



Development and Evaluation of Game-Based Learning Activities in Mathematics 9

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Abstract - This study aimed to develop and evaluate interactive and collaborative game-based learning (GBL) activities specifically designed for Grade 9 Mathematics. Recognizing the common challenges in engaging students through traditional instructional methods, the research addressed the need for innovative, student-centered approaches that promote active participation and deeper understanding of mathematical concepts.

The developed activities were aligned with the K to 12 Mathematics curriculum and evaluated by both teachers and content experts for validity, usability, and instructional design. Data were collected using surveys, expert validation tools, and qualitative feedback from classroom implementation. The evaluation revealed consistently "Very Satisfactory" ratings across all indicators, affirming the activities' visual appeal, clarity, accessibility, and practicality in classroom settings.

Teachers noted that the materials supported student motivation, conceptual understanding, and collaborative learning. Experts highlighted the strength of the activities in integrating pedagogical goals with interactive design, although minor refinements in layout and visual elements were suggested to further enhance user experience.

The findings affirm that game-based learning activities, when thoughtfully designed and aligned with curricular goals, can significantly enhance mathematics instruction. These tools not only support student learning through engagement and interaction but also assist teachers in delivering lessons more effectively. Furthermore, the study supports existing literature on the positive impact of GBL on student achievement and 21st-century skill development, such as communication, critical thinking, and collaboration.

In conclusion, the developed GBL materials present a viable instructional innovation that can bridge the gap between educational objectives and learner engagement in secondary mathematics classrooms.

Key Words: Game-Based Learning Activities, Collaborative and Interactive Activities in mathematics 9

1. INTRODUCTION

Mathematics education remains a vital component of the secondary school curriculum worldwide due to its essential role in developing students' logical reasoning, problem-solving abilities, and analytical thinking skills (National Council of Teachers of Mathematics NCTM, 2020). However, educators continue to face challenges in effectively engaging students in mathematics classes, often due to traditional teaching methods that emphasize rote memorization and passive learning (Bozkurt & Sharma, 2020). This disengagement can result in poor academic performance, negative attitudes toward mathematics, and increased anxiety among students (Ramirez et al., 2021). To address these challenges, educators and researchers have increasingly explored innovative instructional strategies, including game-based learning, which harnesses interactivity and collaboration to foster deeper engagement and understanding.

Game-based learning (GBL) integrates educational content with game mechanics to create immersive and motivating learning experiences (Wang et al., 2021). In mathematics education, GBL has demonstrated promise in promoting active learning, enhancing motivation, and improving academic outcomes (Zainuddin et al., 2020). The interactive nature of games encourages students to participate actively, practice skills in context, and receive immediate feedback, which supports mastery of mathematical concepts (Alhammad & Moreno, 2021). Moreover, collaborative game-based learning activities facilitate peer interaction, communication, and teamwork, which are essential 21st-century skills (Chen et al., 2022). Through collaboration, students can share diverse problem-solving strategies, clarify misunderstandings, and build collective knowledge (Lai et al., 2020).

Despite the growing interest in GBL, there remains a need for well-designed, curriculum-aligned, and contextually relevant game-based activities specifically for Grade 9 Mathematics. This grade level is pivotal as students encounter more complex topics such as quadratic equations, functions, and geometry, which require higher order thinking and application skills (Department of Education DepEd, 2019). Traditional instructional approaches often fail to provide sufficient engagement and opportunities for collaborative learning in these areas (Huang et al., 2020). Therefore, designing interactive and collaborative game-



based learning activities that align with the Grade 9 Mathematics curriculum can address these gaps by making learning more meaningful and enjoyable.

The present study aims to design and evaluate a set of interactive and collaborative game-based learning activities for Grade 9 Mathematics, intended for use throughout the entire first quarter. These activities include various games such as Equation Tug-of-War, Math Vault Breaker, Mystery Treasure Map, and Math Scavenger Hunt, among others. Each game is designed to incorporate interactivity features that promote student engagement and collaboration, while aligning closely with the Department of Education's curriculum standards. By integrating these activities into classroom instruction, the study seeks to enhance students' academic performance, engagement, and collaboration skills in mathematics.

Research indicates that interactivity is a key factor in effective learning environments, as it facilitates active participation, immediate feedback, and cognitive engagement (Mayer, 2020). In game-based learning, interactivity manifests through problem-solving challenges, decision-making opportunities, and dynamic feedback mechanisms that keep learners motivated (Kiili, 2019). When students are actively engaged, they are more likely to retain knowledge, develop critical thinking skills, and apply concepts in novel situations (Fredricks et al., 2019). Collaborative learning further enriches this process by encouraging students to work together, share ideas, and construct knowledge socially (Vygotsky, 2020). Collaborative game-based activities thus provide a dual advantage by combining the motivational power of games with the cognitive benefits of social interaction.

Several recent studies have demonstrated the positive impact of game-based learning on mathematics achievement and attitudes. For example, Zainuddin et al. (2020) found that students who participated in math games showed significant improvement in problem-solving skills and reported higher motivation compared to those in traditional classrooms. Similarly, Alhammad and Moreno (2021) reported that digital math games enhanced students' conceptual understanding and engagement. Collaborative game-based learning has also been linked to improved communication skills and deeper understanding of mathematical concepts (Chen et al., 2022; Lai et al., 2020). However, many existing studies focus on digital games or isolated activities rather than a comprehensive set of interactive and collaborative games aligned with specific curriculum standards.

Review of Related Literature

This chapter presents the literature and different studies that are related to the present study.

1. Development of Interactive and Collaborative Game-Based Learning Activities in Mathematics

The development of game-based learning (GBL) activities in mathematics education has gained significant attention as an innovative approach to enhance student engagement and learning outcomes. GBL integrates game elements such as competition, collaboration, and interactivity to create learner-centered environments that promote active participation and deeper cognitive processing. According to Yllana-Prieto et al. (2023), game-based learning in mathematics positively influences both the cognitive and affective domains by encouraging problem-solving, collaboration, and self-esteem among learners. They emphasize that the development of such activities should focus on embedding meaningful game elements that stimulate intellectual skills such as knowledge application, analysis, and synthesis, which are critical in mathematics education.

Pan and Ke (2023) highlight that the design and development of digital game-based learning activities must simplify complex mathematical concepts through adaptive scaffolds and immediate feedback. These features not only reduce math anxiety but also cater to diverse learner needs by providing differentiated support. Their research underscores that effective GBL development requires balancing game flow with educational scaffolding to maintain student immersion and motivation. Moreover, the collaborative aspect is enhanced by technology, enabling students to engage in socially shared regulation of learning, which deepens group interaction and accountability.

A meta-analysis by Russo et al. (2023) supports the positive impact of game-based learning development on students' academic achievement in mathematics across various grade levels. Their findings suggest that well-developed game activities, whether digital or nondigital, foster motivation and enjoyment, which are essential for sustained engagement. The study also notes that the development process should consider the educational context, including curriculum alignment and technological readiness, to ensure successful implementation.

Furthermore, Hui and Mahmud (2023) in their systematic review emphasize that the development of GBL activities must address both cognitive skills and affective factors such as motivation, interest, and attitude towards mathematics. They argue that integrating these domains in the design phase leads to more effective learning experiences. Their review also highlights the importance of involving experts and educators in the validation process to refine the activities and enhance their relevance and usability in real classroom settings.

In summary, the development of interactive and collaborative game-based learning activities in mathematics involves careful design that integrates cognitive challenges, adaptive supports, and collaborative features. The process benefits from expert validation and alignment with



curricular goals to maximize educational impact and student engagement.

Statement of the Problem

This study aims to develop interactive and collaborative game-based learning activities for Grade 9 Mathematics and to evaluate their quality and appropriateness through expert validation. Furthermore, it seeks to gather insights from Grade 9 Mathematics teachers regarding the description and potential use of these activities in their classrooms.

Specifically, it seeks to answer the following questions:

1. How may the process of the development of interactive and collaborative game-based learning activities be described in terms of:
 - 1.1 Planning Phase
 - 1.2 Development Phase
 - 1.3 Evaluation Phase
 - 1.4 Finalization Phase
2. How may the developed interactive and collaborative game-based learning activities be evaluated by the teachers and experts in the following:
 - 2.1 Content and Curriculum Relevance
 - 2.2 Interactivity and Engagement
 - 2.3 Usability and design
 - 2.4 Format
3. Is there a significant difference in the evaluation of teachers and experts on the developed interactive and collaborative game-based learning activities in Math 9?
4. What suggestions are offered to further improve the developed interactive and collaborative game-based learning activities in Math 9?

MATERIALS AND METHODS

Research Design

This study employed a developmental research design, specifically a design and development research (DDR) approach, to systematically create and evaluate interactive and collaborative game-based learning activities for Grade 9 Mathematics. Developmental research was appropriate for this study because it focused on the iterative process of designing, developing, and validating educational products or tools to address practical problems in teaching and learning (Richey & Klein, 2007/2020; Ismail, 2020). This approach allowed the researcher to produce a validated instructional resource tailored to the specific needs of Grade 9 learners and the Gabaldon District context.

The research process involved two main phases:

- (1) the development of the game-based learning activities aligned with the Grade 9 Mathematics curriculum, and
- (2) the evaluation of these activities through expert evaluation and teacher feedback.

The first phase engaged subject matter experts, including the Division Education Program Supervisor (EPS) in Mathematics and Mathematics Head Teachers from the

Gabaldon District, who assessed the activities for content accuracy, educational quality, interactivity, collaboration potential, and usability. Their professional insights ensured that the developed activities met pedagogical standards and were appropriate for classroom implementation. Following expert validation, Grade 9 Mathematics teachers from the Gabaldon District were surveyed to describe the activities in terms of their relevance, interactivity, and potential for fostering collaboration in teaching. This descriptive, non-experimental design allowed for a comprehensive evaluation and iterative refinement of the developed materials based on expert and teacher feedback.

Developmental research design was well-suited for this study because it emphasized practical problem-solving through the creation of usable educational tools, combining both design and evaluation in a cyclical process (Richey & Klein, 2020). Moreover, design and development research enabled the integration of theoretical frameworks with real-world application, ensuring that the developed learning activities were grounded in sound instructional principles while remaining responsive to the local educational context (Ismail, 2020). This design also facilitated collaboration with stakeholders—experts and teachers—whose feedback was essential for validating the quality and appropriateness of the learning activities (NU Library, 2020).

In addition, design-based research, a subset of developmental research, highlighted the importance of iterative testing and refinement of instructional tools in authentic learning environments, which aligned with the study's plan to validate and improve the game-based activities through expert and teacher input (Sandoval, 2014, as cited in Lifescied, 2020). This approach ensured that the final product was not only theoretically sound but also practical and effective for classroom use.

In summary, the developmental research design provided a rigorous and systematic framework for producing and validating interactive and collaborative game-based learning activities, ensuring they were pedagogically sound, contextually relevant, and ready for implementation in Grade 9 Mathematics classrooms.

Respondents of the Study

The respondents of this study consisted of Grade 9 Mathematics teachers from selected schools in the Gabaldon District. Specifically, the participants were drawn from Bagting National High School with 2 teachers, Ligaya National High School with 4 teachers, Bagong Sikat Integrated School with 2 teachers, Gabaldon Vocational Agricultural High School (GVAHS) with 5 teachers, and F. Buencamino Sr. Integrated School with 3 teachers. In total, 16 Grade 9 Mathematics teachers participated in providing descriptions and feedback regarding the developed interactive and collaborative game-based learning activities.

In addition to the teachers, the study involved expert validators who evaluated the developed activities for content accuracy, educational quality, interactivity, collaboration potential, and usability. The validators included one Head



Teacher from Gabaldon Vocational Agricultural High School (GVAHS), one Head Teacher from F. Buencamino Sr. Integrated School, one Head Teacher from Ligaya National High School, and one Division Education Program Supervisor (EPS) in Mathematics.

Altogether, the study engaged a total of 20 participants, comprising both the respondents and validators, to ensure the developed learning activities were pedagogically sound and contextually appropriate for implementation in Grade 9 Mathematics classrooms.

Instrumentation

The primary instrument for data collection in this study was a researcher-made questionnaire designed to gather expert evaluation and teacher feedback on the developed interactive and collaborative game-based learning activities for Grade 9 Mathematics. The questionnaire was carefully constructed to evaluate the quality and effectiveness of the learning activities across several key domains.

The instrument began with a section that collected demographic information such as name (optional), school, designation, sex, age, years in teaching, and highest educational attainment. Clear instructions were provided to guide respondents in completing the questionnaire accurately.

A 4-point rating scale was used throughout the questionnaire, with the following descriptors: 4-Very Satisfactory, 3-Satisfactory, 2 - Fair, 1 - Poor

This scale allowed respondents to provide nuanced feedback on various aspects of the learning activities, enabling precise evaluation of their quality and impact.

The questionnaire was organized into key domains, starting with Content and Curriculum Relevance. Items in this domain assessed the alignment of the activities with the Grade 9 Mathematics curriculum, clarity and achievement of learning objectives, promotion of critical thinking and problem-solving skills, accuracy and comprehensiveness of mathematical concepts, integration of real-life applications, accommodation of diverse learner abilities, and logical progression of topics. Each item was designed to measure a specific aspect of the game-based learning activities, ensuring clarity and focused responses.

To ensure content validity, the questionnaire was reviewed by experts from Araullo University for relevance, clarity, and appropriateness.

Procedures

the research instruments, the researcher sought formal permission from the Schools Division Superintendent to conduct the study within the Gabaldon District. Following this, approval was requested from the District Supervisor and the principals of the selected schools to ensure cooperation and support during data collection.

The questionnaire was administered to the Grade 9 Mathematics teachers and expert validators either through an online platform or in a paper-based format, depending on the accessibility and preference of the respondents. Online administration was preferred where possible, as it

streamlined data collection, reduced paper use, and allowed for efficient monitoring of response rates (Education Nebraska, 2017).

Statistical Treatment

Data gathered were processed, tabulated, and interpreted using the following statistical tools:

1. Frequency Counts. Frequency distribution was utilized to show the difference in assessment results before and after using the learning material. The data were tallied and counted to arrive at a frequency distribution organized into tables.
2. Percentage. Percentage was used to establish or to compare the proportion of frequencies or responses to the total number of responses.
3. T-Test. T-test was used to determine the difference of the scores before and after utilizing the supplementary learning material.
4. Weighted Mean. Weighted mean was used to determine how the teacher participants evaluated the supplementary learning material.
5. Likert Scale. The following qualitative description, including the Likert Scale was adapted to quantify the responses of each indicator.

RESULTS

This section presents the analysis and interpretation of the data gathered from the respondents of the study.

1. Teachers' and Experts' Evaluation on the Developed Interactive and Collaborative Game-based Learning Activities in Math 9



	Teachers		Experts	
	wm	Verbal Description	wm	Verbal Description
Content and Curriculum Relevance	3.69	Very Satisfactory	4.00	Very Satisfactory
1. The game-based activities are aligned with the mathematics 9 curriculum.	3.75	Very Satisfactory	3.75	Very Satisfactory
2. The learning objectives are clearly stated and achieved through the activities.	3.63	Very Satisfactory	4.00	Very Satisfactory
3. The content promotes critical thinking and problem-solving skills.	3.63	Very Satisfactory	3.75	Very Satisfactory
4. The mathematical concepts are presented accurately and comprehensively.	3.63	Very Satisfactory	3.75	Very Satisfactory
5. The activities integrate real-life applications of mathematical concepts.	3.31	Very Satisfactory	3.50	Very Satisfactory
6. The content caters to a range of learner abilities.	3.50	Very Satisfactory	3.75	Very Satisfactory
7. The progression of topics is logical and well-structured.	3.59	Very Satisfactory	3.79	Very Satisfactory
Average wm				
Interaction and Engagement	3.63	Very Satisfactory	3.50	Very Satisfactory
1. The activities can actively engage students in the learning process.	3.69	Very Satisfactory	3.75	Very Satisfactory
2. The games can encourage student participation and collaboration.	3.44	Very Satisfactory	3.75	Very Satisfactory
3. The materials promote sustained student interest and motivation.	3.44	Very Satisfactory	3.75	Very Satisfactory
4. Students can easily follow the rules and mechanics of the games.	3.50	Very Satisfactory	3.50	Very Satisfactory
5. The activities foster a sense of competition and teamwork.	3.44	Very Satisfactory	3.75	Very Satisfactory
6. The game-based format maintains attention	3.52	Very Satisfactory	3.67	Very Satisfactory
Average wm				
Usability and Design	3.63	Very Satisfactory	3.25	Very Satisfactory
1. The interface/design of the learning materials is visually appealing.	3.75	Very Satisfactory	3.75	Very Satisfactory
2. Instructions are clear and easy to understand.	3.50	Very Satisfactory	3.50	Very Satisfactory
3. The materials are user-friendly and accessible for students.	3.56	Very Satisfactory	3.50	Very Satisfactory
4. The activities can be implemented effectively in a classroom setting.	3.50	Very Satisfactory	3.50	Very Satisfactory
5. The layout and organization support ease of use.	3.50	Very Satisfactory	3.25	Very Satisfactory
6. Visual elements support comprehension of the content.	3.57	Very Satisfactory	3.46	Very Satisfactory
Average wm				

Format	3.69	Very Satisfactory	3.50	Very Satisfactory
A. Text				
1. Size of letter is appropriate to intended user	3.69	Very Satisfactory	3.75	Very Satisfactory
2. Spaces between letters and words facilitate reading	3.69	Very Satisfactory	3.50	Very Satisfactory
3. Font is easy to read	3.69	Very Satisfactory	4.00	Very Satisfactory
B. Illustrations				
1. Simple and easily recognizable	3.56	Very Satisfactory	3.75	Very Satisfactory
2. Clarify and supplement the text	3.69	Very Satisfactory	3.75	Very Satisfactory
3. Realistic / appropriate colors	3.63	Very Satisfactory	3.75	Very Satisfactory
4. Attractive and appealing	3.69	Very Satisfactory	3.50	Very Satisfactory
5. Culturally relevant	3.63	Very Satisfactory	3.75	Very Satisfactory
C. Design and Layout				
1. Attractive and pleasing to look at	3.56	Very Satisfactory	3.75	Very Satisfactory
2. Simple (i.e. does not distract the attention of the reader)	3.56	Very Satisfactory	3.75	Very Satisfactory
3. Adequate illustration in relation to text	3.63	Very Satisfactory	3.75	Very Satisfactory
4. Harmonious blending of elements (e.g. illustrations and text)	3.64	Very Satisfactory	3.71	Very Satisfactory
Average wm	3.69	Very Satisfactory	4.00	Very Satisfactory

Legend: 1.00-1.74 - Poor; 1.75-2.49 - Fair; 2.50-3.24 - Satisfactory; 3.25-4.00 - Very Satisfactory

DISCUSSION

The study's findings demonstrate that the developed interactive and collaborative game-based learning activities in Mathematics 9 are highly effective in enhancing student engagement, motivation, and academic achievement. Both teachers and experts rated the activities as "Very Satisfactory" across multiple dimensions, including content relevance, instructional design, usability, and learner engagement. This aligns with recent empirical evidence indicating that GBL improves cognitive outcomes such as mathematical performance and reasoning, as well as affective outcomes like reduced math anxiety and increased student motivation (Theobald, 2024; Yllana-Prieto et al., 2023).

The integration of interactive and collaborative elements within the game-based activities supports active learning and social interaction, which are critical for deeper understanding and retention of mathematical concepts. Research shows that such collaborative GBL approaches yield higher learning gains compared to individual learning methods and foster productive teamwork and communication skills (Karakoç et al., 2020; Feng et al., 2024). Moreover, the use of technology in GBL facilitates adaptive scaffolding and immediate feedback, which caters to diverse learner needs and maintain engagement without disrupting the flow of learning (Pan & Ke, 2023).



Category	School/Institution	Teachers
Mathematics Teachers	Bagting National High School	2
	Ligaya National High School	4
	Bagong Sikat Integrated School	2
	Gabalidon Vocational Agricultural High School	5
	F.Buencamino Sr. Integrated School	3
	Division Education (EPS) in Mathematics	
		16
Total		20

Chart -1: Distribution of Teacher and Expert Respondents
1. Significant Difference Between Teachers’ and Experts’ Evaluation on Development and Evaluation of Game-Based Learning Activities in Mathematics 9

	F	Sig	Verbal Interpretation
Content and Curriculum Relevance	0.796	0.383	Not Significant
Interactivity and engagement	0.387	0.541	Not Significant
Usability and Design	0.255	0.619	Not Significant
Format	0.079	0.781	Not Significant

There is no significant difference between teachers’ and experts’ evaluation of Interactive and Collaborative Game-based Learning Activities in Math 9.

The results in the table indicate that for all four factors—Content and Curriculum Relevance, Interactivity and Engagement, Usability and Design, and Format—the F-values are low, and the significance (Sig) values are all well above the conventional alpha level of 0.05. Specifically, the Sig values range from 0.383 to 0.781, and each verbal interpretation is “Not Significant.” This means that there is no statistically significant difference between the evaluations given by teachers and those given by experts for any of the measured aspects of the game-based learning activities. This finding demonstrates a strong consensus between classroom practitioners and subject matter experts regarding the quality and effectiveness of the developed materials. Both groups recognize the value of the activities in terms of content alignment, engagement, usability, and format. The lack of significant difference suggests that the materials are not only theoretically sound but also practical and relevant in real classroom settings.

1. CONCLUSIONS

1. The process of developing the interactive and collaborative game-based learning activities for Grade 9 Mathematics is systematically described through four

phases: planning, development, evaluation, and finalization. Each phase contributes to creating materials that are well-aligned with curricular goals and responsive to learner needs, ensuring a structured and effective development approach.

2. The developed activities are evaluated by both Grade 9 Mathematics teachers and experts across four key dimensions: content and curriculum relevance, interactivity and engagement, usability and design, and format. Both groups rate the activities as “Very Satisfactory,” indicating that the materials are appropriate, engaging, user-friendly, and visually effective for classroom use.

3. Statistical analysis shows no significant difference between the evaluations of teachers and experts regarding the quality and appropriateness of the developed game-based learning activities. This consensus validates the reliability of the materials and supports their practical applicability in diverse educational settings.

4. Teachers and experts offer constructive suggestions to further improve the activities, including enhancing adaptive scaffolding, integrating reflective components, managing time effectively, differentiating difficulty levels, and increasing real-life contextualization. These recommendations provide valuable guidance for continuous refinement to maximize the learning impact of the game-based activities.

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BIOGRAPHIES (Optional not mandatory)