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Effects of Flipped Learning with Gamification in Mathematics Performance of Grade 7 Students

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Abstract
Aim: This study aimed to investigate the effects of flipped learning combined with gamification on the mathematics performance of Grade 7 students. Specifically, it sought to examine whether the integration of instructional video lessons with gamified elements such as leaderboards, badges, and points could improve learners' engagement and academic outcomes in mathematics.
Methodology: A quasi-experimental research design was employed, involving 54 Grade 7 students from New Era High School, Quezon City. Two groups were formed: the experimental group was exposed to flipped learning using the EdPuzzle app and classroom gamification elements, while the control group received traditional instruction. A 50-item validated post-test aligned with the Department of Education competencies was used to measure student performance. Statistical tools such as mean, standard deviation, t-tests, and percentage distributions were used for data analysis.
Results: The findings revealed a significant improvement in the mathematics performance of students in the experimental group compared to the control group. Post-test results showed that students who experienced flipped learning with gamification moved from below average to average proficiency, while the control group remained largely at the below average level. Additionally, students demonstrated greater engagement and enthusiasm for learning mathematics through the use of interactive video lessons and gamified activities.
Conclusion: The results of the study conclude that flipped learning with gamification is an effective instructional strategy for improving the mathematics performance of Grade 7 students. While the control group, which received traditional instruction, consistently scored below average in both pre-test and post-test assessments, the experimental group demonstrated a significant improvement in their post-test scores after exposure to the gamified flipped learning approach. The initial equivalence in pre-test scores between both groups confirms that the improvement observed was due to the intervention. These findings highlight the positive impact of integrating technology-driven strategies—such as EdPuzzle, badges, points, and leaderboards—on student engagement and academic performance. Therefore, educators are encouraged to adopt innovative teaching methods like flipped learning with gamification to enhance learning outcomes, especially in subjects like mathematics that students often find challenging.

Keywords: flipped learning, gamification, Ed Puzzle, engagement, mathematics performance

INTRODUCTION

The widespread availability of the internet and technology has significantly transformed education, conventional in-person sessions continue to be the norm, although online distance learning is gaining popularity (DeLozier & Rhodes, 2017). Xie et al. (2020) describes that online education is a flexible, electronic-based learning model that utilizes computers, smartphones, and other devices to deliver instruction, allowing dedicated and motivated learners to excel. This model supports the flipped classroom framework, where teachers adapt their

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strategies to help students balance daily routines and work commitments, thereby enhancing productivity and resource optimization (Dichev & Dicheva, 2017).

Extensive research has shown that gamification—incorporating game elements like rankings, badges, leaderboards, and points into non-game settings—can effectively increase student enthusiasm and commitment (Kapp, 2012; Deterding et al., 2011; Seaborn & Fels, 2015). Gamification aims to make learning enjoyable and engaging, transforming tedious tasks into interactive activities (Cunningham & Zichermann, 2011; Deterding et al., 2011). The concept of gamified motivation includes both extrinsic incentives (e.g., awards, recognition) and intrinsic factors (e.g., enjoyment, satisfaction) (Ryan & Deci, 2000). Studies have demonstrated that gamification strategies enhance participant satisfaction and sustain motivation over time (Cunningham & Zichermann, 2011; Nah et al., 2014).

The flipped classroom paradigm fundamentally changes conventional education by integrating technological resources and promoting problem-solving skills and peer-assisted learning (Abeysekera & Dawson, 2015; Bishop & Verleger, 2013; Lin & Hwang, 2018b). Based on the research conducted by (Bishop & Verleger, 2013; Lin and Hwang, 2018; Lo & Hew, 2017) instructors may optimize the time dedicated to student-centered activities in class by watching instructional videos prior to the class. This model, within the broader category of blended learning, is particularly effective for self-motivated students and allows educators to cater to students' schedules while fulfilling academic requirements (Dichev & Dicheva, 2017; Staker & Horn, 2012; Tucker, 2012).

Utilizing gamified flipped learning is an effective method for increasing student engagement and enthusiasm in subjects that they may not often find interesting or challenging. This approach is particularly effective in situations where students may benefit from customized and interactive learning experiences that improve their ability to understand advanced ideas and solving real-life issues (Lo & Hew, 2017; Kapp, 2012). This approach is also useful when educators aim to foster a more active learning environment, where students are encouraged to participate and collaborate more deeply during in-class activities (Bishop & Verleger, 2013; Dichev & Dicheva, 2017).

Although there has been research on using gamification to enhance students' arithmetic performance (Lanuza, 2020), limited studies are available on flipped classrooms with gamification (Dichev & Dicheva, 2017). Further research is needed to examine the design and execution of flipped learning and gamification (Song et al., 2017; Abeysekera & Dawson, 2015). To address these research gaps, this study first establishes a theoretical foundation to support the flipped learning model. It then examines the effectiveness of flipped learning with gamification on the mathematics performance of Grade 7 students. A quarter-long enrichment course employing flipped learning with gamification was conducted. The general objective of the study is to determine the effect of flipped learning with gamification in mathematics performance of Grade 7 students.

Objectives

The general objective of the study is to determine the effects of flipped learning with gamification in mathematics performance of Grade 7 students at the New Era High School.

Specifically, it sought to answer the following research questions:

1. What is the mathematics performance of the control group based on the pre-tes and post-test score?
2. What is the mathematics performance of the experimental group based on the pre-test and post-test score?
3. Is there any significant difference in mathematics performance between the control group and the experimental group in their pre-test scores?
4. Is there any significant difference in the mathematics performance between the pre-test and post-test scores of the control group?
5. Is there any significant difference in the mathematics performance between the pre-test and post-test scores of the experimental group?
6. Is there any significant difference in mathematics performance between the control group and the experimental group in their post-test scores?

Hypotheses

The hypothesis is tested with the level of significance of 0.05.

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Hypothesis 1: There is no significant difference in the mathematics performance between the control group and the experimental group in their pre-test scores.
Hypothesis 2: There is no significant difference in the mathematics performance between the pre-test and post-test scores of the control group.
Hypothesis 3: There is no significant difference in the mathematics performance between the pre-test and post-test scores of the experimental group.
Hypothesis 4: There is no significant difference in the mathematics performance between the control group and the experimental group in their post-test scores.

METHODS

Research Design

A quasi-experimental non-equivalent group design with post-test experimental and control groups was utilized. The experimental group engaged in a learning environment enriched with gamified elements during in-class activities, while the control group participated in non-gamified activities. This design was chosen due to its suitability for establishing a causal relationship between the independent variable (flipped learning with gamification) and the dependent variable (mathematics performance), particularly when random assignment is impractical due to ethical or practical constraints.

Population and Sampling

The study involved a total population of 60 Grade 7 students from the School of Division in Quezon City. Using Cochran's sample size formula, a total sample size of 54 students was determined. The participants were selected from two sections based on their comparable second-quarter math grades, which ensured an equitable distribution of students with similar academic backgrounds across the chosen sections. This method enhanced the reliability and precision of the study's results.

Instrument

To assess the mathematics performance of Grade 7 students before and after the intervention, a 50-item researcher-made posttest was used. The test was based on competencies designed by the Department of Education, ensuring alignment with required learning outcomes. A table of specifications was created to ensure the test's coherence with these competencies.

The test underwent content validation by experts, including a department head, a master teacher, and a year-level coordinator in mathematics. Their recommendations were incorporated into the final version of the test. To ensure reliability, pilot testing was conducted with 30 participants, and the reliability coefficient (Cronbach's alpha) was found to be greater than 0.70, indicating good reliability.

Data Collection

The study was conducted in three phases: pre-experimental, experimental, and post-experimental. Initially, ethics clearance was secured from the appropriate review board. Permission to conduct the study was then obtained from the Office-In-Charge and the Assistant Schools Division Superintendent of Quezon City through the principal of New Era High School.

During the experimental phase, the experimental group utilized the EdPuzzle application along with gamification elements, including badges, leaderboards, experience points, avatars, and ranking. In contrast, the control group followed traditional teaching methods. The posttest was administered to both groups after the intervention to measure the effects of flipped learning with gamification on their mathematics performance.

Treatment of Data

The data gathered from the tests were recorded, analyzed, and interpreted using the following statistical tools:

1. Frequency and Percentage Distribution: Used to summarize the distribution of values and calculate the overall percentage of respondents.
2. Mean: Calculated to determine the level of proficiency in the performance of both the conventional method and flipped learning with gamification as part of the post-test intervention.

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3. Independent Samples T-Test: Applied to compare the means of the experimental and control groups to determine if there were significant differences between them.
4. Paired Samples T-Test: Used to compare the means within the same group at different times (e.g., before and after the intervention) to assess the effectiveness of the treatment.

Ethical Considerations

The researcher ensured that all research protocols involving ethics in research were complied with for the protection of all people and institutions involved in the conduct of the study.

RESULTS and DISCUSSION

This section presents the results of the study, focusing on the effects of flipped learning with gamification on the mathematics performance of Grade 7 students. The data gathered from the post-tests of both the experimental and control groups are systematically analyzed and interpreted. The findings are presented using tables for clarity, allowing for a concise summary of the observed effects. The discussion aims to contextualize these results within the broader body of educational research, highlighting the significance of the findings in relation to existing literature. The implications of integrating gamification elements into flipped learning environments, particularly in enhancing student engagement and performance in mathematics, are also explored in detail.

Mathematics Performance of the Control Group

Table 1

Pre-test and Post-test Scores of Control Group

Scores	Pre-test		Post-test	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Poor (0-10)	0	0.00	2	7.41
Below Average (11-20)	22	81.48	13	48.15
Average (21-30)	5	18.52	12	44.44
Above Average (31-40)	0	0.00	0	0.00
Excellent (41-50)	0	0.00	0	0.00
Total	**27**	**100.00**	**27**	**100.00**

Table 1 shows the results of the control group's pre-test and post-tests. The results indicate that of the 27 students who took the pre-test, 22 (or 81.48 percent) had below-average scores (ranging from 11 to 20), while 5 (18.52 percent) got scores that were in the average range (ranging from 21 to 30). In the post-test results, 2 students (7.41 percent) got scores ranging from 0 to 10, with a description of poor average. 13 students (48.15 percent) got scores ranging from 11 to 20, with a description of below average. 12 students (44.44 percent) achieved scores in the above average (21-30) category.

Makinde and Yusuf (2019) study found that students in the control group who were taught using the Traditional Classroom (TC) approach had a significant increase in their average pre-test score after the intervention. This suggests that traditional teaching methods can lead to improvements in student performance over time, though the gains may not be as substantial as those achieved through more innovative approaches like flipped learning with gamification.

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Mathematics Performance of the Experimental Group

Table 2

Pre-test and Post-test Scores of Experimental Group

Scores	Pre-test		Post-test	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Poor (0-10)	0	0.00	0	0.00
Below Average (11-20)	22	81.48	9	33.33
Average (21-30)	5	18.52	17	62.96
Above Average (31-40)	0	0.00	1	3.70
Excellent (41-50)	0	0.00	0	0.00
Total	**27**	**100.00**	**27**	**100.00**

The results of the pre-test and post-test for the experimental group are presented in Table 2. In the pre-test, out of 27 students, 22 students (81.48%) scored between 11 to 20, which is categorized as below average. The remaining 5 students (18.52%) scored between 21 to 30, falling into the average category. In the post-test, the performance improved significantly. Nine students (33.33%) still scored between 11 to 20 (below average), but 17 students (62.96%) scored between 31 to 40, indicating above average performance. Additionally, 1 student (3.70%) scored between 31 to 40, also classified as above average. Lo and Hew (2017a) suggested integrating gamification into the flipped classroom approach. As defined by Deterding, Dixon, Khaled, and Nacke (2011), gamification is the "use of game design elements in non-game contexts." Their findings indicate that students in the flipped class generally had a higher level of cognitive engagement, as evidenced by better performance in submission rates, quantity, and quality of optional assignments compared to other classes.

Difference in the Mathematics Performance Between the Control Group and Experimental group.

Table 3

Pre-test Scores of Control Group and Experimental Group

Indicator	Groups	SD	Mean	Descriptions	t-value	P-value	Decision	Remarks
Pre-test	Control	3.30	17.15	Below Average	0.499	0.620	Failed to Reject Ho	Not Significant
	Experimental	3.24	17.59	Below Average				

Note: If p value is less than or equal to the level of significance which is 0.05 reject the null hypothesis otherwise failed to reject Ho. SD- Standard Deviation

Table 3 shows the difference between the control group and the experimental group in their pre-test scores. The mean score for the control group is 17.15, while for the experimental group, it is slightly higher at 17.59. The overall statistical analysis showed a P-value of 0.620, which is higher than the alpha level of 0.05. Therefore, the null

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hypothesis is not rejected. This suggests that there is no significant difference between the pre-test and post-test scores for both groups. In simpler terms, both groups started with similar performance levels in mathematics. In their study, Makide and Yusuf (2019) observed that the distinction between the experimental group and the control group was minimal. This was evident from the mean score and standard deviation, which indicated that there was a uniformity in the level of mathematics performance among all the students prior to the intervention.

Difference in the Mathematics Performance of the Control Group

Table 4
Pre-Test and Post-test Scores of the Control Group

Indicator	Groups	SD	Mean	Descriptions	t-value	P-value	Decision	Remarks
Control	Pre-test	3.30	17.15	Below Average	-1.403	0.172	Failed to Reject Ho	Not Significant
	Post-test	5.66	18.81	Below Average				

Note: *If p value is less than or equal to the level of significance which is 0.05 reject the null hypothesis otherwise failed to reject Ho. SD- Standard Deviation*

Table 4 shows the difference between the pre-test and post-test means and standard deviations for the control group. The mean score in the pre-test increased from 17.15 to 18.81 in the post-test. The analysis showed a P-value of 0.172, which is higher than the significance level of 0.05. This means we do not reject the null hypothesis. In simple terms, there is no significant difference between the pre-test and post-test scores. The control group's performance in mathematics did not show a significant improvement from the pre-test to the post-test. Makinde and Yusuf (2019) study demonstrated a significant increase in the mean pre-test score of the Traditional Classroom (TC) method-taught students in the control group during the post-test period. Furthermore, the standard deviation increased, indicating a wider range of variability in the post-test scores.

Difference in the Mathematics Performance of the Experimental Group

Table 5
Pre-test and Post-test Scores of the Experimental Group

Indicator	Groups	SD	Mean	Descriptions	t-value	P-value	Decision	Remarks
Experimental	Pre-test	3.24	17.59	Below Average	-6.704	<0.001	Reject Ho	Significant
	Post-test	4.25	22.30	Below Average				

Note: *If p value is less than or equal to the level of significance which is 0.05 reject the null hypothesis otherwise failed to reject Ho. SD- Standard Deviation*

As shown in table 5, the mean score increased from 17.59 in the pre-test to 22.30 in the post-test. The analysis showed a P-value of less than 0.001, which is much lower than the significance level of 0.05. This means the null hypothesis is not rejected. In other words, there is a significant difference between the pre-test and post-test scores for the experimental group. The experimental group showed a substantial improvement in their mathematics skills. Gündüz and Akkoyunlu (2020) observed a statistically significant difference when they adjusted the posttest

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results by including students' pretest scores. Implementing gamified flipped classrooms resulted in enhanced academic performance among students.

Difference in the Mathematics Performance between the Control Group and Experimental Group.

Table 6
Post-test Scores of Control Group and Experimental Group

Indicator	Groups	SD	Mean	Descriptions	t-value	P-value	Decision	Remarks
Post-test	Control	5.66	18.81	Below Average	2.557	0.014	Reject Ho	Significant
	Experimental	4.25	22.30	Average				

Note: *If p value is less than or equal to the level of significance which is 0.05 reject the null hypothesis otherwise failed to reject Ho. SD- Standard Deviation*

Table 6 shows the difference in mathematics performance between the control group and the experimental group in the post-test scores. The pre-test results showed that the control group had a mean score of 18.81, categorized as "Below Average," while the experimental group had a higher mean score of 22.30, categorized as "Average." The overall statistical analysis yielded a P-value of 0.014, which is less than the alpha level of 0.05. This led to the rejection of the null hypothesis, indicating a significant difference between the pre-test and post-test scores for the control and experimental groups. Specifically, the experimental group demonstrated a higher performance level compared to the control group. This suggests that the intervention (flipped learning with gamification) had a positive impact on the experimental group's mathematics performance, as evidenced by the higher mean score and more consistent performance. Lo et al. (2017) provided empirical evidence for this idea when they reported that, when compared to conventional learning and online independent study with gamification, flipped learning with gamification improved students' mathematical performance and cognitive engagement. Huang and Hew (2018) conducted the final experiment with forty college students. The impact of gamification on the quantity and quality of anticipated student performance on learning tasks was studied by researchers, who, in the experimental group, explained various badges as game components. Students in the experimental group not only finished more tasks than their control group counterparts, but their work was also of greater quality.

Conclusions

The analysis of the control group's mathematics performance indicates thatstudents consistently scored below average in both pre-test and post-test assessments. These results suggest that the traditional instructional methods used were ineffective in improving students' mathematics performance. The consistent below-average scores underscore the necessity for more engaging and innovative teaching strategies to enhance student learning and achievement in mathematics.

The findings on the mathematics performance of the experimental group indicate a positive shift from the pre-test to the post-test. This demonstrates that the flipped learning with gamification approach effectively enhanced the mathematics performance of the students in the experimental group, leading to better overall results compared to their initial performance. This evidence supports the potential of innovative teaching methods in improving academic outcomes.

The examination of pre-test scores between the control group and the experimental group reveals that there is no significant difference in their initial mathematics performance. The minimal variations in individual scores and standard deviations further support that the two groups were comparably matched in their mathematics performance prior to any interventions.

The analysis of the pre-test and post-test scores of the control group reveals that there was no significant improvement in mathematics performance. This indicates that the instructional methods used for the control group were not effective in enhancing the students' mathematics performance over the period studied. The significant findings suggest the necessity for more effective teaching strategies to improve student outcomes in mathematics.

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The analysis of the pre-test and post-test scores of the experimental group indicates a significant improvement in mathematics performance. This shift suggests that the instructional strategy of flipped learning with gamification was effective in enhancing the mathematics performance of the experimental group. The evidence demonstrates that innovative teaching methods can lead to substantial academic improvements.

The comparison of post-test scores between the control group and the experimental group reveals a significant difference in mathematics performance. This notable improvement in the experimental group suggests that the flipped learning with gamification strategy had a positive impact on their mathematics performance. The findings indicate that innovative instructional methods can lead to better academic outcomes compared to traditional teaching approaches.

Recommendations

It is recommended that teachers, administrators, and mathematics coordinators integrate flipped learning with gamification into the Grade 7 mathematics curriculum. They are encouraged to conduct more seminars and training sessions on using interactive tools like EdPuzzle and incorporating gamified elements such as leaderboards, badges, and brain points.

Teachers are suggested to adopt a hybrid approach combining traditional instruction with digital tools to accommodate diverse learning preferences. They should also receive professional development to design engaging lessons and use data-driven techniques for continuous assessment and feedback to adjust instructional strategies as needed.

Considering the challenges faced by students in far-flung areas, it is recommended that educational policymakers and stakeholders invest in improving technological infrastructure in these regions. This includes providing reliable internet access and necessary technological devices to ensure all students have equal opportunities to benefit from flipped learning with gamification. Additionally, developing offline versions of pre-class learning resources and gamified activities can help accommodate students with limited internet connectivity. Training programs for teachers in these areas should also be tailored to address the unique challenges they face, ensuring that they can effectively implement these innovative teaching methods.

It is recommended that future research ensures that the learning engagement and experience provided to students during experiments remain consistent. Researchers should avoid introducing alternative methods during the study, as variations in the learning experience could impact students' attitudes, mathematics performance, and psychological well-being both positively and negatively. Maintaining uniformity in the educational approach will help to accurately assess the effectiveness of flipped learning with gamification on students' mathematics performance.

For further improvement, it is proposed that future researchers conduct parallel studies to test the effectiveness of flipped learning with gamification in other grade levels and subjects. They should also consider formulating a comprehensive training program for teachers that focuses on the integration of these innovative teaching methods. Additionally, offering supplementary support such as tutoring and additional materials for students will ensure all learners benefit from this approach, ultimately leading to a more engaging and effective educational environment.

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