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Research Paper

Student's Engagement and Perception of Gamification in Mathematics

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Abstract
Many Indonesian students consider mathematics as an uninteresting learning subject that confuses them. An innovative approach to teach mathematics is needed to increase their engagement. In this case study, gamification which has been known as an activity to increase the student's enthusiasm was introduced in learning algebra. An observation with 20 female eighth graders was done in the classroom with and without the gamification activity to see the students' reactions and emotions in playing the game. Then, two focus group discussions with eight students were conducted by purposeful sampling based on their various levels of activeness and competence in mathematics as well as their scores of the game to grasp their perceptions of gamification in mathematics, followed by an individual interview with the math teacher. The findings were analyzed through the lenses of symbolic interactionism in which the students' acts and perceptions were constructively interpreted and confirmed with the teacher's opinion. The literature was also included to strengthen the result. The research found that gamification in mathematics could highly engage the students, especially when the teacher offered a reward. However, the student's perception was highly influenced by their performance in the game. Despite the lack of mechanical skill, the winners were satisfied; the unsuccessful players had different opinions: some of them wanted to play again to increase their scores whereas the rest of them did not suit the game. Thus, to motivate the students, designing gamified activities in mathematics needed to consider individual preferences.

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

INTRODUCTION

Mathematics is a difficult lesson that needs a lot of effort to be taught successfully. For many years, both teachers and learners believe that only certain people are so lucky with mathematical abilities or called "math people" while the rest of them still should struggle to understand this learning subject (Anderson, Boaler, & Dieckmann, 2018). The myth is believed by those who cannot solve a mathematical problem fast. Indonesia is one of the countries with low achievement. The data from PISA 2018 shows that Indonesia is at level one in mathematics (Schleicher, 2019). This problem has appeared, and it is always uneasy to solve.

Improving the students' learning outcomes in STEM (science, technology, engineering, and mathematics) could be done by utilizing digital games (Wang, Chen, Hwang, Guan, & Wang, 2022). The gamification approach is considered positively engaging to learners (Bilro, Loureiro, & de Aires Angelino, 2022). Gamification is defined as putting the elements of the game in non-game activities to motivate a change in behavior (Buckley, DeWille, Exton, Exton, & Murray, 2018). It can increase the student's interest in learning and turn bearable activities to be more fun (Karagiorgas & Niemann, 2017). Not only that, designing gamified activities has been favored by modern theories and practices to satisfy and increase the learners' efficacy (Jain & Dutta, 2019). Gaming experience in learning enables learners to obtain relevant skills and practical knowledge in the 21st century (Moseikina, Toktamysov, & Danshina, 2022).

The previous studies of gamification in educational contexts show mixed results ranging from negative, neutral, and positive (Ciuchita et al., 2022). Some of them maintain that the student's motivation, cognition, and spirit of learning would increase through gamification (Fischer & Barabasch, 2020; Oliveira, Souza, Reis, & Souza, 2021; Patrício, Moreira, & Zurlo, 2018). Research conducted by Solekhah and Damayanti (2022) also shows that students respond positively towards

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gamification in mathematics. However, there are mixed responses where half of the students agree and disagree if gamification is suitable for them (Rahayu, Nugroho, Ferdiana, & Setyohadi, 2022). There are also conflicting and inconsistent results on whether badges could positively motivate players (Ofosu-Ampong, 2020). It is suggested that interviewing the students' engagement with digital games and the use of technology would provide more information (Beserra, Nussbaum, & Oteo, 2019).

This research is aimed to investigate how the gamification activity could engage the students' activeness in learning mathematics and to grasp the different attitudes towards the gamified activities. It is expected that the responses and feedback would be insightful for improving more enjoyable approaches to the subject as well as to improving the game design by considering the student's need.

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.

Two students with high achievement in math also expressed somewhat negative about mathematics. As the subject got a higher level of difficulty, it was harder for them to master.

> *"Math has too many formulas and it's complicated. I like math if the formula is simple with fewer steps to solve the problems. Sometimes it is overwhelming because the teacher gives me new material right after I understand the previous one. It's too much. Sometimes I forget what I have learned"* - [S8]
>
> "*I used to like math but I don't like algebra*" - [S7]

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.

> *"I was not sleepy. I kept watching my friends playing because it was interesting although I was not sure about the answers"* - [S6]

> *"When I watched (a little bit) the game. I was so excited and wanted to play better"* - [S8]

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.

> *"Getting a star is cool!"*- [S8]

> *"The stars make us more active in math and at the end of the semester, we can exchange them with a voucher to buy some snacks"* - [S3]

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.

> *"I wanted to be the fastest but the clouds with the correct answer were so slow to appear and they made me nervous. Unfortunately, I felt like wasted my time and could not be the first winner. But that's okay, at least I got a star (a reward)"* - [S4]

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.

> "*I was in hurry and I got zero. I want to retry the game to increase my score" - [S3]*

"*I was calm when I lost the lives. I continued the game. My friends' response did not affect me*" - [S5]

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.

"I like the game because it's unusual activity." - [S2]

"The game is good because it eases the stress" - [S3]

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.

"*I would replay the game only if could I use the mobile phone instead of a computer. It is okay if the questions are easy or the game is familiar. The game should not be frustrating"* - [S8]

"*I prefer doing the tasks in front of the classroom to get the stars (the reward) to playing games with difficult operating systems*" - [S7]

The second group believed that mathematics was uneasy and its gamification would make it more complicated. It would also be harder for the competition. Most of them felt panic when their peers watched and yelled at them during their turns. They were afraid to make mistakes. Those with four or five scores were satisfied but getting zero made them frustrated. They had different opinions on whether they would play the game again because playing a math game was frustrating. They would be happier if the game was about less difficult material with fewer mechanical problems. The easier math the more enjoyable it would be. It was hard to decide whether they like math after gamification.

Each personality responds differently to the game elements (Moseikina et al., 2022). Based on the students' mixed opinions, Jaskari and Syrjälä (2022) classify the students into several categories of learners in gamification. The students who prefer working individually are called *independent completionists*, while those who prefer cooperative tasks are *social completionists. Pure completionists* are more critical towards gamified activities and focus more on studying seriously, in contrast, *highly motivated completionists* approve of all types of gamification elements.

Students might be less engaged and motivated due to the absence of experiencing the game (Karagiorgas & Niemann, 2017). The experiences of the players rely on their emotions, meaning that they will experience positive emotions if they could understand the process of playing the games and could imply the strong meaning of it before and after the activity (González-González & Navarro-Adelantado, 2021). Indeed, the students' mathematics scores are predicted by their emotional states, meaning that negative emotions would predict negatively the score while the students with positive emotions would like to predict better achievement in mathematics (Lin, Yin,

Han, & Han, 2020 cited Pekrun, 2007). Therefore, there is a relationship between gamification, the students' emotion, and their achievement.

The game mechanisms could create sustainable and encouraging gamified applications if they are carefully manipulated (Welbers, Konijn, Burgers, & de Vaate, 2019). The educational goals could not be obtained by gamification if the mechanics or game features are poorly managed, whereas good mechanics such as tokens, points, and badges could engage and increase the students' performance (Ofosu-Ampong, 2020). To create a successful and effective gamification activity, the game design should consider the curriculum, the context of the subject and organization, as well as the performance of learners (Ofosu-Ampong, 2020).

It is common that students tend to be confused and doubted the first time doing the game especially if they do not know how to play but participation would erase the negative attitudes towards the game (Yasin et al., 2021). Moreover, some students would improve and learn if they repeat the game despite previous failures (Oliveira et al., 2021). Despite the complexity, the challenges, and the required particular skills, it is suggested that the players be taught how to complete the tasks by providing enjoyable tutorials, managing the levels based on the difficulties of the goals, and presenting narratives to stimulate the players to continue playing (Morschheuser & Hamari, 2019).

The proficiency and confidence of students in learning mathematics would likely increase in the next grade if they experience more engaging and enjoyable mathematical activities at their present level of schooling (Christensen & Knezek, 2020). To achieve the learning goals, Welbers et al. (2019) prefer to emphasize the engagement types and the amount that could suit the learners best, rather than engage them as much as possible. Thus, providing different types of games would be highly beneficial to maintain the students' positive attitudes toward gamification in mathematics (Beserra et al., 2019). To maintain engagement and stimulate desired behaviors, some modifications such as tracking systems, feedback, and goals could be put in gamification, (Deterding, 2019).

In response to the student's feedback, the teacher stated that the gamification activity was not very successful because of the limited facilities. In the boarding school, the students could only use computers in the laboratory while using mobile phones was prohibited. Therefore, coordinating with the administrator of the computer laboratory before applying gamification would be beneficial in the future.

Embodying motivation is the first step to designing gamification for educational purposes which includes relatedness of the learning to the learners, the autonomy of the learners, and the competence of the subject. There should be congruency and integration between the game elements and the motivation to achieve educational goals (Buckley et al., 2018). For example, challenging the students' expertise/knowledge about a specific topic could be done by doing peer challenges where they could evaluate their performance among learners (Jain & Dutta, 2019).

The teacher also stated that he had some limitations in modifying free templates on the Wordwall. Designing gamification, especially for mathematics, would require more energy and time. However, he planned to take some courses to design digital games thus he would be able to create more suitable gamified activities.

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.

LIMITATION & FURTHER RESEARCH

This case study was conducted in a very limited context with few participants (20 students and one mathematics teacher in a school). It means that although the finding could provide some insights into learning mathematics and how gamification can engage the students, it could not prove generalization. Therefore, it is suggested that future research should employ more students and teachers from different schools to find more robust findings. Investigating gamification in mathematics by using more professional software could also be beneficial to find a better game design for educational purposes.

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