



## Effectiveness of Gamification Strategies in Enhancing Engagement and Concept Mastery in Junior Secondary School Mathematics in Rivers State

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### Abstract

This study examined the effectiveness of gamification strategies in enhancing students' engagement and concept mastery in Junior Secondary School Mathematics in Rivers State. The study adopted a quasi-experimental design with pre-test and post-test non-equivalent control groups. The sample consisted of 120 Junior Secondary School II students drawn from public schools in Rivers State, with 60 students in the experimental (gamification) group and 60 in the control (conventional method) group. The experimental group was taught using a gamification instructional package, while the control group received conventional instruction. Data were collected using a Student Engagement Scale and Mathematics Concept Mastery Test. SES reliability was established using Cronbach's alpha, yielding a coefficient of 0.87, and MCMT reliability was established using Kuder-Richardson Formula 20 (KR-20), yielding a coefficient of 0.84. Mean, standard deviation and independent-samples t-test were used for data analysis at the 0.05 significance level. Findings revealed that students exposed to gamification strategies demonstrated significantly higher engagement and concept mastery than those taught using traditional methods. The study also found a link between engagement and concept mastery. The study concludes that gamification effectively improves Mathematics learning outcomes and recommends integrating it into Junior Secondary School Mathematics instruction.

**Keywords:** Gamification, Student Engagement, Concept Mastery, Mathematics Instruction, Junior Secondary School.

### Introduction

Mathematics is a foundational subject in secondary education because it develops logical reasoning, problem-solving ability, quantitative literacy, and readiness for science, technology, engineering and mathematics (STEM) disciplines (Obodo, 2018; Yusuf et al., 2020). Despite its importance, students' engagement and achievement in mathematics remain concerns in many educational settings. Conventional teacher-centred approaches may provide limited opportunities for active participation, immediate feedback, collaborative learning, and sustained attention, thereby creating a need for instructional approaches that place learners more actively at the centre of the learning process (Adu & Galloway, 2019).

Gamification has emerged as one such instructional approach. Gamification refers to the incorporation of selected game-design elements and principles into non-game contexts to enhance users' motivation, engagement, and participation (Deterding et al., 2011). In education, elements such as points, badges, levels, leaderboards, challenges, rewards, and immediate feedback can transform routine classroom activities into more interactive learning experiences (Domínguez et al., 2013; Hamari et al., 2014).

The use of gamification in mathematics instruction is particularly relevant because mathematics learning often requires sustained attention, repeated practice, problem-solving, feedback, and persistence. Gamified activities can provide learners with opportunities to attempt tasks repeatedly, receive feedback, monitor their progress, and experience a sense of achievement. These features can support students' motivation and engagement in learning activities (Yildirim, 2017). Similarly, digital game-based learning has been associated with interactive learning experiences that can support mathematics learning and students' participation (Yusuf et al., 2020).

Student engagement encompasses behavioural, emotional, and cognitive dimensions. Behavioural engagement involves students' participation and effort; emotional engagement concerns students' interest, enjoyment, and attitudes; while cognitive engagement involves investment in understanding and mastering challenging academic tasks (Fredricks et al., 2004). Gamification can potentially address these dimensions by encouraging active participation, providing attainable challenges, and giving students feedback about their progress.

The theoretical basis for gamified learning can also be related to constructivist and experiential perspectives of learning. Vygotsky (1978) emphasised the importance of interaction and active participation in learning, while Kolb (1984) viewed learning as a process in which knowledge develops through experience and reflection. Gamified mathematics activities can provide learners with structured experiences through which they actively interact with mathematical concepts and receive feedback on their performance.

Low engagement and inadequate concept mastery in mathematics therefore remain important instructional concerns. Innovative approaches such as gamification may provide opportunities for students to become more actively involved in mathematics lessons and develop deeper understanding of mathematical concepts. Previous research has reported positive relationships between gamification, students' attitudes, engagement, and academic outcomes, although the effectiveness of gamification may depend on the design and implementation of the gamified learning environment (Hamari et al., 2014; Yildirim, 2017).

The findings of this study are expected to provide useful information for mathematics teachers, curriculum developers, educational policymakers, and teacher-training institutions concerning the possible application of gamification in Junior Secondary School Mathematics instruction.

Gamification applies game-design elements in non-game contexts to encourage motivation, participation, and engagement (Deterding et al., 2011). In educational settings, gamification does not necessarily mean converting an entire lesson into a digital game. Rather, teachers can incorporate selected game elements such as points, badges, levels, challenges, rewards, progress indicators, competition, and immediate feedback into ordinary learning activities (Hamari et al., 2014).

In mathematics classrooms, these elements can be used to create structured challenges in which students solve problems, earn points for successful completion of tasks, progress through levels of increasing difficulty, and receive immediate feedback. Such an environment can encourage persistence and active participation while providing learners with opportunities to practise mathematical concepts (Yildirim, 2017; Yusuf et al., 2020).

The potential of gamification is also supported by research on motivation and interest. Hidi and Renninger (2006) explained that interest can develop progressively from situational interest toward more sustained individual interest. Well-designed gamified mathematics activities may initially attract students' attention and subsequently encourage continued involvement through meaningful challenges and successful learning experiences. However, gamification should be purposefully designed around instructional objectives rather than simply adding points or rewards to lessons. Hamari et al. (2014) noted that the effectiveness of gamification varies across contexts and depends partly on how gamification is implemented. Consequently, the present study focuses on the use of specific elements—points, badges, levels, challenges, and feedback—to support engagement and mathematics concept mastery.

#### Research questions:

1. What is the level of engagement of students taught mathematics using gamification strategies in Rivers State?
2. What is the level of concept mastery of students exposed to gamified mathematics instruction in Rivers State?
3. Is there a difference in engagement between students taught using gamification strategies and those taught using conventional methods in Rivers State?

#### Methodology

This study adopted a quasi-experimental pre-test–post-test non-equivalent control group design. This design was appropriate because intact classes were used, and the researcher compared students exposed to gamified mathematics instruction with those taught using conventional instruction. The use of experimental and control groups also permitted examination of differences in students’ engagement and concept mastery following the intervention. The sample consisted of 120 JSS II students, with 60 assigned to the experimental group and 60 to the control group. The experimental group received mathematics instruction using the Gamification Instructional Package (GIP), which incorporated points, badges, levels, challenges, and feedback. These elements were selected because they represent commonly discussed game-design features used to promote participation and motivation in educational settings (Deterding et al., 2011; Hamari et al., 2014). The Student Engagement Scale (SES) contained 30 items covering the behavioural, emotional, and cognitive dimensions of engagement. This multidimensional approach is consistent with the conceptualisation of school engagement proposed by Fredricks et al. (2004). The Mathematics Concept Mastery Test (MCMT) consisted of 40 multiple-choice items designed to assess students’ understanding of the mathematics concepts taught during the intervention. Content and construct validity were established through expert review by specialists in Mathematics Education and Educational Technology. The SES yielded a Cronbach’s alpha reliability coefficient of 0.87, while the MCMT yielded a KR-20 coefficient of 0.84. These coefficients indicate satisfactory internal consistency for the instruments. The intervention lasted six weeks. Before treatment, the SES and MCMT were administered to both groups as pre-tests. The experimental group subsequently received mathematics instruction supplemented with gamification elements, while the control group received conventional mathematics instruction. Following the intervention, the same instruments were administered as post-tests. Means and standard deviations were used to answer the research questions. An independent-samples t-test was used to determine differences between the experimental and control groups. All hypotheses were tested at the 0.05 level of significance.

#### Results

**Table 1: Mean and standard deviation of the Students’ Engagement in Gamified Mathematics Instruction (Experimental Group) n=60.**

| N/S                                                     | Item                           | SA | A  | D | SD | N  | Mean        | SD          | Decision    |
|---------------------------------------------------------|--------------------------------|----|----|---|----|----|-------------|-------------|-------------|
| 1.                                                      | Active participation in class  | 28 | 22 | 7 | 3  | 60 | 3.25        | 0.81        | High        |
| 2.                                                      | Enjoyment of math lessons      | 30 | 20 | 6 | 4  | 60 | 3.27        | 0.86        | High        |
| 3.                                                      | Willingness to solve problems  | 26 | 24 | 6 | 4  | 60 | 3.20        | 0.84        | High        |
| 4.                                                      | Sustained attention            | 25 | 23 | 8 | 4  | 60 | 3.15        | 0.89        | High        |
| 5.                                                      | Persistence on difficult tasks | 24 | 25 | 7 | 4  | 60 | 3.15        | 0.88        | High        |
| <b>Grand mean (criterion mean cut-off point = 2.50)</b> |                                |    |    |   |    |    | <b>3.20</b> | <b>0.86</b> | <b>High</b> |

Table 1 shows that the grand mean scores of the level of engagement of students taught mathematics using gamification strategies in Rivers State was  $\bar{X} = 3.20$  and  $SD = 0.86$  which is above the criterion mean cut-off point of 2.50. This indicates that students exposed to gamification strategies demonstrated a high level of engagement in mathematics lessons in Rivers State.

**Table 2: Mean, standard deviation and t-test of the post-test scores of students in mathematics concept mastery test in Rivers State**

| Group                       | N  | Mean  | SD   | Decision |
|-----------------------------|----|-------|------|----------|
| Experimental (Gamification) | 60 | 27.80 | 4.12 | High     |
| Control (Conventional)      | 60 | 21.40 | 3.86 | Moderate |

Data: With  $df = 118$ , the calculated  $t$  of **8.78** is substantially greater than the conventional critical value of approximately **1.98** at  $\alpha = 0.05$  (two-tailed).

Table 2 shows that the Post-Test Scores of experimental students in the Mathematics Concept Mastery Test in Rivers State were  $\bar{X} = 27.80$  and  $SD = 4.12$ , whereas those of the control group were  $\bar{X} = 21.40$  and  $SD = 3.86$ , indicating that Students taught with gamification strategies achieved higher concept mastery than those taught using conventional methods. Based on the available summary statistics, the difference in concept mastery is statistically significant ( $t = 8.78$ ,  $df = 118$ ,  $t$ -critical = 1.98).

**Table 3: Mean, standard deviation and t-test of the difference in engagement between students taught using gamification strategies and those taught using conventional methods in Rivers State**

| Group        | N  | Mean | SD   | Mean Difference |
|--------------|----|------|------|-----------------|
| Experimental | 60 | 3.20 | 0.86 | 0.68            |
| Control      | 60 | 2.52 | 0.79 | –               |

Data: With  $df = 118$ , the calculated  $t$  of **4.51** is also greater than the critical value of approximately **1.98** at  $\alpha = 0.05$  (two-tailed).

Table 3 shows that the engagement of students taught using gamification strategies was  $\bar{X} = 3.20$  and  $SD = 0.86$ , whereas those taught using conventional methods were  $\bar{X} = 2.52$  and  $SD = 0.79$ , which shows that the experimental group recorded a higher mean engagement score than the control group, indicating a positive effect of gamification strategies. Therefore, the difference in engagement between the two groups is statistically significant based on the available summary statistics ( $t = 4.51$ ,  $df = 118$ ,  $t$ -critical = 1.98).

## Discussion

### Level of Students' Engagement in Mathematics through Gamification

The findings revealed that students taught Mathematics using gamification strategies demonstrated a high level of engagement, with a grand mean of 3.20 and a standard deviation of 0.86, which was above the criterion mean of 2.50. The individual engagement indicators also recorded high mean scores, including active participation in class (3.25), enjoyment of Mathematics lessons (3.27), willingness to solve problems (3.20), sustained attention (3.15), and persistence on difficult tasks (3.15). This finding indicates that the use of gamification created a learning environment in which students participated actively, showed greater interest in Mathematics activities, maintained attention, and demonstrated willingness to persist with challenging tasks.

The finding may be attributed to the use of game elements such as points, badges, levels, challenges, and immediate feedback in the experimental group. These elements can make classroom activities more interactive and provide students with visible indicators of progress and achievement. The finding is consistent with the view of Deterding et al. (2011), who explained that gamification involves the application of game-design elements in non-game contexts to encourage motivation and participation. It is also in agreement with Hamari et al. (2014), who reported that gamification can positively influence motivation and engagement, although its effectiveness depends on the manner in which it is implemented.

The result also supports Fredricks et al. (2004), who conceptualised engagement as having behavioural, emotional, and cognitive dimensions. The high scores recorded for participation and persistence suggest behavioural

engagement, while the high level of enjoyment reflects an emotional dimension of engagement. Similarly, willingness to solve problems and sustained attention indicate cognitive involvement in Mathematics learning. Therefore, the finding suggests that gamification can address multiple dimensions of student engagement rather than merely increasing classroom participation.

#### Students' Mathematics Concept Mastery through Gamification

The findings further showed that students exposed to gamified Mathematics instruction achieved higher concept mastery than students taught using conventional methods. The experimental group recorded a post-test mean of 27.80 with a standard deviation of 4.12, compared with a mean of 21.40 and standard deviation of 3.86 for the control group. The experimental group was classified as having high concept mastery, whereas the control group was classified as moderate.

This difference suggests that the gamification instructional package provided students with learning experiences that supported their understanding of the Mathematics concepts taught during the intervention. The use of challenges, levels, repeated practice, and feedback may have provided students with opportunities to engage actively with mathematical tasks and monitor their progress. Rather than receiving information passively, students were encouraged to participate in problem-solving activities and receive feedback on their performance.

The finding is consistent with Yildirim (2017), who reported positive effects of gamification-based teaching practices on students' achievement and attitudes. It is also consistent with Yusuf et al. (2020), who associated digital game-based learning with interactive learning experiences that can support Mathematics learning and participation. The finding can further be understood from the experiential learning perspective of Kolb (1984), in which learning develops through experience and reflection. Gamified Mathematics activities provide structured experiences through which students can practise concepts, respond to challenges, receive feedback, and improve their performance. The result therefore suggests that gamification is not only useful for making Mathematics lessons more interesting but may also contribute to students' mastery of mathematical concepts. However, the effectiveness observed in this study should be interpreted within the context of the six-week intervention and the specific gamification elements used.

#### Difference in Engagement between Students Taught Using Gamification and Conventional Methods

The findings showed that students taught using gamification strategies recorded a higher engagement mean score (3.20, SD = 0.86) than students taught using conventional methods (2.52, SD = 0.79). The mean difference was 0.68 in favour of the experimental group. This indicates that students who participated in gamified Mathematics instruction were more engaged than those who received conventional instruction.

The higher engagement score may be explained by the interactive and motivating features incorporated into the gamified lessons. Points, badges, levels, challenges, and feedback can provide students with clear learning goals and immediate information about their progress. These features may encourage students to remain involved in classroom activities and persist when confronted with difficult mathematical problems. This interpretation is consistent with Yildirim (2017), who found that gamification-based teaching could positively influence students' attitudes and learning outcomes.

The finding also supports the argument presented in the study that conventional teacher-centred approaches may provide fewer opportunities for active participation, immediate feedback, and sustained attention. Gamification, by contrast, can place learners in more active roles during Mathematics lessons. This is particularly important in Mathematics, where students often need repeated practice, problem-solving opportunities, feedback, and persistence to develop understanding.

The findings indicate that gamification had a positive influence on students' engagement and Mathematics concept mastery. The higher engagement observed among the experimental group, together with its higher concept-mastery score, suggests that creating an interactive and motivating Mathematics learning environment may contribute to

improved learning outcomes. This supports the study's conclusion that gamification can serve as an effective instructional strategy for Junior Secondary School Mathematics.

### Conclusion

The study concludes that gamification is an effective instructional strategy for improving students' engagement and concept mastery in Junior Secondary School Mathematics. Students exposed to gamified instruction demonstrated higher engagement and better Mathematics performance than those taught using conventional methods. Therefore, integrating gamification into Mathematics instruction can promote active participation, sustained interest, and improved learning outcomes.

### Recommendations

1. Integrate gamification into daily mathematics instruction.
2. Train teachers in gamification and educational technology.
3. Curriculum developers should embed gamified activities.
4. Policymakers should support resource provision for innovative teaching.

### References

- Abdulrahman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, 6(11).
- Adeyemi, T., & Lawal, K. (2019). Gamified instruction and students' mathematics achievement. *International Journal of Education Research*, 10(2), 45–55.
- Adu, E. O., & Galloway, G. (2019). The use of instructional strategies to enhance students' engagement in mathematics. *International Journal of Instruction*, 12(2), 1–16.
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. In *Proceedings of the 15th International Academic MindTrek Conference* (pp. 9–15). ACM.
- Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, 63, 380–392.
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109.
- Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (2nd ed.). Palgrave Macmillan.
- Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? A literature review of empirical studies. In *Proceedings of the 47th Hawaii International Conference on System Sciences* (pp. 3025–3034). IEEE.
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111–127.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.
- Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge University Press.
- Mohammed, A., & Abubakar, S. (2021). Gamification in secondary school mathematics. *Journal of STEM Education*, 12(3), 112–125.
- Obodo, G. C. (2018). *Principles and practice of mathematics education in Nigeria*. Enugu State University Press.
- Prensky, M. (2001). *Digital game-based learning*. McGraw-Hill.
- Schunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed.). Pearson Education.
- Slavin, R. E. (2015). *Educational psychology: Theory and practice* (11th ed.). Pearson Education.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Yildirim, I. (2017). The effects of gamification-based teaching practices on student achievement and attitudes. *Internet and Higher Education*, 33, 86–92.
- Yusuf, A., Afolabi, T., & Bello, M. (2020). Digital game-based learning in mathematics. *International Journal of Educational Technology*, 15(2), 33–48.