INTEGRATION OF GAMIFICATION IN TEACHING MEASURES OF POSITION OF GRADE 10 – MATHEMATICS

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DOI: https://doi.org/10.54476/ioer-imrj/549239

ABSTRACT

The alarming findings from the Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) concerning the Philippines were a cause for concern. This presented a significant challenge to all those involved in the country's education system, including teachers, students, and stakeholders, particularly given the context of the ongoing pandemic. Gamification, which refers to incorporating elements of game design into non-game situations, stands out as a promising avenue, leveraging technology to motivate student learning. This study assesses the effectiveness of integrating gamification in teaching measures of position to the performance of Grade 10 students in Mathematics in a private school in Bogo City, Cebu, Philippines. Employing a quasi-experimental approach with pre-and post-test measurements, the study consisted of both a control group taught through traditional lecture-based methods in online distance learning, and an experimental group exposed to gamification techniques. The statistical analysis, utilizing t-tests, indicated that there was no significant difference in the average scores of the experimental group before and after the intervention. This suggests that the use of gamification does not affect students' motivation. However, the t-test results also demonstrated a notable progress in the performance of the experimental group in Mathematics 10, indicating that integration of gamification in teaching measures of position improves student's performance.

Keywords: Gamification, Motivation in Mathematics, Performance in Mathematics

INTRODUCTION

Across generations, Mathematics has consistently retained its importance as the bedrock of science and technology, encapsulating essential principles of arithmetic and logical reasoning. As a result, educational authorities place a premium on students' problem-solving and computational skills. Much of the formal introduction to mathematics occurs in high school. In secondary education, the study of mathematics equips students for their academic pursuits in higher education institutions and furnishes them with an extensive repertoire of mathematical principles and proficiencies essential for post-secondary vocational engagements. The curriculum at this educational stage entails formal, meticulously organized, profoundly symbolic, and notably advanced mathematical content.

Within the context of the Philippines, mathematics assumes various functions: it enables engagement in constructive daily endeavors, it offers a framework for comprehending the intricacies of the world, it acts as a mode of effective communication, and it operates as a gateway to propel national progress. Consequently, the significance of enhancing students' fundamental knowledge and comprehension of mathematics is acknowledged by the Department of Education (DepEd). This acknowledgment is manifested through the introduction of DepEd Order No. 55, s. 2010, recognized as the Policies and Guidelines on Reinforcing Secondary Level School and Mathematics Education. This directive is firmly rooted in DepEd Order No. 41, s. 2004, which delineates the Revised Curriculum of the Engineering and Science Education Program (ESEP) of Science and Technology-Oriented High Schools.

With the endeavors undertaken by the DepEd, evidence from both domestic and global educational evaluations, such as the National Achievement Test (NAT), the Program for International Student Assessment (PISA), and the Trends in International Mathematics and Science Study (TIMSS), illustrates a pattern of subpar performance among Filipino students in mathematics, a condition that existed even prior to the onset of the pandemic.

Evaluating the mean percentage score of Grade 10 students' performance in the NAT between 2009 and 2015, their mastery of mathematics was categorized as "Average." Furthermore, in the context of international comparisons, the Philippines positioned itself at the 41st rank out of 45 participating nations in Grade 8 Mathematics during the 2003 TIMSS assessment. Recent PISA 2018 and TIMSS 2019 results showed Filipino students lagging behind in international math assessments. In both tests, the Philippines placed last out of 79 participating countries, marking their first PISA participation in 2018. These outcomes serve as a foundational reference point for gauging global benchmarks and evaluating the efficacy of educational transformations. The TIMSS and PISA scores alarmed Filipino educators and students, posing a challenge amid the pandemic.

The predicament of inadequate mathematics performance has been exacerbated by the advent of the pandemic. Efforts were undertaken to mitigate this challenge by conducting training sessions and online seminars aimed at enhancing teachers' proficiency in utilizing technology to address the complexities associated with delivering high-quality education amidst the pandemic. However, Online Distance Learning continues to be difficult not only for teachers, but also for students, due to low levels of involvement and participation. The constraints imposed by these limitations had a pronounced detrimental impact on both students' drive and their academic achievements, especially evident in the domain of Mathematics, a subject reliant on the active application and iterative refinement of imparted knowledge and competencies. Given the prevailing educational landscape in the Philippines, educators are compelled to exhibit heightened resourcefulness, adaptability, and ingenuity in their integration of technology to effectively navigate these challenges. Games are used in school to help students become more motivated since they relieve stress and improve their mood.

Gamification, characterized by the utilization of game-design elements within contexts unrelated to gaming, emerges as a promising frontier of new-age technology with the capacity to motivate students towards learning (Deterding et. al., 2013). Games will make learning more dynamic, interesting and engaging, encouraging positive behavior and drive to learn. Embedding educational experiences with gamification has an extensive historical trajectory (Deterding, 2014), a concept rooted in an intuitively comprehensible rationale due to the shared psychological underpinnings of game design and learning theories (Landers, 2014). Kim (2015) defines gamification as the assimilation of game elements into contexts beyond the realm of games, such as frameworks or environments, with the aim of infusing a gamified essence into these elements. Mtitu (2014) agreed that learner-centered strategies must be used in order for teachings to be successful and efficient.

In the educational instruction, the active engagement of educators in the learning journey of students holds paramount importance. This significance of teacher-student interaction finds resonance within the framework of social constructivism, as delineated by Gallimore and Tharp (1988). Aligned harmoniously with the principles of gamification, Vygotsky's constructivist proposition (1978) accentuates the centrality of teacher-student connectivity. Within the sphere of social constructivism, the genesis of ideas is underscored to arise from the dynamic interplay between instructors and learners. Evident within this paradigm is the cooperative nature of the learning process, wherein knowledge germinates not solely from the teacher-student dyad within the classroom's confines, but also emerges from the students themselves, intrapsychologically (Churcher, Downs, & Tewksbury, 2014).

Central to Vygotsky's theoretical underpinning is the concept of the Zone of Proximal Development, a domain conducive to optimal learning (Vygotsky, 1978). It is within this zone that the collaborative essence of gamification thrives. This pedagogical approach engenders collective student participation within a competitive milieu, propelling them to unravel solutions that beckon the genesis of novel insights—thus resonating harmoniously with Vygotsky's constructivist framework. In tandem with the constructivist perspective, the Self-Determination Theory posited by Deci and Ryan (1985) comes to the fore. This theory espouses the potential of gaming environments to cater to the innate human needs for autonomy and interconnectivity. By embedding elements of choice, volitional engagement, contextual relevance, and shared objectives, game-based contexts, as demonstrated by Rigby and Ryan (2011), have the propensity to satiate these intrinsic needs. Given these theoretical foundations, the study focused on the effectiveness of the integration of gamification in teaching measures of position to the performance and motivation of grade 10 students in mathematics in a private school in Bogo City, Cebu, Philippines.

OBJECTIVES OF THE STUDY

This study sought to assess the effectiveness of integrating gamification into the teaching of measures of position for Grade 10 students in mathematics within a private school. The specific objectives were as follows: First, to assess students' mathematics performance before and after the intervention in both the control and experimental groups. Second, to determine if there is a statistically significant difference in students' performance within each group and between the control and experimental groups. Third, to examine changes in students' motivation in mathematics before and after the intervention for both the control and experimental groups. Finally, the study examines whether a significant difference exists in students' Mathematics performance before and after the intervention, both within each group and between the control and experimental groups. This research design encompassed a comprehensive analysis of the impact of gamification on both academic performance and motivation.

METHODOLOGY

This research employs a quasi- experimental design involving a control-group pretest-and-post-test approach. Two distinct classes were randomly allocated to serve as the control and experimental groups, respectively. The study participants were drawn from two sections within the tenth grade, each comprising 36 students. The allocation of these sections into the experimental and control groups was achieved through a simple random sampling technique, utilizing a coin-flipping method. To mitigate potential bias in estimating the treatment impact based on observational data, a careful matching process was implemented.

The research was carried out within the premises of a private educational institution, selected due to its alignment with the investigation's focus on integrating gamification into mathematics education within the context of online distance learning. Capitalizing on the institution's implementation of online learning modalities, the researchers seized the opportunity to conduct the study within this academic setting.

For the purpose of data collection in this research, several tools were employed, encompassing a learning plan, activities and tools, a questionnaire, and a mathematics motivation questionnaire. A subset of these tools was designed by the researcher, while others were borrowed from established studies.

The learning plan adopted in this investigation adheres to the principles of Lev Vygotsky's social constructivism, which underscores the significance of proficient learning within the Zone of Proximal Development (ZPD). Tharp (1993) conceptualizes pedagogy as a means of facilitating performance within the ZPD, extending requisite support as deemed necessary. The study redefines teaching as using gamification to enhance classroom performance. Gamification fosters student- teacher interaction and motivation, aligning with self-determination theory's focus on psychological and social needs, particularly in learning measures of position.

The topic was implemented using an EFDT format designed by PEAC (Private Education Assistance Committee), comprising Explore, Firm-up, Deepen, and Transfer phases. Exploration involves initial activities and connection to previous lessons, with necessary materials. Firm-up refines concepts from exploration, providing examples and exercises. Deepen offers additional exercises to enhance learning. Transfer utilizes performance tasks to assess application of learning in slightly complex scenarios. Gamification enhances exploration by sparking interest and addressing ZPD. Motivation is important throughout; thus, gamification is also integrated into deepening, making activities engaging and collaborative.

In the experimental group, the research incorporated digital learning tools and platforms with gamification elements, specifically employing Quizziz and Edpuzzle. These selections were purposefully aligned with the study's design considerations. In the data collection, a test questionnaire and an adapted questionnaire on mathematics motivation were used.

The student's performance was evaluated using a pre-and post-testing procedure. The researcher used questions from public school quarterly tests and the Division Office's table of specifications for the pretest and posttest because it is considered valid and reliable. In order to prevent participants from becoming accustomed to the examination content, the item numbers and choices for each question were reorganized.

The Science Motivation Questionnaire, adaptable for Mathematics, assesses students' drive to learn math. Glynn crafted the initial motivation survey. Glynn et al. (2009) ascertained the reliability of SQM-II through factor analysis, yielding a Cronbach's alpha value of 0.91. The instrument employs a 30-item 5-point Likert scale to evaluate Science (Math) students' intrinsic motivation, self-efficacy, self- determination, assessment anxiety, career aspirations, and grade-related motivation. Participants rate items as follows: 5 – Always; 4 – Usually; 3 – Sometimes; 2 – Rarely; 1 - Never. Scores range from 30 to 150, indicating motivation levels. 30-59: "rarely," 60-89: "occasionally," 90-119: "frequently," 120-150: "always."

This section delineates the data collection process for evaluating the impact of gamification on the performance of grade 10 learners. Initial permission to study grade 10 students was obtained from the school, with a formal letter sent to the principal following approval from the school president. A questionnaire, comprising a 20-item test and a 30-item math motivation scale, was administered via Google Forms to selected sections (experimental and control) during math class, with permission granted by the high school principal. Post-class retrieval was conducted to enhance response rates. The study was conducted in two grade 10 online distance learning sections, involving five 1-hour sessions incorporating gamified and lecture-based lessons. Following the intervention, post-tests and math motivation questionnaires were administered, and student scores were collected, organized, and encoded using SPSS.

Statistical tools were employed to answer the questions presented under the problem statement. The acquired data from both the experimental and control groups, before and after the intervention, were subjected to analysis using the statistical software SPSS.

To address the initial research query, the calculation of mean scores was executed to assess the academic performance of students in both the control and experimental cohorts, both pre- and post-intervention.

In pursuit of addressing the second I research inquiry, a paired-samples T-Test was administered to compare the academic performance of students within their respective groups, while an independent samples T-Test was utilized to compare their performance between the two distinct groups, both before and after the intervention.

Third, the computation of mean scores was a requisite step to ascertain the levels of motivation among students within the control and experimental groups, both prior to and following the intervention.

Fourth, a paired-samples T-Test was used to compare the students' motivation within groups and an independent T-Test between groups before and after the intervention.

Lastly, to gauge the alteration in average scores within the same individuals or observations pre- and post-intervention, a T-test for paired samples was conducted.

This section of the research paper unveils and provides an analysis of the findings derived from the quasi-experimental research endeavor. The presentation and interpretation of these results follow the sequence outlined by the study's objectives.

RESULTS AND DISCUSSION

This section of the research paper unveils and provides an analysis of the findings derived from the quasi-experimental research endeavor. The presentation and interpretation of these results follow the sequence outlined by the study's objectives.

1. Control and Experimental Groups' Performance in Pre-Test and Post-Test

The calculation of mean scores and standard deviations was executed to ascertain the mathematics performance of students before and after the intervention within both groups.

Table 1
Mean and Standard Deviation of the Control and Experimental Groups' Performance in Pre-Test and Post-Test

Groups	Control		Experimental	
	Pre test	*Post test*	*Pre test*	*Post test*
N	36	36	36	36
M	8.25	8.81	8.08	11.97
SD	2.7607	2.3154	2.771	2.6991

Table 1 displays mean and standard deviation values pertaining to mathematical performance before and after intervention in the two study groups. The control group's post-test mean (M = 8.81, SD = 2.3154) surpassed the pretest mean (M = 8.25, SD = 2.7607), indicating learning. Pretest scores showed a wider spread than post-test in the control group. Similarly, the experimental group's post-test mean (M = 11.97, SD = 2.6991) was higher than the pretest mean (M = 8.08, SD = 2.771), signifying learning. Both groups improved, with the gamification-based experimental group showing greater progress. However, online class performance was low, given the perfect score of 20.

2. Comparison of Mean Scores in the Pre and Post Tests Within the Groups

A paired-sample T-Test was carried out to determine if there was a significant difference in the student's performance in mathematics before and after the intervention within groups. A two-tailed paired-sample t-test was conducted to compare the pretest and posttest scores for the experimental and control groups with a significance level of 0.05.

Table 2
Comparison of Mean Scores in the Pre and Post Tests Within the Groups

Groups	Pre-Test		Post-test	
	Mean	*SD*	*Mean*	*SD*
Control	8.25	2.76	8.81	2.32
Experimental	8.08	2.77	11.97	2.70

t-value	p-value	Interpretation
0.87	0.39	Not significant
6.05	< 0.01	Significant

Table 2 showed the t-value obtained in control group was (t = 0.87), and the p-value obtained was high (p = 0.39 > 0.05), indicating that there was no significant difference between the pre and post test scores in the control group.

This revealed that their performances before and after the lessons were statistically the same. The experimental group's t-value was (t = 6.05), with a p-value that was less than the level of significance (p < 0.05). It indicates that there was a significant difference between the pre and post test scores in the experimental group. This implied that their performance improved after the intervention was being taught via gamification.

3. Comparison of Mean Scores in the Pre-Test Between Groups

To ascertain whether a notable distinction existed in the students' mathematical performance before the intervention across the different groups, an independent T-test was conducted. Table 4 presented the result of the independent t-Test on the pre-test between the control and experimental groups. The t-value between groups was (t = 0.26), with a p-value that was greater than the level of significance (p = 0.80 > 0.05). It showed no significant difference in the means of both groups. The results implied that the two groups performed similarly before the intervention was introduced. It also means that any difference between the two groups' performance can be attributed to the intervention.

Table 3
Comparison of Mean Scores in the Pre-Test Between Groups

Control		Experimental		t-value	p-value	Interpretation
Mean	*SD*	*Mean*	*SD*			
8.250	2.7607	8.083	2.7710	0.26	0.80	Not Significant

4. Comparison of Mean Scores in the Post-Test Between Groups

An independent T-Test was carried out to determine if there was a significant difference between the student's performance in mathematics after the intervention between groups.

Table 4
Comparison of Mean Scores in the Post-Test Between Groups

Control		Experimental		t-value	p-value	Interpretation
Mean	*SD*	*Mean*	*SD*			
8.806	2.3154	11.97	2.6991	5.34	< 0.01	Significant

Table 4 displays the independent t-Test result comparing post-test outcomes between control and experimental groups. The t-value was (t = 5.34) with p-value < 0.05, signifying a significant mean difference. The experimental group outperformed the control group post-intervention, indicating gamification's substantial impact on performance compared to traditional methods. These results align with Hasegawa, Koshino, and Ban's (2015) findings that game-related elements enhance learning outcomes through continuous engagement using badges, leaderboards, and rewards. Mae et al. (2022) also supported this, demonstrating gamification's effectiveness in elevating Mathematics performance among grade 8 students.

5. Control and Experimental Groups' Motivation

Mean and standard deviation were calculated to determine the students' motivation in mathematics before and after the intervention in both groups.

Table 5
Mean and Standard Deviation of the Control and Experimental Groups in Mathematics Pre and Post-Motivation

Groups		N	M	SD
Control	*Initial motivation*	36	109.83	15.4282
	Post-motivation	36	111.64	14.9879
Experimental	*Initial motivation*	36	103.25	18.1602
	Post-motivation	36	105.67	16.7605

Table 5 presents mean and standard deviation data for student math motivation before and after intervention in the two groups. The control group's post-motivation mean (M = 111.64, SD = 14.9879) exceeded the initial mean (M = 109.83, SD = 15.4282), indicating increased motivation. Similarly, the experimental group's post-motivation mean (M = 105.67, SD = 16.7605) was higher than the initial mean (M = 103.25, SD = 18.1602), reflecting increased motivation. These findings align with Haiken's (2020) research showing gamification's impact on student motivation and engagement. Rose (2015) also observed increased motivation with gamified multiple-choice quizzes in a physics course compared to standard quizzes.

6. Comparison of Mean Scores in the Initial and Post Motivation Within Groups

Table 6
Comparison of Mean Scores in the Initial and Post Motivation Within the Groups

Groups	Initial Motivation		Post Motivation		t-value	p-value	Interpretation
	Mean	*SD*	*Mean*	*SD*			
Control	109.83	15.4282	111.64	14.9879	**0.51**	0.61	Not significant
Experimental	103.25	18.1602	105.67	16.7605	**0.51**	0.62	Not significant

A paired-sample T-test was conducted to determine if there was a significant difference in the students' motivation in mathematics before and after the intervention within groups. Table 7 displays the results for the control and experimental groups. In the control group, the t-value (t = 0.61) with a p-value (p = 0.61 > 0.05) suggests no significant difference in math motivation before and after the intervention.

Similarly, the experimental group's t-value (t = 0.51) and p-value (p = 0.52 > 0.05) also show no significant change in motivation before and after gamification. This implies gamification did not positively affect motivation. Similar findings were seen in Mae, Antonio, and Tamban's (2022) study, where external factors could have influenced results due to the new normal of education. Moreover, Werbach and Hunter's (2015) guideline of using suitable game components for effective gamification was not fully met, as the intervention used limited game elements.

7. Comparison of Mean Scores in the Initial Motivation Between Groups

To determine if there is a significant difference in the students' initial motivation in mathematics between groups, an independent T-Test was carried out.

Table 7
Comparison of Mean Scores in the Initial Motivation Between Groups

Control		Experimental		t-value	p-value	Interpretation
Mean	*SD*	*Mean*	*SD*			
109.83	15.4282	103.25	18.1602	1.66	0.10	Not significant

Table **7** displays the outcomes of the independent t-test conducted on the initial motivation levels between the control and experimental groups. The calculated t-value between the groups was 1.66, yielding a p-value of 0.10, slightly exceeding the significance level (p > 0.05). These results indicate no significant difference in the means of both groups, suggesting similar motivation levels before the intervention.

Therefore, any observed disparity in motivation between the two groups can be attributed to the introduced intervention.

8. Comparison of Mean Scores in the Post Motivation Between Groups

An independent T-Test was conducted to determine if there was a significant difference in the students' post-motivation in mathematics before and after the intervention between groups.

Table 8
Comparison of Mean Scores in the Post Motivation Between Groups

Control		Experimental		t-value	p-value	Interpretation
Mean	*SD*	*Mean*	*SD*			
111.64	15.4282	105.67	18.1602	1.60	0.12	Not significant

Table 8 shows the independent t-Test on post-motivation between the control and experimental groups. The t-value was (t = 1.60), with a p-value that was greater than the significance level (p = 0.12 > 0.05). It showed no significant difference in the means of both groups. This implied no increase in motivation with the use of gamification. The results negated the findings of Kapp (2013), Kim (2015), and Zichermann and Linder (2013) that gamification can be used to promote engagement, motivation, learning, and problem solving, among other factors that might affect these findings.

Properly guided instruction within the Zone of Proximal Development (ZPD) can lead to student success, as highlighted by Blake & Pope (2008). ZPD, as described by Doolittle (1995) and Warford (2011), is rooted in social interaction during the learning process and signifies a developmental journey where students flourish with nurturing. This study draws on the Self-Determination Theory of Deci and Ryan, characterizing it as a comprehensive framework concerning human motivation, innate growth tendencies, and psychological needs. This theory's application in the context of games, as seen in prior research (Przybylski et al., 2009; Rigby and Przybylski, 2009), underscores the role of environment in motivation, highlighting its modification potential through gamification—a process enriching the environment with game elements. However, this study's gamification implementation was constrained due to limited available game design elements, ultimately leading to a lack of motivational impact.

Students using Online Distance Learning sometimes faced internet connectivity challenges, but the flexibility in responding to gamified learning tasks accommodated these issues. Immediate feedback was facilitated through gamified assessments like Quizizz, enhancing the learning experience. Despite gamification's limited impact on student motivation, the data confirms its effectiveness as an innovative teaching strategy that notably enhances Mathematics performance.

CONCLUSIONS

This study aimed to assess the impact of integrating gamification into the instruction of measures of position on the performance and motivation of grade 10 students in mathematics in a private school in Bogo City, Cebu, Philippines. The findings revealed that there was no significant difference between the pre and post-motivation mean scores among participants in the experimental group, suggesting that the use of gamification as a teaching strategy did not substantially affect student motivation. However, the investigation also indicated a notable improvement in the academic performance of the experimental group in Mathematics 10, highlighting the effectiveness of integrating gamification in teaching measures of position.

RECOMMENDATIONS

The study's findings suggest several recommendations. Firstly, educators should strategically incorporate gamification into online math education, recognizing its proven effectiveness in boosting student performance. Personalized teaching strategies, informed by an understanding of students' characteristics, can enhance this integration. Secondly, the study recommends integrating game-based learning within math classes to improve students' understanding of complex concepts. Institutions should support educators by providing opportunities to engage in seminars on emerging educational trends. This ensures teachers remain well-equipped to navigate evolving educational landscapes. Additionally, investing in gamified tools allows institutions to tailor elements to students' unique interests. Future research could expand on this study by introducing more variables, exploring different age groups, and extending the experimental timeline to provide broader insights into gamification's effectiveness. Furthermore, researchers should investigate alternative course topics or gamification strategies to determine if gamification significantly boosts student motivation compared to non-gamified methods.

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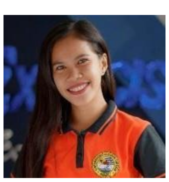

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