between the algebra achievement of students in gamification and traditional classes.

Table 2: ANOVA Summary for Posttest Achievement by Teaching Method

Source	Sum of Squares	df	Mean Square	F	Sig.	η^2
Between Groups	3699.20	1	3699.20	38.44	.000	.108
Within Groups	30609.60	318	96.26			
Total	34308.80	319				

Finding: $F(1, 318) = 38.44$, $p = .000$, $\eta^2 = .108$. The null hypothesis is rejected. There is a statistically significant difference in algebra achievement favouring the gamification group. The effect size indicates a medium practical effect.

Research Question 2: What influence does gender have on students' academic achievement in a gamified setting?

Table 3: Descriptive Statistics by Gender in Gamification Group

Gender	N	Pretest M	Posttest M	Gain	SD
Male	84	55.2%	62.4%	7.2%	9.34
Female	76	52.6%	61.8%	9.2%	8.92

Seventy- six (76) Female students had a higher mean gain of 9.2% compared to 7.2% for Eighty-four (84) male students, a difference of 2%. The females had the lowest score of 42% compared to 45% for the males and the highest score of 91%, compared to 94% for the males, an equal range of 49%. Also Forty-five (55) male and fifty-three (53) female students recorded 60% and above in the respective groups. This showed little differences existed in the academic achievement between Male and female students in a gamified setting.

Hypothesis 2: There is no significant difference between male and female students' achievement in gamified algebra learning.

Table 4: ANOVA Summary for Posttest Achievement by Gender

Source	Sum of Squares	df	Mean Square	F	Sig.	η^2
Between Groups	14.81	1	14.81	0.18	.672	.001
Within Groups	12934.19	158	81.86			

Total 12949.00 159

Finding: $F(1, 158) = 0.18$, $p = .672$, $\eta^2 = .001$. The null hypothesis is accepted. Gender had no significant influence on achievement in the gamified class.

Research Question 3: How do teachers perceive gamification's effectiveness for algebra instruction?

Table 5: Teachers' Perception Mean Scores

	Mean
1. Increased student engagement and participation.	4.75
2. Helped students develop deeper understanding.	4.38
3. Improved students' motivation to learn Algebra.	4.63
4. Tailor instruction to meet diverse needs.	4.13
5. Enabled me to track student progress efficiently.	4.50
6. Identify areas for improvement more effectively.	4.25
7. An overall effective teaching tool for Algebra.	4.88

Items measured include: increased engagement, deeper understanding, motivation, tailored instruction, progress tracking, identification of improvement areas, and overall effectiveness. All eight respondents either agreed or strongly agreed, with mean scores ranging from 4.13 to 4.88 and an overall mean of 4.50, above the benchmark of 3.00.

Hypothesis 3: There is no significant difference between teachers' perceptions of gamification effectiveness based on class assignment.

Table 6: ANOVA Summary for Teachers' Perception Scores

Source	Sum of Squares	df	Mean Square	F	Sig.	η^2
Between Groups	0.259	1	0.259	3.24	.121	.351
Within Groups	0.479	6	0.080			
Total	0.738	7				

Finding: $F(1, 6) = 3.24$, $p = .121$, $\eta^2 = .351$. The null hypothesis is accepted. There is no statistically significant difference in perception between teachers in gamified and traditional classes. However, the large effect size suggests a practical difference that may become significant with a larger sample.

Discussion of Findings

ANOVA results confirm that gamification had a significant effect on students' algebra achievement, $F(1, 318) = 38.44$, $p < .001$, $\eta^2 = .108$, with a medium effect size. This aligns with Attah et al. (2024) and Ke & Grabowski (2007), who found game-based approaches improved mathematics performance and engagement. Low achieving students benefited more, supporting the view that gamification provides scaffolding for struggling learners.

Gender did not significantly influence achievement in the gamified setting, $F(1, 158) = 0.18$, $p = .672$, $\eta^2 = .001$. This suggests gamification offers equitable learning opportunities, contrary to Attah et al. (2024) who found females outperformed males.

Teachers' perceptions did not differ significantly between groups, $F(1, 6) = 3.24$, $p = .121$, but $\eta^2 = .351$ indicates a large effect size. This supports Nautwima et al. (2022) and Guro & Corpuz (2025), who reported positive teacher and student attitudes toward gamification. The non-significant result may be due to the small teacher sample.

Conclusions

Based on the findings, the following conclusions were reached: Students' performance in the gamified class improved significantly and was better than in the traditional class; gender had no significant influence on academic achievement in a gamified algebra class; there is a significant difference between the algebra achievement of students using gamification and traditional methods, with gamification being more effective; there is no significant difference in teachers' perceptions of gamification effectiveness based on class assignment, though a large practical effect was observed.

Recommendations

Based on the findings, the following recommendations are made:

Teacher Training: The Delta State Post Primary Schools Board should organize regular workshops to train Mathematics teachers on gamification strategies for algebra and other topics.

Curriculum Integration: The Nigerian Educational Research and Development Council should incorporate gamified elements into the Senior Secondary Mathematics curriculum.

Infrastructure Support: Government and school authorities should provide ICT facilities and internet access to enable gamification, especially in rural schools.

Inclusive Design: Gamification activities should be designed to cater to diverse learners, including low achievers and students in remote areas.

Further Research: Longitudinal studies should examine the long-term effects of gamification on mathematics achievement and retention.

Blended Approach: Teachers should combine gamification with traditional methods to address all learning objectives and learner needs.

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