International Journal of Mathematical Theory and Applications
Vol 2, Issue 1 2026

Mathematical Gamification: How Students Are Involved and What They Think

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Article Info
Received: 20-01-2026 Revised:22-02-2026 Accepted:07-03-2026 Published:18-03-2026

Abstract
Math is seen by many Indonesian students as a boring and difficult subject. To pique their interest, a fresh strategy for teaching arithmetic is required. Gamification, a strategy to pique students' interest and engage them in learning, was used to teach mathematics in this case study. We observed 20 female eighth graders in both the gamification-enhanced and control groups to gauge their emotional responses to the game. The next step was to interview the math teacher one-on-one, after which eight students were selected for two focus groups according to their mathematical activity and competence levels and game scores to understand how they perceived gamification in mathematics. The results were examined via the symbolic interactionism lenses, which allowed for a constructive interpretation and confirmation of the teacher's perspective through the students' actions and perceptions. To bolster the outcome, the literature was also included. According to the study's findings, kids were far more engaged when teachers used gamification in mathematics and gave incentives. The student's performance in the game, however, had a significant impact on their opinion. The victors were happy regardless of the lack of technical talent, while the losers had mixed feelings about the game. Some wanted to play again to get higher scores, while others thought it was too difficult. Therefore, it was necessary to take into account individual preferences while building gamified activities in mathematics in order to encourage the pupils.

Keywords: *gamification; mathematics; motivation; engagement; boredom.*

INTRODUCTION

Putting in the time and energy necessary to effectively teach mathematics is no small feat. It has long been believed by educators and students alike that mathematics is a topic that only a select few are naturally gifted with, and that the majority of students still have a hard time grasping (Anderson, Boaler, & Dieckmann, 2018). Some people believe the myth because they are slow when it comes to solving mathematical problems. Among the nations with poor performance, Indonesia is one to mention. Indonesia ranked first in mathematics in the 2018 PISA results (Schleicher, 2019). A new issue has emerged, and fixing old problems is never simple.
The use of digital games has the potential to enhance students' learning outcomes in STEM (science, technology, engineering, and mathematics) subjects (Wang, Chen, Hwang, Guan, & Wang, 2022). According to Bilro, Loureiro, and de Aires Angelino (2022), students find the gamification method to be a very engaging method of learning. According to Buckley, DeWille, Exton, Exton, and Murray (2018), gamification is the process of incorporating game mechanics into non-game contexts in order to encourage behavioural modification. As a result, students may find formerly tedious tasks much more enjoyable (Karagiorgas & Niemann, 2017). In addition, current theories and practices support the use of gamification in activity design as a means to both engage and empower learners (Jain & Dutta, 2019). Learners may acquire 21st-century skills and practical knowledge via gaming experiences in the classroom (Moseikina, Toktamysov, & Danshina, 2022).
Ciuchita et al. (2022) found that prior research on gamification in educational settings had a range of findings, from neutral to favourable. Fisher & Barabasch (2020), Oliveira, Souza, Reis, & Souza (2021), and Patrício, Moreira, & Zurlo (2018) are among those who argue that gamification will enhance students' motivation, cognition, and spirit of learning. And according to studies done by Solekhah and Damayanti (2022), pupils also react well to

maths with a gaming mentality. Half of the students are unsure whether gamification is right for them, and the replies are all over the map (Rahayu, Nugroho, Ferdiana, & Setyohadi, 2022). The findings on the potential positive motivation of players by badges are similarly varied and conflicting (Ofosu-Ampong, 2020). According to Beserra, Nussbaum, and Oteo (2019), a more comprehensive approach would be to enquire about students' involvement with digital games and technology use via interviews.

The goals of this study are to(1) understand the various perspectives on gamified activities and(2) determine how gamification activities might motivate students to actively participate in mathematics lessons. It is anticipated that the replies and feedback will provide valuable insights for making the topic more engaging and for enhancing the game design to meet the needs of the students.

LITERATURE REVIEW

Difficulties in Engaging Students in Learning Math

It is worrying that based on PISA 2018, the majority of Indonesian students strongly believe that they would not be able to increase their intelligence, especially in science, literacy, and math (Schleicher, 2019). In learning mathematics, many students experience negative emotions (Kalogiannakis, Papadakis, & Zourmpakis, 2021). Although some students might feel confidence and enjoyment in learning math, both of them decline as learners get older (Christensen & Knezek, 2020). In learning algebra, for example, the students are expected to completely rearrange symbols and understand essential concepts by using symbols and numbers without applying visual skills (Boaler, Chen, Williams, & Cordero, 2016). However, many students have to struggle to understand this subject.

Based on the previous research, there is a cyclical relationship between math confidence and math enjoyment meaning that if the students' confidence is increased at the beginning of the school year, they would likely enjoy the subject at the end of the year, and the students whose enjoyment is increased at the beginning of the school would be more confident at the end (Christensen & Knezek, 2020). Therefore, it is important to design more enjoyable activities for learning mathematics because it could decrease the students' anxiety and improve their success in the subject (İlhan, Poçan, & Gemcioğlu, 2022). When students have less anxiety towards mathematics and experience the flow of teaching, they would likely to have more positive attitudes towards this subject (Kurtuluş & Eryilmaz, 2021). Students with more enjoyment and less anxiety in math could increase their scores in math and lead to higher control and intrinsic value of the subject (Putwain, Schmitz, Wood, & Pekrun, 2021).

Csikszentmihalyi (1990, as cited in Karagiorgas & Niemann, 2017) states that perceived motivation and perceived skill highly impact an individual's motivation. People experience anxiety if their skills cannot overcome the perceived challenge. Instead, they feel bored if their skill is higher than the challenge. Unfortunately, in general, mathematic learners feel guilty and embarrassed when they make mistakes without realizing that those mistakes as well as the struggles are essential to growing their brains (Anderson et al., 2018).

In today's world where high-technology devices are ubiquitous, there should be more visual approaches to teaching mathematics to engage students, especially visual thinkers who are struggling with this subject (Boaler et al., 2016). Teachers' accompaniment during the learning process and their pedagogical support are needed in gamified educational activities (Moseikina et al., 2022). Also, there should be a priority to increase the teachers' competence in using digital technology and invest in technological equipment to deal with difficulties and academic gaps and reading and mathematics after the pandemic (Panagouli et al., 2021).

Gamification in Educational Context

Gamification is an innovation that has been applied in various personalized applications that include scores, motivational values, and competitive opportunities between the players (Deterding, 2019). It is aimed to achieve particular outcomes in particular ways such as behavior change, increasing learning outcomes, or persuading people (Landers, Auer, Collmus, & Armstrong, 2018). Ciuchita et al. (2022) explain that in gamification, there are three functions: production,

consumption, and exchange. How the task is being executed the players by using a certain instrument are related to the production function. The objectives or goals being achieved by the players in the system is related to the consumption function, while the exchange function is about the interaction between players in the community in the form of cooperation or competition.

The examples of mechanics of the game are the mechanism to obtain points, and to compete on the leaderboards (Ciuchita et al., 2022 cite Floryan, Ritterband, and Chow, 2019). While mechanics define the new activities of the game, the dynamics of gamification activities include the players and the relationship among players. Both mechanics and dynamics are important elements of games. The mechanics and dynamics of the game should be related to its context meaning that there should be communication between participants and game designers, the interaction containing causes and effects of actions, the roles and their implications to the players, and the purposes of the activities (González-González & Navarro-Adelantado, 2021). Therefore, both individuals and organizations could achieve higher achievement after utilizing gamification because of the increased motivation and productivity (Thomas, Baral, & Crocco, 2022).

The students who play gamification activities would likely enjoy the learning experience and be more motivated and engaged to study (Hossein-Mohand, Trujillo-Torres, Gómez-García, Hossein-Mohand, & Campos-Soto, 2021). Most of the students have positive attitudes towards playing a mathematics video game (Beserra et al., 2019). Therefore, putting gamified activities in the class might be beneficial when students think that the lesson is boring or when they have difficulties achieving the learning outcome. The teacher needs to be aware of how the students could be motivated to do the tasks (Çakıroğlu & Güler, 2021). In other words, the more teachers understand the types of students in the classroom, the better they could utilize gamified activities to motivate and engage the students (Jaskari & Syrjälä, 2022).

RESEARCH METHOD

After getting permission from the school leader, the observation was conducted on the 8th-grade class consisting of 20 female students in an Islamic boarding school learning algebra. The first half of the lesson started with the student's answering homework on the blackboard and explaining their answers in front of their peers followed by the math teacher giving feedback on the homework. The rest of the lesson was allocated to the game.

The following game was algebra, specifically linear equations in two variables, in which the students were supposed to do the games in identifying the coefficients, the variables, and the constants. The game utilized an interactive template of wordwall.net in the form of an aero plane game. The role of the game was each student should play individually to answer five random questions by flying the aero plane and crushing the clouds containing the correct answer. Each player had three lives to complete the game. Those who got all answers correctly with the names that appeared on the leaderboard would receive a star from the mathematics teacher. One player at the top list would be the winner and deserve five stars.

The mathematics teacher was also interviewed to respond to the students' feedback on the game and mathematics lesson. The observation analysis was done by constructionism lenses (Crotty, 1998) by observing the communication between the students and the teachers as well as other symbolic interactions between the students. It includes the various expressions in playing the games, the results of the game, and the gestures of the students in the classroom.

After the observation, eight students were chosen purposefully based on their responses during the game, the level of their mathematics, and their activeness in the classes. Some students won the game and received the reward, while the rest of them had minimum or zero scores. After giving verbal assent, they were asked to do two focus group discussions. The first group discussion participants: S1 (medium achievement in math but won the game with the highest and fastest score – top on the leaderboard), S2 (the highest score at the beginning of the game receiving applause by her peers – leaderboard listed), S3 (a student with zero scores but looking excited, panic, and dissatisfied at the same time with the results), and S4 (an active and calm student in math class – leaderboard listed). The second group discussion participants: S5 (a less active student with a good score on the game), S6 (a passive student who often sleeps and draws pictures in the classroom but she paid attention to the game), S7 (a student with relaxed expression during the game - leaderboard listed), and S8 (a student with good academic achievement but she did not get any

point even though she had spent quite a long time). The discussions were recorded and played repetitively for thematic analysis. To ensure the trustworthiness of the findings, the data was analyzed using triangulation (Creswell, 2012) based on observation, focus group discussions, and individual interviews. The existing literature was also included to confirm the analysis.

FINDINGS AND DISCUSSION

Students' Engagement with and without Gamification

During the first half of the lesson, the classroom was quiet. The two students who answered the homework attempted to explain solving the algebra by using substitution and elimination techniques. There were six students in the classroom putting their heads on the table and writing down the answers. The rest of the students sat in their chairs quietly listening to their friends' explanations as well as their teachers' feedback on the methods of solving linear equations in two variables. The teacher also used a graph to test the answer. During the focus group discussion, it was found that mathematics was an exhausting learning subject for some students because it needed complex operation and repetitive practice required writing notes and formulas.

The students' statements such as, *"Mathematics is tiring"* - [S2], and *"I don't like mathematics because I don't like counting"* - [S5] were common. The teacher said that after Covid-19, teaching math was more difficult since the students had fewer opportunities to learn the subject at home. Based on the form letter No 4 in 2020, the Indonesian Ministry of Education imposed Urgent Curriculum stating that during the pandemic, the teaching and learning should more focus on the student's life skills rather than academic achievement and there should be not children left behind (Dikdas, 2020). It implied that the learning subject taught was minimum. Learning mathematics in elementary school was ineffective during the pandemic in which students had more difficulties in learning and they were less motivated to study (Fadilla, Relawati, & Ratnaningsih, 2021; Wiryanto, 2020). As a consequence, the students had more difficulties understanding simple mathematical operations.

Responding to the statements of how hard mathematics was, the teacher stated that making math easier was impossible since the level of difficulty in the subject would increase as they study. He preferred to use different approaches such as using PowerPoint presentations or other learning media. Therefore, he believed that game was a useful attempt to make the students more enthusiastic. He used Word-wall because it was an online platform game that could be accessed freely with computers or mobile phones. It had some templates with simple steps to design the game. By creating an account on the website, the teacher could choose some templates and modify them with questions. He could also set the timer and the lives given to the player.

In the observation, it was found that the atmosphere of the class differed when the teacher said that they would have a game of linear equations in two variables. It could be seen from the changes in the students' gestures changed. Some students who previously put their heads on the table sat more properly while others paid more attention to the projector. Before the real game began, there was a simulation of the game using one laptop and the monitor projected on the blackboard. Portable mouse and an internet connection to access the digital game. One student was assigned to fly the aero plane. The rest of the students watched the game and waited for their turns. All students were asked to turn their chairs and turn their backs to the blackboard while students one by one tried the game. Even though there were students who deliberately turned to see the game, they turned their heads not to see the game. The first student was appointed by the teachers.

Students who have already played then choose the next player and were allowed to watch the game.



Figure 1. The students were asked not to see the game but someone peeped.

In doing the game, the students expressed differently from being calm, excited, panicked, and frustrated. Some of the students showed nervousness about using the keyboard or mouse. First, the students looked nervous, but over time they were more relaxed with the questions. They also enjoyed watching their friends playing. As the game went on, the class atmosphere changed to be more vibrant with students' loud voices. The students who initially looked sleepy also watched the game. Participants agreed that game in mathematics could decrease their boredom in learning because it was more attractive and refreshing.

Boredom occurs when an individual could not pay his/her attention or is not stimulated enough to participate satisfyingly, embrace the fact that he/she could engage and could participate to achieve the satisfying activity, and blame the environment for doing so (Eastwood, Frischen, Fenske, & Smilek, 2012; Yacek & Gary, 2023). High intrinsic value in mathematics, that is, interest and curiosity in the subject matter, sustained low levels of boredom regardless of the level of perceived control, even when students experienced very high control. In other words, a high curiosity and interest in mathematics could maintain a lower level of boredom, instead, irrelevant, unchallenging and monotonous learning with a lower students' expectations would make them bored (Putwain et al., 2018). The gamification techniques can encourage students with low participation to be more active in learning (Gündüz & Akkoyunlu, 2020).



Figure 2. A student playing the aeroplane of Wordwall



Figure 3. The students watched the game with excitement

Competition and Reward as Motivational Factors

Before the game began, the teacher said that the students who could appear on the leaderboard would get one star and the fastest would get five stars. Stars were common rewards given by the teacher to the students who were active in the classroom, for example, those who dared to answer the question on the blackboard and explained their answers to their peers. The students were excited to win the game and to collect the stars.

For many students, a competitive activity could increase their willingness to be the best players. The desire to compete with other players and achieve the best result increases the motivation to solve problems in the game (Yasin, Gilani, & Nair, 2021). Achieving a satisfying game result shows mastery of knowledge and makes the students more motivated to study (Zhang, Yu, & Yu, 2021). The students that value the achievement highly and have good perceived control in mathematics would enjoy the lesson more and would be more successful in the future test (Putwain et al., 2018).

Rewards in gamification which are visually represented by badges and points have motivational benefits (Buckley et al., 2018). It can also optimally support and motivate the learning experience of gamification activities (Zhang et al., 2021). In this game, the leaderboard was the objective of the students. They wanted their names to be on the list.

Based on the observation and the focus group discussion, the research found that winning the game was the pride of the students. Related to this, Hung (2017, as cited in Jaskari & Syrjälä, 2022) warns that there is a tendency that gamification relies on extrinsic motivation. The winner will experience the positive effect of the game while the players who lose the game will experience negativity towards the game (Çakıroğlu & Güler, 2021; Ciuchita et al., 2022 cite Hammedi and Poncin, 2018). The gamification could lead to demotivation, especially for the vulnerable players who feel less appreciated or not fairly rewarded because of unsatisfactory results. Therefore, focusing more on the process and appreciating participation as a part of achievement would be beneficial in designing the game (González-González & Navarro-Adelantado, 2021).

The teacher admitted that giving the reward was one of the ways to make the students study harder. It was undeniable that many students believed that mathematics was uninteresting. He maintained that at least the students had more curiosity to learn and collect the stars for having fun. Giving vouchers was not a big deal as long as the students were more actively participating in the lesson. Moreover, Winning or losing was normal in every competition. Although it might have motivational value, the students should not push themselves too hard to win the game. Instead, they should prioritize learning to make a progress because whether they liked it or not, mathematics was an important subject that could benefit them in the future.

Game Challenges and Attitudes toward the Game

The teacher said that the plane game was chosen because he wanted to assess the student's ability in multitasking and focus. Despite the math questions, playing the game would be successful if the players could control their emotions in response to mechanical challenges such as how to operate the game and challenges from the environment. During the observation, it was found that some high-achieving students failed in the game while the students with average achievement performed better.

The game gave each player three lives to give opportunities to the students so they could evaluate their performance. During the discussion, the students stated that they had difficulties operating the game using a mouse or keyboard. Some students were also too ambitious to answer the questions as fast as possible. They did not let themselves get accustomed to the game-controlling system. Consequently, they lost their lives and perform poorly. Moreover, being watched and distracted by their peers' voices might influence their performance. Some students had trembling fingers operating the keyboard or mouse and failed to achieve higher scores. On the other hand, those who successfully manage their emotions and focused more on the game could perform better despite the longer duration of playing.

All students in the first group discussion agreed that the game was suitable for mathematics despite the difficulties to handle the plane up and down. Five questions were not enough and they wanted to do the game again with more questions so that they could achieve higher scores. The problem was some students tried to peep at the game although they were not allowed to do that. They also needed to wait before playing the game. However, they felt happy and wanted to have games of mathematics at least twice a semester for refreshing activities. Digital games were suitable for the first group. They thanked the math teacher for the opportunity to play the game. However, the second group provided more complex responses.

The second set of people thought that math was already difficult and that making it more fun would only make things worse. The competition would also find it more difficult. While they were on stage, most of them freaked out because their classmates were staring and shouting at them. They were terrified of messing up. People who got four or five stars were happy, while others who got zero stars were furious. Since playing a math game proved annoying, they disagreed on whether to play it again. Less challenging content with fewer technical issues would make them pleased. Math would be more fun if it were easy. Whether they enjoy math or not become a difficult decision with gamification. The components of the game elicit distinct reactions from each personality type (Moseikina et al., 2022). Jaskari and Syrjälä (2022) divide students into many gamification learner types based on their contradictory perspectives. Independent completionists are pupils who thrive when given the opportunity to work alone, but social completionists thrive when given the chance to work in groups. In contrast to highly motivated completionists, who embrace all forms of gamification, pure completionists are more sceptical of gamified activities and devote more time to learning. Without playing the game, students may be less interested and driven (Karagiorgas & Niemann, 2017). According to González-González and Navarro-Adelantado (2021), players' experiences are heavily influenced by their emotions. Therefore, for players to have pleasant feelings, it is important for them to comprehend the process of playing the games and to convey its powerful significance both before and after the activity. Students' emotional states are a good predictor of their mathematical performance; students whose emotions are negative are likely to have lower scores, while students whose emotions are positive are likely to have higher scores (Lin, Yin,

[Han and Han, 2020] referenced Pekrun, 2007. Students' emotions, their level of accomplishment, and gamification are all interconnected.
With proper manipulation, the game processes have the potential to produce gamified applications that are both sustainable and encouraging (Welbers, Konijn, Burgers, & de Vaate, 2019). Poorly handled game mechanics or features might prevent gamification from achieving its educational aims; but, well-designed mechanics like tokens, points, and badges could interest students and boost their performance (Ofosu-Ampong, 2020). The curriculum, the topic and organisational backdrop, and the learners' performance should all be taken into account throughout the game design process in order to develop an effective and successful gamification activity (Ofosu-Ampong, 2020). Students sometimes feel unsure of themselves and confused when they play a game for the first time, particularly if they are unfamiliar with the rules, but those feelings quickly fade as they participate (Yasin et al., 2021). Plus, even after failing at the game once, some students would learn and grow from the experience (Oliveira et al., 2021). It is recommended that players are guided through enjoyable tutorials, levels are organised according to the difficulty of the goals, and narratives are used to keep players engaged, despite the complexity, challenges, and specific skills needed (Morschheuser & Hamari, 2019).
Students would be better prepared for the next grade level in mathematics if they had more fun and interesting math exercises at their current level of education (Christensen & Knezek, 2020). Instead of trying to engage students to the maximum extent feasible, Welbers et al. (2019) suggest focusing on the forms of engagement and the quantity that might work best for each learner. According to Beserra et al. (2019), offering a variety of games will greatly help students keep a good attitude towards gamification in mathematics. A few tweaks, such monitoring systems, feedback, and objectives, might be included into gamification to keep participants engaged and encourage the desired behaviours (Deterding, 2019).
Teacher responded to student comments by saying that, due to resource constraints, the gamification

exercise did not go over well. It was strictly forbidden for pupils to use mobile phones at the boarding school and laptops were only allowed in the lab. Hence, going forward, it would be wise to consult with the computer lab administrator before using gamification.
The first stage in creating gamification for educational purposes is embodying motivation, which comprises topic competency, learner autonomy, and learning that is relevant to the learners. The components of the game should complement one another and work together to inspire players to reach their educational objectives (Buckley et al., 2018). One strategy for testing students' subject-matter competence is to have them compete in "peer challenges," in which they assess one another's progress (Jain & Dutta, 2019).
When asked about his experiences using the Wordwall's free templates, the instructor also admitted to having certain limits. It would take more effort and time to design gamification, particularly for mathematics. But he intended to improve his gamified activity creation skills by enrolling in classes for digital game design.

CONCLUSIONS

Based on the research, it can be concluded that gamification could highly engage the students but no game that could suit every learner. The educator should understand the possibility that gamification might be differently engaging and motivating to the students (Jaskari & Syrjälä, 2022). Despite the various outcomes of gamification in educational contexts, the conceptualization of gamification and its holistic perspective needs to be investigated (Ciuchita et al., 2022). Thus, there should be more research that examines the elements of games that suit learners better so that they could be more motivated over time (Ofosu-Ampong, 2020). The challenges of gamification should also be documented as the basis to draw better insights and roadmaps in developing games for educational purposes.

Since boredom is a factor that hinders the student's interest and concerns, it is important to construct more student-centered learning so that they will have more autonomy to direct their own learning space (Yacek & Gary, 2023). Helping the students to maximize the value and control of the lesson would be advantageous for achieving better learning experiences and outcomes (Putwain et al., 2021). The creativity of the teachers is vitally important to ease the problems.

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