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ORIGINAL ARTICLE

Gamification Example in Mathematics Education: Phenomenological Research from Student and Teacher Perspective

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Ethical Statement
Voluntary consent forms were distributed to the participants and parental consent forms were distributed to their families and signed. They were informed about the general framework of the study and that they could leave the study at any time. Permission was obtained from the relevant institution for the realization of the study.

Funding Information
No funding was received for the study.

Conflict of Interest
No conflict of interest is present in the conduction or the reporting of this study.

ABSTRACT

In this study, it was aimed to examine student experiences and teacher opinions about the game designed in mathematics course. In addition, it was also aimed to determine the suggestions of students and teachers to make the game more effective. Using a phenomenological design, a qualitative research method, semi-structured interviews were conducted with 5th grade students (n=29) and mathematics teachers (n=3) attending a Science and Art Center in the Eastern Anatolia Region of Turkey. As a result of the content analysis of the interviews, it was found that the designed game facilitated students' learning, increased the retention of knowledge, and made the mathematics lesson more interesting. Students stated that the game helped them better grasp mathematical concepts and increased their motivation. Similarly, teachers reported that the game increased inclusiveness, engaged students and increased their willingness to learn. However, both groups emphasized that the game's contribution to psychomotor skills was limited and suggested arrangements to increase physical interaction. In conclusion, gamification was found to be a powerful tool to support mathematics instruction, especially in the cognitive and affective domains. The study offers suggestions for integrating gamification into different courses, digitalizing it, and training teachers in this area.

Keywords: Game, gamification, mathematics education, student and teacher views, phenomenology.

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INTRODUCTION

Gamification is a method that accelerates the learning process and is used as a facilitator in teaching complex subjects (Kapp, 2012). Gamification is a process of integrating game design principles into educational processes (Deterding et al., 2011). Game-based mechanisms and gamification can be included in the educational process in order to increase motivation and active participation in students, to realize learning efficiently, and to gain positive attitudes (Kapp, 2012; Yıldırım, 2016; Yıldırım & Demir, 2014). Gamification also contributes to the regaining of students who are demotivated in the classroom environment and the formation of integrity by providing interaction between students and teachers (Yılmaz, 2020). In addition to increasing students' academic achievement, gamification also positively affects their attitudes towards learning. In particular, it is observed that it increases the motivation of students with low achievement levels and enables them to participate more effectively in learning processes (Domínguez et al., 2013). Students may experience difficulties in achieving the desired goal in the teaching process due to differences in academic levels, learning speeds, personal learning paths, etc. With properly designed gamification applications, students will be able to be in a learning environment that is suitable for their individual learning preferences and where they can review their learning when necessary (Yalçın, 2018). With the effect of digitalization, gamification applications can be carried out not only with physical materials, but also through mobile applications and online platforms.

Recent studies show that gamification is an effective tool for increasing both cognitive and affective gains (Sailer & Homner, 2020). Mathematics education can be perceived as challenging for students because it usually involves abstract concepts. In this context, gamification can be used as an effective tool in mathematics teaching to attract students' attention and ensure permanent learning. Especially in areas that require abstract thinking skills such as mathematics, game-based approaches concretize students' learning experience and make it more meaningful (Lee & Hammer, 2011). Mathematical games improve students' problem-solving skills, support their ability to collaborate, and make learning more fun (Clark et al., 2016). In this context, gamification methods in mathematics, which are seen as a boring and challenging course for many students, can offer students more effective learning experience. Gamification in mathematics means transforming mathematical problems into a game format and using game elements such as competition or cooperation to make students' learning processes more effective and interesting. Mathematics games are especially effective tools for increasing students' motivation (Dicheva et al., 2015; Kara, 2021). Games facilitate learning by associating abstract mathematical concepts with concrete situations (Altun, 1998; Soylu, 2001). Again, mathematics games encourage social interaction among students, give students the chance to develop cooperation and teamwork skills in the form of group games, and enable students to learn from each other and solve mathematics-related problems together. This approach can also contribute to changing students' negative thought patterns about mathematics, increasing their interest in learning and strengthening their mathematical skills (Arı & Öncü, 2005).

In this study, a sample mathematics game was designed and implemented. The designed game includes mathematics topics such as factors, multiples, division-divisibility, prime numbers. The game is played with two students and includes numbers from one to one hundred on a wooden game board. The game starts when the first student takes a tile belonging to a number other than one and a prime number and turns it over. Then the second student must turn over a piece of a number that is a multiple or multiplier of the first student's piece. In this way, the game progresses with reciprocal moves and the student who is unable to turn over any piece loses the game. Visuals of the game are shown in Figure 1 below.

Figure 1. Game visuals designed and used in the research

In this study, it was aimed to examine student experiences and teacher opinions about the game designed in mathematics course. In addition, it was also aimed to determine the suggestions of students and teachers to make the game more effective. The research questions are as follows.

1) How can the prepared game contribute to students' understanding of basic mathematical concepts in cognitive, affective and psychomotor areas? What do students think and suggest in this regard?

2) How can the prepared game contribute to students' understanding of basic mathematical concepts in cognitive, affective and psychomotor domains? What do teachers think and suggest in this regard?

3) What are the improvements and updates made following the recommendations?

METHOD

Research Design

Present this study uses qualitative research method. Phenomenology design based on qualitative research method was preferred in the study. The phenomenological approach aims to reveal the experiences of the participants about a particular phenomenon and the meanings they attribute to these experiences in depth (Creswell, 2017). In this context, this design was deemed appropriate to understand and interpret the experiences of students and teachers regarding the gamification process applied in the mathematics course.

Participants

The participants of the study consisted of 5th grade students (n=29) attending a Science and Art Center in a province located in the Eastern Anatolia Region of Turkey and mathematics teachers (n=3) working in the same institution. The participants were selected through criterion sampling, one of the purposive sampling methods, and were chosen among individuals who had experienced gamified mathematics activities in accordance with the purpose of the study. 5th grade students were selected because students at this level are both beginning to learn abstract mathematical concepts and are open to game-based learning approaches. In addition, the fact that the mathematics topic covered in the study and the content of the game had not yet been covered at the classroom level was also an important selection criterion.

Data Collection Tools

In this study, a semi-structured interview form was used to collect data. The semi-structured interview form was preferred because it includes both predetermined questions and flexible question variations in order to understand the experiences, perceptions, opinions and thoughts of the participants in depth (Kallio et al., 2016).

Development of the Interview Form

The interview form was prepared in line with the purpose of the study by taking expert opinion. The questions were inspired by previous studies on gamification-based mathematics teaching (Dicheva et al., 2015; Kapp, 2012; Kara, 2021; Yıldırım, 2016; Yıldırım & Demir, 2014) and aimed to reveal students' and teachers' views on gamification practices in cognitive, affective and psychomotor domains. As a result of the expert evaluation, the content validity of the interview form was ensured and the participants were encouraged to express their opinions in their own words by using open-ended questions. A total of 2 questions prepared in parallel with the research questions constituted the semi-structured interview form.

Implementation Process

Interviews were conducted face-to-face and individually. During the data collection process, participant consent was obtained for recording the interviews and the interviews were conducted in accordance with ethical principles. The responses obtained from the interviews were then written down and coded to be used in the analysis process. Semi-structured interviews provide quality data, especially in qualitative research, as they allow individuals to explain their meaning structures about the subject in their own words (Brinkman & Kvale, 2015). In addition, since this technique offers the researcher the flexibility to direct and deepen the process, the contextual richness of the data obtained increases.

Data Analysis

The collected data were analyzed by content analysis. Content analysis is a data analysis method in which categories and codes are formed with an inductive approach based on the collected data (Yıldırım & Şimşek, 2011). The codes and categories obtained in this context are given in tables and graphs with frequency values. Data analysis was carried out in four main stages:

- Data preparation: The interview records were transcribed and specific codes were assigned to each participant.
- Open coding: Participant statements were read line by line and meaningful statements (open codes) were identified.
- Categorization: The codes were grouped together according to their similarities and grouped under themes.
- Creation of themes: Categories were organized within the framework of cognitive, affective and psychomotor themes.

This analysis process is critical in qualitative research in terms of revealing meaning in depth and providing contextual richness (Vaismoradi et al., 2013).

Reliability and Validity

In order to increase reliability in the research process, the analysis process was conducted independently by two researchers and mutual control was made. The agreement rate was calculated by comparing the codings obtained; agreement above 80% was accepted as sufficient (Miles & Huberman, 1994). For the validity of the data, the participant statements were directly included and the researcher's interpretations were based on the data. The content analysis approach is a systematic structure that allows us to understand the world of the participants by considering their experiences in their own context. Therefore, it is widely preferred in phenomenological research (Graneheim & Lundman, 2004; Nicmanis, 2024).

RESULTS

In the research, interviews were conducted to examine student experiences and teachers' opinions and suggestions regarding the game designed using gamification in mathematics class. The findings compiled from the data obtained within the scope of the research are given in Table 1 and Table 2 below.

Table 1. Student and Teacher Opinions

Theme	Category	Codes	Frequency (f)
Student Opinions	Cognitive	Facilitating learning	12
		Increasing retention	7
		Enabling repetition	3
	Affective	Being engaging	10
		Increasing motivation	8
		Being fun	5
	Psychomotor	No effect	10
		Only fingers are active	1
Teacher Opinions	Cognitive	Ensuring inclusivity in learning outcomes	3
		Facilitating learning	2
		Providing reinforcement and repetition	1
		Ensuring retention	1
	Affective	Enabling concretization	3
		Encouraging the desire to learn	2
		Providing a fun activity	2
		Ensuring interest and attention	1
		Easing the transfer to daily life	1
	Psychomotor	Having no effect	3
		Positively influencing attitude	1

Looking at the students' opinions in the cognitive domain in Table 1, it is seen that the “facilitating learning” effect of the game was emphasized with a high frequency (f=12). Students stated that they understood mathematics subjects more easily thanks to this game and abstract concepts became concrete. For example, a student clearly expressed the facilitating effect of the game on learning by saying, “Thanks to this game, I immediately understood the multiplication topic that I did not understand before (S3).” This view reveals that gamification contributes to the learning process at the cognitive level. Similarly, codes such as “increasing retention” (f=7) and “repetition” (f=3) show that the game helps the learned information to stay in the mind longer and provides reinforcement through repetition. Another student emphasized that the game both provided feedback and made the learning process cyclical with the statement “When I

failed, I played again and realized my mistakes (S6).” In the affective domain, students stated that gamification was “interesting” (f=10), ‘motivating’ (f=8) and “fun” (f=5). These statements indicate that attitudes towards learning changed positively and intrinsic motivation increased. One student made a comparison with traditional lessons by saying, “Normal mathematics lessons are boring, but this game made the lesson fun (S9).” Another student stated that gamification provided motivation through competition with the statement, “The feeling of competition pushed me to solve more (S1).” In the psychomotor domain, students thought that the game did not require any physical movement. Statements such as “It has no effect (S5)” (f=10) and “Only fingers work (S14)” (f=1) show that physical interaction is limited. This result indicates that the game should be redesigned to support psychomotor skills.

In the same direction, when Table 1 is examined, the contributions of gamification especially in cognitive processes come to the fore in teacher opinions. “Ensuring inclusiveness in achievements” (f=3) and “facilitating learning” (f=2) reveal that teachers think that the game is suitable for students at different achievement levels. One teacher emphasized inclusiveness by saying, “All students were active in the game, which made participation in the lesson widespread (T1).” “Providing concretization” (f=3) was the most frequently emphasized theme in the sensory domain. It was stated that abstract mathematical concepts became more understandable by supporting them with physical materials. One teacher exemplified this situation by saying, “Abstract operations became more understandable with concrete game pieces (T3).” In addition, expressions such as “creating a desire to learn” (f=2) and “providing interest and attention” (f=1) show that students' interest in the lesson was reconstructed through games. One of the teachers said, "Students listened more carefully just to play the game (T2). " and stated that the game became a source of motivation. In the psychomotor domain, the majority found the impact of the game on physical skills to be limited. The code “no effect” (f=3) is a clear indication of this. However, one teacher suggested that an attitudinal change can also trigger physical performance by saying, “Students' positive attitude towards the game can also be effective in the psychomotor domain (T3).”

Table 2. Student and Teacher Suggestions

Suggested by	Suggestions for Improving the Game	Frequency (f)
Student	Making the pieces easier to move	26
	This version is sufficient	7
	Rules can be compiled into a booklet	1
	Using colorful pieces	1
Teacher	Using more durable materials to extend the game's lifespan	2
	Improving the design to enhance playability	2
	This version is sufficient	1

Table 2 categorizes students' and teachers' suggestions for improvement of a gamified mathematics activity thematically and shows the frequency of these suggestions. The suggestion with the highest frequency was “making the pieces easier to move” (f=26), which clearly reveals the students' expectation of functionality regarding the physical use of the game. Among other suggestions, aesthetic and guidance-oriented improvements such as “making the pieces colorful” and “making the rules into a booklet” stand out. In addition, the fact that some students found the current state sufficient (f=7) indicates that the basic structure of the game was generally appreciated. As for teacher suggestions, “more durable material” and “improving the design” were the most prominent, indicating that the teachers emphasized the importance of making the material long-lasting and pedagogically more functional. Just like the students, the teachers also expressed opinions that the current state of the game was sufficient (f=1). In general, Table 2 shows that both students and teachers gave constructive feedback for the improvement of the game in terms of physical structure, visualization and playability.

Improvements and updates made after the suggestions

According to the students and teachers' suggestions obtained within the scope of the research, various updates have been made and continue to be made in the design of the game. The physical materials of the game have been ergonomically reorganized and will be improved to increase the ease of use by taking into account the suggestions of the students such as "moving the pieces more easily" and "turning the rules into a booklet". Similarly, the game is being structurally revised in line with the teachers' suggestions that the game should be produced with more durable materials and the design should be reconsidered to increase playability. In this context, the game was improved not only in terms of pedagogical effectiveness but also in terms of user experience. In these respects, integrating participant opinions into the design in the gamification process both supports the student-centered learning approach and contributes to the improvement of the application in accordance with the cyclical structure of qualitative research. Thus, the research process functioned not only as a data collection process but also as a developmental and transformative practice area.

CONCLUSION AND RECOMMENDATIONS

This study aimed to determine the effects of gamification in mathematics teaching on students' cognitive, affective and psychomotor development and to reveal teachers' opinions. In the light of the findings, it was concluded that gamification makes meaningful contributions to students' learning processes in educational environments. According to the results obtained in the study, based on student experiences and teacher opinions, it was determined that the game supported cognitive learning, increased the retention of subjects and made learning processes more interesting. However, it was stated that the contribution of the game to psychomotor skills was limited. Students expressed that they were satisfied with the cognitive contributions of the game such as repetition, facilitating learning and providing concretization. Teachers, on the other hand, emphasized that the game contributed positively to students' learning processes, but the content and structure of the game were not sufficient in terms of psychomotor skills.

The findings of the study show that gamified activities help students better understand mathematical concepts, reinforce knowledge, and increase the retention of learning. This result is in line with the meta-analysis study conducted by Sailer and Homner (2020), which emphasized that gamification elements had positive effects on task completion and conceptual learning. Furthermore, in the systematic review by Clark et al. (2016), it was stated that digital games improve students' critical thinking and problem-solving skills. In this context, although the physical game material used in this study was not digitized, it had a similar effect on cognitive skills because it provided structured and meaningful content.

Both student and teacher views suggest that gamification increases interest in learning, increases students' motivation, and contributes to the development of positive attitudes towards mathematics. Similarly, studies such as Domínguez et al. (2013) and Hamari et al. (2014) show that gamification has a significant impact on intrinsic motivation and makes the learning process more engaging. In this context, making a course such as mathematics, which is often perceived as difficult and abstract, more attractive through gamification creates a positive change in students' affective approaches to learning.

The research findings revealed that the game used did not directly contribute to psychomotor skills and physical mobility was limited. This shows that the game was designed more for mental activities. This finding suggests that the game should be redesigned to support physical interaction in order to increase psychomotor contributions. Kalogiannakis et al. (2021) states that digital gamification tools can further support psychomotor learning through tactile and interactive elements. In this context, the proposal to digitize the game may offer a potential solution to address this shortcoming.

The results show that gamification makes significant contributions in cognitive and affective learning areas. Therefore, it is recommended that gamification applications should be integrated into the curriculum in all disciplines, especially in mathematics courses. International research shows that incorporating gamification into curricula in a structured way increases learning outcomes (Sailer & Homner, 2020). In-service training programs should be organized to increase teachers' knowledge and skills on gamification practices. In these programs, game design principles, digital gamification tools and student-centered implementation techniques should be presented to teachers (Dicheva et al., 2015). These training courses are expected to contribute to teachers' use of more creative and interactive methods in classroom practices. In the research findings, it was observed that gamification had a limited effect on psychomotor skills. To overcome this deficiency, game materials with more physical interaction or augmented reality (AR) and virtual reality (VR) based applications can be developed (Kalogiannakis et al., 2021). Especially in STEM fields, such applications can increase both motor skills and technological competencies. Transferring games such as “Multiply, Divide, Fold and Understand This Topic” to digital platforms both increases access and diversifies learning environments. Digital gamification allows students to learn in feedback-based and audiovisually rich environments that are suitable for their individual learning pace (Clark et al., 2016). The proliferation of online learning processes, especially in the post-pandemic period, has further increased the importance of digital gamification.

Limitations and Implications of the Study

Gamification not only increases students' academic achievement but also supports the development of high-level skills such as cooperation, attention, time management, decision-making and motivation (Dicheva et al., 2015). In this context, this study demonstrates that gamification can be an effective tool in mathematics teaching and reveals the pedagogical potential of this method based on the experiences of teachers and students. The limitations of the study include the limited psychomotor contribution of the game due to its physical design and the small sample size of the study. However, considering the qualitative methodology of the study, the in-depth data obtained provide meaningful clues to the teaching processes. In the future, a comparative study of the effects of gamification in different age groups and in different socio-cultural contexts may be considered. In addition, measuring the effect of gamification on academic achievement by adding quantitative data collection techniques will allow for multidimensional evaluation (Domínguez et al., 2013).

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