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Educational Game Design Experiences of Prospective Secondary School Mathematics Teachers

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Abstract

In this study, it was aimed to reveal the mathematical games designed by prospective secondary school mathematics teachers and their views on this process. The participants of the study, in which a case study, one of the qualitative research designs, was used, consisted of 45 prospective secondary school mathematics teachers who took the Teaching Mathematics with Games course. The data obtained from the study were subjected to descriptive and content analysis. According to the results obtained from the study, while the majority of the games were designed as board/card games, the most preferred learning area was numbers and operations. In addition, according to the grade levels, the most games were designed for the 8th grade and the least for the 5th grade level. In the process of mathematical game design, prospective teachers mostly aim to provide meaningful learning, develop procedural skills, reinforce what has been learned, and make learning mathematics fun. In addition, although the prospective teachers experienced some difficulties during the game design process, it was determined that this process affected them positively in cognitive, affective, and pedagogical terms. According to the results of the research, it is recommended to create a game pool on a digital platform where the suitability of educational mathematics games is audited.

Keywords: Educational game, mathematics education, game design, prospective mathematics teachers.

Ortaokul Matematik Öğretmeni Adaylarının Eğitsel Oyun Geliştirme Deneyimleri

Özet

Bu araştırmada, ortaokul matematik öğretmen adaylarının tasarladıkları matematiksel oyunları ve bu sürece yönelik görüşlerini ortaya koymak amaçlanmıştır. Nitel araştırma desenlerinden durum çalışmasının kullanıldığı çalışmanın katılımcılarını Oyunla Matematik Öğretimi dersini alan 45 ortaokul matematik öğretmen adayı oluşturmaktadır. Araştırmadan elde edilen veriler betimsel ve içerik analizine tabi tutulmuştur. Araştırmadan elde edilen sonuçlara göre, oyunların önemli çoğunluğu masa/kart oyunları türünde tasarlanırken; öğrenme alanı olarak en çok tercih edilen Sayılar ve İşlemler öğrenme alanı olmuştur. Ayrıca, oyunlar ortaokul sınıf düzeylerine göre, en fazla sekizinci en az beşinci sınıf düzeyine göre tasarlanmıştır. Matematiksel oyun tasarımı sürecinde öğretmen adayları en çok anlamlı öğrenmeyi sağlamayı, işlemsel becerilerin geliştirilmesini, öğrenilenlerin pekiştirilmesini ve matematik öğrenmeyi eğlenceli hale getirmeyi amaçlamışlardır. Ayrıca, öğretmen adayları, oyun tasarımı sürecinde bir takım sıkıntılar yaşamakla birlikte; bu sürecin onları bilişsel, duyuşsal ve pedagojik anlamda olumlu yönde etkilediğini belirtmiştir. Araştırma sonuçlarına göre, eğitsel

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matematik oyunlarının uygunluğunun denetlendiği dijital platformda oyun havuzu oluşturulması önerilmektedir.

Anahtar Kelimeler: Eğitsel oyun, matematik eğitimi, oyun tasarımı, matematik öğretmeni adayları

Introduction

"There were games before there were schools," says Aristotle. Huinziga (1955) states that games, which are as old as the history of mankind, existed before the formation of culture and that games are effective actions for the realization of vital activities in the processes of becoming an individual and a society. Throughout history, mathematicians have always been interested in games. The reason for this may be curiosity about the unknown, the urge to find something first, or the feeling of happiness that comes from solving problems. Perhaps the real reason is that mathematicians identify mathematics with games and even see mathematics as a game (Umay, 2002). As a matter of fact, Lucas's Towers of Hanoi, Euler's Round of Horses Problem, the Seven Bridges Problem, the Thirty-Six Officers Problem, and Rubik's Rubik's Cube are some of the important indicators of how much importance mathematicians attached to games in the history of mathematics. With these games, mathematicians not only solved problems but also made other people sympathize with mathematics (Uğurel & Moralı, 2008).

Mathematics is perhaps the most fundamental discipline that individuals need to maintain their daily lives as well as shaping many branches of science. However, for many people, mathematics is perceived as one of the lessons that make life miserable (Sertöz, 2002). In this context, Wadsworth (2015) stated that students hate mathematics because they do not understand it. Understanding mathematics is significantly related to the active participation of the learner (Ernest, 1986). At this point, we come across an active learning approach in which the learner is at the center of the learning process. Active learning is defined as an approach to learning that makes students aware of what they do and how they do it (Prince, 2004). This approach provides students with the opportunity to have their own experiences and express themselves in terms of mathematics education at a point where teacher-centered teaching methods cannot meet the needs of the age (Aksoy, 2010; Çetin, 2016). With the active learning approach, one of the methods in which individual differences will be taken into account in mathematics lessons, students are at the center of the learning process, and individuals can freely discuss their ideas, is the game teaching method. As a matter of fact, Dienes (1963) drew attention to the importance of games in the development of mathematical thinking; he pointed out that a mathematical concept can be constructed through games and the importance of games in increasing motivation. Nesin (2008) also stated that play is a necessity for every healthy individual; for this reason, children should be made to play games so that they do not fear mathematics but love mathematics.

A game is a system in which players engage in a rule-based artificial struggle that results in a measurable outcome (Salen & Zimmerman, 2003). Educational play, on the other hand, is a set of purposeful and rule-based activities that positively affect the child's physical, mental, and spiritual development, make him/her aware of his/her abilities, and teach him/her good behaviors (Gmitrova, Podhajecká & Gmitrov, 2009; Pehlivan, 2014; Varışoğlu, Şeref & Yılmaz, 2013; Xu, 2010). Prensky (2001) lists the basic components required for an activity to be considered a game as rules that set the boundaries of the game, goals and objectives that evoke a sense of duty in the player, feedback, challenge, interaction between game-player or players, and presentation of the game. These essential components also apply to mathematical games. A mathematical game can be considered a mathematical problem (Winicki-Landman, 2008). Although there is no clear classification of mathematical games (Uğurel & Moralı, 2008), Oldfield (1991) categorized mathematical games under 12 headings in terms of their characteristics and the purposes for which they can be used: Puzzle-type games, games to reinforce concepts, games to practice skills, games to stimulate mathematical discussion, games to encourage the use of strategies, multicultural games, mental games, computer games, collaborative games, compatibility games, calculator games, and games for emphasizing underlying mathematical structures. Furthermore, mathematical games can be categorized into race-style games, board games, card games and domino games based on the materials used and the actions in which the players are involved (Way, 2011). Regardless of the type of game, if a connection is established between games and students' worlds, the process of engaging students in mathematical activities can be successfully realized (Foster, 2004).

In the mathematics curriculum, it is stated that games provide students with affective skills such as being aware of the contribution of mathematics to scientific development and the importance of mathematics in real life, feeling self-confidence, believing that they can learn mathematics, being willing to learn, enjoying problem solving, being patient, believing that mathematics develops thinking skills, and working efficiently in mathematics lessons (Ministry of National Education [MoNE], 2013). As a matter of fact, in the studies conducted in the literature, it has been determined that games positively affect attitudes towards mathematics, students have positive opinions about the use of games in mathematics lessons, and they increase motivation (Aksoy, 2014; Charles, Bustard & Black, 2009; Chiang & Qin, 2018; Romine, 2004; Russo, Bragg & Russo, 2021; Tükle, 2020). In addition, it is also seen that teaching with games increases students' success in mathematics lessons (Altunay, 2004; Karamert, 2019; Kavasoğlu, 2010; Ku, Chen, Wu, Lao, Chan, 2014; Rawansyah, Pramudhita & Pramitarini, 2021). However, there are also studies that address the views of prospective teachers or teachers on teaching with games (Cansız & Karamustafaoğlu, 2022; Doğan & Sönmez, 2019; Gürbüz, Gülburnu, & Şahin, 2017; Özata & Çoşkuntuncel, 2019; Usta et al., 2017; Yıldız Durak & Karaoğlan Yılmaz, 2019). However, although it is frequently stated in many studies that games are effective in teaching, it is noteworthy that there are limited studies in which examples of mathematical games integrated into teaching environments are reported (Baran Kaya & Gökçek, 2021; Ünveren Bilgiç, 2021).

In the study conducted by Baran Kaya and Gökçek (2021) with 38 prospective mathematics teachers, the games designed by prospective teachers were classified in terms of the type of game, the place where the game was played, the learning area, the grade level, the purpose of use, and the number of players. The results obtained from the study showed that almost all of the games were designed for reinforcement purposes, and most of them were board or card games. In the study conducted by Ünveren Bilgiç (2021) with 22 prospective mathematics teachers, the games designed by the prospective teachers were evaluated with an observation form, and the opinions of the prospective teachers about the design and implementation process were taken. The results of the study revealed that there were deficiencies in prospective teachers' theoretical and practical knowledge about designing educational games. Razak, Connolly, and Hainey (2011) stated that the obstacle for teachers to transfer their positive thoughts about educational games into practice is their lack of skills in designing and using educational games. Therefore, the description of the games designed by future teachers may provide encouraging examples for other mathematics teachers who want to make use of games in their mathematics lessons. In addition, the examples of games prepared by prospective teachers can give important clues to the reader about their previous educational experiences, learning areas of interest in mathematics, pedagogical knowledge, and creative thinking skills. In this context, the aim of this study is to reveal the mathematical games designed by prospective secondary school mathematics teachers and their views on this process.

Methodology

Research Design

This study model was determined as a case study using qualitative research methods. A case study is a preferred design to shed light on phenomena such as processes, events, and people and to reveal the phenomena in an in-depth and flexible manner (Creswell, 2013; Yin, 2009). In this study, since it was aimed to describe the games of prospective secondary school mathematics teachers at a state university in the Central Anatolia region and their views on this design process, a case study was preferred. In this context, it is not aimed to generalize the results of the study.

Participants

The participants of the study consisted of 45 prospective teachers, 39 female and 6 male, who had taken the "Teaching Mathematics with Games" course at a university in the Central Anatolia Region. The participation of prospective teachers who took the course for the first time was based on volunteerism. The researcher informed the prospective teachers that the games to be prepared at the end of the course would be used as a document in scientific research and that their opinions about the games they prepared would be taken into account. In this context, within the framework of ethical rules, the games of 45 prospective teachers who approved the use of their games and their opinions were included in this study. In addition, the prospective teachers were coded as PT1, PT2, etc.

Data Collection Tool

In this study, first of all, games with one or more learning outcomes designed by prospective teachers were used as data collection tools. In the process of designing the games, the prospective teachers were left free to work individually or in groups; 18 prospective teachers worked in groups of two, and 27 prospective teachers worked individually to develop a total of 36 different games. In the game design process, prospective teachers prepared their games based on Prensky's basic components of the game. Another data collection tool was an opinion form that included the opinions of prospective teachers about the game design process. Before the opinion form was created, a literature review was conducted and possible questions were written. Then the questions were presented to two mathematics educators for expert opinion. In the opinion form, three questions were asked of the prospective teachers: "For what purpose(s) did you design your game?", "What are the difficulties you experienced during the game design process?" and "What are the contributions of the game design process?" In order to check the comprehensibility and appropriateness of the questions, 10 prospective teachers who had received mathematics teaching with games in the previous year were asked to answer the questions. After the pilot implementation, it was decided that the questions were suitable as a data collection tool.

Data Collection Process

The research data were collected within the scope of the "Teaching Mathematics with Games" course, which was taught as an elective course in the fall semester of the 2022-2023 academic year. Within the scope of this course, the researcher provided detailed information about games, educational games, types of games, how games are designed, and their importance for mathematics education. During the semester, the researcher gave lectures on "games and game types" in the first week, "the importance of games in mathematics teaching" in the second week, "theoretical approaches to games" in the third week, "examples of games used in mathematics teaching" in the fourth and fifth weeks, "games developed by mathematicians" in the sixth week, "technology-supported games and intelligence games" in the seventh week, and "game theory and cultural mathematics games" in the eighth week.

Starting in the fifth week, it was stated that the prospective teachers should plan the game they would design. During the design process, the prospective teachers were left free in terms of learning outcomes, grade level, determining game types, etc.; without intervening in the game design, the prospective teachers were supported by another field education specialist working on mathematics with games when necessary. In addition, the prospective teachers were asked to name their games and prepare a manual containing the rules of their games. After the researcher's lectures, the prospective teachers completed and presented their game designs in the remaining 5 weeks. The other field education specialist was also present during the presentation of the designed games and gave feedback to correct the parts that were not understood or missing. After the presentation of the designed games, opinion forms were given to the prospective teachers, and they were asked to answer the questions in the form sincerely without any time limitation.

Credibility

The descriptive analysis method was used to analyze the data obtained from the designed games. The games designed by prospective teachers were analyzed according to the type of game, grade levels, and learning areas, and frequency values were included. The data obtained from the opinion form used to reflect the views of the prospective teachers were evaluated by content analysis. Content analysis (Cohen, Manion, & Morrison, 2000), in which the basic contents of the written information and the messages they contain are summarized and specified; direct quotations are also included. During the data analysis process, each data was checked with the other expert. The data obtained from the opinion form were coded by the researcher and another field expert; the reliability percentage was calculated as .96 as a result of the formula developed by Miles and Huberman (1994).

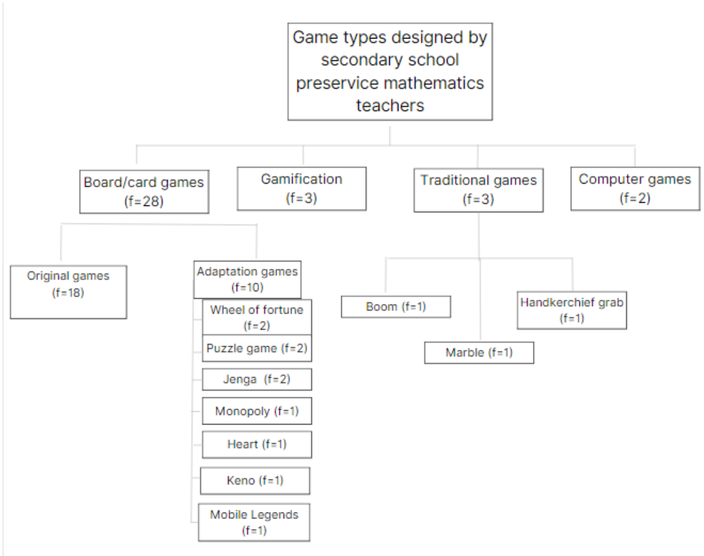
The ethics committee permission for the research was obtained following the decision of Selçuk University Ethics Committee dated 03.11.2022, and numbered E.398704.

Findings

Findings about the games designed by prospective teachers

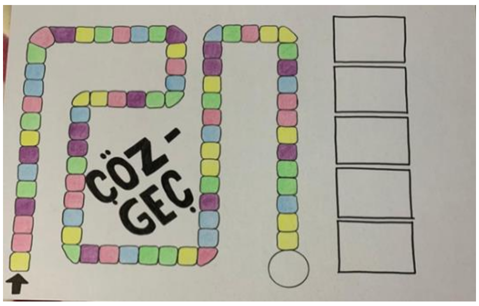
In this section, the games designed by prospective teachers were analyzed descriptively according to the types of games, grade levels, and learning domains.

Figure 1. Game types designed by secondary school prospective mathematics teachers



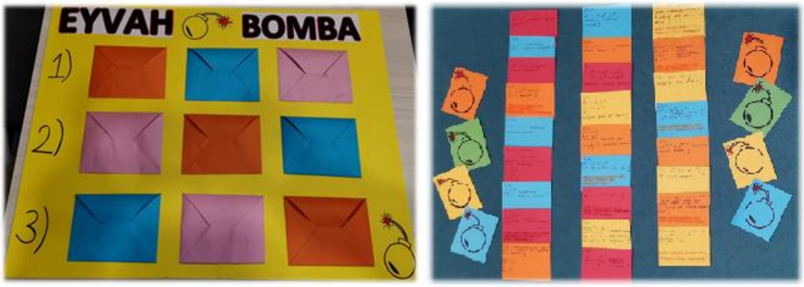
As seen in Figure 1, 28 board and card games were designed by prospective secondary school mathematics teachers. While prospective teachers created three gamification examples, three prospective teachers designed games by adapting traditional games. However, only two computer games were designed. Examples of these games are given below.

Figure 2. The original board game developed by PT10 and PT11



The "Solve-Pass" game in Figure 2 is a board game prepared for the 6th grade algebraic expressions topic. In the game, the class is divided into four groups. There are 16 green, yellow, purple, blue, pink, purple, blue, and pink question cards. Each question card of the same color is a category. One person from each group is selected as the chairman. The presidents roll the dice in turn. After four dice rolls, the group with the biggest number starts the game. When the group that starts the game rolls the dice again, it moves forward by the number of units. When it advances, it chooses a question from the card group in the color of the circle it has reached. If he or she answers the question correctly, he or she stays where he or she advanced. If he or she answers incorrectly, he or she returns to the place before moving forward. In the game that continues in this way, the group that reaches the last circle wins the game.

Figure 3. The original board game developed by PT21

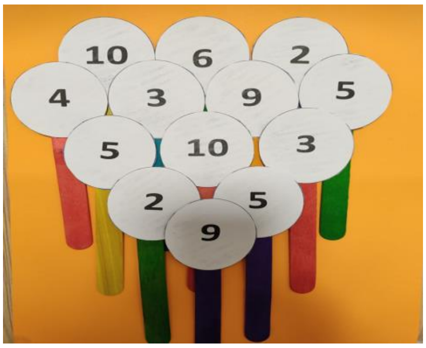


The "Oops, Bomb!" game in Figure 3 was prepared based on the objectives "Calculates integer powers of whole numbers." and "Understands the basic rules of exponential expressions and forms equivalent expressions." in the 8th grade "Numbers and Operations" learning domain. In the game, the class is divided into two groups. Each group is responsible for the questions they choose and solve. One student from each group takes the board, respectively. He or she chooses a question from the envelopes at the level he or she wants. He or she takes the board pen and solves the question on the board. If he or she solves the question correctly, he or she draws a part of the house that needs to be completed to win the game. Students take turns choosing and solving the questions from the envelopes. Some of the questions contain Jokers. Sometimes this allows them to draw two compartments of the house; sometimes it allows them to bomb the opponent's house or erase a compartment. However, if the card drawn is one of the caution cards and the student fails to solve the question, they will put their own house in danger. The process proceeds in this way. The group that completes the house or draws the most houses during the time set by the teacher wins the game.

Figure 4. Adaptation game developed by PT25 and PT26

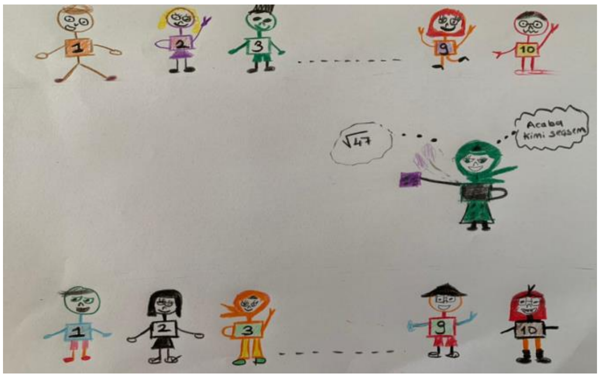
The game in Figure 4 is adapted from Monopoly and is called "Matapoly". In the game played with four players, the first player rolls both dice and moves his pawn forward as many squares as the sum of the two numbers. When a mathematician square arrives, he draws a question from the question cards in the middle and tries to solve the question in a certain time. If he knows the correct answer, he wins the mathematician card of the mathematician on his square. If not, he/she stays in the square but does not win the mathematician card. When it is the other player's turn, the player rolls the dice and moves forward as many squares as the sum of the two dice. If he/she lands on a lucky square, he/she draws a card from the lucky cards section and solves the question there. Depending on whether he gets it right or not, he follows the instructions written at the bottom of the lucky card. In other words, he gets a reward if he gets it right and a penalty if he doesn't. If a player reaches the waiting point, he cannot draw any cards and does not solve any questions. If a player advances his pawn and it lands on a prison square, he rolls a die and does not play for that many turns. If a player's pawn lands on the mathematician square and a friend has won the card for that mathematician square, the player draws a question card and tries to solve the question. If he gets it right, he gets to roll the dice again and continues the game for a chance to win the mathematician card; if not, he stays where he is and it is the next player's turn. The teacher checks whether the questions have been answered correctly. The player who collects the most mathematician cards wins the game.

Figure 5. Gamification example prepared by PT44 and PT45



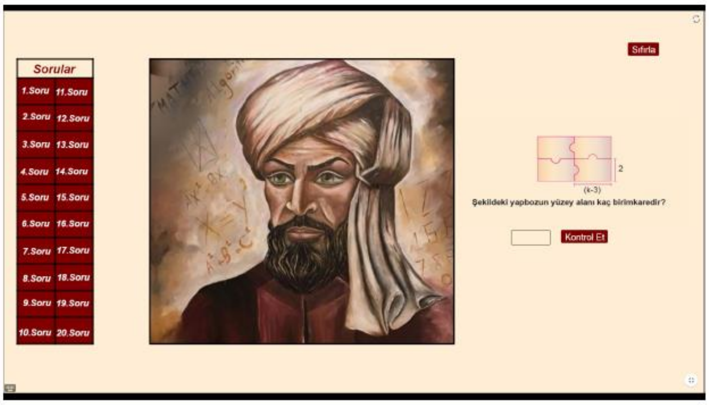
In Figure 5, the gamification example prepared by two prospective middle school mathematics teachers aims to reinforce the rules of divisibility. Pre-prepared rods are given to the students. On these sticks, the numbers to be divided exactly are written. In other words, 2, 3, 4, 5, 6, 9, and 10. The teacher gives a number and asks the students which number on the bars this number is exactly divided by. And the students immediately removed the exact divisors. The last student to remove them is eliminated from the competition. The game was named "Hands in the air!" because the sticks were raised in the air to indicate which numbers the given number was exactly divided by.

Figure 6. The drawing of the traditional game adapted by the prospective teacher coded as PT12



The prospective teacher coded PT12 adapted the game "Handkerchief Grab" to mathematics teaching. The game was prepared based on the acquisition "Determines between which two natural numbers a number with a square root that is not a perfect square is between." In the game, the class is divided into two groups. Then the people in the group are given numbers starting from 1. The two groups sit in the designated rows and the person holding the handkerchief (the one who directs the game, the one who says the square root expression) stands in the middle of the two groups. The students with the same number in both groups stand facing each other and say their numbers aloud so that it is clear who is competing with whom. The game starts when the teacher calls out a number close to the number value of any two of the students with the same number. After the teacher says the square root number, the students with the number close to that square root expression run towards the handkerchief. The first player to take the handkerchief and pass it to his/her team wins the game and gives one point to his/her team. The game continues in this way until the team with the most points is determined and all players compete. The team with the most points wins the game.

Figure 7. Computer game designed by PT5 and PT6 in GeoGebra



In the digital game prepared by the prospective teachers in the GeoGebra environment in Figure 7, the game was named "Who am I?" since it was aimed at finding a famous mathematician, Harezmi. In the game, the class is divided into two groups. Each group is given question cards (provided that each group has the same questions). These question cards are randomly distributed to the students. All students are given enough time to solve the questions. At the end of the time, the students are asked to write the answers to the questions on the question cards and hold them up and show them. (The numbers of the question cards are 1, 4, 8, 5, 9, 12, 16, 13, 17, 20, 2, 19, 18, 3, 7, 10, 15, 14, 6, 11, respectively. The reason is to make it more difficult to find the puzzle image). According to the answers given by the groups; 10 points are given for each correct answer, and no points are given for the wrong answer. For each correct answer to the questions, the relevant puzzle piece in our game is opened. For wrong answers, the puzzle piece will not be opened. After the answers to each question are taken, if a question is answered incorrectly in two groups, time is given to solve those questions again. The whole group tries to reach the solution. Each group has 3 chances to guess who the person in the puzzle is. After all the puzzle pieces have been opened, clues are given if the groups have not found the mathematician. The group that knows the mathematician in the puzzle wins the game.

The findings showing the distribution of the games designed by the prospective teachers in terms of grade level, learning, and sub-learning areas are given in Table 1.

Table 1. Distribution of the games designed by the prospective teachers in terms of grade level, learning, and sub-learning areas

Grade Levels	Learning Areas	Sub-learning area	f	Total
5th	Numbers and Operations	Operations with fractions	2	6
		Operations with natural numbers	1	
		Fractions	1	
		Percentages	1	
	Geometry and Measurement	Area measurement	1	
6th	Numbers and Operations	Multipliers and factors	4	9
		Operations with fractions	2	
		Integers	1	
	Algebra	Algebraic expressions	1	

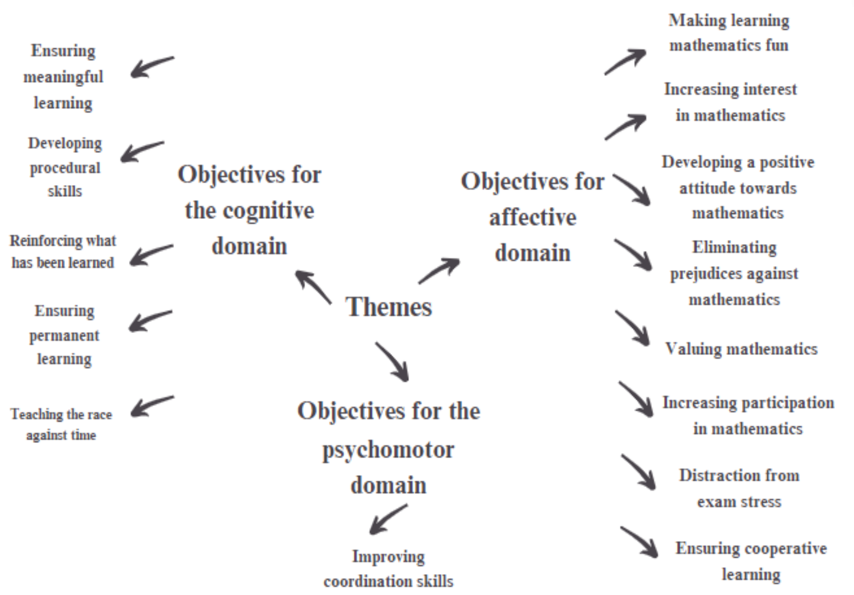
	Geometry and Measurement	Measuring liquid	1	
7th	Numbers and Operations	Operations with integers	2	7
		Ratio-proportion	1	
		Percentages	1	
		Operations with rational numbers	1	
	Geometry and Measurement	Polygons	1	
		Views of objects from different angles	1	
8th	Numbers and Operations	Square Root Expressions	5	14
		Exponential expressions	4	
		Multipliers and factors	2	
	Algebra	Algebraic expressions and identities	1	
	Geometry and Measurement	Triangles (Pythagorean relation)	1	
		Geometric objects	1	

When Table 1 is examined, it is seen that prospective secondary school mathematics teachers designed games mostly at the 8th grade level (f=14) and least at the 5th grade level (f=6). Considering all grade levels, it is seen that the majority of games were designed for the learning domain of numbers and operations (f=28), followed by geometry and measurement (f=6) and algebra (2). Multiples and multiples (f=6), square root expressions (f=5) and exponential expressions (f=4) were the sub-learning areas for which the most games were designed. In addition, operations with fractions (f=4) and operations with whole numbers (f=2) were other sub-learning areas that attracted attention.

Findings related to prospective teachers' views on the design process

The findings regarding the purpose for which the prospective teachers designed their games are given in Figure 8.

Figure 8. Purpose for which the prospective teachers designed their games



From Figure 8, it is seen that prospective secondary school mathematics teachers set more cognitive goals when designing games; in this context, they primarily aimed at meaningful learning (f=23) and developing procedural skills (f=14). When the affective domain goals were analyzed, it was determined that they aimed to make learning mathematics fun (f=9) and to increase interest in the lesson (f=6). Finally, two prospective teachers stated that they also aimed to develop coordination skills in the mathematics games they developed. Below are some of the statements of the prospective teachers regarding the purpose for which they designed the games:

"Students first learn the concept of whole number in the 6th grade, and when they do not fully grasp it here, the subject of whole number is always in the air, and all subjects in mathematics are based on numbers and students need to fully grasp this subject in order to make sense of other subjects. But unfortunately, most of the students do not understand how to place negative numbers. For this reason, I aimed for students to better comprehend the positions of numbers by placing them themselves." PT3

"...I created a game by selecting acquisitions for the EBOB-EKOK subject, which I think there is a special need to comprehend its logic. Unlike this subject,

this subject is a subject that is thought to be learned after each study, but after a while it starts to be confused." PT34

"Improving students' computational skills helps them to learn the subjects to be learned in the 6th, 7th and 8th grades more easily. Because this skill is necessary when solving each question and students should not have difficulty because of operations while learning a new subject." PT40

"...I aimed to reinforce the subject with this instructive game." PT36

"In this game, which is an adaptation of the Twister game, I aimed for the students to answer the questions by having fun. Thus, I wanted them to see that mathematics can be an enjoyable lesson." PT7

"The topic of percentages is one of the topics used in the solution process of many problems in mathematics. With this game I prepared, I aimed to make the subject fun and increase students' interest in the lesson." PT22

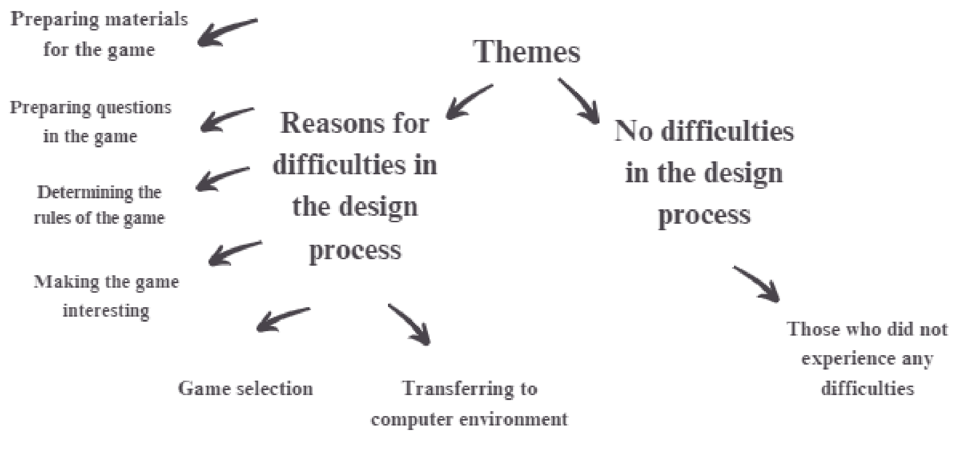
"As far as he observed, students have a prejudice that they cannot do square root expressions. So I aimed to break students' prejudices against mathematics with the game I prepared." PT1

"Our aim in this game was to transfer the studies of a mathematician who has an important place in the history of mathematics to the students within the framework of the curriculum. In this way, we aimed to make students value mathematics." PT5-6

"With the Prime Soccer game I prepared, I aimed to entertain the students and improve their coordination skills while distracting them from the stress of the exam they will take." PT31

The findings related to the difficulties encountered by prospective secondary school mathematics teachers during the game design process are given in Figure 9.

Figure 9. The difficulties encountered by secondary school prospective mathematics teachers during the game design process



As seen in Figure 9, prospective teachers had the most difficulty in preparing materials for the games they designed (f=19), preparing the questions in the game (f=12) and determining the rules of the game (f=9). On the other hand, 6 prospective teachers stated that they did not experience any difficulty in the game design process. Some of the statements of the prospective teachers about the difficulties they experienced during the game design process are given below:

"While preparing the game, I spent a lot of time covering the boxes I would use in the game. I can say that this situation made it difficult for me." PT23

"We had difficulty in cutting the product we would use to prevent our playing cards from wearing out quickly because there were many cards and it took a lot of time to cut them." PT17-18

"We had difficulty in preparing questions because we wanted to be meticulous in choosing questions appropriate to the curriculum. We also had difficulty in choosing the game because we wanted it to be a game that attracted the attention of the whole class." PT10-11

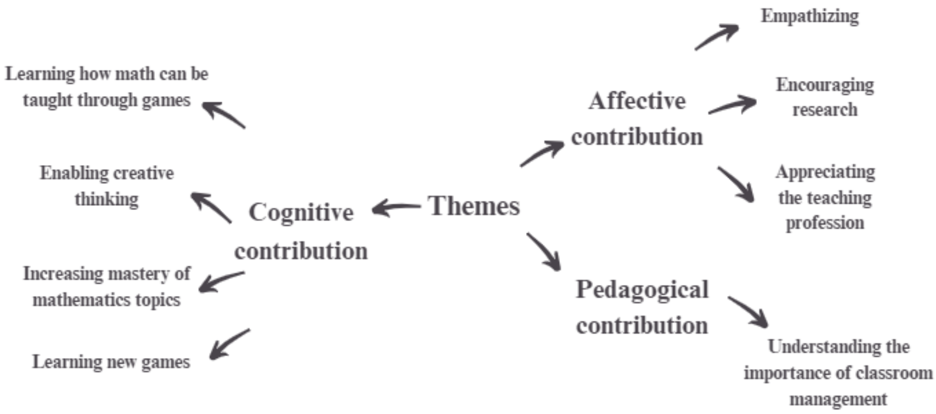
"In our game, it was difficult for us to create the rules of the game in order to avoid distraction and to ensure the participation of each student." PT32-33

"In the process, after determining the outlines of the game, we had difficulties in how to move it to the GeoGebra environment. We also had some problems in choosing questions in terms of their suitability for the learning outcomes." PT5-6

"Before I started preparing the game, I thought I might have a hard time coming up with an idea, and even if I did, I had hesitations about which learning outcome I could adapt it for. So, to be honest, I was a bit biased towards the assignment at first. However, after I started doing the assignment, it was not as difficult as I thought. As I researched the games, ideas started to form in my head, and then the rest came like socks. I prepared for the game with a lot of fun. In short, it was not a difficult situation for me." PT24

Finally, the findings obtained from the views of prospective secondary school mathematics teachers about the contributions of the game design process to them are presented in Figure 10.

Figure 10. The views of secondary school prospective mathematics teachers about the contributions of the game design process to them



When Figure 10 is examined, it is seen that the contributions of game design processes to prospective teachers are grouped under the themes of "Cognitive contribution", "Affective contribution" and "Pedagogical contribution". During the game design process, prospective teachers learned how mathematics can be taught through games by experiencing (f=17) and in this process, they empathized with the students they would play the games with (f=19). In addition, this process helped the prospective teachers to understand the importance of classroom management in the game design process (f=10). Some of the prospective teachers' views on the contributions of the game design process are given below:

"During the time I designed my game, I learned that mathematics can also be taught through games by doing-living. Although examples were given in the lesson, it was much more meaningful to experience it myself in practice." PT2

"I designed a game by adapting the game of marbles. In fact, the most important contribution of this process is to see that I can teach mathematics by setting certain rules and questions even in a game that seems very classic and simple." PT15

"This process showed me how we can think differently if we want to and how we can transfer this to the classroom environment. I can say that it expanded my limits in creative thinking." PT4

"I think that the game design process helped me see the scope of square root expressions, which is the subject I chose, and the variety of questions in the curriculum." PT40

"The process of designing a game reminded me that I had to do research first. Because I needed to make a different, original design. Having learned many new games during the research process is a great pleasure for my future working life." PT36

"I learned to empathize with the students. I had the opportunity to think more about what they would like and what would attract their attention." PT12

"In the process of designing a game, preparing materials, determining the rules of the game, thinking about how they will think in this process... Even just this process has shown me how labor-intensive, disciplined and patient this profession is. I am glad I am studying in this department." PT7

"The teacher should manage the class well so that there is no chaos while the students are playing the game. This process allowed us to see the importance of how to manage the whole class at the same time by playing this game with the whole class." PT42-43

4. Discussion, Conclusion and Recommendations

In this study, which aims to reveal the games designed by prospective teachers and their views on the game design process, it is seen that approximately 78% of the games (28 out of 36 games) are board/card games. When the designed board/card games are analyzed within themselves, the majority of the designed games are original games developed by prospective teachers in accordance with the outcome. When the adaptation games are analyzed, it is seen that prospective teachers designed games inspired by Wheel of Fortune, Jigsaw Puzzle, Jenga, Monopoly, Batak, Bingo and Mobile Legends games. In the board/card games designed by prospective teachers, there are questions/problems within the scope of the learning outcome(s) and the game progresses with their solutions. Considering that, as Way (2011) states, board games that are supported by problems and adapted to the classroom environment are the most useful mathematical games for students, it can be said that this situation is positive for prospective teachers. In the study conducted by Baran Kaya and Gökçek (2021) with 38 prospective secondary school mathematics teachers, it was observed that the majority of the prospective teachers designed board/card games. The reason for the results of both studies may be that the boundaries of board/card games are well-defined with certain rules. Since people shape their behaviors with rules from an early age and rules are an integral part of our daily lives (Campos & Mooreira, 2016); this situation may also be reflected in the game preferences of prospective teachers. In this context, more time can be allocated to topics related to different types of games within the course of teaching mathematics through games.

One of the types of games designed by secondary school prospective mathematics teachers is traditional games, albeit few in number. Traditional games can make learning mathematics easier and more fun by providing a comfortable classroom atmosphere (Salsabilah, Rahmah, Wulandari & Soebagyo, 2022). Traditional games are important not only in this respect but also in terms of preserving cultural values (Pais, 2011). Fouze and Amit (2018) state that teaching mathematics without a cultural context by claiming that mathematics is universal is one of the reasons for student failure; when mathematics is associated with cultural ties, students' desire to learn will improve. In a study conducted by Hacısalihoğlu-Karadeniz (2017) with 17 prospective mathematics teachers, traditional children's games were adapted to mathematics by prospective teachers and then the games were played in school environments. As a result of the application, it was revealed that students' interest in mathematics and their participation in the lesson increased, lessons became more fun, prejudices against mathematics disappeared, and the application helped permanent and meaningful learning. The reason why traditional games, which can have many benefits for mathematics teaching, are less preferred by prospective teachers may be that prospective teachers born in the 2000s play individually or with technological tools and their outdoor play behavior has decreased considerably (Ahiloğlu-Lindberg, 2012; Clements, 2004). Here, especially primary school teachers and secondary school mathematics teachers should include traditional games, which are part of our culture, as much as the climate and physical environments allow.

In the study, while three prospective teachers prepared gamification examples, only two digital games were developed. However, when the literature is examined, it is seen that digital games used in education have many benefits such as ensuring active participation, increasing motivation and success, and developing positive attitudes towards the lesson (Divjak & Tomić, 2011; Kim, 2015; Nguyen, Hsieh & Allen, 2006; Russo, Bragg & Russo, 2021; Tükle, 2020; Watson Huggins, 2018). The reason why prospective teachers do not prefer to design digital games may be due to their deficiencies in preparing technological games. As a matter of fact, Çağıltay et al. (2001) stated that the fact that prospective teachers do not have sufficient knowledge and skills in technology integration is an obstacle to the use of educational game technologies. At this point, Bourgonjon et al. (2013) emphasize that prospective teachers should be informed about the practices related to educational games before they experience designing games. In this context, it can be suggested to enrich the content of the courses in faculties of education that will form the basis for prospective teachers' digital game design.

When the games designed by the prospective teachers are analyzed according to the grade level, it is noteworthy that the most games were developed at the 8th grade level and the least at the 5th grade level. As a matter of fact, when the outcomes chosen by the prospective teachers are analyzed, it is seen that the majority of them are square roots and exponential expressions belonging to the 8th grade numbers and operations learning domain. When the opinions of the prospective teachers were examined, they stated that they designed games at this grade level in order to realize meaningful learning and to reduce exam stress in the last grade because these subjects are difficult to learn. Kinchin (2018) also stated that learning while having fun and playing games is much easier than sitting and concentrating on learning. From this point of view, it can be considered that the prospective teachers' desire to include more games in their mathematics lessons at the senior secondary school level is the right approach. On the other hand, it is another remarkable result that while the highest number of gameswere developed for the learning areas of numbers and operations, geometry and measurement, and algebra, there were no games developed for the learning areas of data processing and probability. The reason for this situation may be due to the low number of learning outcomes in both learning domains, especially probability, when the mathematics curriculum is examined. A similar situation was found in the study conducted by Baran Kaya and Gökçek (2021). The reason(s) for this situation can be questioned in different studies that can be conducted on the game design process of prospective mathematics teachers.

When it was questioned for what purpose the secondary school prospective mathematics teachers designed their games, they stated that they developed games cognitively in order to provide meaningful learning, to improve students' computational skills, to reinforce what has been learned, to provide permanent learning, and to teach racing against time. Affectively, they stated that they developed the games to make mathematics teaching fun, to increase interest and participation in the lesson, to develop positive attitudes towards mathematics, to reduce prejudice towards mathematics, to value mathematics, to distract students from exam stress, and to ensure cooperative learning. Finally, three prospective teachers stated that they designed games to improve students' coordinated movement skills in the psychomotor domain. In this context, when the frequency values of the objectives determined by the prospective teachers in the process of designing games are analyzed, it is seen that they mostly include cognitive, then affective, and finally psychomotor learning domain objectives. Horzum (2021), on the other hand, states that the positive effects of the use of games in mathematics lessons occur in the first step in the affective and psychomotor domains and then in the cognitive domain. The reason for the predominance of cognitive domain-oriented goals of prospective teachers in the game design process may stem from their perspectives on mathematical games. Another reason may be that many studies in the literature have focused on the effect of teaching mathematics with games on mathematics achievement (Altunay, 2004; Başer & Narlı, 2002; Kavasoğlu, 2010; Kebritchi, Hirumi, & Bai, 2010; Lee & Choi, 2020; McIntosh, 2018; Stanton, 2017). Therefore, as stated in the mathematics curriculum, the importance of not only cognitive but also affective and psychomotor learning domains should be emphasized more in mathematics education courses in the faculty of education.

While designing their games, secondary school prospective mathematics teachers stated that they had difficulties in preparing the material, preparing the questions on the game cards, determining the rules of the game, choosing the game, making the game attractive, and transferring the game to the computer environment. These results obtained from the research are in parallel with the results of the studies in which prospective teachers' views on the design process are discussed (Hacısalihoğlu Karadeniz, 2017; Ünveren Bilgiç, 2021; Yıldız Durak & Karaoğlan

Yılmaz, 2019). The important point here is to minimize the difficulties that may be experienced by taking into account the results obtained from these studies. As a matter of fact, studies have shown that teachers do not include game activities in mathematics teaching because they have difficulty in finding and preparing games (Çil & Sefer, 2021; Ergül & Erşen, 2023). In this context, a game pool can be created on a digital platform where the suitability of educational mathematics games is audited.

According to prospective secondary school mathematics teachers, the mathematical game design process enabled them to see how to teach mathematics through games, to think creatively, to learn new games, and to increase their knowledge of the outcomes in the mathematics curriculum and the extent to which these outcomes are included. In the studies conducted by Yıldız Durak and Karaoğlan Yılmaz (2019) and Hacısalihoğlu Karadeniz (2017), prospective teachers had similar views on mathematical game design. However, Aksoy and Küçük Demir (2019) found that prospective teachers' game design positively affected their creativity. In terms of affective aspects, prospective teachers stated that the game design process enabled them to empathize with students, encouraged them to research, and made them realize the importance of the teaching profession. In addition, prospective teachers stated that they also understood the importance of classroom management in the process of developing games. As a matter of fact, in the studies conducted by Usta et al. (2017) with prospective secondary school mathematics teachers and Güneş (2010) with secondary school mathematics teachers, in which the applications of educational games were discussed, teachers and prospective teachers stated that they had some difficulties in classroom management in the process. Of course, problems in classroom management will negatively affect the effectiveness of game activities in mathematics teaching. In this context, including implementation processes as well as the design process in future studies can increase the quality of educational games along with their reorganization.

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