G.A.M.E.S.: Gamification and Mathematics Education Synergy

Neil Arden B. Sotto[1]
Public Secondary Mathematics Teacher, Department of Education, Philippines

Ma. Janet S. Geroso[2]
Northern Negros State College of Science and Technology
Program Head MAED & PhD-EM, Philippines

Heide S. Hofileña[3]
Public School District Supervisor, Department of Education, Philippines

Princess Jeah Marie S. Geroso[4]
Northern Negros State College of Science and Technology
Program Head MPA & DPA, Philippines

Guarin S. Maguate [5]
Public Secondary Science Teacher, Department of Education, Philippines
*Corresponding Author

Abstract

Filipino learners have been left behind in terms of Mathematics education, scoring below the lowest level of proficiency in the Programme for International Student Assessment (PISA) in 2018. In response to the challenges in teaching Mathematics and the apparent decline in Mathematics proficiency, teachers seek new approaches to motivate learners and improve academic performance. One such approach is integrating games into the learning process. The process of Gamification has become one of the most popular concepts and innovative instruction implemented in the field of education to motivate and engage student learning. The purpose of this study is to develop non-digital gamified instructional materials and test its effectiveness in improving academic performance in Mathematics. This study employed a quasi- experimental research design using the developed gamified instructional materials as intervention. Purposive sampling was used to determine the respondents which resulted in 32 learners. Findings revealed that academic performance in Mathematics of the respondents improved significantly after exposure to the gamified instructional materials. This study concluded then that the use of the developed gamified instructional materials and activities marked a highly significant difference in the level of academic performance in Mathematics. Thus, the developed gamified instructional materials and activities effectively improved academic performance in Mathematics. These findings further solidifies the gamification approach's effectiveness in improving learning engagement, and games generally have an overall positive effect in enhancing engagement and motivation.

Keywords: Games in Mathematics Education, Gamification, Gamified Instructional Materials, Non-digital Gamification

Introduction

Individuals learn in various learning environments and academic experiences. Some flourish in traditionally prepared settings, while others thrive in an open environment (Santos et al., 2022). The conventional method for learning mathematics is a repetitive and boring task. To motivate the learners in this tedious duty, teachers try to find new approaches to integrate entertainment into the educational process (Rebollo et al., 2022). Games are excellent forms of entertainment. They are primarily known for their ability to engage and excite. When playing games, people commonly experience mastery, competence, enjoyment, immersion, or flow, all characteristics of intrinsically motivated human behavior. An essential aspect of playing games is the self-purposeful nature of the activity, as well as the engagement and enjoyment of the action (Koivisto & Hamari, 2019). Games are a crucial aspect of human culture and society and promote motivation and engagement (Zainuddin et al., 2020). They utilize several mechanisms that encourage people to engage with them, regardless of the presence of a rewards system, just for the joy of playing and the possibility of winning. Gamification is the application of game features into non- game contexts to promote motivation and engagement in learning (Alsawaier, 2018). The process of gamification utilizes the usage of game-based mechanics, aesthetics, and game- thinking to engage people, motivate action, promote learning, and solve problems. Gamification is like turning life and learning activities into a fun game. By utilizing game-like activities as part of the learning method, learning tasks become infused with enjoyment. The concept employs

game mechanics or game elements in non-gaming systems to raise learner motivation with a fun competition (Zainuddin & Keumala, 2021).

There is growing evidence to suggest that Gamification is increasingly accepted as an effective learning strategy used to create highly engaging learning experiences (Zainuddin et al., 2020). Education is a mechanism that allows students to acquire knowledge and develop skills, being a fundamental factor in the development of human beings and society. However, not all people learn in the same way or at the same rate. With the appearance of emerging technologies, such as Gamification, innovative pedagogical practices have developed, promoting flexibility and active learning. Gamification is a strategy used primarily to motivate to perform tasks that a priori can appear little fun (ACOSTA- MEDINA et al., 2020). Gamification in the educational sphere is understood as a learning technique that uses elements from games and, or computer games in non-recreational environments, with its main objective being to create behavioral patterns or to encourage certain behaviors in students (Arufe et al., 2022). The rapid rate of Gamification adoption and the use of game elements in education have numerous effects on learner outcomes and engagement. The concept of Gamification has encouraged an insightful number of studies in trying to understand its application in education and all spheres of life (Ofosu-Ampong, 2020). Gaming mechanics are increasingly transferred to generally game-free contexts, such as primary and secondary school education to promote desired motivational, behavior, and learning outcomes (Zainuddin et al., 2020). Gamification has the potential to improve academic performance because it provides a variety of learning opportunities by incorporating different elements into the game. It increases the capacity for remembrance, improves attention, and motivates students to increase their efforts to comprehend concepts and content (ACOSTA-MEDINA et al., 2020). Gamification is typically implemented digitally. Gamification studies have mainly focused on digital modes, which often require gamified digital platforms or applications. However, digital Gamification is not always possible because of limited resources and logistical problems. It is thus necessary to explore low-threshold and easy-to-adopt Gamification methods in classrooms. One such method is non-digital Gamification using physical game design elements. Both non- digital and mixed (i.e., a combination of digital and non-digital) Gamification approaches led to a similar improvement in learning achievement (Qiao et al., 2022). In this context, the researchers were motivated to develop non-digital gamified instructional materials and test its effectiveness on academic performance in Mathematics.

Methods

Research Design. This study is focused on the development and field testing of the gamified class instructional materials for Grade seven students. In the field testing of the gamified materials, the Quasi-Experimental Design, specifically the Pre and Post Nonrandom Design, was utilized.

Materials Development. In designing, developing, and validating these gamified instructional materials, the proponent adapted Johnson's Systems of Material Design Model. The model consists of three phases, the design phase, the development phase, and the evaluation phase.

Design Phase. Researching existing games and game elements was the first stage in the design phase. The purpose of the research was to seek out games or game elements that can be used to gamify instructional materials in Mathematics 7. Likewise, the survey of the games and game elements gave the proponent ideas and information about the possible format, game mechanics, and style of presenting the gamified instructional material. After thoroughly examining different games and game elements from various sources, the format, game mechanics, and styles were determined. The selected game and game elements were made content-appropriate for the target Most Essential Learning Competencies (MELCs) set by the Department of Education for the 3rd Quarter in Grade 7 Mathematics before including them in the final draft of the gamified instructional material. The researcher also included drawings and illustrations to boost visual aesthetics and make the materials age-appropriate. Some of the browsed games and game elements were adapted and or modified by the proponent.

Development Phase. Examination of the different existing games and game elements helped in determining the format adopted in the development of the gamified instructional materials. The development of the gamified activities was based mainly on the mechanics of existing games and game elements before making it content-appropriate for target MELCs. The researcher modified some of the gamified activities browsed to make the game mechanics simple and age-appropriate. The practicality of the implementation of the gamified material as well as its applicability in real-life situations was also taken into consideration. Relevant graphics and illustrations were also included for the gamified activities to make them more appealing to Grade 7 students and maximize the effect of the materials on their academic performance in Mathematics through increasing motivation and engagement. After the development stage, the researcher presented the gamified instructional materials to experts for evaluation.

Evaluation Phase. The prepared gamified instructional materials were subjected to evaluation and validation by identified evaluators considered for their expertise in the field of Mathematics and Learning Resources

Management and Development Systems (LRMDS). Expert evaluators were chosen by designation, specifically in Learning Resources Management and Development Systems (LRMDS).

Respondents of the Study. The respondents were 32 grade- seven learners of Dr. Vicente F. Gustilo Memorial National High School – Daga Extension for the school year 2022-2023. Purposive sampling was used to select one out of three sections for the experiment. Purposive sampling, also called deliberate sampling, is a type of sampling where the researcher determines the members of a sample according to the purpose of the study. The reason for purposive sampling   is the better matching of the sample to the aims and objectives of the research, thus improving the study's rigor and the trustworthiness of the data and results.

Research Instrument. This study utilized the developed gamified instructional materials as intervention, and the researcher-made 40-item test to determine the respondents' academic performance in Mathematics. The developed gamified instructional materials underwent evaluation by Learning Resource experts on set criteria for Printed Resources for its acceptability. The researcher-made test underwent a validity test using Cohen and Wollack criteria for multiple-choice tests and a reliability test using the Kuder- Richardson Formula21.

Data Gathering Procedure. With the approval of the Schools Division Superintendent, through the School Head, to conduct the study, the researchers conducted the experiment all throughout the third quarter targeting specific Most Essential Learning Competencies (MELCs) set by the Department of Education. The developed gamified instructional materials were used in classroom instruction and the researcher-made test was used to determine academic performance in Mathematics before and after the experiment.

Data Analysis. In achieving the objectives of the study, the data obtained from the questionnaires were analyzed using inferential statistics. In order to identify the level of academic performance in Mathematics, mean and standard deviation were used. To determine significant difference in the level of academic performance in Mathematics before and after the experiment, t-test for paired samples was employed.

Results and Discussion

This section presents the gathered data concerning the specific problems and hypotheses outlined in this study using tabular presentation. It consists of findings such as the Level of Academic Performance in Mathematics before and after the experiment and the difference in the Level of Academic Performance in Mathematics before and after the experiment.

Table 1.1: *Level of Acceptability of the Developed Gamified Instructional Materials in terms of Content*

Content	Weighted Mean	Verbal Interpretation
1. Content is suitable to the student's level of development	4.00	Very Satisfactory
2. Material contributes to the achievement of specific objectives of the subject area and grade/year level for which it is intended	4.00	Very Satisfactory
3. Material provides for the development of higher cognitive skills such as critical thinking, creativity, learning by doing inquiry, problem solving, etc.	4.00	Very Satisfactory
4. Material is free of ideological, cultural, religious, racial, gender biases and prejudices		Very Satisfactory
5. Material enhances the development of desirable values and traits such as: Pride in being a Filipino, Scientific attitude and reasoning, Desire for excellence, Love for country, Helpfulness/Teamwork/Cooperation, Unity, Desire to learn new things, Honesty and trustworthiness, Ability to know right from wrong, Respect, Critical and creative thinking and Productive	4.00	Very Satisfactory
6. Material has the potential to arouse interest of target reader	4.00	Very Satisfactory

7. Adequate warning/cautionary notes are provided into pics and activities where safety and health are of concern	4.00	Very Satisfactory
Composite Mean	4.00	Very Satisfactory
Sum of Weighted Means	27	PASSED

Table 1.1 presents the level of acceptability of the developed gamified instructional materials as evaluated by the learning resource evaluators with respect to Content. There are seven criteria to evaluate the Content of the advanced instructional materials, as seen in the table. It can verify that the created materials were subjected to a thorough assessment. A composite mean of 3.86 is interpreted as the developed material having Very Satisfactory acceptability in terms of content. Findings show that the gamified materials scored four on all but one criterion. A sum of 27 out of 28 points for Content means that the material has passed the evaluation for this criterion. The findings suggest that the educational materials' contents were both essential and appropriate for the student's level, as well as relevant to their day-to-day activities.

Table 1.2: *Level of Acceptability of the Developed Gamified Instructional Materials in terms of Format*

Prints	Weighted Mean	Verbal Interpretation
1. Size of the letters is appropriate to the intended user	4.00	Very Satisfactory
2. Spaces between letters and words facilitate reading.	4.00	Very Satisfactory
3. Font is easy to read.	4.00	Very Satisfactory
4. Printing is of good quality (i.e., no broken letters, even density, correct alignment, properly placed screen registration)	4.00	Very Satisfactory

Illustrations	Weighted Mean	Verbal Interpretation
1. Simple and easily recognizable	4.00	Very Satisfactory
2. Clarify and supplement the text	4.00	Very Satisfactory
3. Properly labelled or captioned (if applicable)	4.00	Very Satisfactory
4. Realistic/appropriate colors	4.00	Very Satisfactory
5. Attractive and appealing	4.00	Very Satisfactory
6. Culturally relevant	4.00	Very Satisfactory

Design and Layout	Weighted Mean	Verbal Interpretation
1. Attractive and pleasing to look at	4.00	Very Satisfactory
2. Simple (i.e., does not distract the attention of the reader)	4.00	Very Satisfactory
3. Harmonious blending of elements (e.g., illustrations and text)	4.00	Very Satisfactory

Paper and Binding	Weighted Mean	Verbal Interpretation
1. Paper used contributes to easy reading	4.00	Very Satisfactory
2. Durable binding to withstand frequent use	4.00	Very Satisfactory

Size and Weight of Resource	Weighted Mean	Verbal Interpretation
1. Easy to handle	4.00	Very Satisfactory
2. Relatively light	4.00	Very Satisfactory
Composite Mean	4.00	Very Satisfactory
Sum of Weighted Means	68	PASSED

Table 1.2 presents the level of acceptability of the developed gamified instructional materials evaluated by Learning Resource experts concerning their Format in terms of Prints, Illustrations, Design and Layout, Paper and Binding, and Size and Weight of Resources. The result showed a composite mean of 4.00 which means that the Format of the developed gamified instructional materials has Very Satisfactory acceptability. Sixty-eight (68) points for the Format passed the evaluation for this criterion. They view this aspect as: "printing is good quality (i.e., no broken letters, even density, correct alignment, properly placed screen registration." An overall mean of 4.0 for this criterion means that the teacher is receptive to the required format for the printed materials utilized in the classroom. As a result, the developed gamified instructional materials used clear, straightforward language that appeals to the learners understanding.

Table 1.3: *Level of Acceptability of the Developed Gamified Instructional Materials in terms of Presentation and Organization*

Presentation and Organization	Weighted Mean	Verbal Interpretation
1. Presentation and engaging interesting, and understandable	4.00	Very Satisfactory

2. There is logical and smooth flow of ideas	4.00	Very Satisfactory
3. Vocabulary level is adapted to target reader's likely experience and level of understanding	4.00	Very Satisfactory
4. Length of sentences is suited to the comprehension level of the target reader	4.00	Very Satisfactory
5. Sentences and paragraph structures are varied and interesting to the target reader	4.00	Very Satisfactory
Composite Mean	4.00	Very Satisfactory
Sum of Weighted Means	20	PASSED

Table 1.3 presents the level of acceptability of the developed gamified instructional materials evaluated by Learning Resource experts concerning their Presentation and Organization. All criteria earned a rating of 4.00 which interprets as very satisfactory. The result showed a composite mean of 4.00 which means that the overall Presentation and Organization of the developed gamified instructional materials have Very Satisfactory acceptability.

A sum of 20 points for the Presentation and Organization passed the evaluation for this criterion. These findings imply that the advanced gamified instructional materials are engaging, interesting, and understandable. Sentence structures and choice of words are suited for the level of comprehension of the target readers and in a manner that captures their interests.

Table 1.4: *Level of Acceptability of the Developed Gamified Instructional Materials in terms of Accuracy and Up-to-datedness of Information*

Accuracy and Up-to-datedness of Information	Weighted Mean	Verbal Interpretation
1. Conceptual errors	4.00	Very Satisfactory
2. Factual errors	4.00	Very Satisfactory
3. Grammatical errors	4.00	Very Satisfactory
4. Computational errors	4.00	Very Satisfactory
5. Obsolete information	4.00	Very Satisfactory
6. Typographical and other minor errors (e.g., inappropriate, or unclear illustrations, missing labels, wrong captions, etc.)	4.00	Very Satisfactory
Composite Mean	4.00	Very Satisfactory
Sum of Weighted Means	24	PASSED
Overall Mean	3.97	Very Satisfactory

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Table 1.4 presents the level of acceptability of the developed gamified instructional materials evaluated by Learning Resource experts concerning their Accuracy and Up-to-datedness of Information. All criteria earned a rating of 4.00 which interprets as very satisfactory. The result showed a composite mean of 4.00 which means that the overall Accuracy and Up-to-datedness of Information of the developed gamified instructional materials have Very Satisfactory acceptability. A sum of 24 points for the Presentation and Organization passed the evaluation for this criterion. These findings imply that the developed gamified instructional materials are free of conceptual, factual, grammatical, computational, typographical, and other minor errors. The materials are also up-to-date and free from obsolete information. The overall mean is the mean value for all four major factors of the LR Evaluation Tool. An overall mean of 3.97 means that the advanced gamified instructional materials have very good acceptability.

Table 2: Level of Academic Performance in Mathematics of Grade 7 Students in the Pretest and Posttest

Variables	N	Mean	Standard Deviation	Verbal Interpretation
Pretest	32	13.88	3.957	Low
Posttest	32	22.09	6.836	Average

Table 2 shows the level of academic performance in Mathematics of Grade 7 students in the pretest and posttest. The pretest result showed a standard deviation of 3.957 and a mean of 13.88 interprets as low. The posttest result shows a standard deviation of 6.836 and a mean of 22.09 interprets as average.

Table 3: Comparison of Pretest and Posttest Performance in Mathematics of the Respondents

Variables	Std. Deviation	Mean	Df	Comp. t	P	Verbal Interpretation
Pretest	3.957	13.88				Highly
Posttest	6.836	22.09	31	-7.901	.000	Significant

Table 3 reflects the difference in the level of academic performance in Mathematics of the Grade 7 students in the pretest and posttest. As shown in Table 3, there is a highly significant difference in the level of academic performance in Mathematics of Grade 7 students in the pretest and posttest. Because the p-value of .000 is connected with the t-value being lower at the 0.05 level, it will reject the hypothesis in the learners' performance before and after exposure to the developed gamified instructional materials. The result of the posttest implies that the exposure of the Grade 7 students to the advanced gamified learning materials and activities caused significant improvements in selected competencies throughout the experiment.

As a result of the findings, it can be concluded that learners' performance improves once they are exposed to gamified instructional materials. As a result, the instructional materials are also practical learning resources for Grade 7 students. It is similar to Arufe's (2022) study on the influence of Gamification on academic performance, which found that students exposed to a Gamified Learning Environment (GLE) had statistically significant improvement in the group's participation and had a higher academic performance. Similarly, in Chang's (2015) study, results indicate that students in the game intervention group showed higher mathematics proficiency than those in the paper-and-pencil control group.

Conclusions

It is concluded that the use of the developed gamified instructional materials and activities marked a highly significant difference in the level of academic performance in Mathematics of the respondents during the pretest and posttest. Thus, the developed gamified instructional materials and activities effectively improved academic performance in Mathematics. These findings further solidified the gamification approach's effectiveness in improving learning engagement, and games generally have an overall positive effect in enhancing engagement and motivation.

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