

Math-Mazing Roulette: Effects on Grade 9 Learners' Achievement and Engagement in Radicals

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ABSTRACT

Gamified learning environments are increasingly explored as alternative assessment strategies that promote motivation and engagement in mathematics. This study investigated the effects of Math-mazing Roulette, a classroom-based gamified summative assessment tool, on Grade 9 learners' achievement and engagement levels in radical expressions, specifically rational exponents and radical equations. Using a quasi-experimental posttest-only non-equivalent group design, two intact Grade 9 classes ($N = 80$) from a public secondary school in Marawi City were assigned to either a traditional written summative test or a gamified summative test consisting of five rotating game stations containing the same assessment items.

Quantitative findings revealed that learners who completed the gamified summative test demonstrated significantly higher achievement scores than those who took the written test, as evidenced by the Mann-Whitney U test. Engagement data showed high behavioral, emotional, and cognitive engagement during the gamified assessment. Students displayed active participation, enthusiasm, collaboration, and perseverance throughout the activity. Thematic analysis of student reflections further revealed key themes such as reduced test anxiety, increased motivation, enjoyment, peer support, and deeper focus during problem solving.

The results indicate that gamified summative assessments can serve as meaningful alternatives to traditional paper-based tests by reducing pressure and creating a supportive and interactive environment for demonstrating mathematical understanding. This study contributes to the growing evidence that classroom gamification can enhance assessment experiences, particularly in topics where students often struggle. Integrating structured game elements into assessment practices may help teachers promote both engagement and improved achievement in mathematics.

Keywords: gamified assessment, mathematics achievement, student engagement, radical expressions, quasi-experimental design

INTRODUCTION

Assessment plays a central role in mathematics learning, yet traditional written summative tests are frequently associated with heightened anxiety, disengagement, and reduced confidence among learners, particularly in abstract topics such as radical equations and rational exponents (Putwain & Symes, 2018). When students perceive assessment as threatening, their performance may not accurately reflect their conceptual understanding. Consequently, educators have increasingly explored assessment approaches that preserve academic rigor while fostering supportive learning environments.

Gamification, defined as the integration of game elements into non-game contexts, has gained prominence as a strategy for enhancing motivation and engagement in educational settings (Deterding et al., 2011). Empirical studies suggest that gamified environments can promote sustained attention, persistence, and enjoyment, which are closely linked to improved learning outcomes (Hamari et al., 2014; Plass et al., 2015). Within mathematics

education, gamified activities have been shown to reduce anxiety and encourage learners to engage more deeply with challenging content (Harrold et al., 2021).

Despite growing evidence supporting gamification as an instructional strategy, fewer studies have examined its use as a summative assessment format, particularly in secondary mathematics classrooms. Most existing research focuses on game-based instruction rather than game-based evaluation, leaving a gap in understanding how assessment design itself influences learner achievement and engagement (Barata et al., 2013; Black & Wiliam, 1998).

In the Philippine public school context, where mathematics anxiety and low engagement remain persistent concerns, especially in post-conflict and resource-limited areas such as Marawi City, assessment innovations are urgently needed. This study addresses this gap by examining the effects of Math-mazing Roulette, a gamified summative assessment, on Grade 9 learners' achievement in radicals and their engagement during assessment.

Background of the Study

Gamification has been widely explored as an educational strategy that enhances learner motivation through challenge, feedback, and enjoyment (Deterding et al., 2011; Hamari et al., 2014). These elements are grounded in Self-Determination Theory, which highlights autonomy, competence, and relatedness as core components of intrinsic motivation (Deci & Ryan, 2000). When assessment tasks incorporate game mechanics, students feel more involved and perceive the learning activity as less threatening (Harrold et al., 2021).

In mathematics education, game-based learning environments have been linked to increased engagement, deeper conceptual understanding, and improved retention (Plass et al., 2015; Sung & Hwang, 2013). Collaborative games, in particular, encourage students to discuss strategies and support one another (Johnson & Johnson, 2009). These interactions may also reduce the performance anxiety that commonly accompanies high-stakes assessments (Black & Wiliam, 1998).

Studies investigating students' difficulties in radical expressions reveal consistent challenges: misapplication of exponent laws, incorrect simplification, and confusion in isolating variables in radical equations (Wijaya et al., 2020; Lim & Kor, 2021). These difficulties are exacerbated when students avoid practice due to fear of failure or negative mathematics experiences.

A gamified summative assessment may help strengthen students' perseverance by presenting challenging tasks in a more approachable, low-pressure format (Barata et al., 2013; Wang, 2015). The Math-mazing Roulette intervention seeks to merge assessment rigour with interactive design, offering a meaningful alternative to traditional paper-based tests.

Research Questions

This study aimed to examine the effects of the Math-mazing Roulette gamified summative test on learners' achievement and engagement. Specifically, it sought to answer:

1. What is the level of behavioral, emotional, and cognitive engagement exhibited by learners during the gamified summative test?
2. Is there a significant difference in the achievement scores of learners who completed the written summative test and those who completed the gamified summative test?
3. What themes emerge from students' reflections on their experience with the gamified assessment?

Research Hypothesis

H_0 : There is no significant difference in achievement between learners who completed the written summative test and those who completed the gamified summative test.

H₁: There is a significant difference in achievement between learners who completed the written summative test and those who completed the gamified summative test.

METHODS

Research Design

This study employed a quasi-experimental posttest-only non-equivalent group design using intact classes, following the framework of Campbell and Stanley (1963). Two Grade 9 sections from a public secondary school in Marawi City, Lanao del Sur, Philippines, were assigned to different assessment conditions: a traditional written summative test and a gamified summative test.

Because random assignment and pretesting were not feasible, equivalence between groups was addressed procedurally. Both groups completed identical test items, under equivalent time constraints, and were scored using the same scoring rubric, thereby minimizing threats related to instrumentation and scoring bias.

Participants

The participants consisted of 80 Grade 9 learners, with 40 students in the written summative test group and 40 students in the gamified summative test group. All learners had received the same instruction on rational exponents and radical equations prior to the assessment.

Intervention: Math-mazing Roulette

Math-mazing Roulette was implemented as an individual, station-based gamified summative assessment conducted during regular class hours. The assessment consisted of five stations, each containing summative test items aligned with the Grade 9 mathematics curriculum on rational exponents and radical equations.

Students were oriented on the rules, time limits, movement procedures, and scoring system prior to the activity. A roulette wheel was used only to determine the sequence of stations each student would visit. Despite the game-based format, all tasks were completed individually, and peer assistance or discussion of answers was strictly prohibited to ensure fairness with the written summative test group.

Each station was allotted 10 minutes, resulting in a total testing time of approximately 50 minutes, comparable to the traditional written assessment. Each station contained four test items, for a total of 20 items. The content, difficulty level, point values, and scoring scheme were identical to those in the written summative test. No bonus points or game-based incentives were added to academic scores.

Stations were physically spaced to prevent visibility of other tasks. Notes, mobile devices, and unauthorized materials were prohibited. The teacher and an assisting observer monitored compliance throughout the assessment.

Instruments

Achievement was measured using a teacher-made 20-item summative test on rational exponents and radical equations. Test reliability was established using KR-20, indicating acceptable internal consistency.

Learner engagement during the gamified assessment was measured using a student engagement scale covering behavioral, emotional, and cognitive dimensions, based on the framework of Fredricks et al. (2004). Engagement behaviors were further documented using an observation checklist, while students' perceptions were captured through open-ended reflection prompts.

Data Analysis

Achievement scores were analyzed using the Mann-Whitney U test, appropriate for comparing independent groups when assumptions of normality are violated (Field, 2018). Mean ranks, U values, z statistics, p values,

and effect size (r) were reported. Engagement data were analyzed descriptively. Qualitative reflections were examined using thematic analysis following established procedures for coding and theme development (Chen & Law, 2016).

RESULTS

Achievement in Radicals

Results of the Mann-Whitney U test indicated a statistically significant difference in achievement scores between the two groups. Learners in the gamified summative assessment group obtained higher ranks than those in the written summative test group, $U = 220.00$, $z = -5.618$, $p < .001$, with a large effect size ($r = .63$). According to Cohen's (1988) criteria, this represents a substantial difference in achievement associated with assessment format.

Mann-Whitney Test

Ranks				
	Group	N	Mean Rank	Sum of Ranks
Test	Written	40	26.00	1040.00
	Gamified	40	55.00	2200.00
	Total	80		

Test Statistics^a

	Test
Mann-Whitney U	220.000
Wilcoxon W	1040.000
Z	-5.618
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Group

Learner Engagement During the Gamified Assessment

Descriptive analysis revealed very high levels of behavioral, emotional, and cognitive engagement during the gamified summative assessment. Students demonstrated sustained attention, enthusiasm, persistence, and task completion throughout the activity. Observational data supported these findings, indicating high levels of on-task behavior and compliance with assessment rules.

Because engagement measures were collected only for the gamified condition, engagement findings are interpreted as descriptive indicators of learners' experiences during the gamified assessment rather than as comparative outcomes between groups (Fredricks et al., 2004).

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
BE_MEAN	40	4.00	5.00	4.5000	.28244
EE_MEAN	40	4.00	5.00	4.5000	.28244
CE_MEAN	40	4.00	5.00	4.4250	.34581
ENGAGEMENT_MEAN	40	4.00	5.00	4.4750	.28243

Qualitative Reflections

Thematic analysis of students' written reflections revealed five recurring themes: enjoyment, reduced test anxiety, increased motivation, improved focus, and persistence. These themes reflect learners' positive emotional and cognitive responses to the gamified assessment format. To enhance trustworthiness, responses

were coded through repeated readings, theme verification, and the selection of representative quotations grounded in students' own words (Chen & Law, 2016).

Theme	Sample Statement	Interpretation
Reduced test anxiety	"I did not feel nervous because it felt like playing."	Gamified assessment lowers emotional pressure.
Increased motivation	"I wanted to finish the game and get the right answer."	Games spark motivation and goal-oriented behavior.
Collaboration	"My group helped me understand the problems."	Peer learning strengthens understanding.
Enjoyment	"This is the first time I enjoyed a math test"	Gamified tests transform assessment into positive experience

Observational data further strengthened these results. Most students exhibited active participation (95%), collaborated effectively (100%), and showed enthusiasm (85%). Persistence was also evident in 80% of learners who continued working despite difficult items. These behaviors align with cooperative learning and social interaction theories that emphasize the value of peer support during tasks (Vygotsky, 1978; Johnson & Johnson, 2009).

Indicator	Frequency (Yes)	Percentage	Interpretation
Participates actively in the game	38	95%	Very Evident
Collaborates with group members	40	100%	Very Evident
Shows enthusiasm and enjoyment	34	85%	Evident
Persists in solving difficult items	32	80%	Evident

DISCUSSION

The results demonstrate that learners who completed the gamified summative assessment achieved significantly higher scores than those who completed the traditional written test. The large effect size suggests that the observed difference is not only statistically significant but also educationally meaningful (Cohen, 1988). Because both groups completed identical test items individually and under equivalent conditions, the difference in achievement is associated with assessment format rather than collaboration or content variation.

High engagement levels observed during the gamified assessment support previous findings that gamified environments can reduce anxiety and promote sustained attention during learning tasks (Hamari et al., 2014; Plass et al., 2015). Reduced test anxiety, as reflected in students' reflections, may have enabled learners to demonstrate their understanding more effectively, consistent with research on affective influences in mathematics assessment (Putwain & Symes, 2018).

The triangulation of engagement data from self-reports, classroom observations, and reflective responses strengthens the credibility of the findings and aligns with recommendations for mixed-method approaches in educational research (Johnson & Onwuegbuzie, 2004).

CONCLUSION

This study provides empirical evidence that a gamified summative assessment, when carefully designed to ensure individual accountability and scoring equivalence, can enhance Grade 9 learners' achievement in

radicals. Math-mazing Roulette transformed assessment delivery without compromising academic rigor, resulting in higher achievement and positive engagement experiences. These findings support the integration of gamified assessment formats as viable alternatives to traditional written tests in secondary mathematics classrooms.

RECOMMENDATIONS

1. Teachers may incorporate gamified summative assessments to enhance motivation and support diverse learning needs.
2. Schools may explore wider applications of classroom-based gamification to complement existing assessment practices.
3. Future research may compare different types of games, include pre–post measures, or integrate digital game-based assessment tools.

Limitations

The use of a posttest-only non-equivalent group design limits causal inference, as baseline differences between groups cannot be fully ruled out (Campbell & Stanley, 1963). Engagement outcomes were measured only for the gamified condition and should therefore be interpreted descriptively. Additionally, qualitative data were based on brief written reflections, which may not capture the full depth of learners' experiences.

Ethical Considerations

Permission to conduct the study was obtained from school authorities. Participation was voluntary, and students' anonymity and confidentiality were ensured in accordance with ethical research standards.

Conflict Of Interest

The authors declare no conflict of interest.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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