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Article

Exploring Pre-service Mathematics Teachers' Perceptions and Experiences Regarding Gamification in Mathematics Education

Anıl Ayseli Duran Dündar[1], Gökhan Öztürk[2]

[1]Department of Mathematics and Science Education, Necmettin Erbakan University, Konya, Türkiye; [2]Department of Mathematics and Science Education, Middle East Technical University, Ankara, Türkiye
aanilduran@gmail.com; gozturk@metu.edu.tr

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Abstract

Recent advances in educational technologies have made gamification a promising approach for increasing student motivation and engagement in mathematics education. However, how pre-service teachers perceive and experience gamification has not been adequately examined. This study aims to explore how pre-service mathematics teachers define the concept of gamification, the factors they consider when integrating it into their teaching processes, and their perceptions of the advantages and disadvantages of this approach. In this qualitative case study, semi-structured interviews were conducted with eleven pre-service teachers selected through purposive sampling, and the data were analyzed through thematic analysis. Findings indicated that most participants confused gamification with games and viewed the concept more as a fun activity. Participants emphasized that gamification should be planned appropriately for students' ages, learning goals, and competitive balance. They also highlighted challenges such as classroom management, lack of resources, and differences in motivation among students. By revealing pre-service teachers' conceptual deficiencies, the study emphasizes the importance of theoretical and practical training for the meaningful implementation of gamification. The findings suggest that teacher preparation programs should address gamification in a planned and pedagogical manner.

1. Introduction

Educational environments are constantly evolving and transforming. In this context, developing innovative approaches to enhance the effectiveness of teaching processes and increase students' interest in learning is becoming increasingly important. Although mathematics education is a fundamental discipline that aims to develop students' analytical thinking, problem-solving, and understanding of abstract concepts, traditional teaching methods are not always sufficient to achieve these goals [1]. In particular, standard teaching

techniques may be insufficient to attract students' attention and may cause a lack of motivation towards mathematics [2]. This situation has directed teachers and educational researchers to more engaging and interactive learning approaches [3]. Gamification has come to the forefront as one of the methods that has attracted attention in education in recent years and is considered a potential solution in mathematics teaching [4], [5].

Gamification is defined as "the use of game design elements in non-game contexts" [4]. [6] considers gamification as a strategy that motivates individuals, increases interaction, and makes the problem-solving process more fun. Although often confused with game-based learning, gamification aims to motivate individuals by using game elements in non-game contexts rather than teaching directly in a game environment [7]. Game mechanisms such as achievement-oriented reward systems, competitive elements, instant feedback, and interactive tasks can encourage students to participate more in the learning process [1], [8], [9], [10]. For gamification to be effective, it must include a problem situation that motivates students, game mechanics aimed at solving this problem, and a structure aimed at behavioral change [11].

The use of gamification in education has the potential to make learning more meaningful and interesting, especially in areas where abstract concepts such as mathematics are taught [12]. The addition of game elements to mathematics courses, which are traditionally perceived as challenging, can contribute to students' better understanding of mathematical concepts and their development of more positive attitudes toward the courses [13], [14], [15], [16], [17], [18], [19]. In this context, how educators perceive gamification and implement it in their classrooms emerges as an important research topic.

1.1 Gamification in Education

One of the persistent problems in today's education systems continues to be students' lack of motivation and limited active participation in the learning process [20], [21], [22]. Educators are trying to develop various strategies to increase students' interest in the course and create a more interactive learning environment [23]. Gamification, as an approach arising from these needs, aims to ensure that students are more involved in the learning process and motivated [24], [25]. The most basic feature of gamification is to think and design the teaching process like a game [6]. This approach plays an important role in facilitating the participation of students with low motivation in the educational process [20], [22]. Gamification attracts students' attention and increases their commitment to the course by making educational environments more fun [4], [26]. In addition, it prevents students from getting bored and increases their attention by making the work more enjoyable and satisfying [27], [28], [29]. Furthermore, it can increase learning outcomes while making the teaching process more interesting and accessible, increase motivation by rewarding achievements, and strengthen teamwork and collaboration [26], [30].

Many studies in the literature examine gamification's effects on education. These studies generally focus on motivation theories and address the contribution of gamification to academic success [31], [32], [33]. [34] evaluated the integration of gamification into learning processes in his study, examining Turkish and English sources. [35] examined the effect of gamification on student motivation and stated that this method positively affects attitudes but does not directly increase motivation. Similarly, [36] noted that middle school students developed positive attitudes toward the digital gamification process. On the other hand, [37] and [38] revealed that gamification applications increase students' academic performance and motivation related to the course. [39] emphasizes the positive effects of gamification on student success, learning retention, and attitudes in the context of online education. These findings show that gamification is a powerful tool that makes learning processes more efficient.

Gamification, an innovative approach to education, aims to encourage active interaction among students by integrating game design principles into educational processes [40]. The use of game elements in educational environments makes the learning process fun and motivating

[4], [41]. Gamification applications supported by technological platforms have a wide range of potential uses in different educational areas [42].

In general, gamification can be deduced as an effective strategy to increase students' motivation and make learning processes more interactive. Studies show that this approach increases students' interest in the course, strengthens their participation, and contributes to the improvement of learning outcomes. In addition, gamification plays an important role in attracting students' attention and preventing boredom by making learning more fun and satisfying.

1.2 Gamification in Mathematics Education

Mathematics education, as an area where abstract concepts and challenging topics need to be made understandable for students, requires the use of innovative teaching methods [43]. Gamification has gained an important place in this field in recent years as it aims to increase students' motivation in lessons and ensure more active participation by integrating game elements into the learning process [44]. Gamification in mathematics education can help students develop problem-solving skills, understand subjects more deeply, and develop positive attitudes toward the course [45].

There are many studies examining the effects of gamification in teaching mathematics. For example, [46] stated in his research that gamification positively changes students' attitudes toward mathematics, increases their motivation, and improves their overall performance. Similarly, [47] stated that gamification increases student success, especially in complex mathematical subjects such as index and logarithm. In addition, [48] shows that gamification tools, especially ranking systems based on student participation, effectively increase student motivation. Similarly, in a study conducted by [49], three different gamified learning contents were created for primary school 2nd and 3rd-grade students, namely competitive, collaborative, and adaptive, and it was observed that the application for four operations subjects increased student success. In another study conducted by [50], a three-level gamification content, including addition-subtraction, multiplication-division, and all operations, was applied to 120 students. It was observed that teaching became more effective and interesting.

Gamification has the potential to improve not only students' academic performance but also their cognitive, emotional, and social skills. [51] emphasize that gamification improves skills such as collaboration, communication, and social learning, and increases students' interest in mathematics. [52] revealed the effects of serious games on increasing mathematical fluency in different classes and student groups. In addition, researchers such as [42] emphasize that gamification allows students to interact more with course materials and makes learning more fun.

To summarize, gamification increases student motivation and participation in mathematics education, making the learning process more effective. Research shows that this method creates a student-centered learning environment and makes mathematics more interesting. In addition, gamification supports not only academic success but also the development of cognitive and social skills. Therefore, it is thought that the use of gamification in mathematics education can increase the quality of education.

1.3 Present Study

The effectiveness of gamification methods depends on their design relative to the students' age, cognitive levels, and learning goals [41]. [41] emphasize that these are decisive factors in the success of gamification applications. To be successfully implemented in education, teachers need to have knowledge of this subject and gain application skills. Pre-service teachers who have not yet entered the profession are in the process of discovering gamification techniques,

and the perceptions they gain during this process can shape the approaches they will adopt in the classroom in the future.

However, it is seen that the effect of gamification in mathematics education is mostly examined through experimental studies in the literature. No qualitative studies have been found addressing the perspectives of pre-service mathematics teachers on gamification. While quantitative research offers insights into the effectiveness of gamified environments, it falls short of revealing how teachers conceptualize, interpret, and experience gamification in actual educational contexts. Therefore, examining pre-service teachers' perceptions through qualitative research can reveal not only what they think about gamification but also how they internalize it and potentially implement it in their teaching practices. This gap in the literature makes it difficult to understand how pre-service mathematics teachers perceive gamification methods, what factors they consider in integrating them into mathematics education, and what advantages and disadvantages they associate with their use. However, the perceptions and perspectives of pre-service mathematics teachers can provide important clues for making gamification more effective in mathematics education.

Understanding these perceptions is particularly important for teacher education programs that aim to prepare future teachers for technology-integrated and student-centered learning environments. The insights gained from this study can inform the design of training modules that address both the conceptual and practical aspects of gamification. Furthermore, by identifying teachers' misconceptions and needs, the study can guide curriculum developers in incorporating gamification principles into mathematics education courses.

This study aims to contribute to the development of teacher education programs and examines pre-service teachers' awareness of gamification and their approaches to integrating these methods into their educational processes. Through in-depth interviews, the views and perceptions of pre-service teachers regarding the meaning of gamification, considerations for integrating gamification, and its advantages and disadvantages were investigated. This research not only documents the views of pre-service teachers but also interprets them within the broader framework of mathematics education and gamification theory, offering implications for both educational practice and policy.

The findings obtained may contribute to the development of new approaches to make mathematics teaching more motivating and interactive. In addition, it aims to provide educators and researchers with an important perspective on how the gap between traditional teaching methods and the changing expectations of 21st-century students can be closed. As a result, understanding pre-service teachers' views on gamification can be an important step to make mathematics education more effective and fun.

In summary, the significance of this study lies in its potential to deepen conceptual understanding of gamification among pre-service teachers, provide evidence-based implications for teacher education programs, and contribute to the ongoing debate on innovative pedagogies in mathematics education.

The research questions created within the scope of the study are as follows.

- How do pre-service teachers experience and perceive the integration of gamification in mathematics education?
- What are the pre-service teachers' perceptions of gamification in the context of mathematics education?
- What do the pre-service teachers think should be considered when integrating gamification into mathematics education?
- What advantages do pre-service teachers identify in integrating gamification into mathematics teaching?
- What disadvantages do pre-service teachers identify in integrating gamification into mathematics teaching?

2. Methods and Material

2.1 Research Design

This study employed a qualitative case study design [53, 54] to explore how pre-service mathematics teachers perceive and experience the use of gamification in mathematics education. The case is bounded by the institutional context, academic year, and internship experiences of fourth-year pre-service mathematics teachers at a public university in Türkiye. A qualitative case study approach is appropriate when the goal is to answer "how" and "why" questions in a real-world context, particularly when the researcher has limited control over behavioral events [54]. This exploratory design allowed for a holistic and in-depth examination of the integration of gamification from the perceptions and experiences of the participants.

2.2 Participants

Participants were selected using purposive sampling to ensure rich, information-dense insights from individuals with direct experience in the research context [55]. The study included 11 fourth-year pre-service mathematics teachers enrolled in a teacher education program at a public university in Türkiye. At this academic level, all participants were enrolled in the final year of their undergraduate education, during which they had taken numerous courses in mathematics education taught by expert instructors in the field. Participants were between the ages of 21 and 23 and had completed courses such as "Instructional Technologies," "Material Design in Mathematics Education", and "Middle School Mathematics Curricula," which covered topics such as digital tools, material development, classroom management, and strategies for fostering student engagement and motivation through interactive and game-based learning activities. However, since there was no specific course directly focused on gamification, this study aimed to explore whether the participants had any prior knowledge or awareness regarding gamification and its application in mathematics instruction.

The pre-service teachers who formed the study group were selected based on the opinions of the instructors who taught their courses. Pre-service teachers who demonstrated high academic achievement and were thought to be able to provide more detailed and in-depth information on the research topic were included in the study. The sample consisted of four male (P1, P4, P7, P9) and seven female (P2, P3, P5, P6, P8, P10, P11) students. All pre-service teachers who participated in the interview process were included in the study, and no participant was excluded from the scope of the research.

2.3 Data Collection

Data were gathered through semi-structured, in-depth interviews conducted in Turkish. Each interview lasted approximately 30 minutes and was held face-to-face at the university. Interview sessions were audio-recorded with participants' consent and later transcribed verbatim. The interview protocol was developed based on the literature on gamification in mathematics education and was pilot-tested with two pre-service teachers to refine question clarity and structure. The semi-structured format allowed for consistency across interviews while providing flexibility to explore emergent themes. Participants were informed about the purpose of the study and assured of the voluntary nature of their participation. The interview questions are presented in Appendix A.

2.4 Data Analysis

Thematic analysis was conducted following [56, 57] six-phase framework. An inductive approach was used to allow patterns and themes to emerge organically from the data. Initial

codes were generated from the raw transcripts and refined through iterative cycles to develop a coherent and comprehensive coding framework. To ensure analytical rigor and credibility, intercoder agreement was established through independent coding by a second researcher, followed by a discussion to resolve discrepancies. Peer debriefing and memo writing further contributed to the trustworthiness of the findings. Table 1 presents sample interview statements, generated codes, their categories, and associated themes to illustrate the coding process.

Table 1. Sample coding table

Participant Statement (Direct Quote)	Code	Category	Theme
I also need to adjust it according to their age group. It needs to be appropriate for their level.	Being suitable for student-level	In the planning process	Factors to Consider in the Integration of Gamification into Mathematics Education
It really has a great effect... When we did it in class, there was such extreme motivation. The class suddenly came alive and came to its senses.	Increasing motivation	Students' affective development	Perceived Advantages of Gamification Integration into Mathematics Education
...preparing it separately for each class is very costly.	Financial issues	Teacher related	Perceived Disadvantages of Gamification Integration into Mathematics Education

2.5 Ethical Considerations of the Study

Ethical approval was obtained for the study. All participants were informed of the study's aims and procedures, and written informed consent was secured. Confidentiality and anonymity were preserved through the use of pseudonyms. Participants were informed of their right to withdraw at any stage without penalty. All digital files, including recordings and transcripts, are stored on encrypted drives and will be retained securely for five years before permanent deletion.

2.6 Trustworthiness of the Study

To ensure the rigor of this qualitative research, the criteria of trustworthiness proposed by [58] were employed, involving credibility, transferability, dependability, and confirmability. Credibility was enhanced through several strategies, including pilot testing of the interview protocol, triangulation of researcher perspectives during coding, member checks during interviews, and peer debriefing to validate the interpretations. Transferability was supported through thick description of the research context, participant characteristics, and through illustrative quotations that allow readers to evaluate the applicability of the findings to other settings. Dependability was addressed by maintaining an audit trail, documenting all stages of data collection, coding, and analysis to provide a transparent record of the research process. Finally, confirmability was ensured through reflexive memo writing, intercoder reliability checks, and collaborative discussions, minimizing researcher bias and reinforcing the objectivity of data interpretations. Collectively, these procedures strengthened the overall trustworthiness of the study.

3. Results

This chapter is organized into four main parts: the perceptions of pre-service teachers about gamification, factors to consider in the integration of gamification into mathematics education, and perceived advantages and disadvantages of gamification in mathematics education. A table

was created for each part, and frequency information was given. Although frequency may not be included in new qualitative approaches, frequencies were included in this study with the idea of understanding which points the majority or minority emphasized.

3.1 Perceptions of Pre-service Teachers About Gamification

Under this part, the mental images of pre-service teachers regarding the concept of gamification, their initial associations with the idea, and their perceptions of what gamification means to them were analyzed. As seen in Table 2, participant pre-service teachers perceive gamification in five ways: a tool for learning with fun, a tool for concretization, a tool for practicing after the lecture, a tool that includes material use or activities, and a tool that enables students to be active in the classroom.

Table 2. Perceptions of pre-service teachers about gamification

Main Category	Frequency
A tool for learning with fun	9
A tool for concretization	7
A tool for practicing after the lecture	6
A tool that includes material use or activities	3
A tool that enables students to be active in the classroom	3

When the perceptions of pre-service teachers regarding gamification were examined, it was determined that gamification was mostly seen as a tool for learning with fun. Most of the participants stated that gamification made lessons more interesting and added motivation to the learning process. The view that gamification is also a tool for concretization came to the fore. Some pre-service teachers think that gamification makes it easier to understand complex subjects, especially in disciplines such as mathematics. At this point, P3 used the following expression regarding how gamification supports learning:

"In my opinion, gamification is all about concretization. So, we know that mathematics is an abstract science. I think that the activities carried out to enable the student to understand both conceptually and functionally are gamification. It is all about concretization."

The findings also show that gamification is perceived as a tool for practicing after the lecture. In this direction, some participants stated that gamification is especially important in terms of students repeating what they have learned and ensuring permanent learning. In addition, the view that gamification is a tool that includes material use or activities was expressed by fewer participants. Participants who defend this view state that gamification is not only a method but also a process that should be supported by certain materials or activities. P2 makes the following assessment on this issue:

"When you try to prepare something from the internet, not just material, for example, an activity, I think this is also gamification. I guess it will because it's something different. So, instead of explaining the topic, we do something different."

Finally, three participants stated that gamification is a tool that allows students to be more active in the classroom. Participants stated that students take on more responsibility with gamification applications, and this increases their participation in the lesson. In this direction, it was emphasized that gamification allows students to be more actively involved in the learning process.

The findings generally reveal that pre-service teachers make various evaluations regarding gamification practices and provide positive feedback from different perspectives. Although the participants' views on gamification appear to contain a common positive attitude, there are

differences in the intensity and emphasis levels of these views. It is particularly noteworthy that gamification stands out as a method that supports learning through fun and as a tool that helps concretize concepts.

3.2 Factors to Consider in the Integration of Gamification into Mathematics Education

This section aims to determine the basic elements that should be taken into consideration in the process of integrating gamification applications into mathematics education based on the opinions of pre-service teachers. In this context, perceptions about what should be taken into consideration for gamification to be used effectively in mathematics lessons were analyzed. Considering the data obtained, factors that should be considered when integrating gamification into mathematics education were grouped under two categories, which are the planning process and the classroom process. Table 3 presents these categories and their subcategories with the frequencies for each subcategory.

Table 3. Factors to consider in the integration of gamification into mathematics education

Main Category	Subcategories	Frequency
In the planning process	Appealing to all students	9
	Being suitable for student-level	6
	Being instructive	6
	Respecting student differences	6
	Avoiding creating misconceptions	5
	Being designed in balance with the lesson	4
	Being suitable for the learning objective	3
	Researching	3
	Being clear for the students	2
	Being suitable for the physical environment of the classroom	2
	Including technology use	2
In the classroom process	Creating a competitive environment	8
	Rewarding	7
	Informing students	4
	Creating homogenous groups	3
	Managing time effectively	3

According to participant pre-service teachers, in the integration of gamification into mathematics education, there are some factors to consider in the planning process and the classroom process. One of the most emphasized factors during the planning phase was appealing to all students. Participants stated that gamification activities should appeal to all students. P2 made the following statement on this subject:

"I am in favor of having activities that the whole class can participate in at the same time or where the whole class can access the same information. This way, I can prepare a game for an event or at work."

In addition, the factors being suitable for student level, being instructive, and respecting student differences were found to be equally important. Participants emphasized that

gamification should be appropriate to the level of students and appeal to different learning styles. P11 stated the following on this subject:

"Also, if the level of the game is not, if it is not appropriate for the class, in other words, while trying to do something good, we may have done something worse for the child. If it is not at their level, we may have made the subject more complicated. It needs to be at their level. I cannot go to a primary school kid and make a game that a high school student can understand."

Other important factors include avoiding creating misconceptions, being designed in balance with the lesson, and being suitable for the learning objective. In this context, some participants stated that gamification can lead to misconceptions if not planned carefully. In addition, pre-service teachers emphasized that the researching factor is important for the effective implementation of gamification. Participants stated that teachers should conduct comprehensive research before incorporating gamification into their lessons and that planning based on scientific foundations will increase the success of the process. In addition, the factor of being clear for the students was also stated as an element to be taken into consideration. Participants stated that gamification should be clear and understandable for the students and that complex structures could alienate students from the process rather than motivate them. Another factor that stood out was being suitable for the physical environment of the classroom. Participants stated that the classroom environment should be suitable for gamification and that the application may not be effective in cases where physical space is limited. It was stated that gamification activities may be difficult to implement, especially in small classroom environments or large student groups. Finally, the factor including technology use was seen as an important point in terms of the integration of gamification into today's education system. Some participants stated that gamification should be supported by digital tools and that the process can become more interesting thanks to the effective use of technology.

In the classroom process, the most emphasized factor was creating a competitive environment. Participants stated that creating a competitive structure through gamification could increase student motivation. In addition, the rewarding factor also has an important place, and it is thought that rewarding students will increase their participation in the course. Other factors include informing students, creating homogeneous groups, and managing time effectively. About informing students, P1 stated:

"Before starting the application, I would explain to the children everything about the game in detail: what it can have, what its rules are, why we play, and why we engage in such an activity. They also need to know that our focus is mathematics."

3.3 Perceived Advantages of Gamification Integration into Mathematics Education

This section aims to determine the advantages of integrating gamification into mathematics education from the perspective of pre-service teachers. In light of the data obtained, perceived advantages of gamification integration into mathematics education were grouped under four categories, which are students' academic development, students' affective development, students' social development, and teacher and teaching development. Table 4 presents these categories and their subcategories with the frequencies for each subcategory.

Table 4. Perceived advantages of gamification integration into mathematics education

Main Category	Subcategories	Frequency
Students' academic development	Increasing student participation	10
	Providing permanent learning	9
	Understanding mathematical concepts	8
	Increasing student focus	5
	Providing peer learning	3
	Revealing misconceptions	2
Students' affective development	Attracting student attention	11
	Increasing motivation	7
	Developing positive attitudes towards mathematics	6
Students' social development	Strengthening the teacher-student relationship	5
	Increasing classroom interaction	3
Teacher and teaching development	Increasing teacher motivation	5
	Developing teachers' pedagogical knowledge	5
	Facilitating teaching	3
	Developing teachers' content knowledge	3
	Saving time	2

The most emphasized advantage in terms of students' academic development was increasing student participation. Participants stated that gamification enabled students to participate actively in the course and facilitated their inclusion in the learning process. P4 talked about an experience he had during his internship on this issue:

"It increases participation by a hundred percent. There wasn't even a bad student in that class that day. I mean, I saw that everyone in the class followed that lesson, and even our interns attended the lesson that day. The effect of the game is very important regardless of age, and it makes everyone participate in the lesson. I mean, I'm at university right now. Even if I go to class right now, if we try to play a game. I mean, even our whole class goes and plays games. No one fails. Because the effect of the game is that it's fun, it can pass the time that hasn't been spent. Instead of the child sitting there idly, he says, 'What are they doing?' It looks like it's so fun, and he says, 'Let me take a look.' He sees that he does it once, and he says, 'Oh, it's done.' Then he keeps trying. In this way, everyone participates in the lesson. In other words, gamification has an incredible effect on mathematics."

In addition, the advantages of providing permanent learning and understanding mathematical concepts were also seen as important. Participants stated that gamification increased the permanence of knowledge and helped students understand mathematical concepts better. Another important advantage was increasing student focus. It was stated that gamification activities focused students' attention more on the lesson and extended their attention span. In addition, the factors providing peer learning and revealing misconceptions were also seen as important for academic development. One participant, P1, stated that gamification is effective in revealing students' misconceptions. He stated:

"Let's say there is a child who has a misconception of the concept of digits, and we show the multiplication of digits with natural numbers. We have given a certain time for the

multiplication process with two-digit numbers. If you can do it during this time, your group will win. I'm thinking of a game like Survivor. We did something like that. Since children are racing against time, they will focus directly on past information and try to solve it in a shorter time. According to the solution methods, we can determine whether their previous learning is a misconception or not. In other words, it may reveal the misconception there."

According to the information obtained from the participants, the advantages of gamification in mathematics education include the students' affective development. All participants emphasized that gamification attracts student attention. In addition, factors such as increasing motivation and developing positive attitudes towards mathematics also show that gamification is effective in making students love mathematics. Participants stated that gamification helps students develop a positive attitude toward mathematics.

The most emphasized advantage in terms of social development was strengthening the teacher-student relationship. Participants stated that gamification strengthened the teacher-student relationship and provided a more intimate interaction in the classroom environment. In addition, the factor increasing classroom interaction also stood out as an important advantage. It was stated that thanks to gamification, students communicated more with each other and their teachers, creating an interactive learning environment.

In terms of teacher and teaching development, the factors increasing teacher motivation and developing teachers' pedagogical knowledge were found to be equally important. Participants stated that gamification could increase teachers' interest in teaching and contribute to the development of pedagogical knowledge. In addition to these, the factors facilitating teaching and developing teachers' content knowledge were also seen as important advantages for teachers. It was stated that the gamification process improved both teachers' subject knowledge and teaching methods. Finally, the factor of saving time also shows that gamification can provide advantages for teachers in terms of time management. Some participants stated that well-planned gamification activities enable more efficient use of lesson time and that teachers can cover topics more fluently.

3.4 Perceived Disadvantages of Gamification Integration into Mathematics Education

This section aims to determine the disadvantages of integrating gamification into mathematics education from the perspective of pre-service teachers. According to the data obtained, perceived disadvantages of gamification integration into mathematics education were grouped under two categories, which are for the teacher and those for the students. Table 5 presents these categories and their subcategories with the frequencies for each subcategory.

Table 5. Factors to consider in the integration of gamification into mathematics education

Main Category	Subcategories	Frequency
Teacher related	Time-consuming	7
	Classroom management issues	7
	Exam-related unwillingness in older classes	5
	Financial issues	5
	Negative attitudes of parents	2
Student related	Focusing on games instead of mathematics	5
	Having the potential for physical harm to the student	2
	Having the potential to create misconceptions	2

When the disadvantages of integrating gamification into mathematics education are examined, it is seen that the negative effects should be evaluated from the perspective of both teachers and students. The most emphasized disadvantages for teachers were time-consuming and classroom management issues. About the problem of time-consuming, P2 stated:

"If you try to prepare the activities yourself, it will take time. Even preparing a paper for each student or preparing a question for each student takes time. You need to cut down on the time in your own daily life."

In addition, the factor of exam-related unwillingness in older classes was also seen as a significant disadvantage. Participants stated that especially upper-class students have an exam-focused approach and may be uninterested in gamification. Another important disadvantage was highlighted as financial issues. It was stated that gamification sometimes requires additional materials, technological tools, or rewards, and this can create an economic burden. It was stated that the sustainability of gamification can be difficult, especially in schools with limited resources. In addition, the negative attitudes of parents were also mentioned by some participants. Participants stated that some parents may see gamification as an unnecessary entertainment method and think that it will harm the teaching process.

The most frequently mentioned negative aspect by students was focusing on games instead of mathematics. Participants stated that if gamification is used incorrectly, students may only be interested in the game part instead of focusing on the mathematical content. P1 used the following expression on this subject:

"It can distract from the focus on mathematics unless used correctly."

Moreover, one of the participants, P3, expressed the potential for gamification to cause physical harm to students as a disadvantage:

"If we are going to play a game and, let's say, the material I will use in that game or the game itself may be a game that can directly harm the student, for example, or cause physical harm. This is also a disadvantage for me."

Finally, the factor having the potential to create misconceptions also shows that gamification should be implemented carefully. It was stated that incorrectly or incompletely designed gamification activities can lead to misconceptions in students. Overall, the findings indicate that gamification offers numerous advantages but also has some downsides if not carefully planned.

4. Discussion and Conclusion

In this study, the perceptions of pre-service teachers regarding the use of gamification in mathematics teaching, the factors to be considered in integrating gamification, and their views on the advantages and disadvantages of this approach were examined across four thematic dimensions. The findings reveal not only how pre-service teachers define and conceptualize gamification but also how their limited understanding of this concept may influence their future teaching practices. Although the research process focused directly on the concept of gamification, the frequent emphasis on the concept of the game in the participants' responses indicates a conceptual ambiguity. This situation becomes especially evident in the first dimension.

In the first dimension of the research, the perceptions of pre-service teachers towards the concept of gamification were examined. The data obtained revealed that most of the participants generally defined gamification with expressions such as "making the lesson fun," "teaching the lesson by playing games," or "involving the student in the game." This finding shows that pre-service teachers confuse the concept of gamification with games and are often unaware of the conceptual difference between them. While the concept of a game is generally defined as a voluntary, fun activity with rules and usually involving a win-lose situation [59],

gamification is explained as the use of game-specific elements in non-game contexts instead of real games [4, 60]. In this context, game and gamification stand out as two related but conceptually distinct structures. Although the participants were not asked any questions about the concept of games, almost all participants emphasized games in their responses. This is the clearest indication of the conceptual confusion in defining and exemplifying gamification. Most pre-service teachers defined gamification as "teaching lessons by having students play games" and included very limited use of typical gamification elements such as points, badges, and leaderboards.

This conceptual confusion suggests that pre-service teachers may enter the profession without a clear understanding of how to effectively integrate gamification into teaching. Similar misconceptions have been noted in previous research, highlighting the need for explicit training in the theoretical foundations of gamification in teacher education programs [61]. Therefore, teacher education should not only introduce gamification tools but also focus on their pedagogical foundations, such as how elements such as feedback, challenge, and progression contribute to cognitive engagement rather than mere entertainment.

Compared to the [4] framework, this finding highlights a gap between theory and practice. While gamification aims to strategically utilize game mechanics and dynamics to increase learning motivation, pre-service teachers' limited conceptualization reduces it to a playful activity. This gap suggests that universities should provide pre-service teachers with structured opportunities to design, implement, and evaluate gamified lessons in their coursework. In educational terms, this implies that without conceptual clarity, teachers risk implementing gamification superficially, emphasizing enjoyment over learning goals. Consequently, professional development modules focusing on design-based thinking and motivational theory [41] could help teachers use gamification purposefully to support cognitive, affective, and behavioral outcomes.

Within the scope of the second dimension, the views of the pre-service teachers regarding the elements that should be taken into consideration in the integration of gamification into mathematics teaching were analyzed. The participants emphasized that for the gamification process to be effective, the age and development levels of the students should be taken into consideration. In addition, it was stated that the materials used should be suitable for the purpose, the process should be well planned, and the competition should be structured carefully so that it does not cause negative feelings among the students. These findings reveal that integrating gamification into the teaching process in an unplanned or superficial manner may be ineffective, and as [62] also stated, gamification elements should not be selected randomly but based on pedagogical foundations.

The emphasis on planning and student relevance aligns with literature indicating that meaningful gamification requires alignment between game mechanics, learning outcomes, and learner characteristics [25]. Therefore, teacher education programs should include guided design activities where pre-service teachers analyze student profiles, identify learning objectives, and select appropriate game elements. This allows them to transform gamification from a motivational gimmick into a structured instructional strategy that enhances learning.

The participants also stated that teachers' lack of equipment regarding the process may limit gamification applications. This situation points to the need for further strengthening of the practical aspect of teacher education. From a policy perspective, this highlights the need to equip pre-service teachers with both the digital literacy and material design skills needed to effectively implement gamification. Integrating these skills into their practical experience can prepare teachers to use gamification in a variety of classroom settings.

In the third dimension, the advantages perceived by pre-service teachers regarding gamification applications were discussed. Participants stated that gamification could increase students' motivation, keep their interest in the lesson alive, and make learning more permanent. At the same time, statements that skills such as attention, participation, and the tendency to

group work in groups could also be developed were noteworthy. These findings are consistent with the literature indicating that gamification can provide positive affective gains in the teaching process [6], [60].

The motivational benefits reported by participants mirror findings from experimental studies demonstrating that gamified learning can increase engagement and foster positive attitudes toward mathematics [13], [47]. However, to maximize these benefits, teachers need to move beyond the superficial use of rewards and competition to incorporate mechanisms that foster mastery, self-regulation, and collaboration [31]. Therefore, pre-service education programs should focus on designing gamification scenarios that balance extrinsic and intrinsic motivation, thereby contributing to sustained student engagement.

While participants emphasized positive aspects such as fun and motivation, few addressed the impact on deep learning, indicating a limited pedagogical framework. Therefore, future studies could investigate how targeted gamification design training impacts pre-service teachers' ability to address student diversity, individual strategies, and long-term learning. Consequently, this perception highlights the need to reposition gamification in teacher education not as a fun add-on, but as a pedagogically informed design approach aligned with constructivist learning principles [40]. Incorporating such perspectives into teacher education will ensure that gamification serves cognitive development as well as engagement.

In the last dimension, the disadvantages perceived by the participants regarding gamification applications were examined. In the interviews, some pre-service teachers stated that gamification may make classroom management difficult, may not have the same effect on all students, may exclude some students, or may establish a structure where only competition is at the forefront, which may create anxiety in some students. These criticisms indicate that gamification may not have the same effect on every student and that its social-emotional aspects should also be carefully considered. This aligns with previous research warning that excessive competition or poorly designed reward systems can lead to anxiety or disengagement in some students [62]. Therefore, educators should be trained to design inclusive gamification experiences that foster collaboration, equity, and psychological safety [29].

In addition, some pre-service teachers stated that the process might be interrupted in the event of a lack of necessary materials and technical infrastructure. Such limitations highlight the importance of ensuring adequate technological resources and classroom materials for the effective implementation of gamification. Therefore, the success of gamified practices should be evaluated not only from a pedagogical perspective but also in terms of teachers' technical readiness and institutional support.

Overall, the findings suggest that while gamification offers pedagogical potential for increasing motivation and engagement in mathematics, its success depends on teachers' conceptual understanding, design competence, and ability to align game elements with educational objectives. In mathematics education, this study highlights the urgent need to integrate gamification theory, design practice, and critical thinking into teacher preparation programs. This allows educators to transform gamification from a superficial motivational tool into a sustainable pedagogical strategy that fosters deeper learning and engagement.

4.1 Recommendations

In line with the findings of this study, it is seen that theoretical and practical content related to the concept of gamification in teacher training processes should be structured more consciously. Especially considering that pre-service teachers have difficulty distinguishing between the concepts of game and gamification, it is important to include content that addresses the differences between these two concepts in training programs. Therefore, teacher education curricula should include explicit modules that present gamification as a pedagogical design framework, not as a series of fun activities. These modules could include case studies and

design-based projects that help pre-service teachers connect gamification theory to classroom realities.

In addition, the fact that pre-service teachers see gamification only as an entertaining tool that attracts students' attention reveals that gamification should be associated with its pedagogical foundations. Therefore, in training for pre-service teachers, topics such as how gamification contributes to learning processes, what theoretical foundations it has, and how it can be integrated in a planned manner should also be addressed. For example, integrating gamification into instructional technology or methods courses will allow pre-service teachers to design lesson plans using game elements such as feedback loops, progression systems, and challenges linked to learning objectives. These experiences will strengthen their ability to make pedagogically sound design decisions rather than relying solely on motivation and entertainment.

The findings obtained in the study also show that pre-service teachers may encounter various difficulties when transferring gamification applications to the classroom environment. In this context, having practical experiences such as developing, implementing, and evaluating gamification-based lesson plans will both contribute to their professional development and enable them to put their theoretical knowledge into practice. It is recommended that universities and faculties of education create app-based learning environments where pre-service teachers can pilot gamified lessons and receive feedback from their peers and instructors. Such authentic experiences can enhance thinking, creativity, and problem-solving skills relevant to real-world classroom challenges. However, considering the difficulties that pre-service teachers often experience in terms of a lack of materials, technical infrastructure problems, and access to digital tools, studies on material development skills should also be supported in the teacher training process. Providing access to low-cost or open-source gamification platforms (e.g., ClassDojo, Kahoot, Quizizz) during training can help overcome these barriers and make the approach more accessible. Introducing digital gamification tools, providing guidance on their use, and sharing alternative methods will increase pre-service teachers' skills in this area.

Finally, the participants' statements that gamification may have exclusionary effects on some students indicate that inclusiveness should be observed in gamification processes. In this context, it is important to develop gamification designs that are suitable for different learning styles, individual differences, and classroom diversity. Future teacher education initiatives should emphasize inclusive gamification practices that minimize competitive pressures and ensure the participation of all students, including those with low academic self-esteem or special needs. Embedding universal design principles in gamified learning environments can promote equity and psychological safety, making gamification a tool for inclusion rather than exclusion.

4.2 Limitations

This study was structured as a qualitative study, and in-depth interviews were conducted with a limited number of pre-service teachers. This situation limits the generalizability of the findings. In addition, only the views of the pre-service teachers were sought in the study, and no observation or application-based data were collected regarding the implementation process. Therefore, it could not be determined to what extent the views expressed by the pre-service teachers overlapped with the practices in the real classroom environment. In addition, the fact that the participants occasionally turned to the concept of the game during the interviews suggests that the perceptions regarding the concept of gamification may not have been fully established yet. This situation, while being a limitation of the study, also reveals the need for conceptual clarity in the field. Finally, the context of the study was limited to mathematics education only; no data was collected regarding how gamification is perceived or implemented in different disciplines. These limitations are an important reference for future studies.

Conflicts of interest

The author declares that there are no conflicts of interest.

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Appendix A

Interview Questions

1. How would you describe your initial thoughts and feelings about the concept of gamification in mathematics education?
2. How would you describe a specific instance or lesson where you integrated gamification into your mathematics teaching?
3. How would you define gamification in the context of mathematics education?
4. If you were to integrate gamification into your future mathematics classes, how would you do it step by step?
5. Based on your experiences or observations, how do you believe gamification influences students' understanding of mathematical concepts?
6. In your opinion, how does gamification impact student engagement in mathematics?
7. What might be the advantages and disadvantages of integrating gamification into mathematics?
8. How do you think the integration of gamification affects your personal and professional development as a future mathematics educator?
9. What criteria would you use to determine the success or effectiveness of gamification in mathematics education?
10. What advice would you give to other pre-service teachers considering incorporating gamification into their teaching practices?